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BLACK BEAR PREDATION ON MOOSE
(BEAR ECOLOGY STUDIES)

by

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SUMMARY

Studies of black bear ecology including density, movements, and home range; denning chronology; morphometry; and blood and hair physiology are reported.

Forty-seven different black bears (Ursus americanus) were captured 111 times between October 1977 and June 1982. Mean age of captured bears and their offspring was 5.6 years. During 1977-1982, the mean sex ratios of study area bears was 107:100 males to females, and was not different from the expected 50:50 ratio.

Female black bears in this study reached sexual maturity at 3.5 years of age and produced cubs at 4 years. Mean litter size was 1.9 cubs/female based on litters. The percentage of sexually mature females (age 4) producing cubs each year was 39, lower than the expected 50% if adult females produced cubs every other year. Breeding season, based on observations of females in estrus, observed copulations, and male/female associations occurred in June, with a peak during the middle of June.

Minimum survival rate for bears during this study was 6.2 years. Added to the average of 3.7 years for all bears at capture, mean minimum life span for the radio-collared bears was 9.9 years.

Eighteen of 47 bears (38%) captured died during the study. Of the 18 deaths, 10 (56%) were killed by hunters, 4 (22%) were capture-related mortalities, and 4 (22%) died of natural causes.

Movements and home range information indicated that black bears in this study used 2 distinct areas: (1) a home range area from den emergence until late July and again in late fall until den entrance; and (2) a summer feeding area which was usually separate from the home range area. Summer feeding areas were mature forest stands that contained devil's club (Oplopanax horridus), the principle food eaten at that time.

Mean size of home range for adult male and female bears was 141 and 21 km^2, respectively. Females with cubs tended to reduce their home range size the year they had cubs.

Denning entrance and emergence dates for a 4-year period were remarkably similar, with most bears entering their dens by mid-October. Denning emergence, occurred around mid-April to early May, but varied between years. Black bears in this study denned exclusively in underground dens; no tree dens or caves were used. Den dimensions varied between individuals and sex classes of bears, with large males constructing the largest dens and juveniles the smallest.

Serial morphometric measurements and body weights were obtained from 19 black bears which provided data on seasonal weight changes and growth. Adult female weight loss during late winter/spring was greater in sows with cubs (34%) than in those sows with no cubs or yearlings (8-22%). Sows with cubs also gained more during summer (32-37%) than sows without cubs. Adult females weighed over consecutive years during June did not gain weight between 3 and 5 years of age, but males continued to gain until 7 years of age. One adult male lost 40% of body weight during the winter denning period. Body measurements other than from skull and teeth were highly variable, and measurements other than pad width and length are less useful for population assessments or comparisons. Sex differentiation may be done from skull length, skull width, tooth measurements, and pad length and width.

Blood data from 104 black bears sampled by year, age, sex, and season provided a method to select values potentially useful for condition evaluation. Those values selected were packed cell volume, hemoglobin, and sodium. Globulin and beta globulin were useful to a lesser degree. Serial samples from the same animals appeared to be the most useful for population assessments. More data are needed from bears during stressful periods and during denning to better determine boundary conditions. The blood values useful for black bear condition evaluation from these data are similar to those for ungulates.

Hair element levels may prove to be potentially useful in detecting bears that have been nutritionally stressed. Hair copper levels increased in bears severely stressed, but more data are needed to substantiate these findings.

Key Words: black bear, moose, predation, Ursus americanus.

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BACKGROUND

This study of black bears (*Ursus americanus*) on the Kenai Peninsula was initiated as part of a comprehensive predator-prey study (Franzmann and Bailey 1977), involving moose (*Alces alces*), timber wolves (*Canis lupus*), brown bear (*Ursus arctos*), and black bears. Studies of moose calf mortality (Franzmann and Schwartz 1978, 1979, Franzmann et al. 1980) indicated that black bears were the major cause of neonatal calf mortality. In 2 years, black bears killed 34% of all radio-collared calves. Although high calf mortality had been documented in the past (LeRoux 1975), and black bear predation had been observed on the Kenai Peninsula (Lucas 1932, Palmer 1939, Chatelain 1950), the extent had not been documented prior to these predator-prey studies.

Black and brown bear studies were initiated in fall 1977, but major fieldwork did not begin until spring 1978 (Franzmann and Schwartz 1979). The initial objectives of the study centered around bear movements, density, and food habits as they related to moose mortality. Results of the 1st year's fieldwork indicated the following: (1) brown bear densities in the study area were quite low; (2) brown bear movements were extensive, and the time and effort required to locate them was great; and (3) brown bear predation on moose calves was low (6%). Therefore, we modified the bear segment of the predator-prey study to eliminate the brown bear research and intensify our efforts on black bears.

Population Ecology

We also modified the black bear research as a result of our 1st year's fieldwork. Initially, we attempted to radio-collar all black bears in the moose calf mortality study area. Because the calf study area was quite large (308 km^2) and black bear density quite high (0.2-0.3 bears/km^2), it became obvious that this objective was unrealistic. For this reason, we reduced the size of the study area to 127 km^2. We also modified the original objectives of the black bear study to evaluate and document the following: (1) reproduction, (2) survival, (3) mortality, (4) density, and (5) denning ecology of the black bears. This report contains a summary of those results. Detailed information on individuals has been presented elsewhere (Franzmann and Schwartz 1979; Schwartz and Franzmann 1980, 1981; Schwartz et al. 1982).

Morphometric Measurements and Body Weights

Morphometric measurements and body weight are potentially valuable for studies of animal populations because the values are not subject to short-term stress-related changes. Because body constituents (fat, water, protein) vary in response to season, nutrition, and environmental factors, morphometry provides a means to monitor changes in populations where baseline data are available. In long-term studies, serial measurements and weights provide an ideal method for monitoring the condition of a population.

Blood Chemistry and Hematology

The use of hematologic and blood chemistry values to monitor a population also requires that baseline values be established. LeResche et al. (1974) outlined the procedure for establishing nutrition-blood parameter relationships as: (1) determine boundary conditions, or those characteristics that may potentially influence blood parameters; (2) establish normal values within these boundary conditions; and (3) determine the nature and magnitude of changes in blood values resulting from known changes in food intake, nutrition, or related parameters.

Franzmann and Schwartz (1982) reviewed blood chemistry and hematology reports for North American wild cervids. Boundary conditions and sources of variation were identified as the following: species, sex, age, season, excitability, reproductive status, handling method, fasting, chemical immobilization, habitat, protein intake, and pathological conditions. Normal values within some of the boundary conditions have been established for moose and white-tailed deer (*Odocoileus virginianus*) which satisfy the 2nd criterion for applying and interpreting blood values. Except for the magnitude of changes in blood parameters in white-tailed deer (Franzmann and Schwartz 1982), little data are available for the 3rd criterion.

Black bear blood studies are in the 1st stage of investigation, i.e., identifying boundary conditions. Blood values for black bears have been reported, but quantification and qualification of sources of variation were lacking (Svihla et al. 1955, Jacobs 1957, Youatt and Erickson 1958, King et al. 1960, Hock 1966, Halikas and Bowers 1972, Eubanks et al. 1976, Bush et al. 1980). Studies of black bear hibernation (torpid bears) have identified torpidity as a source of variation in blood values (Brown et al. 1968, 1971, Nelson et al. 1973, Azizi et al. 1979, Franzmann et al. 1981). Erickson and Youatt (1961) identified seasonal variations in black bear blood values. Seal et al. (1967) reported differences in hematology associated with species, age, and season; McMillan et al. 1976 reported an annual rhythm of blood testosterone levels. Matula et al. (1977) identified sex, age, and seasonal differences in blood profiles of black bears. Blood studies of other North American species are useful for comparative purposes. Results from brown bears have been reported by Halloran and Pearson (1972), Pearson and Halloran (1972), and for polar bears (*Ursus maritimus*) by Manery et al. (1966) and Lee et al. (1977).

One of the most important considerations in studies of blood parameters of wild animals is minimizing sources of variation by use of standard procedures (Franzmann 1971, LeResche et al. 1974). When standardization is not possible, it is necessary to identify and quantify identifiable alterations in procedure (Franzmann et al. 1976). Large sample sizes are needed to separate procedural sources of variation from those associated with the biology of the species.

This study afforded an opportunity to collect blood from captured black bears in an attempt to further quantify and qualify the characteristics of various blood parameters.

Hair

Hair mineral element analysis has been increasingly utilized in biological research, primarily due to improved laboratory capability and the desirability of hair as a relatively stable physiologic parameter. Hopps (1974) reviewed the biological basis for use of hair in trace element analyses. Hair analysis has been extensively utilized in human and domestic animal research to monitor mineral metabolism and exposure to toxic elements. Hair element monitoring in wild mammals was first reported in the mid-1970's. Toxic element monitoring was reported for mercury in hair of coyotes (*Canis latrans*) and small rodents (Huckabee et al. 1973), and bobcats (*Lynx rufus*) and raccoons (*Procyon lotor*) (Cumbie 1975). Raymond and Forbes (1975) reported hair lead levels in urban and rural small mammals. Monitoring essential mineral metabolism for wild animals was first reported for moose (Flynn and Franzmann 1974*a*; Franzmann et al. 1974, 1975*a*, 1977). Identification of a copper deficiency in a population of moose was made based upon hair element analysis (Flynn and Franzmann 1974*b*, Flynn et al. 1977). Hair element analysis to assist in identification of origin of an animal based on geochemical variation was reported for moose (Flynn and Franzmann 1977).

Hair element levels of black bears have not been reported. Analyses of black bear hair to determine baseline values and potential application for monitoring mineral metabolism and toxic element accumulation was integrated into this study.

OBJECTIVES

To determine the population density, age structure, and productivity of the black bear population within the study area at the Moose Research Center (MRC).

To determine seasonal movements and habitat usage by resident bears within the study area.

To evaluate seasonal, temporal, and spatial aspects of bear movements as they relate to moose calving areas at the Moose River Flats and Willow Lake areas.

To evaluate seasonal usage and avoidance of the Willow Lake and MRC 1947 moose browse rehabilitation areas by black bears.

STUDY AREA

The study area lies approximately 57 km southwest of Anchorage, Alaska on the northcentral Kenai Peninsula (Fig. 1). The study took place on the Kenai National Wildlife Refuge at the Kenai Moose Research Center, a cooperative research facility of the Alaska Department of Fish and Game and the U.S. Fish and Wildlife Service. The MRC is located in the northwestern lowlands of the Kenai Peninsula. According to Sigman (1977), the climate of the region is characterized by both continental and maritime zones, although the moderating influences of Cook Inlet diminish rapidly with increased distance from the coast. Annual precipitation ranges from 40-50 cm, half of which falls as rain during the late summer (Jul-Sep). Annual snowfall is about 135-150 cm. Cushwa and Coady (1976) characterize snow depth as ranging from 40 cm for short periods of time and seldom reaching 60 cm. Snow generally covers the ground from late October to late April or early May. Winter thaws are common, and bare ground may be expected at any time.

Topography of the study area consists of ground moraine with low ridges, rolling hills, and areas of muskeg. Relief ranges from 35 to 90 m above sea level. The area is covered by podzol soils that are glacially scoured and dotted with numerous lakes and bogs. The area is similar to an Interior Alaskan forest (Spencer and Hakala 1964, Oldemeyer et al. 1977) containing a mixture of white spruce (*Picea glauca*), black spruce (*Picea mariana*), paper birch (*Betula papyrifera*), aspen (*Populus tremuloides*), and willow (*Salix* spp.). White spruce is the climax type on well-drained soils, while black spruce dominates poorly drained forest sites. Other vegetation types represent various transitional stages toward climax and are discussed by Lutz (1953).

About 40% of the study area was burned during a 1,255-km^2 fire in 1947. Mature white spruce-birch-aspen stands remain as islands within the burn. Regrowth consists mostly of black spruce, paper birch, willow, and aspen. Major shrubs in the unburned stands are aspen saplings and highbush cranberry (*Viburnum edule*). Ground vegetation in both the burned and unburned stands is dominated by lowbush cranberry (*Vaccinium vitis-idaea*), bunchberry (*Cornus canadensis*), rose (*Rosa acicularis*), twin flower (*Linnaea borealis*), and fireweed (*Epilobium angustifolium*).

The major study area was defined as a 127 km^2 (49 mi^2) unit surrounding the MRC within the extensive 1947 Kenai burn. This area supports a mosaic of vegetation types interspersed with many lakes and ponds. A 2.5 km^2 portion of the study area contained 624 individual vegetation stands ranging in size from 0.2 to 18.4 ha (LeResche et al. 1973). Remnant stands of mature forest composed 46% of this area and were extremely fragmented, making up 411 stands distributed throughout the area. The large number of stands and their irregular shapes represented tremendous amounts of ecotone--112 km in the 2.5 km^2 area. As stated by LeResche et al. (1973:95), "this 2.5 km^2 by no means represents an extreme case, but rather is a fair sampling of the entire 260-km^2 area affected by the (1947) burn." In the 2.5-km^2 area examined, 46% was mature forest, 46% regrowth forest, 6% grass and sedges, and 2% bog.

METHODS AND MATERIALS

Capture and Handling

Black bears were captured using several techniques. During fall 1977 and spring 1978, bears were captured with Aldrich foot snares (Jonkel and Cowan 1971) using techniques described by Flowers (1977). Snares were set in cubby-type trap sites constructed of logs and covered with freshly cut spruce trees. Various baits and/or scents were tested to determine which type of lure attracted bears most effectively. Snares were set on existing roads around the perimeter of the MRC.

Because of poor results with the Aldrich foot snares, we abandoned their use. From 1979 through 1981, black bears were captured with barrel traps systematically located throughout the study area (Fig. 2). These traps were constructed from 2 55-gallon steel barrels welded together end-to-end and fitted with a sliding steel door and wooden trigger mechanism (Fig. 3). During spring 1979, we cleared 18 km of seismographic trails within the study area to allow for a more uniform distribution of trap sites. Barrel traps were also set along existing roads at the MRC. Trap site locations varied each year as new sites were tested and unproductive sites abandoned. Bears were also captured by darting them from a helicopter (Bell Jet Ranger 206B) using a projectile syringe fired from a Cap-Chur gun (Palmer Chemical and Equipment Co., Douglasville, Ga.). The final method used to capture black bears consisted of immobilizing them in their winter dens using techniques described by Rogers (1977). Bears handled in winter dens were radio-collared females and their yearling offspring.

Captured bears were immobilized with phencycline hydrochloride (Sernylan, Bio-Ceutic Laboratories, Inc., St. Joseph, Mo.) alone, or as a mixture with promazine hydrochlorine (Sparine, Wyeth Laboratories). Bears in traps, snares, or in their winter dens were immobilized with a jab stick. Drug dosage was calculated from estimated weight for each bear and administered according to recommendations of Seal et al. (1970). Cubs of the year were not drugged. Newly captured females and adult males were marked with numbered, yellow plastic ear tags (Rototags, Nasco, F. Atkinson, Wis.). Because of their transient nature, juvenile males (age 3 years) were marked with large white (1979), pink (1980), or yellow (1981) ear tags and not radio collared unless they were born in the study area. The large ear tags permitted identification of these bears from the air as juvenile males handled and marked in the study area during different years. Except for the bears captured in fall 1977, all bears were fitted with radio transmitter collars manufactured by Telonics Inc., (Mesa, Ariz.); AVM Instrument Co., transmitters (Champaine, Ill.) were used in 1977. Age of individual bears was determined by counting cementum annuli in decalcified, stained sections of premolar teeth (Goodwin and Ball 1979). A copy of the field data form is provided in Fig. 4.

Radio Tracking and Home Range

Most location data (except trapping locations) and virtually all observational data were obtained from aerial radio-tracking techniques (Mech 1974) using a Piper Super Cub (PA-18). We made 1,472 radio fixes of instrumented bears during about 316 hours of flying. Once a radio-collared bear was located, its location was plotted on a map (scale 1:63,360); the bear's activity, associations, and the vegetation type was noted. Like Fritts and Mech (1981), the lack of a radio signal was interpreted to mean the following: (1) the transmitter had failed, (2) the animal had dispersed out of the area, or (3) the bear had been shot and the transmitter destroyed.

During tracking flights, we made every effort to visually sight bears that were initially located by their radio collar. During the 4 years of radio tracking (1978-1981), the individual bears being located were observed during 56% (4-year range 47-64) of 1,472 aerial fixes. This sightability was dependent on flight conditions, pilot, habitat, and season. Location error for bears not sighted varied but was usually less than 100 m. In those cases, where a bear was not observed and the habitat type occupied was in question, data were recorded as questionable and only used when appropriate. The number of times each bear was located varied each year (Table 1). We preferred to make tracking flights in the morning, but we flew at other times of the day when necessary (Fig. 5).

Home range, that area formed by connecting the outside points (a convex polygon) of an individual's locations (Mohr 1947), was determined for all bears with more than 10 location points per year. Center of activity of a home range was the mean of all X and Y coordinates for location points, except only 1 location at the den site was included in calculations.

All data recorded during flights plus habitat data were entered in a computer data file by data processing staff. Observations were transferred to digitized point-locations and analyzed for home range sizes, distances between points, and movement rates using geoprocessor software (ALARS) on the Data General computer system. Many of the data generated by the geoprocessor were entered for analysis onto the computer data file for observation information. Details of the analytical procedures have been presented by Miller and Anctil (1981).

Bear density, the number of bears per unit area, was estimated in 9-1 mi^2 areas located near the center of the study area (Fig. 6). Density was estimated using the methods discussed in detail in the Density section of this report.

Morphometric Measurements and Body Weights

Measurement and weight data collected from black bears included the following: total body length (tip of nose to tip of tail), neck circumference (at base of skull), heart or chest girth (circumference of chest posterior to shoulder), hind foot width (widest point across pad), hind foot length (from tip of pad on longest toe to end of pad at heel), skull width (widest point on zygomatic arches), skull length, (junction of gums and upper incisors to the posterior end of sagittal crest, length, and the maximum anterior-posterior and labial-lingual thickness of the left upper and lower canine teeth. In addition, baculum and testicle length were measured for males and vulva and teat length for females. All animals were weighed using a spring scale.

Blood

Blood samples were obtained from the femoral artery or vein using the B-D Vacutainer system (Bection-Dickinson Co., Rutherford, N.J.). Three 15-ml plain vials and 1 10-ml vial with an anti-coagulant (EDTA) were used. The clotted blood was centrifuged within 24 hours to obtain blood serum which was subsequently frozen at -17 C. Uncoagulated blood was used to determine percent hemoglobin (Hb) and packed cell volume (PCV) values at the MRC field lab. Percent Hb was read using an AO Hb-Meter (American Optical, Buffalo, N.Y.); PCV was determined using a microhematocrit centrifuge (Triac-Clay-Adams Co., Parsippany, N.J.). Frozen blood serum was sent to Pathologist Central Laboratory (Seattle, Wash.) and analyzed with an auto-analyzer for the following blood parameters: glucose, cholesterol, triglyceride, lactic dehydrogenase (LDH), serum glutamic oxalacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), serum alkaline phosphotase (SAP), inorganic phosphorus (P), calcium (Ca), sodium (Na), potassium (K), chloride (Cl), carbon dioxide (CO_2), blood urea nitrogen (BUN), creatanine, bilirubin, uric acid, total serum protein (TSP), albumin, and electrolyte balance. Protein fractions were determined by standard protein electrophoresis for TSP, albumin, globulin, alpha 1 globulin, alpha 2 globulin, beta globulin, and gamma globulin. Blood parameter relationships were calculated from the results and included Ca/P ratio, creatanine/BUN (C/BUN) ratio, albumin/globulin (A/G) ratio, and mean corpuscular hemoglobin concentration (MCHC).

Some serum samples were analyzed for beta-endorphin using radioimmuno assay techniques. These analyses were done by the Cleveland Clinic Foundation, Cleveland, Ohio. Beta-endorphin results have been published elsewhere (Franzmann et al. 1981) and will not be discussed in this report. Blood serum was also sent to the Communicable Disease Center (Atlanta, Ga.) for trichinosis determination using the bentonite floculation technique (see Disease and Parasites section of this report).

Blood data were recorded on a Game Biological Input Form (Fig. 7), and data were entered to accommodate the SPSS (Statistical Package for the Social Sciences) program (Nie et al. 1975). The program was used to sort the data and make comparisons.

Hair

Hair samples were obtained by plucking hair from the shoulder. A hair bundle 1 cm in diameter was the minimum sample. Samples were stored and shipped in plastic containers and analyzed by Dr. Arthur Flynn (Cleveland Clinic Foundation, Cleveland, Ohio) using flame atomic absorption spectroscopy. Hair samples were washed twice prior to analysis with diethylether to remove surface particulate matter without leaching minerals from the keratin structure. A 200-mg sample of hair was digested in 10.0 ml of 24% tetramethyl ammonium hydroxide (TMAH) for 2 hours at 55 C (Gross and Parkinson 1974). Appropriate dilutions of the digestant were made with distilled, deionized water. The 16 elements analyzed were zinc (Zn), copper (Cu), calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), cadmium (Cd), cobalt (Co), iron (Fe), lead (Pb), manganese (Mn), chromium (Cr), mercury (Hg), molybdenum (Mo), selenium (Se), and aluminum (Al).

RESULTS AND DISCUSSION

Age and Sex

Forty-seven black bears were captured and processed 111 times (Table 1; Appendix A). Mean age of resident bears in the study area from 1978-81 was 5.6 years (Table 2). Age of bears (determined for bears alive 1 May that year) was similar to that of black bears killed in Unit 15 for the same years of study. The mean age of radio-collared females in the study area increased from 1978 (3.8 years) to 1981 (6.3 years). This reflects several things: 1) not all adult female bears were captured the 1st year of study, 2) most females captured were not harvested by hunters, and 3) there was low recruitment. Bears were considered residents if they were born in the study area or used it more than 1 year. By the 3rd year of the study, nearly all residents were marked. This was evident because 1) the number of unmarked bears sighted within the study area was close to zero; 2) few new bears were captured; 3) most of the study area was occupied by radio-collared bears; and 4) the associations of radio-collared bears during the breeding season within the study area were common.

The mean age of male bears was constant from 1978 (5.9) to 1980 (6.0), with a slight increase in 1981 (7.4). The increase in mean age for males between 1980 and 1981 reflects the 1980 harvest of 3 juvenile male bears (B26, B28, B29) by hunters and the natural mortality of a yearling male (B32) the same year.

The oldest bears captured were 2 males (B10, B17), both 12 years old in 1981, while the oldest female (B20) was 10 years old in 1981.

The sex ratio for the 47 bears captured in the study area between 1977-1981 was 27 males and 20 females. This ratio is biased however, since 1) captured bears were included only once; and 2) after the 1st 2 years of study, almost all resident bears were marked; and 3) most bears captured during later years were transient juvenile males, not study area residents. The sex ratio of known resident bears, both radio-collared and newly captured for all years, was 107 males:100 females (Table 2). This total was based on all bears known to be alive in the study area each year on 1 May. Therefore, the same bear was counted each year as long as it was known to be alive. The sex ratio for 13 of 21 cubs of known sex born in the study area was not different ($\underline{P} > 0.05$) from 50:50 (Table 2).

Reproduction

Female black bears generally reach reproductive maturity at age 3.5 (Erickson and Nellor 1964, Poelker and Hartwell 1973). In a Montana study on poor black bear range, Jonkel and Cowan (1971:26) did not observe females younger than 4.5 years old in estrus and no female younger than 6.5 years with cubs. In this study, 6 females produced cubs at 4 years of age, indicating reproductive maturity during their 3rd year (Table 3). Two other bears (B30, B31) did not produce cubs during the study period. B30 was harvested as a 4.5-year-old in the fall, while B31 was harvested at age 5.2 in the spring after leaving her den. She was observed on a routine tracking flight before being shot, and no cubs were observed. If these 2 bears bred at 3 years of age, they both should have produced cubs in 1979. However, B30 did not produce cubs as a 4-year-old and B31 did not produce cubs as a 5-year-old. Both bears were in apparent good physical condition when processed.

Mean litter size (cubs/female at den emergence) was 1.9 based on of 15 litters born to radio-collared females between 1978-1982 (Table 4). This value is similar to other reported black bear litters (see Erickson and Nellor 1964:39; Jonkel and Cowan 1971:27). Mean litter size based on sighting records of 23 uncollared females with cubs was 2.2 cubs/adult female (Table 4). This value was similar to that for radio-collared bears, but may be biased because of the following: 1) the same litter may have been counted more than once; 2) loss of a cub and the subsequent reduction in litter size was not detectable; 3) some cub(s) may not have been observed with a female (radioed bears were observed repeatedly and exact numbers of cubs were known); and 4) data were based on observations over the entire summer rather than just at den emergence.

The percentage of sexually mature females (age ≥4) observed with cubs within the study area varied from 0 to 62% between 1979 and 1982, with a mean of 39% during this period (Table 5). If adult females breed and produce cubs every other year, the overall breeding frequency should have been 50%. Of all the females observed between 1978 and 1982, only 1 (B20, Table 3) followed this pattern. The other 5 females skipped a year between cycles. The effect of the changing proportion of adult females breeding was reflected in the age composition of the population, particularly in 1981 when no females produced cubs. This lack of production will be discussed in a later section of this report.

Breeding occurred mainly during June (Fig. 8) based on observations of the following: 1) trapped females in estrus; 2) bears copulating; and 3) associations of known males and females. This period coincides closely to those reported for Montana (Jonkel and Cowan 1971), Michigan (Erickson and Nellor 1964), Washington (Lindzey 1976), and Minnesota (Rogers 1977).

Survival and Mortality

Average minimum survival of radio-collared black bears after capture was calculated following the procedures used by Hoskinson and Mech (1976) and Nelson and Mech (1981) for deer. The number of bear days alive from capture through death, or through 31 December 1981 if the bear survived, was totaled and divided by the number of deaths. Mean minimum life span was estimated by adding this survival estimate to the mean age of the bear at capture. The radio-collared bears survived a minimum of 31,738 days, or 87 bear years (Table 6). During that time, 14 bears died, giving an average minimum survival of 6.2 years. Added to the average age of 3.7 years for all bears (adults and cubs) at capture, the calculated mean minimum life span for radio-collared bears was 9.9 years.

Estimates of mean minimum survival are just that, estimates and minimal. Life spans were minimal since bears that were alive when this study was terminated (31 December 1981) did not contribute a total life span to survival estimates. Accuracy of the estimate was dependent upon the ratio of live:dead bears used for calculations. The greater the number of live bears at the end of the study, the less accurate the estimate. Accuracy was also dependent upon the age of bears when first captured. Our initial sample contained a large number of young bears (Table 1); consequently, we never had enough old bears to witness natural deaths.

For marked cubs, the mean minimum period of survival was 6.2 years (Table 6). This figure was also minimum because the period of survival was related to the time of radio tracking; bears with a failed radio or bears that lost a radio may have lived much longer. In addition, since only 3 of 11 cubs died during the period of study, the minimum survival estimate was probably low. We used the age at birth (1 day) as the time of capture, even though most cubs were not radio-collared until their yearling birthday. We felt this was acceptable, since cubs were readily visible with the sow and no cubs died during the study.

Eighteen of 47 bears (38%) captured in the study area died (Table 7). Of the 18 deaths, 10 (56%) were killed by hunters and 4 (22%) were accidently killed by us. Causes of natural mortality within the study area were obscure. Of 4 known deaths (22%), 1 yearling was killed and eaten by another black bear, 2 yearlings died from malnutrition, and 1 11-year-old male died of undetermined natural causes.

Cubs of marked females ($\underline{N}$ = 13) had a high survival rate their 1st year, with none dying between 0.3 and 1.7 years. Nine of the 13 cubs were radio-collared and observed during their 2nd year. Two of the remaining 4 were killed during capture, and 2 lost their collars prior to 2.5 years of age. Of the 9 radio-collared yearlings, 6 (67%) survived until 2.5 years, and 3 (33%) died during their yearling summer (B32, B44, B46).

Yearling mortality rates were based on a small sample size and should be treated with discretion. Malnutrition, 1 cause of yearling mortality, does not occur at the same rate each year. Yearlings B44 and B46 died during summer 1981 following a fall with a poor food crop and an open winter with no snow and considerable rain. The winter of 1980-81 was marked by little snowfall, lots of rain, and subsequently no snow cover on the ground. This lack of snow coupled with moist conditions resulted in bear dens being exposed to ambient temperatures as opposed to being protected by the usual 0.5-1.0 m snow. This exposure resulted in colder den temperatures. A 2nd factor that may have contributed to starvation was the lack of early spring foods, mainly lowbush cranberry. During a "normal winter," the berries of lowbush cranberry remain on the plant because they are protected by snow. Without this protection, these berries fall off and are not available as spring food. The lack of snow during the winter of 1980-81 was reflected in yearling bear weights. Both bears' weights (B44 and B46, 8.9 and 6.1 kg, respectively), were below the 13-16 kg average for yearlings captured in other years. Third, the denning location of female B14, the mother of B44, was in a poor location for the type of winter in 1980-81. B14's den was excavated in a peat bog and was waterlogged when visited in summer 1981. A large area of the roof had caved in sometime during the winter, and the bears were visible when the den was marked during January. The nest was soaked with water. Siblings of B44 and B46 (B43 and B45, respectively) both died when we immobilized them in spring 1981 because of their poor physical condition.

Nutrition and physical condition are determined by food supply and the physical environment. Juvenile animals expend most of their energy intake toward growth and less to fat deposition. Consequently, starvation is more pronounced in the juvenile age class. The extent of this form of mortality is dependent upon several environmental factors all working together. The periodicity of such an event is unknown at this time.

Twice as many male bears (64% male vs. 36% female) marked in the study area died (excluding capture mortality) between 1978 and 1981. Excluding 3 capture mortalities in males, 7 of 9 male bears (78%) were killed by hunters.

Male black bears can be more susceptible to hunting and, consequently, tend to be harvested at a younger age. Bunnell and Tait (1977) indicate that if hunting is the major cause of mortality in a bear population, then the sex ratio of the harvest should be close to 50:50 males:females assuming an equal sex ratio at birth. In this study, our data indicate the sex ratio in cubs approximates 50:50 and that hunting accounted for 71% of all deaths (excluding capture mortality). Why then was the number of males killed by hunters twice that for female bears? This can be explained. Some male bears marked in the study area were not residents, but transient and only tagged while passing through the study area. Consequently, data on the harvest of marked bears are biased because we could not identify a young male as resident until additional data were collected (i.e., radio-tracking and home range identification, recapture several times in subsequent years in the study area). Several males killed by hunters were shot the same year they were tagged; consequently, we were unsure whether they were study area residents, transients, or possible immigrants.

Movements and Home Range

Movements of radio-collared black bears in the MRC study area revealed 2 distinct areas of use. Bears occupied an area which we refer to as their "home range" from den emergence until late July and again from mid-September until den entrance. They also traveled some distance to a 2nd area, which we refer to as "summer feeding areas." In most cases, the home range and the summer feeding area were distinct geographically, although some bears (22%, 12 of 55) used a summer feeding area that was included within their home range.

Home range areas (Table 8) for all bears from 1978-1981 were analyzed by sex, age class (juvenile $\geq$1 to 3 vs. adult >3 years), and reproductive status (female with cubs, yearlings, or barren). Only bears with 10 or more locations per year were included. Home range size for adult males (Table 9) was significantly ($P < 0.05$) larger than the home range of all other classes of bears; all other classes had home ranges of similar size. Further analysis of home range data indicated that females with cubs tended to reduce the size of their home range the year they had cubs. This was not apparent using analysis of variance, because the variation between females was so large it masked the change in home range area among treatments. Because of this large variation, we compared home range areas of individual females from year-to-year using a sign test. We were able to measure the home range area of 6 females the year they did not have cubs or yearlings (mainly 3-year-old animals) and again the following year when they were accompanied by cubs. Five of 6 home ranges of females without cubs decreased in size when the female had cubs; 1 home range increased ($P < 0.25$). The same sign test was also applied to change in home range size for females with cubs 1 year and the same female with yearlings the following year. Of 7 bears observed, 5 increased their home range size and 2 decreased it from their cub-to-yearling years; differences were not significant. For the 2 bears that decreased their home range areas, however, both had summer feeding areas within their home ranges and the reduction in home range size probably reflected a shift in summer feeding areas rather than a reduction in home range size from cub-to-yearling years. If these 2 bears are excluded, there was a significant ($P < 0.10$) increase in home range size for females with cubs to females with yearlings. It was apparent that females accompanied by cubs were less mobile than other classes of bears. Females accompanied by cubs left their denning areas much later in the spring than females with yearlings, barren females, or males (see Denning Ecology section of this report). Distances between successive locations were also smaller for females with cubs.

Black bears in this study appeared to occupy a home range rather than defend a territory (an exclusive area occupied by an individual and its young). This observation is in agreement with findings of Lindzey and Meslow (1977) in Washington, Amstrup and Beecham (1976) in Idaho, and contrary to those of Rogers (1977). Rogers (1977) suggested that females were territorial, but accepted female offspring within their established territories. Since we did not know the kinship of individual females at the start of this study, we cannot accept or reject territoriality among black bears of different kinships. We did, however, make several observations of home range overlap between individuals and observe associations between individuals where home ranges overlapped. These overlaps of home range (Figs. 9, 10) and associations of bears lead us to believe that bears in this study area were not territorial for the following reasons: (1) associations of bears of different ages (1 year apart) probably were not offspring of the same female; (2) associations of 2 or more adult females within overlap areas; (3) a lack of aggressive behavior of individuals toward each other when visual contact was made.

Home range areas for each bear that we obtained serial data for change annually in size and shape. These changes were a product of changes in flight schedules, shifts in home range size, reproductive status, and other factors. Shifts in centers of activities from year to year were small (Table 10) and did not exceed 1.3 km for females and 3.5 km for males. In general, it appeared that bears maintained a home range within a given area, but the boundaries were variable.

Home range sizes for adult male black bears in this study were similar to those reported by Miller and McAllister (1982), and Modafferi (1982) in Alaska, and by Amstrup and Beecham (1976) in Idaho, but were larger than those reported in Arizona (LeCount 1977) and in Washington (Poelker and Hartwell 1973, Lindzey 1976) (Table 11). Home ranges for adult females in this study were similar to those found by Modafferi (1982) in Prince William Sound, Alaska, but much smaller than those reported in the Susitna River basin by Miller and McAllister (1982). Large home range size reported by Miller and McAllister results from inclusion of summer feeding areas and movement corridors in home range delineations. We excluded these areas in our determinations. Adult female home ranges from the Kenai were also similar to those reported in Arizona and Idaho, but larger than those reported in Washington (Table 11).

During the 4 years of study (1978-1981), most bears left their home range areas and traveled some distance to summer feeding areas. Time of departure varied between bears, and between years (Table 12), but most bears began their migration in late July and early August. Distance traveled between the center of activity of the home range and summer feeding areas for each bear in all years averaged 23 ± 3 km, with males and females traveling an average of 31.4 ± 3.4 km and 17.2 ± 1.3 km, respectively.

We tested for differences in travel distance between animals and years (Table 13) using ANOVA and Duncan's new multiple range test. Results indicated that distances traveled by males were not different between years; likewise, distance traveled by females was not different between years. Males traveled a significantly ($P < 0.05$) longer distance than females in 1980 and 1981, but not in 1978 and 1979. The reasons for this difference are unknown, but we suspect that these statistics reflect an artifact in sample size for male bears. This artifact resulted because we had more male bears in successive years (less serial data) than females. We suspect that males did travel further than females even if the statistics did not show this trend. We will address this fact later.

Summer feeding areas in this study were upland forests with an understory of devil's club (*Oplopanax horridus*). Scat analysis indicated that black bears were feeding almost exclusively on the fruit of the devil's club plant while they were in their summer feeding areas.

Because of its patchy distribution and limited acreage, devil's club is not uniformly distributed on the Kenai Peninsula and appears to be associated with old-growth forest and upland cottonwood stands. We often observed several bears in the same area. Devil's club also appears to be fire-sensitive since it does not occur in the 1969 burn, is quite rare in the 1947 burn, but is found adjacent to both burns on similar upland unburned sites. Fruit of devil's club ripens earlier than other major berry-producing species on the Kenai, and therefore is the 1st major food available to bears during summer. Devil's club appears to be a very important food item for Kenai Peninsula black bears since all bears each year traveled to feed upon the fruits.

Usage of summer feeding areas appeared to be traditional and probably a learned behavior. Most bears that we radio-tracked in successive years returned to the same summer feeding area each year. Likewise, cubs that traveled to summer feeding areas with their mothers, returned to the same area after they separated from her. This was also true for juvenile male bears that dispersed from the study area. Both B39 at age 2 and 3 years and B41 at age 2 years, males born in the study area, were radio-tracked to the summer feeding area used by their mothers while they were cubs. Both bears were no longer residents of the study area.

This traditional use of summer feeding areas may explain why male bears tend to travel longer distances to summer feeding areas than females. Since juvenile females in this study and in other studies (see Rogers 1977) establish a home range within that of their mother's, they rarely disperse from an area. On the other hand, juvenile males usually disperse from their mother's home range and may travel quite a distance before they locate a suitable area to establish a home range. Consequently, their home range may be some distance from their maternal summer feeding area. This may explain why male bears B16, B25, B33, B9, B34, and B11 all traveled a considerable distance across the 1969 burn to the North Kenai area to their summer feeding areas. All of these bears passed through at least 2 mature forests which contained devil's club stands that were known summer feeding areas of female black bears. The summer feeding area that these male bears used was also utilized by other black bears, mainly females from the 1969 burn.

The length of time that bears remained in their summer feeding areas varied considerably between years (Table 12). In 1978, most bears returned to their home range areas in early October and denned 1-2 weeks later. In contrast, bears returned to their home ranges on 7 and 1 September in 1980 and 1981, respectively. Upon return, these bears fed heavily on lowbush cranberry prior to denning. Bears returned on 22 September in 1979.

We do not know what mechanism triggers the return of bears to their home range areas. At first, we suspected that use of devil's club was greater in years of poor cranberry crops. This was the case in 1978, when there was a poor cranberry crop on the Kenai and bears returned late. However, 1979 and 1980 both had cranberry crops that we rated as "average" on a subjective basis. In 1979, bears returned late while they returned in early September in 1980; 1981 had a scattered cranberry crop that was abundant in local areas. Bears returned early in 1981. We know nothing about the abundance of devil's club during these same years. Consequently, bear return may have been triggered by a decline in devil's club availability. This aspect of black bear seasonal movements deserves further study. Additional studies on the ecology of devil's club are also important since this plant species appears to be a key component of black bear habitat on the Kenai Peninsula lowlands.

Density

Animal density ($\hat{D}$) has been defined as the number of individuals per unit area. Although density is a term that is easily defined, its application to animal populations has been difficult. Techniques to estimate animal density are numerous (see Davis and Winstead 1980, White et al. 1982). Many of these procedures determine the number of individuals within a study area based on ratios of marked vs. unmarked animals, utilizing capture-recapture techniques or others that attempt to accurately estimate the number of animals. Most have been given rigorous mathematical and statistical evaluation, and variance estimates can be calculated. Capture-recapture techniques have certain assumptions which must be met before the technique can be properly applied. These assumptions include (1) no loss (or gain) of marked animals, (2) no recruitment (birth or immigration), (3) no difference in mortality of the marked and unmarked individuals, (4) identical rates of catchability in marked and unmarked individuals, and (5) mixing of marked and unmarked individuals. In most instances, bear populations being studied do not meet all these criteria. Various researchers (Jonkel and Cowan 1971; Kemp 1972, 1976; Beecham 1977) have utilized trap-retrap methods to estimate bear density or made adjustments to their data in an attempt to satisfy these assumptions. However, additional problems exist when using capture-recapture ratios.

Density ($\hat{D}$) is composed of 2 variables, the number of animals (N) per unit area (A). Most of the ratio-techniques concentrate on making an accurate estimate of N. The researcher, based on previous knowledge, study area size, animal distribution, and home range area determines the size of A used to calculate density. However, density estimates cannot be made by simply dividing the study area size into the animal number estimate. Biologists must consider the relationship of animal home range size to study area size. A good discussion pertaining to this subject is presented by White et al. (1982:120-131). In summary, if the study area is very large relative to home range size, very little error results when A = study area. However, when the study area is small relative to home range size, valid density estimates probably cannot be obtained using A = study area. Attempts have been made to correct for the latter situation, with the most frequent method employing the incorporation of a boundary strip into the study area.

Black bears occupy very large home ranges, in Alaska 10-150 km^2, and it is impractical and cost prohibitive to obtain a study area:home range ratio large enough to accurately estimate $\hat{D}$ using capture-recapture methods. For this reason, we have employed a new technique which we feel most accurately estimates bear density within the study area.

The method operates under the following assumptions: (1) all individuals that utilize areas used to estimate density are radio-collared, (2) bears utilize the areas within their home range at a uniform rate, and (3) areas selected for density estimates are typical and representative of the study area. The technique is based upon the assumption that if all bears that utilize a given area are radio-collared, then bear density is a function of the ratio of study area size to home range area, summed for all bears. Density then can be expressed as follows:

$$\hat{D} = \frac{\sum_{i=1}^{i=n} \frac{AO}{HRAi}}{A}$$

where: $\hat{D}$ = Density estimate

A = size of study area or portion of study area (subunit) used to estimate density

HRA = individual bear home range area

AO = area of overlap between A and HRA.

Density estimates can be made for several selected subunits within a study area, thus allowing for calculation of variance.

Several factors potentially affect the validity and accuracy of density estimates made using the above formula. Home range area must be accurately estimated and usage of a home range area is assumed to be uniform. We are aware of the problems associated with valid estimates of home range area (see Schoener 1981), and accurate density estimates made using HRA as an input parameter necessitate an accurate HRA estimate. Bears, like most other animal species, do not utilize their defined home range areas in a uniform manner. Certain vegetation types, terrains, or other environmental characteristics within the defined HRA are utilized to a greater or lesser extent than others. Consequently, individuals spend more time in certain areas within their HRA, and less in others. Likewise, this usage can fluctuate seasonally. We are aware of these problems, but suggest that if the study area or subunits within the study area chosen represent "typical" habitat being evaluated, $\hat{D}$ probably reflects bear usage of that particular study area or subunit.

Density estimates using this technique require delineation of all individual HRA's within the study area. This objective is not easily obtained, and due to radio equipment malfunctions it is difficult to maintain. Even with these obstacles, we feel the technique offers an accurate estimate of bear density, and overcomes the problems associated with capture-recapture methods and their assumptions.

For the purposes of this study, we selected 9 1 mi^2 areas (Fig. 6) located in the center of the study area as subunits for density calculations. These subunits were chosen because they were in the center of the study area where we felt all resident bears were radio-collared. Our density estimates are underestimated because of the following: (1) juvenile males captured within the study area were not radio-collared, and therefore are not included in all estimates; (2) some resident bears lost their radio collars during a field season, precluding accurate delineation of their home range; and (3) we probably did not have every adult male that utilized the 9 subunuts radio-collared. Home range of adult males is very large and consequently capturing an adult male when it was in the study area was less likely than for a female. In addition, very large males that were radio-collared were infrequently captured in barrel traps even though their presence in the study area was known. We did feel that only a few adult males at most were probably missed, because it was very infrequent that "large bears" (assumed to be males) were sighted in the study area, and all radio-collared resident females were sighted with marked males during the breeding season. We feel confident about having had all resident females marked. This confidence was gained for the following reasons: (1) the distribution of home range areas of females uniformly covered the study area (i.e., no big gaps were present); and (2) we did not continue to catch additional adult females after the 1st 2 years of trapping. Bear B35 was an exception to this. She was not captured until spring 1981. However, home range maps from 1978 and 1979 revealed a big gap in the area she occupied. In addition, flights made in 1979 and 1980 revealed an unmarked adult female (judged to be an adult female because she had offspring) in this area. Once B35 was captured and her home range delineated in 1981, the gap in home range distributions detected in 1978 and 1979 was filled. We further feel this was the case because as the offspring of these residents matured, we were able to maintain radio contact with them, thereby documenting recruitment (at least of young females) within the study area.

One technique employed to overcome the temporary loss of radio contact with an individual was to apply the mean density estimate for that individual from known years to a year when HRA was not delineated. For example, bear B1 was first radio-collared in fall 1977. We were able to obtain good HRA data for the years 1978 and 1979. Her radio failed in fall 1979 while she was in her summer feeding area. We did not regain radio contact with her until 21 June 1981 when she was trapped in the study area. We obtained good HRA data in 1981. Since adult females are resident and maintain approximately the same HRA each year, we applied the mean of 1978, 1979, and 1981 HRA information to calculate an individual density estimate for B1 in 1980. We realized that HRA of B1 in 1980 was probably different from this mean, but felt that the mean was the best estimate available. We also felt that excluding B1 from 1980 density calculations would have caused a more serious error. Individual density estimates made in this manner are noted (Tables 14-16).

Home range areas used to make individual density estimates were based on data location points obtained from den emergence in the spring through den entrance in the fall, excluding migration and summer feeding area locations. Consequently, our density estimates represent an average over the entire "bear summer." We feel this method is superior to estimates made at 1 season, because it eliminates the possibility of biased estimates resulting from seasonal concentrations of individuals. We excluded migration and summer feeding area locations because HRA calculated with these points would not be representative. Our bear density estimates represent bear numbers within the 1947 burn habitat at the MRC, except during midsummer, when the bear density approaches zero.

Since bear densities were calculated for the entire season, bears that died before den entrance in the fall are also excluded from these calculations. Therefore, density estimates represent the lowest seasonal density and were no doubt higher in spring and early summer.

Results of density calculations, Tables 14-16, indicated density estimates (bears/km^2) ranged from a high of 0.26 in 1980 to a low of 0.13 in 1981. Density in 1979 was close to that of 1980 (0.22 bears/km^2). As discussed earlier, these values are low because juvenile males were not included, and we probably did not have all adult males radio-collared. Estimates for females and cubs are probably quite accurate.

Density changed within the study area each year. Densities for females and cubs were similar in 1979 and 1980 (Tables 14, 15), but declined by 50% in 1981 (Table 16). This decline was real, and a direct result of no cub production in 1981, a loss of 2 adult females to hunting, and deaths of 4 yearlings. This lack of cub production and the yearling mortality was a product of a poor fall berry crop in 1980 and poor denning conditions during the 1980-1981 winter.

Density of bears within the MRC study area fitted well into the ranges of density listed for bears elsewhere in North America. MRC density was lower than that reported by Modafferi (1982) in Prince William Sound, but probably reflects the difference in estimation techniques. Densities at the MRC were also lower than those reported in Alberta, Washington, and Idaho, but similar to those reported in Montana, Michigan, and Minnesota (Table 17).

Denning Ecology

Between 1978 and 1982, 49 black bear dens were located and measured. Of the 49 dens, 35 were used by females, 13 by males, and 1 by an unidentified bear (Appendix B).

Black bears exhibit a period of winter dormancy, which has been referred to by Hock (1960) as "carnivore lethargy," but which may approach a hibernating state quite similar to typical mammalian hibernators (Folk et al. 1976, 1977). Denning behavior has been described as an adaptive mechanism to survive a food shortage during extensive periods of severe weather (Gilbert 1952, Spencer 1955, Erickson 1965, Jonkel and Cowan 1971, Amstrup and Beecham 1976, Rogers 1976). Although black bears also exhibit denning behavior in areas that have mild winter weather and available food (Lindzey and Meslow 1976; Hamilton and Marchington 1977; Johnson 1978; Johnson and Pelton 1979; Novick et al. 1980; LeCount, In Press), in this study all bears denned each year.

Most bears in this study exhibited signs of lethargy prior to entering their dens for winter as many bears moved to the denning area several weeks to several days prior to actual denning. This behavior was exhibited by both female and male bears, although some adult males were not sighted at their dens prior to entrance, and probably did not spend much time in that vicinity prior to denning. Since radio-tracking flights were made weekly, exact day of den entrance was unknown. Denning chronology determined from observing several individuals in any 1 year probably reflects accurate trends. Den entrance as used here is defined as the date that a bear entered its den for the winter. If a bear was sighted at the den entrance, but was not in the den itself, or was observed in a den, but was later observed outside the den, this was not considered entrance for the winter. In most cases, once bears entered their dens in late fall, they remained in the den. Flights were terminated after all bears were declared to be in their winter dens, and existing environmental conditions were such to indicate they would remain there (extreme cold and snowfall). The dates bears entered their dens varied among bears and years (Table 18). Mean dates of den entrance were remarkably identical for the 4 years with adequate records. In 3 of the 4 years, the mean denning date was 21 October; the 4th year, it was 22 October. Mean denning dates for males and females likewise were quite similar (Table 18) and were no greater than 4 days different. Various investigators (Erickson et al. 1964; Jonkel and Cowan 1971; Johnson 1978; Johnson and Pelton 1979; LeCount, In Press) have observed females denning earlier than males, although considerable overlap occurred. In Idaho, Beecham et al. (In Press) felt pregnant females denned earlier than males. Our data indicate that there is considerable overlap in den entrance between sexes, age classes, and reproductive classes, and no 1 group of bears obviously den either earlier or later than any other group. The overlap may be a result of monitoring frequency, but is more likely real.

Onset of denning activity was probably a result of many factors. Most bears began to show signs of lethargy weeks before entering their dens. Observations made at this time of year indicated that bears were fat (judged from body configuration of bears handled), and spent more time resting and sleeping and less time feeding. Actual den entrance, although quite similar each year, appears to be affected by a combination of low temperature and/or early winter snow storms that resulted in snow accumulation on the ground.

In 1978, the 1st snowfall that resulted in snow accumulation on the ground occurred on 28 October, and all bears were in their dens on 30 October (Fig. 11). Bears began denning that year on 18 October when 76% of all bears radio-collared were denned. The 1st snow storm in 1978 occurred on 20 October. Minimum daily temperatures during October (Fig. 12) indicated a decline in temperature on 15, 22, and 23 October.

In 1979, the 1st snow storm occurred on 21 October; over 75% of the radio-collared bears were denned by 18 October. A 2nd snowstorm occurred between 26 and 29 October, and all bears were denned when checked on 28 October. Although there was no snow accumulation on the ground until 13 November, subsequent flights made after 28 October indicated all bears had remained in their dens. Major drops in temperature occurred on 6 and 7 October, and a 2nd drop began 13 October and lasted through the 21st.

In 1980, the 1st snow storm occurred on 8-10 October, and bear denning began that week. Additional storms occurred on 17 and 29 October and 3, 5, 7, and 11 November. Snow did not accumulate on the ground until 13 November. All bears were considered denned on 11 November. Temperatures fluctuated during October and November with major drops occurring on the 4, 11, 17, and 30 October and 1, 2, and 8-11 November.

In 1981, all bears were denned by 27 October. The 1st major storm occurred on 27 October, with snow accumulation on the ground 28 October. Two light storms occurred on 4-5 and 8-9 October with no accumulation. A major temperature drop occurred on 25 October.

It appears from the above data that snowfall and temperature affect denning chronology. In 1978 and 1981, all bears were denned just prior to the major storm of the month that resulted in snow accumulations adequate to cover the ground. In 1979 and 1980, snow accumulation did not occur until after all bears were denned. However, in 1979, snow storms during the middle of the month probably were responsible for all bears denning by 27 October. The only year that did not have abrupt snow-temperature changes was 1980. October had a few light snow storms, but mainly mild weather. This was the only year where the den entrance period was drawn out, and although some bears began denning as early as 11 October, all bears were not denned until 11 November (Fig. 12). In all other years, denning was complete by the end of October, and the duration (start to finish) much shorter. There was a major drop in temperature from 8-11 November, and a major snowstorm on 12 November 1980.

The onset of denning by bears in this study approaches the dates given by Erickson (1965) for Alaska, but are almost 2 weeks later than dates observed by Miller and McAllister (1982) for black bears in the upper Susitna River basin in Alaska.

Data on cessation of denning (Table 18) were obtained from 1979 through 1981. Here, den emergence is defined as the 1st time a bear was sighted out of its den. Bears that were sighted at their den entrance, but had not left the vicinity of the den, were considered emerged. This was common for females with cubs; they often remained at the den up to 2 weeks after emergence.

Den emergence dates for all bears did not vary much between the years 1979 and 1981. Dates were slightly later in 1980; however, this may be an artifact of poor flight weather during the 1st week of May when many bears probably emerged from their dens (Fig. 13; Table 18).

In 1979, bears began to leave their dens soon after the remaining snow had melted, and the temperatures turned mild. Since a key flight was missed in 1980, emergence data are difficult to integrate. However, in 1981, bears did not begin to emerge from their dens until 15 April; most did not emerge until 22-27 April. The winter of 1980-81 was marked by little or no snowfall and mild temperatures. There was no snow on the ground after 9 March. We began tracking flights on 20 March on a regular basis, but all bears remained denned in spite of "spring-like" weather and lack of snowfall. Bears did not emerge until mid-April.

Other investigations (Amstrup and Beecham 1976; Johnson and Pelton 1979; Reynolds and Beecham 1979; Novick et al. 1980; LeCount, In Press) showed differences in emergence time between sexes, with males generally leaving dens first. Likewise, these observers noticed that females with cubs were the last to emerge from their dens. In our study, we could not detect differences in emergence time between sexes, or for females with cubs. We did notice that females with cubs spent from 10 to 14 days at their dens after emerging in the spring, while males and females without cubs usually left their den sites within a week of emergence. Females with cubs probably remain at or near the den for several weeks in the spring while newborn cubs gain strength and ability to effectively travel with their mother. Den emergence was not defined in some studies and may well include the period that a female with cubs remained at the den site.

Our data for den emergence are comparable to dates reported for Idaho (Beecham et al. In Press), Maine (Spencer 1955), and Minnesota (Rogers 1977), but are earlier than those reported by Miller and McAllister (1982) and later than those reported by Lindzey and Meslow (1976) and LeCount (In Press).

Comparisons of mean entrance dates and the time span required for all bears to den suggests that weather (snow and temperature) controls the onset of denning, while some other factors controlled den emergence in the spring (probably day length). It is doubtful that a species would evolve with different mechanisms to control den entrance and den emergence. Alaska, because of its extreme northern location, is subject to rapid changes in day length and temperatures from summer to winter. Spring and fall tend to be very short seasons. Because of this rapid shift from "summer" to "winter," environmental conditions during October usually set the stage for denning. Proximal factors that regulate den entrance (i.e., day-to-day) are probably stimulated by environmental factors like lowering temperatures or snowfall. However, this does not explain why bears den in areas that lack such environmental perturbations. Ultimate factors controlling denning entrance and emergence are probably keyed to day length (i.e., year-to-year). This would explain why bears did not emerge from their dens in early March 1981, even though temperatures were warm and there was no snow on the ground.

Some investigators (Beecham et al. In Press) have suggested that food shortages may stimulate bears to enter dens. Our data only partially support this hypothesis. Bears entered their dens in 2 of 4 years (1978, 1981) just prior to major snowstorms that resulted in snow accumulation and when lowbush cranberries were still available. They also entered dens (1979, 1980) before snow accumulation reduced or eliminated food availability. Spring emergence in 3 of 4 years was keyed to snow melt/warm temperatures, which probably influenced food availability. However, in spring 1981, bears did not leave their dens until late April in spite of warm temperatures, no snow cover, and available food. In all years, there was no "green-up" of vegetation when bears emerged; consequently, food avalilable in late March-early April would have been similar to that in late April-early May. Since we began tracking flights on 20 March in 1981, we would probably have detected any bears that may have ventured out of their dens to check food availability.

Black bears on the Kenai Peninsula denned exclusively in underground excavated dens. No bears denned in trees; only 2 dens were associated with rocks and were dug dens under large glacial rock. In contrast, Miller and McAllister (1982) found 57% of black bears on the Susitna River, Alaska denned in natural rock caves; the remainder denned in excavated dens. Miller et al. (1982) found 62% of radio-collared bears in Prince William Sound, Alaska denned in rock caves, and the remainder in hollow trees (see Appendix C). In other areas, Beecham et al. (In Press) found bears in Idaho denning in excavated cavities (71%), hollow trees (21%), and hollow logs or rock cavities (8%), while Jonkel and Cowan (1971) and Lindzey and Meslow (1976) reported that black bears denned primarily in hollow trees in Montana and Washington, respectively.

It was not surprising that black bears from the Kenai Peninsula did not den in tree cavities. The mature timber in the MRC study area was not large enough to provide adequate space for a tree den. The only tree species that attains a size substantial enough to contain a den is black cottonwood (<u>Populus trichocarpa</u>), which is uncommon in the study area.

Although MRC black bears did not den in tree cavities, 41% ($\underline{N}$ = 20) of all dens were excavated under the root mass of live trees, tree stumps, or wind thrown trees. The remaining dens (47%, $\underline{N}$ = 23) were excavated into hillsides, on flat ground (8%, $\underline{N}$ = 4), or under boulders (4%, $\underline{N}$ = 2).

Because the elevational change in the study area was minimal (35-90 m), we did not measure elevation of den sites. The aspect of 49 dens (Fig. 14; Appendix B) was not significantly different from random ($\underline{X}^2$ = 4.3, $\underline{P}$ > 0.10) when we compared dens facing N, S, E, or W (316-45°, 46-135°, 136-226°, 226-316°). We also checked for selection by quarters of a circle (0-90°, 91-180°, 181-270°, 271-360°) because there appeared to be a large gap in dens facing SE (see Fig. 14). This test also was nonsignificant ($\underline{X}^2$ = 5.1, $\underline{P}$ > 0.10). This is different than data presented by Beecham et al. (In Press) for Idaho, where many dens faced W, NW, or N. They felt that these exposures accumulated more snow which persisted for longer periods. LeCount (In Press) found that 68% of all black bear dens investigated in central Arizona were on northeast-facing slopes. Lindzey and Meslow (1976) reported that aspect did not influence den site selection from black bears in Washington.

Twenty-one of 49 (43%) black bears denned on slopes of 0-10°, while 49% (24 of 49) denned on slopes of 11-35°. Black bears in Idaho (Beecham et al. In Press) denned on slopes mostly from 11-35° (83%), while 53% denned on slopes of 20-40°. In our study, only 33% of all bears denned on slopes 20-40°. The steepest slope measured was 30°, and probably reflects the more gentle terrain within the study area, as opposed to more mountainous areas elsewhere in Alaska. Miller and McAllister (1982) and Miller et al. (1982) measured slopes up to 50° and 60° for dens of black bears in the Susitna River Valley and Prince William Sound, Alaska, respectively (Appendix C). Both study areas were in mountainous areas that were quite precipitous.

Black bears at the MRC study area denned in the following 2 major vegetation types (Table 19): mature upland forest (31%) and regrowth upland forest (67%). One den was located in a black spruce-bog (1%). We compared these percentages with those discussed by LeResche et al. (1973) for a typical 2.5-km^2 area within the study area where mature forest, regrowth forest, spruce bog, and grass-sedge composed 46, 46, 1, and 6% of the area, respectively.

The chi-square test for independence was significant ($\underline{X}^2$ = 20.1, $\underline{P}$ < 0.05). These data indicate that black bears in the MRC study area tended to select regrowth vegetation and denned less in mature forest. Bears did not den in grass-sedge openings and avoided bogs in most cases. These avoidances are explainable, since these habitat types are low, tend to be wet, and flood during spring thaws and during periods of heavy rainfall. We are not sure why the black bears in the study area tended to select regrowth areas for denning. LeCount (In Press) indicated black bears in Arizona tended to den in chaparral and felt this selection was based on both adequate cover and reliable spring food supplies. He found total canopy coverage, although dense in chaparral, is not as thick as pine-oak woodland, pine, and riparian areas, but the total cover at bear heights (0.3-1.8 m) more abundant than in the latter types. Black bears in Alberta (Tietje and Ruff 1980) selected mature forest at a significantly higher rate than its occurrence, and a regenerated forest at a lower rate than its occurrence. Black bears also avoided muskeg in Alberta.

We do not know why bears selected 1 vegetation type over others for denning, but it was obvious why they did not den in muskeg and grass-sedge areas. These are frequently wet, and an excavated den would be prone to winter or spring flooding. For example, a den dug in a spruce bog (B14, 1980-81) flooded in the spring. The female and her yearlings that used this den did poorly that winter. Selection of regrowth areas tends to support data of LeCount (In Press) since the vegetation in these areas is much thicker and provides better cover from weather and better concealment of the den. This is, however, contrary to data of Tietje and Ruff (1980), except that the cover value of regenerated forest in this Alberta study was not quantified.

Dimensions of 49 dens based on measurements depicted in Fig. 15 are summarized in Table 20 and listed in Appendix B. We compared the dimensions of the various cohorts of bears (Table 20) to determine if they differed, using the same method of Tietje and Ruff (1980). We compared both the entrance area and chamber volume excavated by various subclasses of bears (i.e., adult male, subadult male, adult female, subadult female), using a 2-way analysis of variance; either entrance area or chamber volume was the dependent variable, and sex or age the independent variable.

We found the entrance area was significantly larger ($\underline{P} < 0.01$) for adult bears than juveniles, with entrance areas of 0.24 and 0.16 m^2, respectively. This statistic seems logical, since a large bear needs a bigger entrance to get into its den. The age effect, and the age by sex interaction were nonsignificant.

Likewise, there was a significant difference ($\underline{P} < 0.01$) in chamber volume between adult and juvenile bears, with chamber volumes of 0.99 and 0.54 m^3, respectively. Again, this statistic seems logical. The age effect and age by sex interaction were nonsignificant.

Investigations of dens revealed that juvenile bears constructed smaller entrance ways and chambers. This was apparent when looking at the dens in the field. Juvenile dens were usually shallow and appeared poorly constructed when compared to those of adults. Other than apparent differences in physical body size, there may be a learning process in den construction, with deeper dens excavated with experience. Some of the dens occupied by juvenile bears were also classified as used; most had probably been built by adult bears in previous years. This reuse of dens probably affected the ANOVA, but sample sizes were too small to include this factor (new vs. used) in the ANOVA.

We also compared entrance area and chamber volume of dens between females with cubs, yearlings, and barren females, using 1-way ANOVA. Results indicated a significantly ($\underline{P}$ < 0.05) larger den entrance for female bears with cubs (0.28 m^2), than females with yearlings (0.19 m^2) or for barren females (0.20 m^2). This may reflect enlargement of the entrance through constant usage of a den by a female with cubs during early spring since we did not collect den statistics until midsummer after bears had left the denning area.

The 1-way ANOVA was nonsignificant ($\underline{P}$ > 0.10) when we compared female reproductive class and chamber volume. Although there appeared to be large differences in chamber volume between females with cubs (0.92 m^3), females with yearlings (1.02 m^3), and barren females (0.67 m^3), within-group variation was too large to make them significant.

Morphometric Measurements and Body Weights

Serial samples were obtained from 19 black bears which provided data on weight gain and loss among seasons and years. Seven adult female black bears were serially weighed and several observations made (Table 21). Weight loss during winter and spring ranged from 8% and 22% for females with no cubs or yearlings to 34% for a sow with cubs. Highest weight gains during summer were by 2 females with cubs, 32% and 37%. A female without young gained 24% during summer. The sows with young experienced greater seasonal weight fluctuations than those without young. Three females were weighed as 3-year-olds and once again at 4 years and the other 2 at 7 and 5 years, all during June. No weight changes were detected (Table 21). Another female was weighed at 10 and 12 years during June with no weight change. These female black bears attained their maximum weight at 3 years and did not change significantly ($\underline{P}$ > 0.05) thereafter.

Serial weights were obtained from 7 adult male black bears (Table 22). Only 1 adult male was weighed during the fall and following spring; his weight loss over the period was 40%. We did not obtain serial weight to determine weight gains during summer, but with the 40% loss one may presume that high percentage weight gains are experienced by male black bears. Serial weights during May/June between years was obtained for male bears between 2½ and 4½ years, with a gain of 25% in body weight; 35% between 2 and 4 years; 42% between 6 and 7 years; and no change from 7 to 9 age or 10 to 11 years (Table 22). These data suggest male bears continue to gain weight to at least 7 years.

Serial weights were obtained from 5 juvenile bears (Table 23) and data from 3 bears (2 females and 1 male) indicate weight gain of 100% (F), 100% (M), and 87% (F) during summer as yearlings. One

2-year-old female had a weight gain of 36% during summer. Two cubs (1 female and 1 male) did not lose weight from fall to June, but a yearling male lost 24% of its body weight during the same period (Table 23).

When we combined all weight data from bears captured and then sorted by season, the information provided reasonably good data for adult females. However, the adult male sample size was too small during the fall and denning seasons, and those males captured were young, smaller males (Table 22). Weight data from subadult bears when combined by season were not useful, because they included age classes from 4 to 36 months. However, male juvenile black bears were heavier in all comparisons for the same age, but the differences were not significant ($\underline{P} > 0.05$). Three yearlings (1 male and 2 females) were weighed in May 1981 following an open, wet winter and a poor fall cranberry crop (see Density section). The mean weight of the yearlings was 8.5 kg. Mean yearling weight from other years was 2 to 3 times greater.

Adult female combined weight data indicated a 41% weight gain during summer (Table 24) compared to serial data of 24%, 32%, and 37% (Table 21). The higher percentage in combined data could be attributed to sampling error. Adult female postdenning weights averaged 52.0 kg ($\underline{N} = 6$); fall weights averaged 74.8 kg ($\underline{N} = 7$); and denning weights averaged 58.3 kg ($\underline{N} = 2$).

The heaviest weight for an adult female was 90.9 kg from bear B2 (6.6 years of age) on 17 September 1981. She had no young accompanying her. The heaviest weight for an adult male was 145.4 kg from bear B25 (7.3 years of age) on 28 June 1980. No large male bears were weighed during fall; however, projecting from weight gains attained during summer by females, it may be postulated that B25 may have attained a weight of 204 kg (40% increase) by October. Largest recorded weights of black bears are from the eastern United States, where a male black bear from New York weighed 272 kg (Black 1958).

Black bear weights from the Kenai Peninsula are similar to black bear weights from other populations in western United States and Canada. Mean weights for adult females from Alberta were 74 kg ($\underline{N} = 16$) (Nagy and Russell 1978); 58 kg ($\underline{N} = 17$) from Washington (Poelker and Hartwell 1973); 58 kg ($\underline{N} = 110$) from California (Piekielek and Burton 1975); and 68 kg ($\underline{N} = 8$) from Montana (Jonkel and Cowan 1971). Mean weights from eastern United States bears ranged from 83 kg ($\underline{N} = 11$) in New Hampshire (Harlow 1961) to 99 kg ($\underline{N} = 16$) in New York (Black 1958) and in general were heavier than western and Alaskan black bears. Similar data exist for male weights. Black bear weight data from another study in southcentral Alaska (Rausch 1961) reported adult female weights of 79.7 and 69.0 kg during summer. These are higher than our mean (59.1 kg) for the same period. Rausch (1961) reported denning weights of adult males of 91.0 and 93.2 kg; a summer weight of 73.2 kg and fall weights of 100.0, 112.3, and 76 kg. From Prince William Sound, Alaska, Modafferi (1978) reported August weights of black bears which ranged from 54.5 to 90.9 kg for adult females ($\bar{x}$ = 70.5 kg, N = 2). The Prince William Sound female mean weight was comparable to the Kenai Peninsula fall mean weight (74.8 kg, N = 7); however, most Prince William Sound bears were weighed in August and most Kenai Peninsula bears were weighed in September. This makes comparisons between the regions difficult, because the difference in time includes the period of greatest potential weight gain. From the upper Susitna River, Miller and McAllister (1982) reported weights of black bears which ranged from 46.8 to 100 kg during spring (primarily May) for adult females ($\bar{x}$ = 61.5 kg, N = 5) and from 53.1 to 74.5 kg during August ($\bar{x}$ = 61.8 kg, N = 6). Upper Susitna adult male black bears ranged in weight from 51.4 to 130.5 kg during May ($\bar{x}$ = 88.4 kg, N = 4). Black bear weight data from Alaska do not reflect any major regional differences from the small samples available, and there was greater variability within region by season.

From our serial data, it is evident that tremendous fluctuations occur in black bear body weights over a short period of time. Jonkel and Cowan (1971) reported seasonal weight fluctuations in serially weighed bears of 37% and 42% in females with cubs. These fluctuations were similar to those bears we weighed with cubs. Females without young fluctuated less in the Montana study (Jonkel and Cowan 1971) as was noted with Kenai Peninsula bears (Table 21). Adult males in the Montana study did not show marked seasonal change in weight, and our sample was too small during fall for any population comparison. However, weights were obtained from bear B34 in October 1979 and in June 1980; his weight loss was 40% (75.0 kg to 44.5 kg). This individual may not represent the population, but certainly major seasonal fluctuations do occur.

Comparing weight data between populations or even within populations is not meaningful without supportive information. With the great seasonal fluctuations and weight gain or loss up to 0.7 kg/day over 22 days (Jonkel and Cowan 1971), we must use weight data judiciously, particularly for comparisons. Obviously, we can conclude from weight data that sexual dimorphism is represented by weight differences; stress periods are during the spring or postdenning periods; denning period and fall berry failure were reflected in postdenning yearling weight. In general, Alaskan black bears are similar in weight to other western North American bears.

Serial measurement data were obtained from 7 adult female black bears (Table 25), 7 adult males (Table 26), and 5 juveniles (Table 27). These data reflect 1 suspicion we had during the sampling process; body measurements contained a certain amount of variation associated with sampling. Discrepancies were not numerous but did suggest caution when assessing the data. Glenn (1977) concluded from brown bear data that all body measurements have descriptive value, but only a few are of practical significance. Skull measurements were the best indication of growth rate and measurement reliability from over 500 bears measured. Our data are not as extensive, and we have limited our discussion accordingly.

Neck circumference measurements are important data for placing radio collars on bears. Neck circumference of female bears varied from 32 cm for yearlings in the den (B38, Table 27) to over 50 cm during fall as adults. The mean for 6 female bears during fall was 49.5 cm. If 1 expandable collar is used, the potential expansion should be 56% (32 to 50 cm). Male bear neck circumference varied from 32 cm for a yearling (B41, Table 27) to over 66 cm in June for a 10-year-old bear, and 57 cm for a 4-year-old male in fall (Table 26). For males, the potential expansion should be 78% (32 to 57 cm), if the radio can be replaced at 3 to 4 years of age and the bear is radio-collared as a yearling. There is a substantial increase in neck circumference as the male matures (Table 26). A suitable expandable collar to accommodate the growth in neck circumference is not presently on the market. For this study, efforts were made to recollar bears that were collared as yearlings with an expandable collar the following year.

Accommodating seasonal growth in neck circumference for radio-collaring must also be considered because female black bears may vary from spring to fall from 44 to 51 cm (B1, Table 25). There are changes of 16 and 17%, respectively, for females. Our only data on males is for B34 with a 42-cm neck circumference in June as a 3.3-year-old bear to 57 cm as a 4.8-year-old bear. This is a 36% increase, but represents a year's growth, as well as seasonal change. Adult bears were radio-collared for this study with nonexpandable collars; however, the seasonal differences in neck circumference were considered and the collar fastened accordingly.

Sexual dimorphisim was evident from our adult bear measurement data (Tables 24, 28, 29) and some values were more useful than others for differentiating sex. Seasonal weight changes alone may influence neck circumference, chest circumference, and, of course, body weight. Total body length and chest girth may be influenced by seasonal weight change, but more importantly, they are both subject to measurement error associated with positioning the animal (Tables 25, 26). Differences in body measurements due to sexual dimorphism can be used for sealing programs, and for forensic application when sex is unknown. Measurements considered potentially useful for sex differentiation were the following: hind foot length and width; skull length and width; upper and lower canine tooth length; and anterior/posterior and labial/lingual thickness (Table 29).

Body weights from adult black bears sorted by season (Table 24) and seasonal weight changes detected by serial sampling were evident for females. Females during postdenning period (May) weighed 52.9 kg and during fall 74.8 kg, a 41% increase

(Table 24). Data for males did not reflect the weight changes by season (Table 22) because we did not capture adult males during fall trapping operations.

Subadult males and female measurements were tested for sex differences (1-way ANOVA); none were detected. Glenn (1977) first detected sexual dimorphism in brown bears with body measurements at 1 year of age. Beecham (1980) did not detect sexual dimorphism in Idaho black bears until 2.5 years of age in the Council population and 5.5 years in the Lowell population using weight and total length measurements.

Blood Chemistry and Hematology

Population Blood Parameters:

Blood collections were made from 71 adult black bears (>36 months and 35 subadult black bears (<36 months) from fall 1977 to January 1982. Blood values were sorted by year, sex, and season for adult and subadult. Seasons consisted of postdenning (May), summer (Jun, Jul), fall (Aug, Sep, Oct), and denning (Nov-Apr). Because we detected no differences between years by season, we combined years. Significant differences ($\underline{P}$ > 0.05) were detected by sex for the following values in adults: TSP and globulin were higher in males during postdenning and summer seasons, and glucose was higher in males during the postdenning season. No differences were detected between male and female subadults, but differences were detected between adults and subadults (Table 30). Subadults had significantly higher ($\underline{P}$ < 0.05) levels of SAP, P, Na, creatanine, alpha 1 globulin, A/G ratio, and MCHC. Adults had significantly ($\underline{P}$ < 0.05) higher levels of triglyceride, TSP, globulin, beta and gamma globulin, and PCV.

Seasonal influence on blood values were tested using 1-way analysis of variance and Duncan's multiple range test (Table 31). The only values not influenced by season for either adults or subadults were the following: glucose, SGOT, SGPT, CO_2, BUN, bilirubin, beta globulin, and MCHC. Seasonal influences were detected in subadults and not adults for triglyceride, SAP, Ca, Ca/P, TSP, alpha 2 globulin, gamma globulin, and A/G ratio. Conversely, seasonal influence on adults and not subadults were demonstrated in levels of cholesterol, K, and Cl. The values influenced by season for both adults and subadults were the following: LDH, P, Na, creatanine, uric acid, albumin, globulin, alpha 1 globulin, Hb, and PCV.

Blood parameters not influenced by any of these criteria were SGOT, SGPT, CO_2, BUN, bilirubin, beta globulin, and MCHC. Blood values from these parameters were considered as baseline values for this population (Table 32). Bilirubin, CO_2, beta globulin, and MCHC have relatively small standard deviations. We can conclude that these are not influenced by year, age, sex, or season, or by factors which may have influenced other values on this list with high standard deviations, namely, SGOT, SGPT, and

BUN. Serum gluamic oxalic transaminase and SGPT are both cellular enzymes and are released into the blood with tissue breakdown. Both are highly responsive to excitability and stress (Franzmann et al. 1975b). Blood urea nitrogen is affected by protein intake (Bahnak et al. 1979). We may conclude that these 3 values are influenced more by these factors than by year, sex, age, and season.

The remaining values (all those except in Table 32) were influenced by either sex, age, or season. Since our primary goal was to evaluate blood parameters in black bears that may be useful in assessing body condition, we examined the data for those values that were correlated positively with body condition. Blood values should be low during postdenning, increase through summer, and peak during fall. Values that do this include cholesterol, Na, Cl, globulin, alpha 1 globulin, Hb, and PCV for adults and Na, TSP, globulin, alpha 2 globulin, Hb, and PCV for subadults (Table 31). Values that were consistent for both subadults and adults in reflecting improved condition among seasons were the following: Na, globulin, Hb, and PCV. To confirm that Na, globulin, Hb, and PCV were useful as condition evaluators, we summarized serial blood data.

Serial Blood Parameters:

Serial blood samples were obtained from 6 adult black bears (5 females, 1 male) (Table 33), and 5 subadults (3 females, 2 males) (Table 34). We selected blood parameters considered potentially useful for condition assessment of ungulates, including those which may reflect nutritional intake and those influenced by stress (Coblentz 1975, Franzmann et al. 1975b). In addition to PCV, Hb, Ca, P, TSP, glucose, albumin, globulin, beta globulin and cholesterol, we selected Na based upon information discussed above.

Adult black bears were selected (Table 33) whose serial collection dates best represented both the peak condition period during fall and the low condition period during spring.

Packed cell volume was the best indicator of condition in moose (Franzmann and LeResche 1978), so we evaluated it for black bears as well. Packed cell volumes above 60% were detected in 2 adult females (B1, B2) during October (Table 33). Neither female had cubs or yearlings. Values below 40% were detected in the same 2 females during June, and both were accompanied by 2 yearlings (Table 33).

Since values for PCV reflected expected changes in condition by seasons and reproductive status, we also looked at the other condition-related parameters of moose and to see if they reflected body condition in black bears. Values were selected from the 2 bears with adequate serial data (B1, B2) and listed for the same season and collection date that exhibited the PCV extremes (Table 33). The only values that were consistent with PCV in identifying extremes for both bears were Hb, beta globulin, and Na. All values (PCV, Hb, Ca, P, TSP, glucose, albumin, globulin, beta globulin, and Na) identified the peak period for bear B1 (Table 35). Total serum protein, beta globulin, and Na identified peak periods for both B1 and B2. It is of greater value to the biologist to identify the low condition period; the only values that consistently did that for these 2 bears were PCV, Hb, beta globulin, and Na. Serial data from other black bears (Table 33) did not reflect the extremes as did B1 and B2, but the seasonal trends for PCV and Hb in particular reflected condition change related to season.

Subadult black bears followed a similar trend based on serial data (Table 34). Packed cell volume and Hb were highest during fall and lowest during spring for all the subadult bears serially sampled (Table 34). Other values were less consistent. Calcium and P for both adults and subadults appear to be the least valuable for condition assessment in black bears.

Cholesterol levels from the serially sampled bears were also of interest. Although cholesterol did not appear to be related to condition in moose, it was suggested that for white-tailed deer it may have significant value as an index of nutritional condition (Coblentz 1975). For bears B1 and B2, high levels of cholesterol were associated with peak condition in the fall; cholesterol levels were significantly ($\underline{P}$ < 0.05) lower during spring (Table 35). For other serial sampled adults (Table 33) and subadults (Table 34), this pattern was not evident.

Blood parameters that best reflected condition change in our black bear population were PCV, Hb, globulin, and Na. Packed cell volume, Hb, beta globulin, and Na were selected from serial sampling. The consistent values for both were PCV, Hb, and Na; however, beta globulin is a fraction of globulin so there was consistency.

These findings add Na to the list of potential condition evaluators, and additional sampling will be useful to see if the relationship holds. From a physiological standpoint, it is difficult to explain the seasonal differences in Na concentration. Sodium is the principal cation of extra cellular fluids of the body.

Sodium is important in regulation of osmotic pressure, acid-base balance, maintenance of membrane potential, and the transmission of nerve impulses (Hays and Swenson 1970). Sodium is an essential element, and an acute increase or decrease in intake requires physiological adjustments. The increase we detected with improving condition is physiologically normal and may simply reflect increased well being of the physiological system.

The finding that PCV and Hb reflect condition with seasonal change in black bears is similar to the relationship found in moose (Franzmann and LeResche 1978). We believe PCV and Hb should be considered as good condition evaluating tools for black bears.

In Tables 32 and 33, we listed capture method (snare, helicopter, trap) to evaluate methods most stressful to bears based upon release of cellular enzymes (LDH, SGOT). Unfortunately, we only obtained serial data from 2 bears (both adult females, B1 and B2) that were captured by all 3 methods. The LDH and SGOT levels indicated that snaring was the most stressful handling technique (Table 34). For other reasons, we no longer use snares to capture bears, but the added stress due to snaring would be reason alone to use another method.

Blood urea nitrogen (BUN) reflects protein intake. We did not detect differences in BUN by year, age, sex, or season (Tables 32, 33). Serial sampling (Tables 33, 34) did not reflect changes in BUN by season. More information is needed regarding protein intake in bears before we can evaluate these data. Controlled studies with captive animals would provide an ideal means to obtain these data.

Serial blood SAP levels (Tables 33, 34) reflect active growth periods in black bears. Denned bears had low levels, subadults were generally higher than adults, and summer levels were generally higher than fall. Active skeletal growth and development results in elevated SAP levels (Coles 1974).

Blood was collected from 8 black bears during their denning period (2 adult females, 4 subadult females, and 2 subadult males). All blood values obtained are listed as reference sources (Table 36). Means, standard deviations, standard errors, and 95% confidence intervals for blood values of the population are listed as reference sources (Table 36). This total population listing did not separate values by sex, age, or season, but each value was noted if influenced by any or all. The listing provides a set of baseline blood values for Kenai Peninsula black bears.

Hair

Seventy-two hair samples collected between spring 1979 and fall 1981 were analyzed for 4 essential macroelements (Co, K, Mg, and Na), 7 essential microelements (Co, Cu, Fe, Mn, Mo, Se, and Zn) and 5 nonessential (potentially toxic) microelements (Al, Cd, Cr, Hg, and Pb). Collections were not obtained throughout the year but were made in spring (primarily June) and fall (primarily September). During fall only 14 samples (19%) were obtained; only 1 sample was obtained during the denning period.

Results of the chemical analysis samples were sorted, and means and standard deviations listed by year, season (spring only), sex and age (Table 37). Black bears 3 years old and older were considered adult, and those under 3 as juveniles. Data for adult bears were sorted by sex, but the juvenile bear classification included both sexes. Sample sizes from fall collections were not adequate to sort by sex and age; therefore, fall hair values were sorted by year only with sexes and ages combined (Table 37).

Differences between treatments (i.e., sex, age, etc.) were determined with Student's _t_ test (Snedecor and Cochran 1967). Few differences were detected among treatments due in part to the small sample sizes and high variability. Copper levels were extremely high for juvenile bears in spring 1981 (111 ± SD 21 ppm) and fall 1981 (110 ± SD 28 ppm); both values were significantly higher ($P < 0.01$) than all other treatments. During spring 1979, differences were detected in Zn levels between all sex and age classes (adult males, adult females, juveniles).

Some bears were recaptured several times which allowed us to serially sample these individuals (Table 38). Two adult female bears were captured each spring of 1979, 1980, and 1981. Bear B2 was also sampled in fall 1981; B15 was captured and sampled in her den during March 1979. Both bears had relatively low Cu levels in June 1981. The Cu level of B2 increased 18-fold from June to September 1981. Other than Cu, the hair element levels for the 2 bears did not vary that much between years or seasons. The sample from B15 in her den showed no unusual or significant variations from other periods.

Two young bears (B41 and B42), which were litter mates, were sampled during fall 1980 as cubs, in spring 1981 as yearlings, and in fall 1981 as yearlings (Table 38). Great differences occurred between sampling periods, particularly for Zn, Cu, Ca, and Al for both bears. Bear B41 had high variability between sampling periods for Fe, Pb, and Mn (Table 38).

The most significant variation in hair element levels occurred with Cu. There was a 16-fold increase in Cu in adult female bear B2 from June to September 1981, a 15-fold increase in juvenile male bear B41 from September to June 1981, and a 13-fold increase in juvenile female bear B42 from October 1980 to June 1981. Mean Cu levels for our sample of juvenile bears also reflected drastic increases; the spring 1980 mean for juveniles was 18 ± SD 8 ppm ($N = 5$), while the spring 1981 mean was 111 ± SD 19 ppm ($N = 5$, Table 37).

The increase in Cu levels seem to contradict our field studies as one would ordinarily expect a high level of an essential element to reflect positive environmental conditions (Flynn et al. 1975). However, the metabolism of Cu in an animal under stress results in mobilization of Cu, primarily from bone to the liver where it is combined with the protein ceruloplasmin and subsequently transported to tissues (A. Flynn, pers. commun.). The mobilization of Cu is what we detected in the hair samples from bears during this period of stress. Two other elements may also be influenced in this process resulting in depressed levels of Zn and Fe, but to a lesser degree (A. Flynn, pers. commun.). Bear B2 had a decrease from 108 to 82 ppm of Zn while Cu increased. Iron levels, however, increased. Bears B41 and B42, both juveniles, also experienced decreases in Zn with increases of Cu levels. Iron levels decreased in bear B41 but remained the same for bear B42. In all instances, a decrease in Zn or Fe was not as dramatic as the increases in Cu. For Fe, changes were not always consistent with the pattern noted for Cu.

This finding may provide an additional method to monitor stress in black bears, particularly when the stress is severe enough to impair reproduction and survival. Copper in black bear hair prior to this stress period was low in relation to baseline data established for domestic animals, and was indicative of the situation on the Kenai Peninsula where a Cu deficiency was detected in the moose population (Flynn and Franzmann 1974b, Franzmann et al. 1976).

The hair element values reported (Tables 37, 38) provide initial baseline values for black bears. Additional samples throughout the season and particularly during denning would be most useful. If we obtained black bear hair growth rates, it would also assist us in using the hair as an estimator of past mineral intake (Flynn et al. 1974, 1975).

Hair element analyses, particularly for Cu, of black bears may provide a useful adjunct to blood parameters for condition evaluation. Additional sampling and evaluation will be required before we add hair element Cu to our list of evaluating criteria.

Disease and Parasites

Blood sera collected from 34 black bears were sent to the Center for Disease Control in Atlanta, Georgia through Dr. Thad L. Woodard, Alaska Health Department for trichinosis diagnosis. The serologic test used was the bentonite floculation. All samples were negative. This does not necessarily indicate that the bears were trichinosis free. It only indicated that this test, designed for human diagnostics, did not detect trichinosis. If we would have detected an antigen/antibody response in our sample, it would have perhaps given us another tool to diagnose trichinosis in black bears. Further testing of the procedure is indicated.

Chaetopsylla tuberculaticeps, a flea that is a true parasite of the brown bear, was found when we made measurements of B13's den in 1980. Specimens were sent to Dr. Glen Haas, Flagstaff, Ariz., for identification and were reported as a new record for that species (Haas et al. 1982). Additional specimens were later collected from a black bear shot by a sport hunter on Caribou Island in Tustumena Lake, and were also reported by Haas et al. (1982) as a record.

Bear Movements and Moose Calving Areas

One of the objectives of this study was to evaluate the seasonal and temporal movements of black bears as they relate to the moose calving areas and the Willow Lake crushed area.

Bear movements have been previously addressed (Schwartz and Franzmann, In Press) for areas crushed for vegetation rehabilitation. Bear movements in the Moose River Flats calving area indicated that black bears associated with the calving area were residents of that area. We did not witness seasonal movements or migrations of bears to the calving flats from adjacent areas. Black bears remained within their respective home range areas during the calving season, although 2 large males (B10, B19) shifted the usage within their home range during the calving season to the calving areas.

Although moose tend to concentrate on the Moose River Flats during the calving season, moose calved throughout the study area in smaller numbers. Consequently, bears whose home range did not overlap the calving flats had limited access to calves within their respective home range.

Although the number of bears sighted on calf kills was small ($\underline{N}$ = 7), it appeared that black bear predation on moose calves was not associated with 1 age class or sex of bear (3 adult males, 1 juvenile male, 2 adult females, 1 juvenile female). It is also important to note that although in 4 seasons of radio-tracking bears, with only 7 calf kills sighted, black bear predation accounted for 34% of the reported calf mortality (Franzmann et al. 1980). Based on kills located via radio-tracking bears, a false impression of predation rates is highly probable. Calf mortality rates are most accurately estimated with radio telemetry studies of calves (prey), not bears (predators).

Based on a limited number of observations ($\underline{N}$ = 5), it appeared that black bears actually pursued moose calves whenever encountered. In 4 out of 5 observations, the bear first detected the presence of a cow and calf by smell rather than sight (all predation attempts witnessed were in spruce regrowth which was fairly dense). In every case, once the bear smelled the cow and calf, it ran in a straightline direction toward them. Once the cow sensed the bear's presence (sound and/or sight), she immediately fled. In all instances observed, the calf ran next to or in front of the cow. Depending upon the circumstances, the cow and calf outran the bear, the cow stood and defended the calf, or the bear gave up pursuit. Only 1 kill was witnessed. An adult female moose with twin calves was observed, while radio-tracking, standing in the water on the shore of Falcon Lake. Black bear B24 and her 2 yearlings were less than 20 m away in mature timber. The cow moose turned to walk down the shoreline (still in water) with 1 calf in front of her and the other behind her; B24 ran out of the trees and into the lake. She grabbed the calf behind the head by the neck and carried it back into the trees with such speed that the cow moose had no chance to prevent the predation of her calf. The cow and remaining calf swam across the lake. The calf only got halfway across (150 m) before it became obviously weak and drowned. The cow swam to shore and entered the timber.

RECOMMENDATIONS

Although data summarized here represent 4 years of field research, the major recommendation coming from this study is that additional work (years of study) is required to fully understand the population dynamics of the Kenai Peninsula black bear. Black bears are long-lived animals, and environmental factors affecting population biology require long-term study. We have already documented some of the factors affecting cub production, migration timing, food abundance, etc., but the frequency of such events is not clear at this time.

Long-term ecological studies enhance our knowledge of a population as it is affected by the environment and reduce the chance of sampling error. For example, if one only analyzed the 1st 2 years of data from this study, the reproductive biology of black bears would have been markedly different from what it was the 3rd year.

To accomplish these objectives, the MRC black bear study has been extended for 3 years, and expanded to include a portion of the 1969 burn. Reasons for this are explained in the study plan in Appendix D. We have also incorporated a graduate student project (Appendix E) into our long-range studies. Paul Smith will evaluate cranberry production in various successional stages of forest, and determine black bear food habits via scat analysis. Paul's work fits well into our long-range objectives.

In addition to reduced sampling errors, certain statistics are only obtainable with a large sample. Sample size is increased with increased years of sampling (e.g., yearly survival). This strategy is superior to a large sample in a few years, because it overcomes effects of environmental variation or includes them on a regular frequency.

Additional blood chemistry and hematologic data should be obtained to further strengthen and substantiate findings based on present sample size. Data are needed from the postdenning and denning periods.

Additional hair element data should be obtained from black bears, particularly during stress periods to help substantiate our preliminary findings.

Measurement data from black bears have a definite priority for use in population assessments and comparisons. Skull length and width or tooth measurements may be used to determine sex of an animal if only the skull is presented for sealing. Foot pad measurements are relatively reliable; however, total length, chest girth, height at shoulder, and neck circumference are all extremely variable and should be used with discretion for population comparison or evaluations.

Body weights from adult male black bears were lacking for fall season, and efforts should be made to obtain these data.

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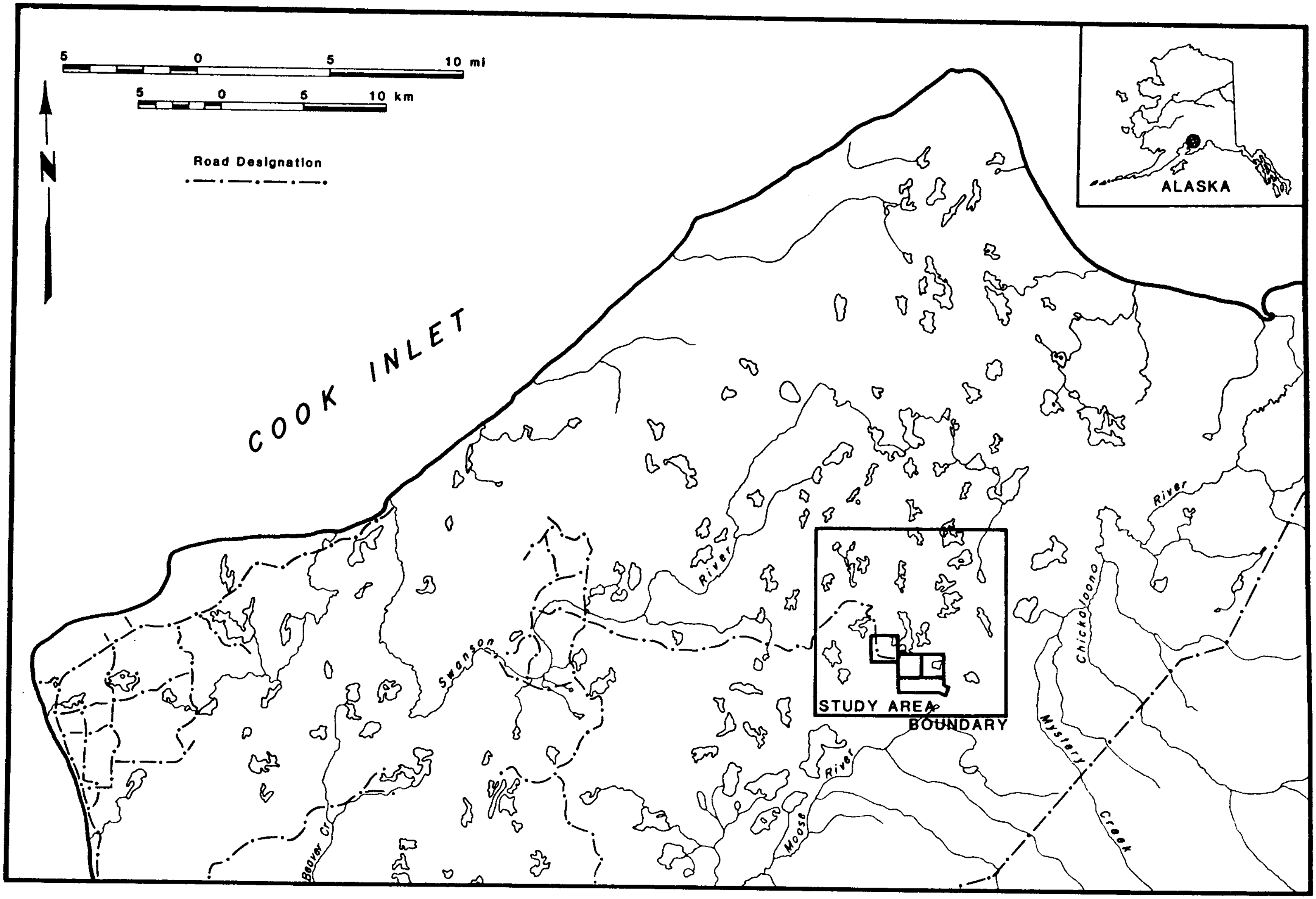

Fig. 1. Black bear study area at the Moose Research Center study area located on the northcentral Kenai Peninsula, Alaska.

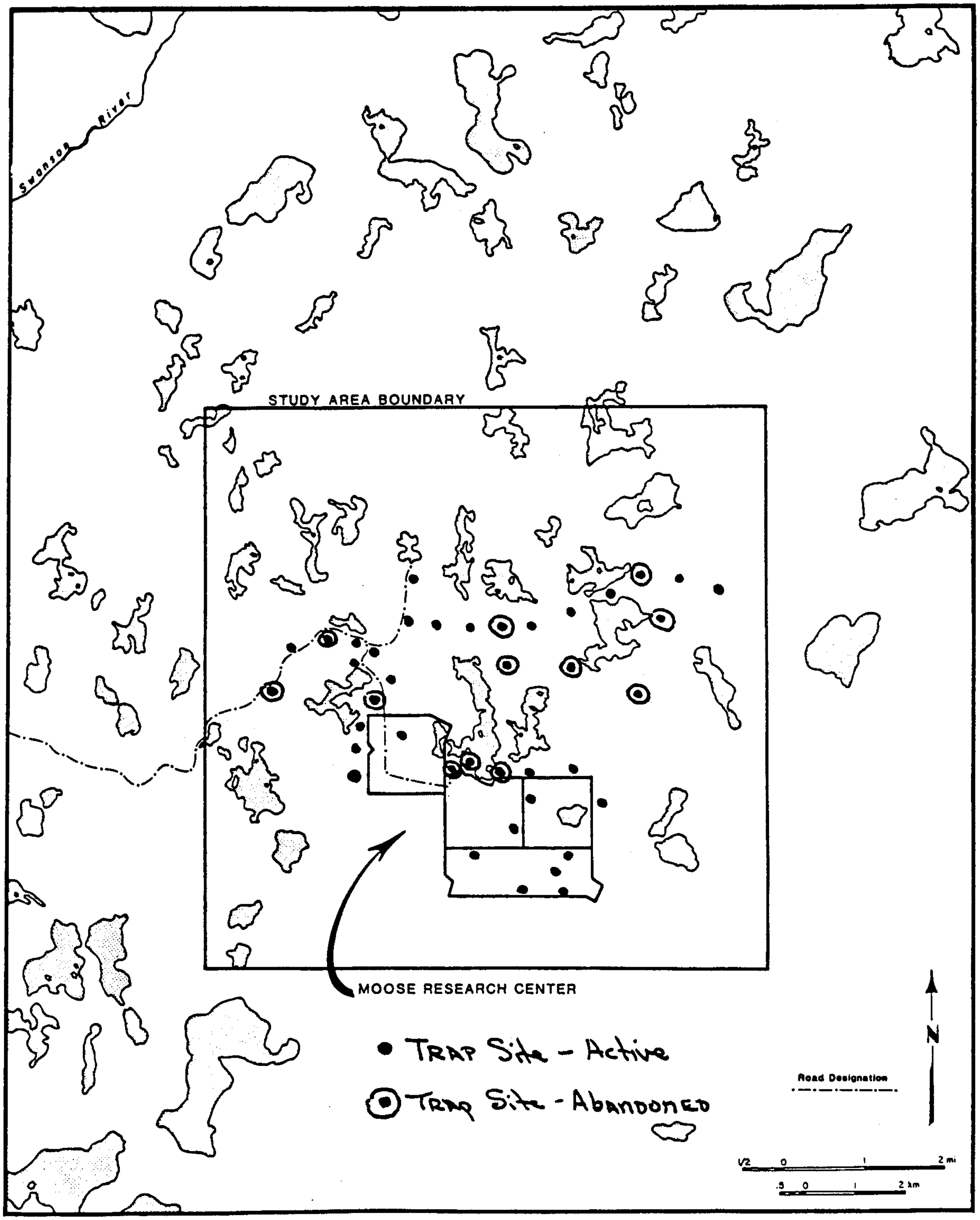

Fig. 2. Location of trapping sites used to capture black bears at the Moose Research Center study area, 1978-81.

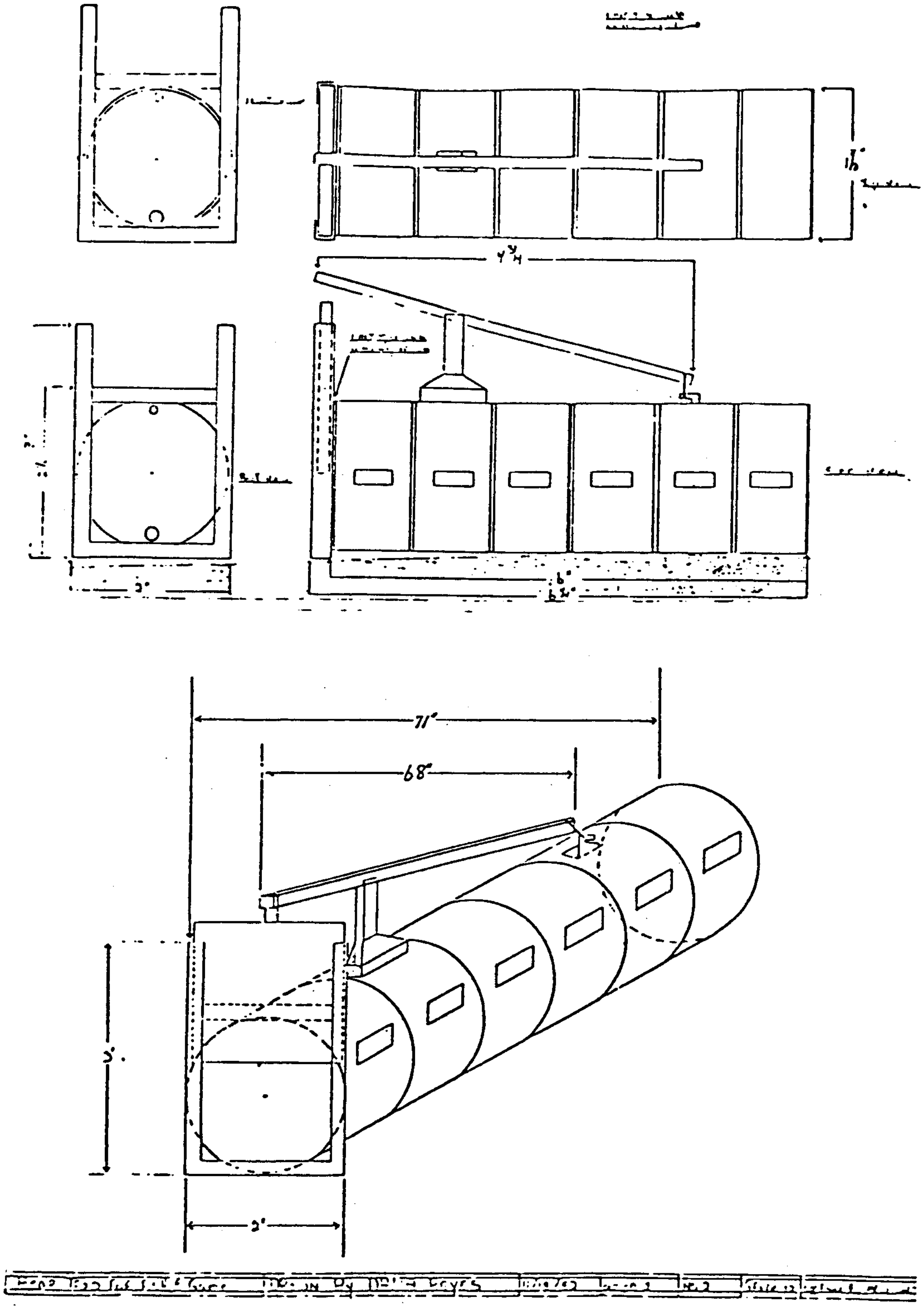

Fig. 3. Design of barrel traps used to capture black bears.

Bear Tagging Data

Moose Research Center

Bear No. ____________ Type ____________ Date ____________ Sex ____________

Estimated Age ____________ Cem. Age ____________ Collectors ____________

Location ____________________________ Method of Take ____________________

Drug Data

Drug	Amount	Hit Time	Down Time	Comments

Measurements: Weight __________ T.L. _________ Ht. Sh. _________ HF ____________ L
____________ W
Neck ____________

Girth ____________ Head: Width ______________ Length ____________

Upper Canine R L Length ______ L-L ______ A-P ______

Lower Canine R L Length ______ L-L ______ A-P ______

Specimens Collected: Tooth Location __________ Blood vol. _________ PCV __________
HB __________

Hair __________ Feces __________ Milk ________ Urine ________

Productivity: Female with young: Yes ____ No ____ (If yes, age and no. of cubs) ______

Mammae: Length ______ Color ______ Vulva ______ Male: Testes Descended: Yes ___ No___
Width ______ Length ______ Length ________
Baculum Length ________

Tagging Data: Ear tags: Left No. _________ Right No. __________ Color ____________

Collar: Type ________ Color __________ Freq. _________

Tattoo: No. ______________

Coat description and white markings:

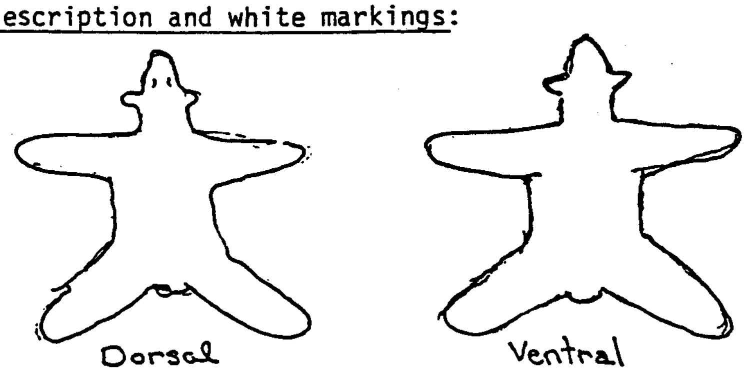

Fig. 4. Black bear tagging data form used at the Moose Research Center study area, 1978-81.

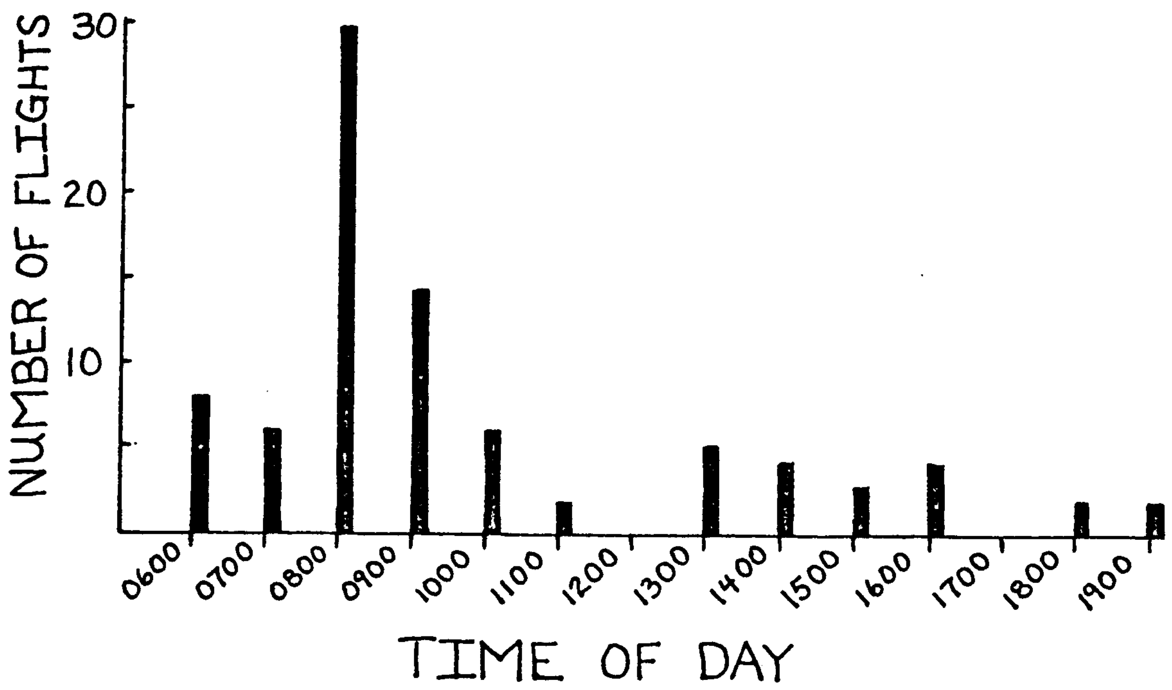

Fig. 5. Diurnal distribution of 116 radio-tracking surveys flown between 1978-81. Time indicated represents start of flight which averaged 2 hr 31 min each.

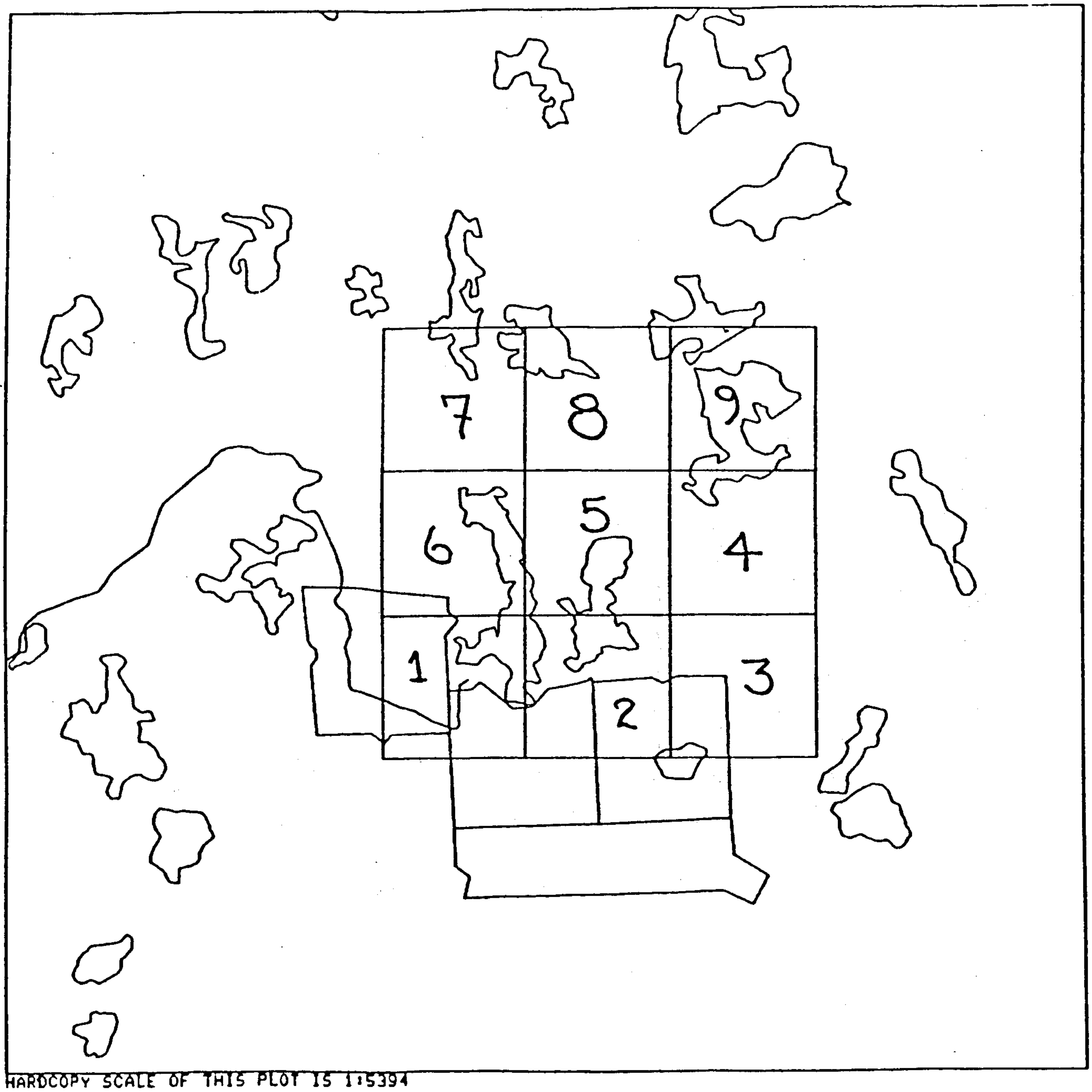

Fig. 6. Location of 9 1-mi^2 subunits used to estimate black bear density in the Moose Research Center study area. Numbers represent subunit identification labels.

STATE OF ALASKA DEPARTMENT OF FISH AND GAME - GAME BIOLOGICAL INPUT FORM

SYSTEM NUMBER	SPECIE	IDENTIFICATION	DATE MONTH	DATE DAY	DATE YEAR	UPDATE CODE: 1 - DELETE, 2 - ADD, 3 - REVISE
1 1 A						
01	04	06	11	13	15	17

CARD	SEX	DRUG	DOSE	DOWN TIME	LOCATION	[illegible]	AGE (MONTHS)	TOTAL LENGTH (CM)	HIND FOOT (CM)	SHOULDER HEIGHT (CM)	CHEST GIRTH (CM)	EAR (CM)	TAIL (CM)	NECK (CM)	WEIGHT BODY (KG)	WEIGHT CARCASS (KG)	WEIGHT HIDE (KG)
1																	
18	19	20	21	22	24	28	29	32	35	38	41	44	46	48	50	54	58 60

CARD	GLUC.	CHOL.	TRI GLYCER	LDH	SGOT	SGPT	ALK. PHOS.	PHOS.	CA	IRON	CA/P RATIO	C/BUN RATIO	NA	K
2														
18	19	22	25	28	31	34	37	40	43	46	49	52	55	58 59

CARD	CHLO-RIDE	CO2	BUN	CREAT	BILI	TP SMAC	ALB SMAC	URIC ACID	GLOB SMAC	BAL-ANCE	TP (ELEC)	ALB (ELEC)	GLOB (ELEC)	ALPH 1	ALPH 2	BETA	GAMMA	A/G RATIO
3																		
18	19	22	24	26	28	30	32	34	36	38	40	43	46	49	51	53	55	57 59

CARD	WBC	NEUT ROPH	LYMP HOCY	DIFF	HB (GM)	PCV	MCV Z	MCHC Z	MARROW Z FAT	EXCP	COND	HEART RATE	RESP. RATE	RECT TEMP	CLASS	AMB. TEMP	CLASS	AGE-CL	SEASON AGE CLASS	PARA
4																				
18	19	21	23	25	26	29	31	34	37	40	41	43	46	49	52	53	56	57	58	60

CARD	CA	MG	K	NA	ZN	CU	CD	CO	FE	PB	MN	CR	HG	MO
5														
18	19	23	26	30	34	38	41	43	45	49	52	54	56	59 60

CARD	SE	AL	NI	AS	CESSIUM	RUMP FAT	FLANK FAT	BACK FAT	STERN FAT	LOIN SCAN.	RUMP SCAN.	ANTLER SPREAD	ANTLER BASE	BOONE CROCKETT SCORE
6														
18	19	21	23	25	28	32	34	36	38	40	44	48	51	54 57

CARD	SKULL LENGTH (CM)	SKULL WIDTH (CM)	V.L.C LGTH (CM)	L.L.C LGTH (CM)	TEAT WDTH (CM)	AGE WEAR MO.	COLOR NUMBER (PICK)	WRIST TO NAIL	WRIST TO PAD	SHOULDER TO NAIL	SHOULDER TO PAD	HOCK TO NAIL	HOCK TO PAD	PAD WIDTH	FOOT WIDTH
7															
18	19	22	25	27	29	31	34	39	42	45	48	51	54	57	59 60

Fig. 7. Game Biological Input form used to record black bear blood results.

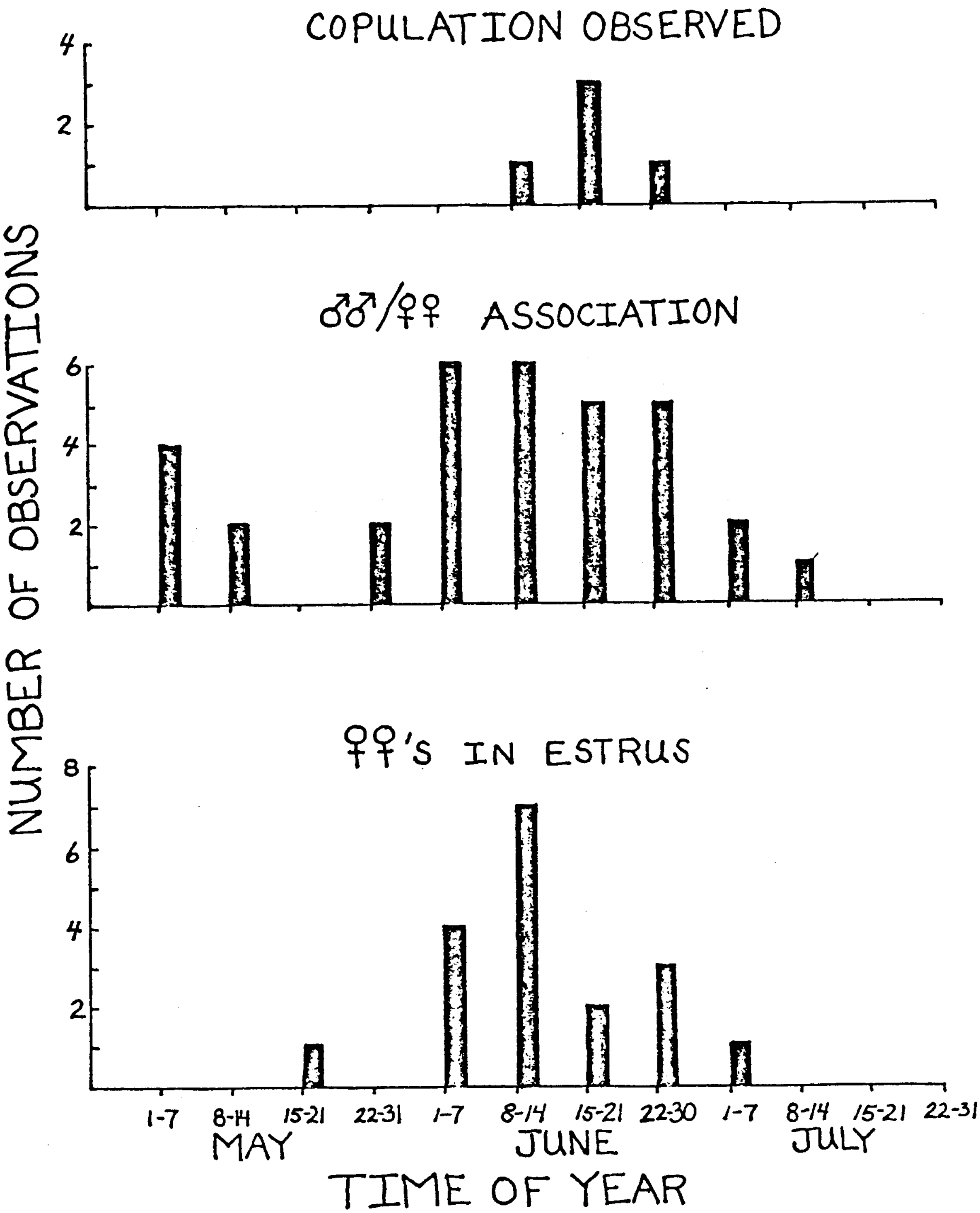

Fig. 8. Chronology of the breeding season for black bears based on (1) observed copulation, (2) male-female associations, and (3) females judged to be in estrus at time of capture at the Moose Research Center study area, 1978-81.

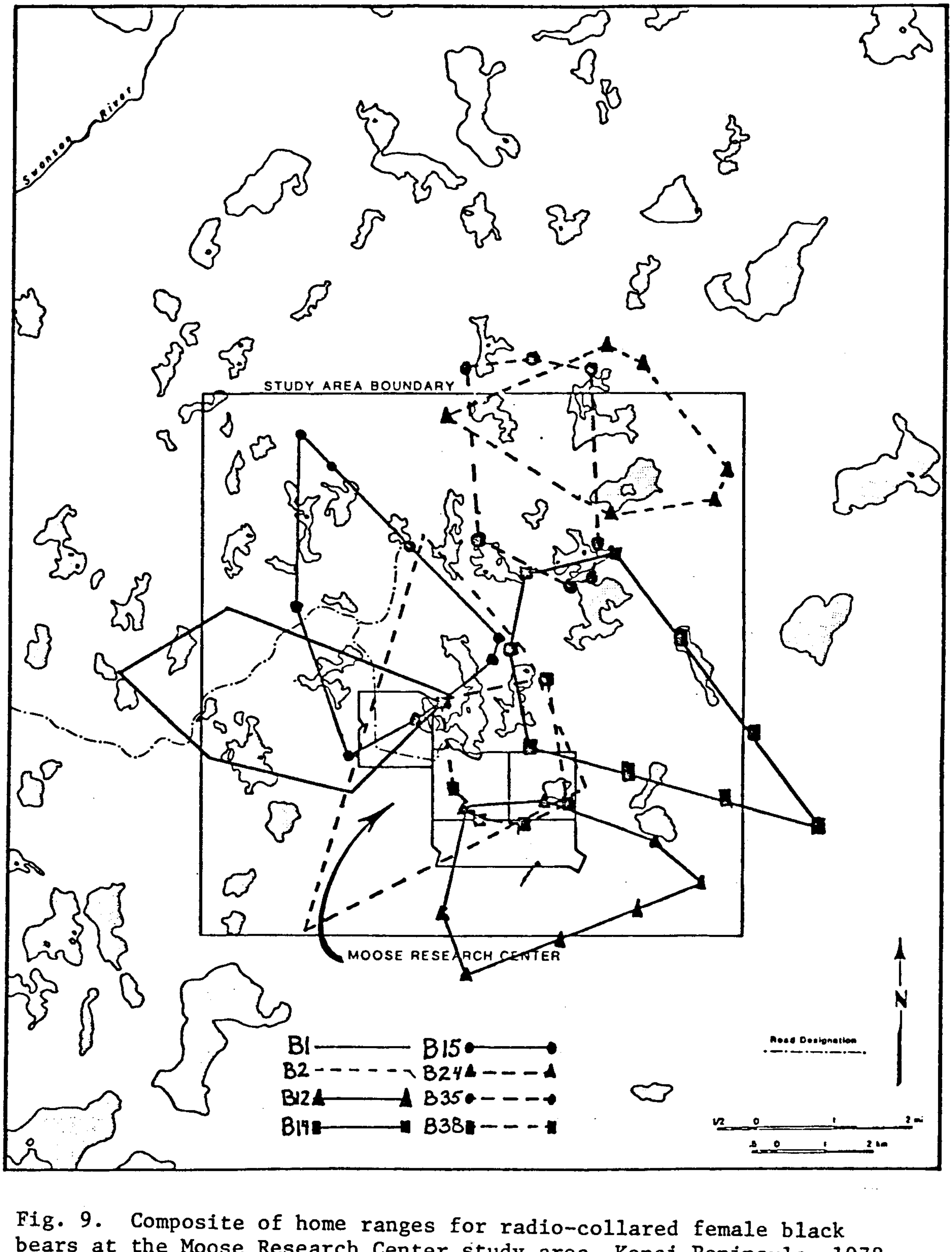

Fig. 9. Composite of home ranges for radio-collared female black bears at the Moose Research Center study area, Kenai Peninsula, 1978.

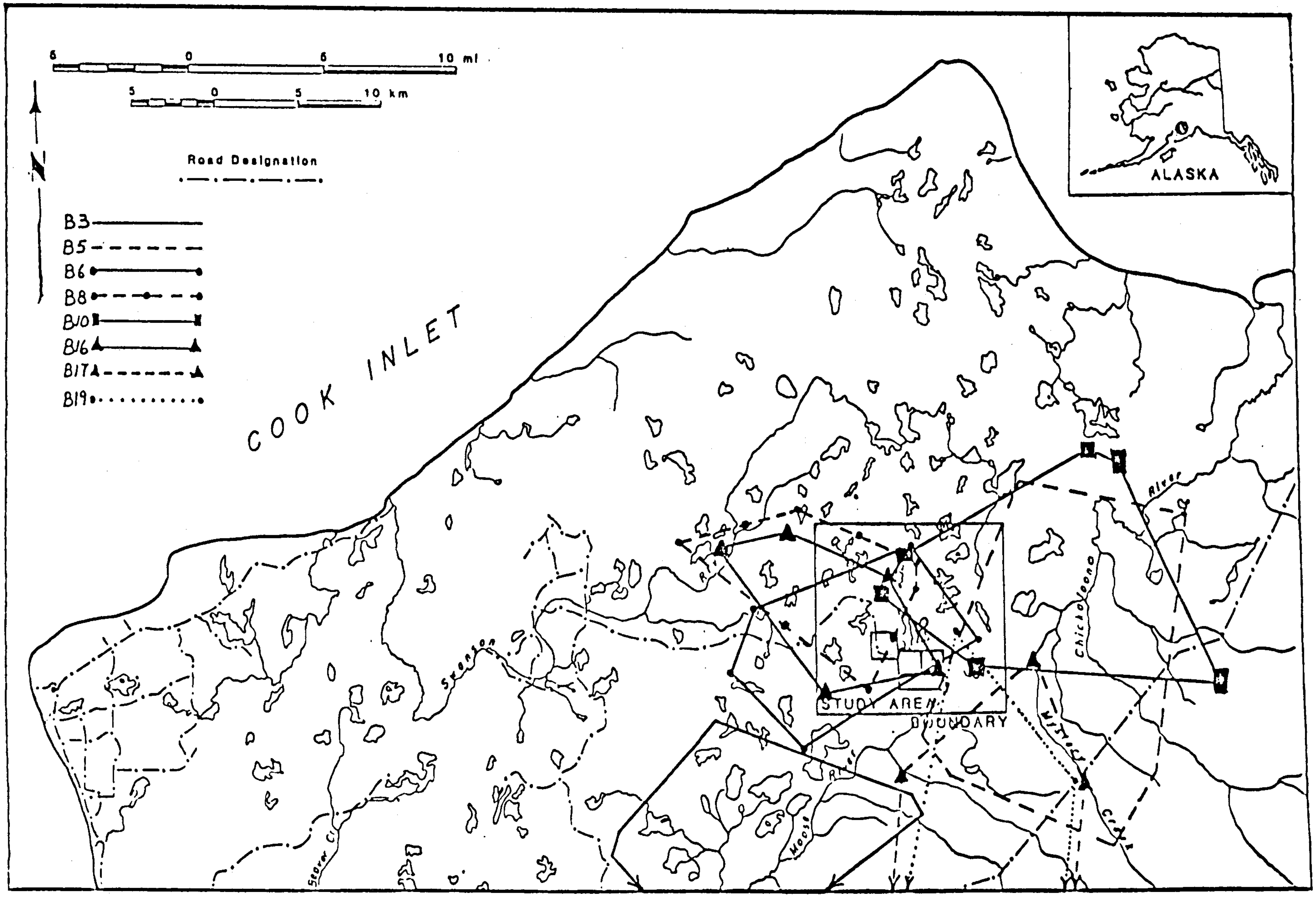

Fig. 10. Composite of home ranges for radio-collared male black bears at the Moose Research Center study area, Kenai Peninsula, 1981.

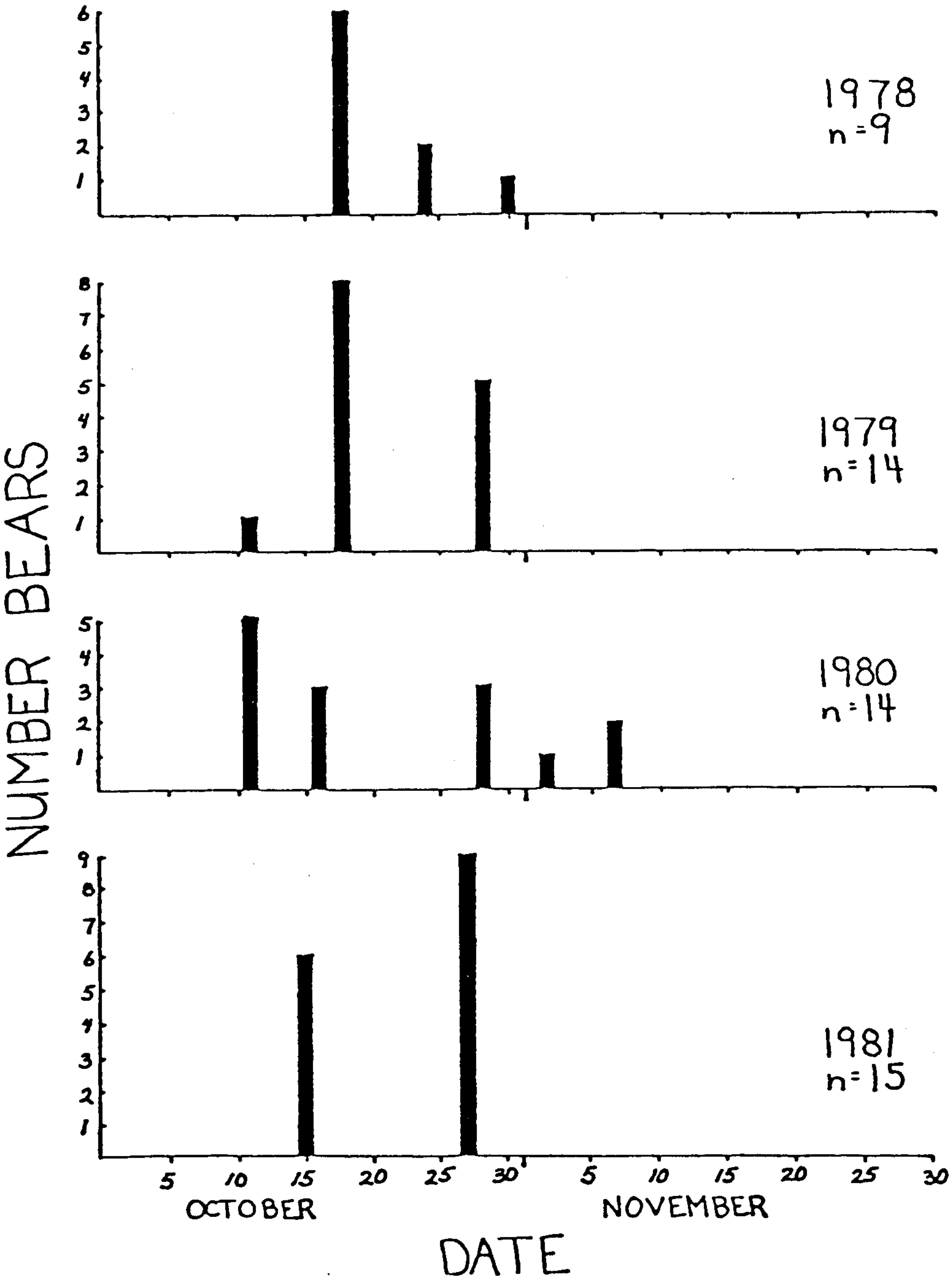

Fig. 11. Date black bears entered their dens for years 1978-81, on the Kenai Peninsula.

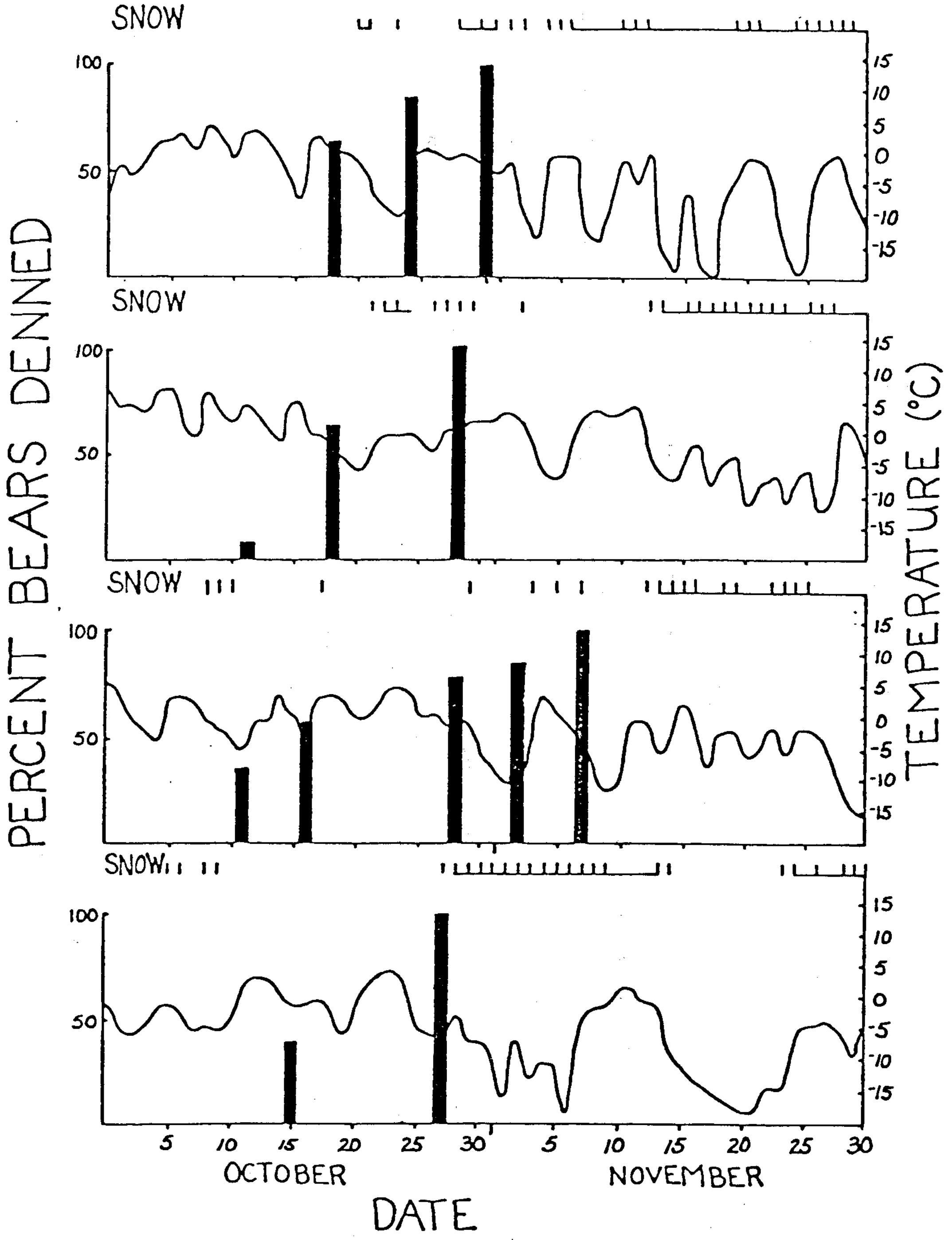

Fig. 12. Cumulative percent of black bears in their dens, and average daily minimum temperatures for the Kenai Peninsula, 1978-81. Snowfall is indicated by vertical tick-marks and snow on the ground by a horizontal line.

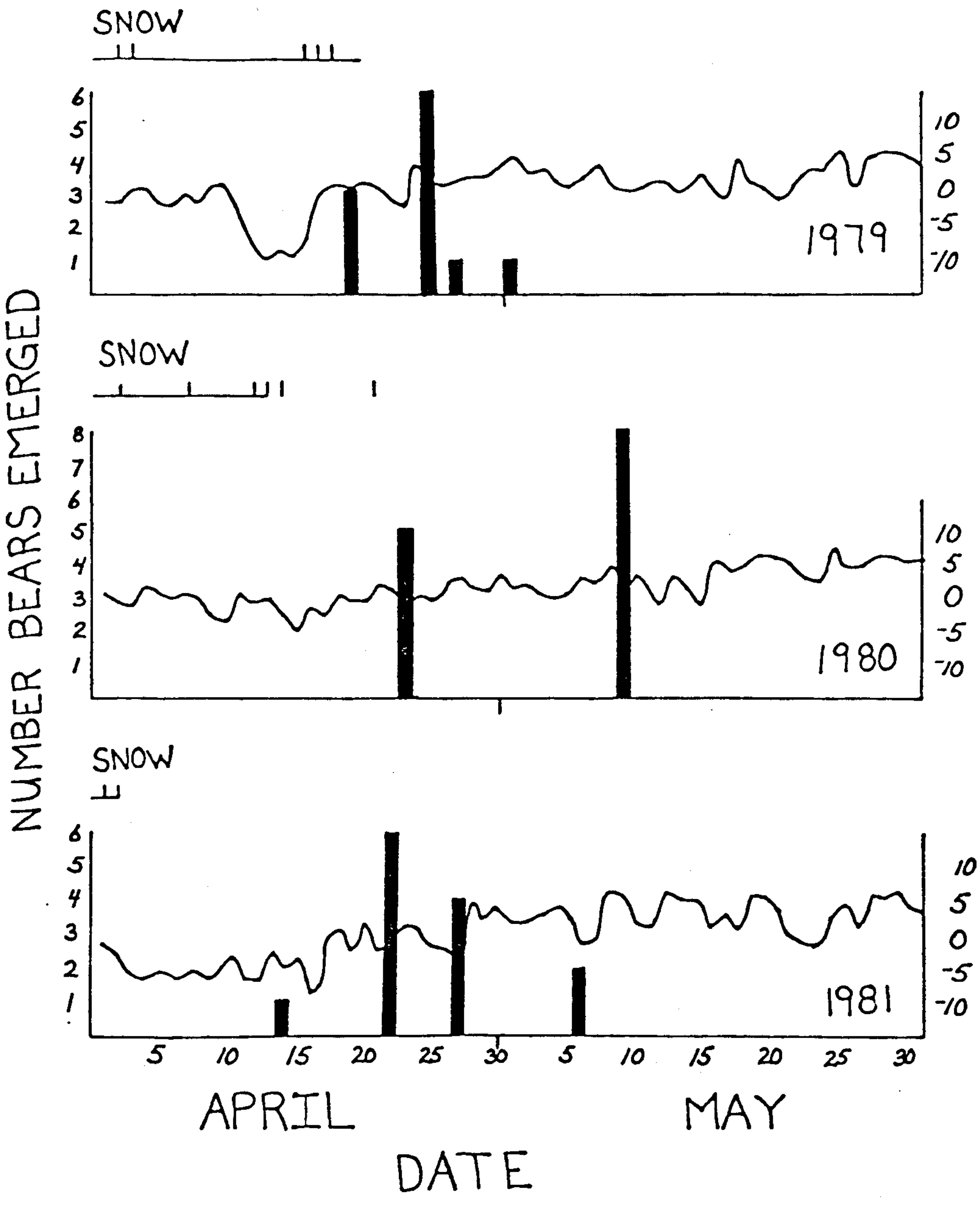

Fig. 13. Number of black bears emerged by date and average minimum temperatures for the Kenai Peninsula, 1979-81. Snowfall is indicated by tick-marks and snow on the ground by a horizontal line.

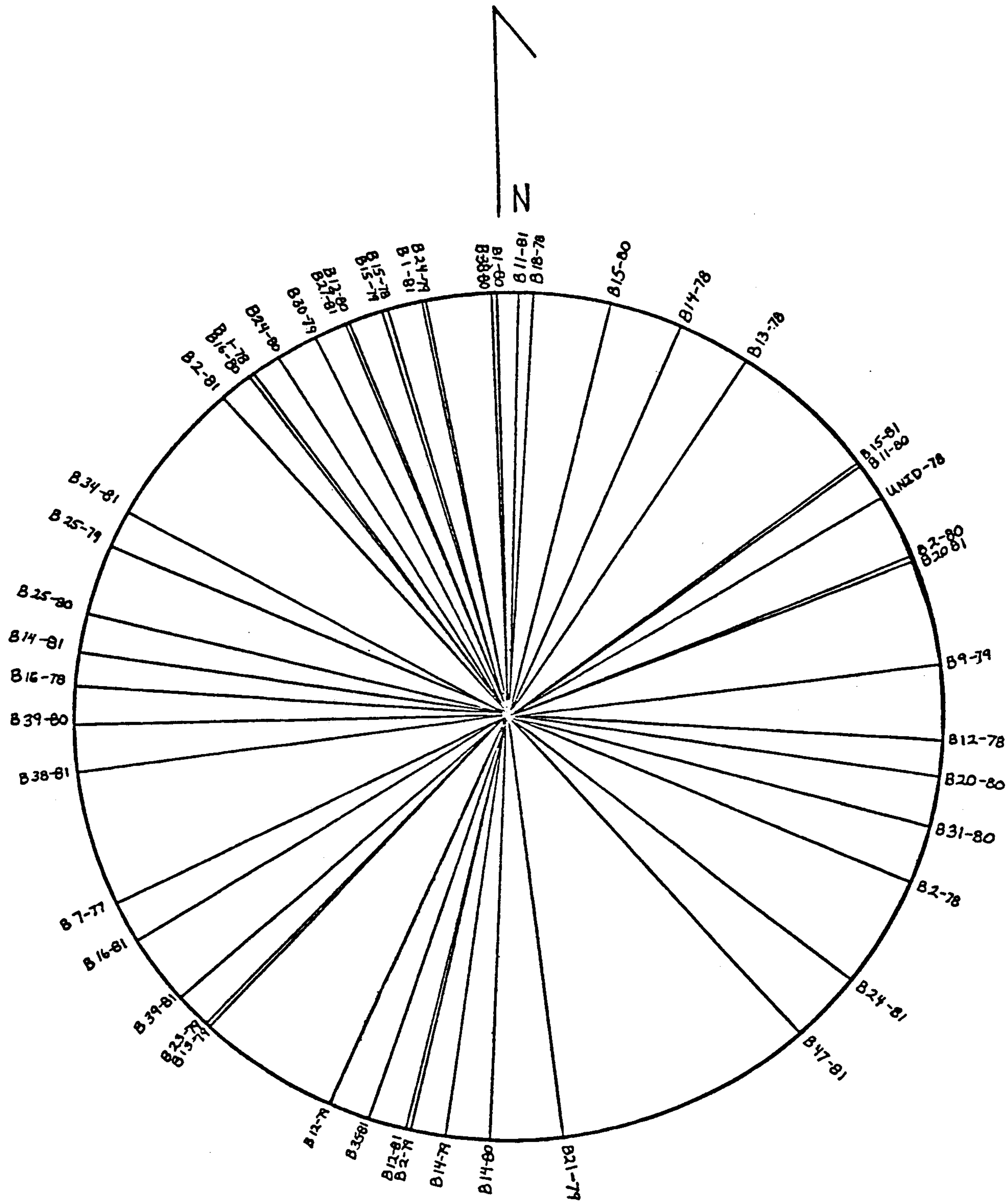

Fig. 14. Aspect of 49 black bear dens from the Kenai Peninsula, 1977-81.

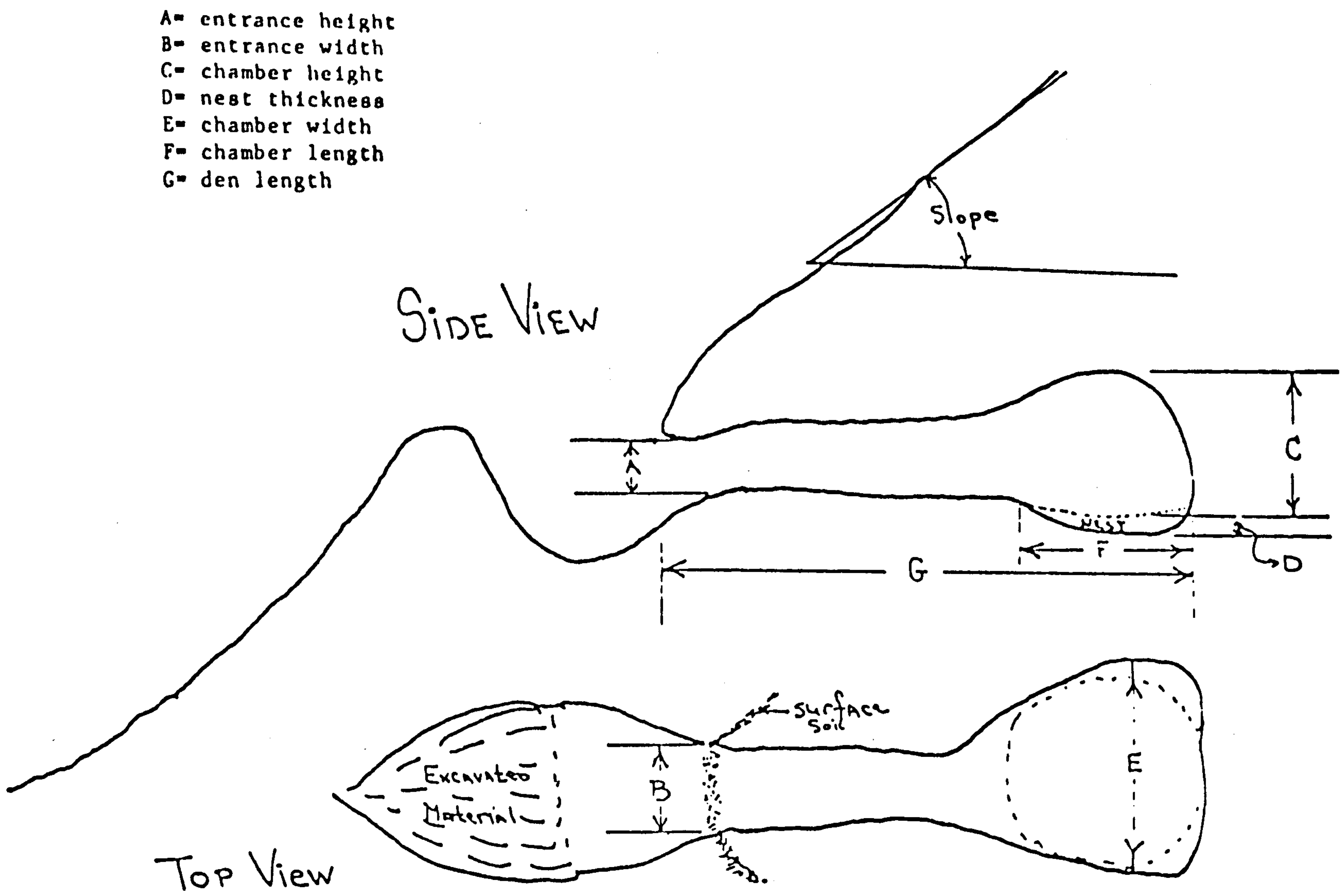

Fig. 15. Schematic of a typical black bear den on the Kenai Peninsula, showing location of measurements listed on Table 20.

Table 1. Capture information, aerial tracking data, and current status on black bears captured between 1977-1981 at the Moose Research Center (MRC) study area, Kenai Peninsula, Alaska.

Bear No.	Sex	Year of birth	Capture date	Age at capture (days)	Tracking period	Times located				Comments	Min. surv. (days)
						1978	1979	1980	1981		
B1	F	1974	10/8/77	1,317	5/31/78-8/6/79 6/21-12/31/81	30	28	0	10	Alive	1,544
B2	F	1975	10/17/77	961	10/15/77-12/31/81	28	36	21	19	Alive	1,535
B3	M	1975	4/28/78	1,155	4/28-8/22/78	14	0	0	0	Radio malfunction	1,341
B4[a]	M	1975	5/2/78	1,161	--	0	0	0	0	Capture mortality	0
B5	M	1972	5/2/78	2,259	5/2-10/30/78	23	0	0	0	Radio malfunction	175
B6	M	1973	5/2/78	1,891	5/30-6/3/78	10	0	0	0	Radio malfunction; hunter kill 9/1/78	122
B7[a]	F	1970	5/9/79	3,357	--	0	0	0	0	Capture mortality	0
B8	M	1968	5/16/78	3,727	5/16/78-4/25/79	29	0	0	0	Natural mortality	344
B9	M	1974	5/17/78	1,538	5/17/78-5/7/81	2	33	18	6	Radio malfunction	1,085
B10	M	1969	5/17/78	3,730	5/17/78-12/31/81	26	31	10	16	Alive	959
B11	M	1970	6/12/80	3,757	6/12/80-12/31/81	0	0	15	17	Alive	567
B12	F	1975	5/17/78	1,201	5/17/78-12/31/81	29	37	22	21	Alive	1,298
B13	F	1975	5/19/78	1,178	5/19/78-9/4/80	31	37	12	--	Hunter kill 9/4/80	838

Table 1. Continued.

Bear No.	Sex	Year of birth	Capture date	Age at capture (days)	Tracking period	Times located 1978	1979	1980	1981	Comments	Min. surv. (days)
B14	F	1976	5/25/78	819	5/25/78-12/31/81	30	37	21	21	Alive	1,315
B15	F	1976	5/30/78	824	5/30/78-12/31/81	10	36	22	20	Alive	1,310
B16	M	1971	6/2/78	2,652	6/2/78-9/6/79 6/15/80-12/31/81	18	31	14	20	Alive	1,307
B17	M	1969	6/5/78	3,385	6/5-11/8/78	18	0	0	0	Hunter kill 9/14/81	1,196
B18	F	1973	6/13/78	1,933	6/13/78-10/19/80	21	35	1	0	Radio mal-function	858
B19	M	1975	6/13/78	1,203	6/13-8/1/79	21	26	0	0	Hunter kill 9/18/81	1,192
B20	F	1971	5/2/79	2,986	5/2/79-12/31/81	0	33	19	18	Alive	973
B21	F	1978	5/14/79	1	5/14/79-8/26/79	0	20	6	0	Radio mal-function	546
B22	M	1979	6/20/80	443	Not radio-collared	0	0	0	0	Unknown	0
B23	F	1978	5/14/79	1	5/14-10/18/79	0	19	0	0	Lost radio-collar	611
B24	F	1969 or 1970	6/7/79	3,751	6/7/79-12/31/81	0	23	22	20	Alive	938
B25	M	1973	6/8/79	2,293	6/8/79-12/31/81	0	23	21	15	Alive	936
B26	M	1975	6/12/79	1,567	Not radio-collared	0	0	0	0	Hunter kill 5/24/80	346
B27	M	1977	6/16/79	841	6/13-6/30/81	0	0	0	8	Alive	928
B28	M	1977	6/20/79	845	Not radio-collared	0	0	0	0	Hunter kill 5/18/80	302

Table 1. Continued.

Bear No.	Sex	Year of birth	Capture date	Age at capture (days)	Tracking period	Times located 1978	1979	1980	1981	Comments	Min. surv. (days)
B29	M	1976	6/21/79	1,211	6/6-9/25/80	0	0	11	0	Hunter kill 9/1/80	491
B30	F	1975	6/25/79	1,580	6/25/79-9/3/80	0	21	13	0	Hunter kill 9/3/80	435
B31	F	1975	6/28/79	1,583	6/28/79-5/20/81	0	17	21	0	Hunter kill 5/20/81	691
B32	M	1979	10/9/79	1	10/9/79-6/21/80	0	2	5	0	Black bear predation 6/18/80	510
B33	M	1974	7/9/80	2,324	7/9/80-12/31/81	0	0	10	1	Alive	540
B34	M	1978	10/9/79	591	12/16-12/31/81	0	0	0	4	Alive	813
B35	F	1973	6/9/81	3,024	6/9-12/31/81	0	0	0	11	Alive	205
B36	F	1979	1/10/80	1	--	0	0	3	0	Lost radio-collar	318
B37	M	1979	1/10/80	1	--	0	0	15	0	Lost radio-collar	318
B38	F	1979	1/10/80	1	1/10/80-12/31/81	0	0	21	18	Alive	1,038
B39	M	1979	1/10/80	1	1/10/80-12/31/81	0	0	21	9	Alive	1,038
B40	M	1978	6/10/80	835	Not radio-collared	0	0	0	0	Hunter kill 5/21/81	345
B41	M	1980	6/27/80	1	6/5-12/31/81	0	0	0	11	Alive	673
B42	F	1980	6/27/80	1	6/9/-12/31/81	0	0	0	11	Alive	673
B43[a]	M	1980	5/13/81	1	--	0	0	0	1	Capture mortality	441
B44	F	1980	5/13/81	1	--	0	0	0	5	Malnutrition 7/14/81	503

Table 1. Continued.

Bear No.	Sex	Year of birth	Capture date	Age at capture (days)	Tracking period	Times located 1978	1979	1980	1981	Comments	Min. surv. (days)
B45[a]	M	1980	5/13/81	1	--	0	0	0	1	Capture mortality	441
B46	F	1980	5/13/81	1	--	0	--	--	3	Malnutrition 6/11/81	473
B47	M	1979	9/14/81	931	9/14-12/31/81	0	0	0	2	Alive	108

[a] Bears killed during trapping operations were not included in calculations used to determine minimum survival estimates.

Table 2. Age and sex of black bears in the MRC study area, Kenai Peninsula, 1978-81.

Age	Number of bears															
	1978			1979			1980			1981			1978-81			
(yrs.)	M	F	UKS[a]	M	F	UKS	M	F	UKS	M	F	UKS	M	F	UKS	Total
Live-captured sample																
Cub	0	2	2	3	2	2	3	3	4	0	0	0	6	7	8	21
1	0	0	0	0	2	2	3	2	2	3	3	4	6	7	8	21
2	0	2	0	0	0	0	2	2	0	1	1	0	3	5	0	8
3	3	3	0	4	2	0	0	0	0	1	0	0	8	5	0	13
4	1	1	0	1	5	0	4	2	0	0	0	0	6	8	0	14
5	1	1	0	2	1	0	1	5	0	1	2	0	5	9	0	14
6	1	0	0	0	2	0	3	1	0	1	3	0	5	6	0	11
7	1	0	0	0	0	0	0	2	0	3	2	0	4	4	0	8
8	0	1	0	1	1	0	0	0	0	0	0	0	1	2	0	3
9	2	0	0	0	0	0	1	1	0	0	1	0	3	2	0	5
10	1	0	0	2	0	0	1	0	0	1	1	0	5	1	0	6
11	0	0	0	0	0	0	2	0	0	1	0	0	3	0	0	3
12	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	2
$\bar{x}$	5.9	3.75		5.4	4.6		6.0	5.1		7.4	6.3		6.2	5.0		5.6
N[b]	10	10	2	13	15	4	20	18	6	14	13	4	57	56	16	129
Unit 15 kill sample																
$\bar{x}$	5.3	5.2		6.1	5.0		4.5	4.8		--	--		5.3	4.9		5.2
N	33	24		59	19		55	38		--	--		147	81		228

[a] UKS = Unidentified Sex.

[b] Based on total bears known to be alive in the study area each spring (same bears counted each year as long as it was known alive).

Table 3. Age at 1st breeding and cub production for black bears in the MRC study area, Kenai Peninsula, 1978-1982.

Bear No.	Year of birth	Year 1978	1979	1980	1981	1982
B1	1974	2 cubs	2 yearlings	?cubs	2 yearlings	Barren
B2	1975	Barren	2 cubs	2 yearlings	Barren	2 cubs
B7	1970	2 cubs	Dead	--	--	--
B12	1975	Barren	2 cubs	2 yearlings	Barren	2 cubs
B13	1975	Barren	1 cub	1 yearling	Dead	--
B14	1976	Barren	Barren	2 cubs	2 yearlings	Barren
B15	1976	Barren	Barren	2 cubs	2 yearlings	Barren
B18	1973	??	2 cubs	2 yearlings	Radio collar malfunction	--
B20	1971	?cubs	2 yearlings	2 cubs	2 yearlings	1 cub
B24	1970	--	Lactating, in estrus when captured.	2 cubs	2 yearlings	2 cubs
B30	1975	Barren	Barren	Barren	Dead	--
B31	1975	Barren	Barren	Barren	Barren	Dead
B35	1973	--	--	--	In estrus, signs of past nursing when captured.	3 cubs

Table 4. Litter size in black bears from the Kenai Peninsula, 1978-1982.

Group type	No. of litters	Size of litter 1	2	3	Mean litter size
Radio-collared	15	2(13)[a]	12(80)	1(7)	1.93
Unmarked[b]	23	3(13)	12(52)	8(35)	2.22
Totals	38	5(13)	24(63)	9(24)	2.10

[a] Number (%).

[b] Visual sightings of females and cub(s) made during routine radio-tracking flights. Some animals may have been counted more than once on different flights.

Table 5. Numbers and percentages of marked adult females (age >3) with or without cubs in the MRC study area, Kenai Peninsula, 1979-1982.

Year	Adult females	No. w/cubs	% w/cubs
1979	9	4	44
1980	11	5	45
1981	8	0	0
1982	8	5	62
Totals	36	14	$\bar{x}$ = 39

Table 6. Summary of survival analysis of black bears radio-tracked from October 1977 through 31 December 1981.[a]

Age category[b]	N	Total age at capture: Days	Total age at capture: Years	$\bar{x}$ capture age (years)	Total minimum survival: Days	Total minimum survival: Years	No. deaths	Years per death	$\bar{x}$ minimum life span (years)
Cubs	11	11	0.0	0.0[c]	6,701	18.4	3	6.2	6.2
Adults	32	57,892	158.6	5.0	25,037	68.6	11	6.2	11.2
Totals	43	57,903	158.6	3.7	31,738	87.0	14	6.2	9.9

[a] Data for individuals listed in Table 1.

[b] Calculations were made excluding all bears who were capture mortalities (B4, B7, B43, B45).

[c] Survival rates for cubs calculated from time of birth (assumed to be 1 Feb) rather than time when captured since we did not mark cubs until their 1st birthday when they were in the den.

Table 7. Cause of death of 18 marked black bears at the MRC study area, Kenai Peninsula, from October 1977 through 1981.

Bear No.	Sex	Age at death (yrs.)	Date of death	Comments
B4	M	3.2	2 May 1978	Capture mortality
B6	M	5.5	1 Sep 1978	Hunter harvest
B7	F	9.2	9 May 1979	Capture mortality
B8	M	10.2	25 Apr 1979	Natural causes
B13	F	5.5	4 Sep 1980	Hunter harvest
B17	M	12.6	14 Sep 1981	Hunter harvest
B19	M	6.6	18 Sep 1981	Hunter harvest
B26	M	5.2	24 May 1980	Hunter harvest
B28	M	3.1	18 May 1980	Hunter harvest
B29	M	4.5	1 Sep 1980	Hunter harvest
B30	F	5.5	3 Sep 1980	Hunter harvest
B31	F	6.2	20 May 1981	Hunter harvest
B32	M	1.4	18 Jun 1980	Black bear predation
B40	M	3.2	21 May 1981	Hunter harvest
B43	M	1.2	13 May 1981	Capture mortality
B44	F	1.3	14 Jul 1981	Malnutrition
B45	M	1.2	13 May 1981	Capture mortality
B46	F	1.3	11 Jun 1981	Malnutrition

Table 8. Home range area (km^2) for black bears in the MRC study area, Kenai Peninsula, 1978-81.

Bear No.	Sex	Year 1978	1979	1980	1981
B1	F	14.2	28.2	--	--
B2	F	19.9	4.4	15.6	22.0
B3	M	191.8	--	--	--
B5	M	340.4	--	--	--
B6	M	101.0	--	--	--
B8	M	78.1	--	--	--
B9	M	--	88.2	40.6	--
B10	M	170.7	297.3	114.0	115.9
B11	M	--	--	165.4	64.6
B12	F	31.0	11.3	25.1	11.6
B13	F	18.6	21.4	33.4	--
B14	F	26.4	35.0	11.7	18.1
B15	F	--	31.5	14.9	27.3
B16	M	69.2	87.7	95.1	56.3
B17	M	179.2	--	--	--
B18	F	37.2	10.0	--	--
B19	M	224.8	219.1	--	--
B20	F	--	45.8	42.8	26.4
B21	F	--	30.1	--	--
B23	F	--	77.6	--	--
B24	F	--	23.0	20.3	15.5
B25	M	--	170.9	118.7	120.1
B27	M	--	--	--	83.3
B29	M	--	--	11.6	--
B30	F	--	12.2	21.0	--
B31	F	--	15.3	18.2	--
B35	F	--	--	--	13.0
B37	M	--	--	6.5	--
B38	F	--	--	8.6	5.9
B39	M	--	--	10.9	--
B41	M	--	--	--	20.9
B42	F	--	--	--	20.9

Table 9. Home range area for different sex, age class, and reproductive class of black bears in the MRC study area, Kenai Peninsula, 1978-1981.

Bear class	Home range (km^2)	N	Range (km^2)
Female with cub(s)	17.6	8	4.4-42.8
Female with yearling(s)	26.2	9	15.5-45.8
Female, no offspring	19.7	12	13.0-31.5
Juvenile female ($\leq$3 years)	17.0	6	3.0-26.4
Adult male (>3 years)	141.1	21	40.6-340.8
Juvenile male ($\leq$3 years)	15.9	2	10.9-20.9

Table 10. Distance (km) between the center of activity of the home range area in different years for black bears from the MRC study area, Kenai Peninsula, 1978-1981.

		Years compared					
Bear No.	Sex	1978-79	1979-80	1980-81	1978-80	1978-81	1979-81
B1	F	0.1	--	--	--	1.4	1.5
B2	F	0.9	0.3	0.9	1.0	0.7	0.7
B9	M	--	1.8	--	--	--	--
B10	M	3.9	1.2	4.5	5.0	1.6	3.6
B11	M	--	--	2.2	--	--	--
B12	F	0.9	0.2	0.2	0.7	0.8	0.1
B13	F	1.3	1.8	--	1.3	--	--
B14	F	0.5	1.1	0.2	0.8	0.8	0.9
B15	F	1.9	3.0	0.8	1.1	0.5	2.3
B16	M	0.9	2.6	1.6	1.8	1.2	2.6
B18	F	2.1	--	--	--	--	--
B19	M	1.7	--	--	--	--	--
B20	F	--	0.8	1.2	--	--	1.9
B23	F	--	1.6	--	--	--	--
B24	F	--	1.8	1.0	--	--	1.4
B25	M	--	4.3	3.5	--	--	2.0
B30	F	--	0.2	--	--	--	--
B31	F	--	0.3	--	--	--	--
B38	F	--	--	0.3	--	--	--
$\bar{x}$ ± SD							
All males		2.1 ± 1.6	2.5 ± 1.3	1.4 ± 1.4	3.4 ± 2.3	1.4 ± 0.3	3.1 ± 0.7
All females		1.1 ± 0.7	1.1 ± 0.9	0.7 ± 0.4	1.0 ± 0.3	0.8 ± 0.3	1.3 ± 0.7
All bears		1.4 ± 1.1	1.5 ± 1.2	2.9 ± 1.3	1.7 ± 1.5	1.0 ± 0.4	1.7 ± 1.1

Table 11. Average home range size for black bears in North America.

Study location	Home range size (km^2) Mean (range): Adult (>3 years) Male	Adult (>3 years) Female	Subadult (<3 years) Male	Subadult (<3 years) Female	Reference
Alaska					
Prince William Sound	(79-100)[a]	(10-30)[a]	--	--	Modafferi (1982)
Susitna River	153(4-611)[b]	117(3-1,036)[b]	--	--	Miller and McAllister (1982:98)
Kenai Peninsula	141(41-341)	21(4-46)	16(11-21)	17(3-26)	This study
Arizona	29(15-69)	18(10-30)	42(19-64)	13(10-19)	LeCount (1977)
Idaho	105(61-156)	18(12-26)	--	--	Reynolds and Beecham (1977)
Idaho	112(109-115)	49(16-130)	--	--	Amstrup and Beecham (1976)
Washington (island)	5(2-13)	2(1-4)	2(1.8-2.4)	3(2-4)	Lindzey (1976:39)
Washington (mainland)	61(13-87)	5(3-6)	--	--	Polker and Hart (1973:72)

[a] Includes all age classes of bears: no table presented to separate age classes.

[b] Includes all bears >2 years old: home range includes summer excursions.

Table 12. Dates of departure and return for radio-collared black bears going to and returning from summer feeding areas, MRC study area, Kenai Peninsula, 1978-1981.

Bear No.	Sex	1978		1979		1980		1981	
		Depart	Return	Depart	Return	Depart	Return	Depart	Return
B1	F	4 Aug	18 Oct	6 Aug	--	--	--	--	--
B2	F	8 Aug	25 Sep	23 Jul	6 Sep	5 Aug	28 Aug	30 Jul	25 Aug
B12	F	15 Aug	18 Sep	1 Aug	6 Sep	31 Jul	5 Aug	30 Jul	24 Aug
B13	F	11 Aug	3 Oct	1 Aug	6 Sep	5 Aug	28 Aug	--	--
B14	F	11 Aug	3 Oct	23 Jul	6 Sep	31 Jul	28 Aug	30 Jul	25 Aug
B21	F	--	--	23 Jul	6 Sep	--	--	--	--
B23	F	--	--	23 Jul	2 Oct	--	--	--	--
B24	F	--	--	23 Jul	6 Sep	31 Jul	28 Aug	30 Jul	25 Aug
B38	F	--	--	--	--	28 Aug	11 Sep	--	--
All females		10 Aug	1 Oct	27 Jul	9 Sep	7 Aug	26 Aug	30 Jul	25 Aug
± SD in days		4	11	6	10	10	12	0	1
B8	M	8 Aug	--	--	--	--	--	--	--
B9	M	14 Aug	11 Oct	22 Jul	10 Oct	--	--	--	--
B10	M	8 Aug	18 Oct	27 Jul	2 Oct	5 Aug	11 Sep	30 Jul	25 Aug
B16	M	12 Aug	18 Oct	1 Aug	?	31 Jul	16 Oct	31 Jul	8 Sep
B17	M	11 Aug	?	--	--	--	--	--	--
B25	M	--	--	21 Aug	2 Oct	31 Jul	11 Sep	30 Jul	22 Sep
B37	M	--	--	--	--	31 Jul	17 Sep	--	--
B39	M	--	--	--	--	5 Aug	11 Sep	--	--
All males		11 Aug	15 Oct	2 Aug	5 Oct	2 Aug	19 Sep	30 Jul	8 Sep
± SD in days		3	4	4	3	5	5	3	3
All bears		10 Aug	8 Oct	30 Jul	22 Sep	4 Aug	7 Sep	30 Jul	1 Sep

Table 13. Distance in (km) between the center of activity of the home range and summer feeding area for black bears from the MRC study area, Kenai Peninsula, 1978-1981.

Bear No.	Sex	Year 1978	1979	1980	1981
B1	F	18.0	16.8	--	--
B2	F	23.3	27.9	28.8	27.4
B6	M	19.6	--	--	--
B8	M	23.8	--	--	--
B9	M	--	40.8	41.0	--
B10	M	16.0	24.1	23.1	22.1
B11	M	--	--	27.6	--
B12	F	17.0	19.0	18.6	11.4
B13	F	11.0	18.3	8.2	--
B14	F	12.6	14.3	15.6	12.9
B15	F	--	12.8	29.4	--
B16	M	34.3	33.2	31.8	32.0
B17	M	42.7	--	--	--
B18	F	--	8.8	--	--
B21	F	--	21.1	--	--
B23	F	--	18.6	--	--
B24	F	--	22.8	0.3	10.3
B25	M	--	33.7	39.9	36.9
B31	F	--	22.2	21.9	--
B33	M	--	--	68.2	--
B37	M	--	--	24.1	--
B38	F	--	--	24.4	17.3
B39	M	--	--	26.8	--
All males ± SD		27.3[ab] ± 11.0	32.9[ab] ± 6.8	36.4[a] ± 16.1	30.3[ab] ± 7.5
All females ± SD		16.4[bc] ± 4.9	18.4[bc] ± 5.2	18.4[bc] ± 10.0	15.9[c] ± 7.0
All bears ± SD		21.8 ± 9.9	22.3 ± 8.6	26.8 ± 15.1	21.3 ± 10.0
All years, males		31.4 ± 3.4			
All years, females		17.2 ± 1.3			
All years, all bears		23.0 ± 2.5			

abc Any 2 means followed by a different letter are significantly different ($\underline{P} < 0.05$) according to Duncan's new multiple range test.

Table 14. Density estimates for black bears in the MRC study area, Kenai Peninsula, 1979.

Bear No.	Sex	Subunit[a] 1	2	3	4	5	6	7	8	9	Mean ± SD
B1	F	0.011[b]	--	--	--	--	0.030	0.006	--	--	--
B2	F	0.023	0.443	--	--	0.091	--	--	--	--	--
B2 cubs	F	0.023	0.443	--	--	0.091	--	--	--	--	--
B2 cubs	M	0.023	0.443	--	--	0.091	--	--	--	--	--
B13	F	0.064	0.119	0.121	0.092	0.121	0.121	0.098	0.087	0.005	--
B13 cub	M	0.064	0.119	0.121	0.092	0.121	0.121	0.098	0.087	0.005	--
B14	F	--	--	0.018	0.074	0.050	0.008	0.070	0.074	0.074	--
B15	F	--	--	--	--	--	0.045	0.070	--	--	--
B21	F	0.421	--	--	--	--	--	--	--	--	--
B23	F	0.019	--	--	--	--	--	--	--	--	--
B24	F	--	--	--	0.007	0.002	--	0.083	0.122	0.122	--
B30	F	0.014	--	--	--	--	--	--	--	--	--
B31	F	--	--	--	--	--	0.008	0.078	--	--	--
B35[c]	F	--	--	--	--	--	--	0.041	0.091	0.029	--
All females		0.552	0.562	0.139	0.173	0.264	0.212	0.446	0.374	0.230	0.328 ± 0.161
All cubs		0.110	1.005	0.121	0.092	0.303	0.121	0.098	0.087	0.005	0.216 ± 0.306
Females and cubs		0.662	1.567	0.260	0.265	0.567	0.333	0.544	0.461	0.235	--
B10	M	--	--	--	--	--	0.002	--	0.001	0.008	--
B16	M	0.030	0.012	--	--	0.008	0.030	0.028	0.028	0.001	--
B25	M	--	--	--	--	0.001	0.008	0.015	0.007	--	--
B9	M	--	--	--	--	--	--	0.023	0.005	--	--
Males		0.030	0.012	--	--	0.009	0.040	0.066	0.014	0.008	0.020 ± 0.022
All bears		0.692	1.579	0.260	0.265	0.576	0.373	0.610	0.475	0.243	0.447 ± 0.413

[a] Subunit numbers, representing specific areas for research purposes, are listed in Fig. 6; they are different from Subunits of Game Management Units.

[b] Density represents bears per 2.59 km^2 (1 m^2).

[c] Estimates include B35 who was first captured as an adult in 1981. She was known to be in the study area in 1979 and 1980. See text for detailed explanation.

Table 15. Density estimates for black bears in the MRC study area, Kenai Peninsula, 1980.

Bear No.	Sex	Subunit[a] 1	2	3	4	5	6	7	8	9	Mean ± SD
B1[b]	F	0.010	--	--	--	--	0.019	0.002	--	--	--
B1 cub	?	0.010	--	--	--	--	0.019	0.002	--	--	--
B1 cub	?	0.010	--	--	--	--	0.019	0.002	--	--	--
B2	F	0.073	0.166	0.047	--	0.109	0.009	--	--	--	--
B12	F	0.102	0.057	0.003	--	--	0.026	--	--	--	--
B13	F	0.004	0.056	0.078	0.078	0.078	0.060	0.032	0.047	0.055	--
B14	F	--	0.009	0.087	0.223	0.154	--	0.020	0.129	0.101	--
B14 cub	F	--	0.009	0.087	0.223	0.154	--	0.020	0.129	0.101	--
B14 cub	M	--	0.009	0.087	0.223	0.154	--	0.020	0.129	0.101	--
B15	F	0.020	--	--	--	--	0.069	0.092	--	--	--
B15 cub	F	0.020	--	--	--	--	0.069	0.092	--	--	--
B15 cub	M	0.020	--	--	--	--	0.069	0.092	--	--	--
B24	F	--	--	--	--	--	--	--	--	0.005	--
B24 cub	F	--	--	--	--	--	--	--	--	0.005	--
B24 cub	M	--	--	--	--	--	--	--	--	0.005	--
B30	F	--	--	--	--	--	--	0.026	--	--	--
B31	F	--	--	--	--	--	--	0.014	--	--	--
B38	F	0.052	0.301	0.102	0.010	0.240	0.025	0.002	0.010	--	--
B35[b]	F	--	--	--	--	--	--	0.041	0.091	0.029	--
All females		0.261	0.589	0.317	0.311	0.581	0.208	0.229	0.277	0.190	0.329 ± 0.151
All cubs		0.060	0.018	0.174	0.446	0.308	0.176	0.228	0.258	0.212	0.209 ± 0.127
Females and cubs		0.321	0.607	0.491	0.757	0.889	0.384	0.457	0.535	0.402	--
B9	M	0.017	0.064	0.023	0.062	0.064	0.025	0.034	0.064	0.064	--
B11	M	--	--	--	0.004	0.001	--	0.012	0.015	0.016	--
B16	M	--	--	--	--	--	--	0.023	0.014	0.003	--
B39	M	0.075	0.237	0.064	0.017	0.152	0.004	--	--	--	--
B25	M	--	--	--	--	--	--	0.022	0.015	0.005	--
All males		0.092	0.301	0.087	0.083	0.217	0.029	0.091	0.108	0.088	0.122 ± 0.083
All bears		0.413	0.908	0.578	0.840	1.106	0.413	0.548	0.643	0.490	0.660 ± 0.241

[a] Subunit numbers, representing specific areas for research purposes, are listed in Fig. 6; they are different from Subunits of Game Management Units.

[b] Estimates include B1 and B35 which were not radio-collared in 1981. See text for explanation.

[c] Density represents bears per 2.59 km^2 (1 mi^2).

Table 16. Density estimates for black bears in the MRC study area, Kenai Peninsula, 1980.

Bear No.	Sex	Subunit[a] 1	2	3	4	5	6	7	8	9	Mean ± SD
B1	F	0.020[b]	--	--	--	--	0.016	--	--	--	--
B2	F	0.118	0.118	0.037	--	0.080	0.118	0.077	0.006	--	--
B14	F	--	0.024	0.096	0.143	0.076	--	--	0.059	0.132	--
B15	F	0.007	--	--	--	0.011	0.080	0.095	0.073	--	--
B24	F	--	--	--	--	--	--	--	--	0.012	--
B35	F	--	--	--	--	--	--	0.041	0.091	0.029	--
B38	F	0.158	0.429	0.014	--	0.112	0.036	--	--	--	--
B42	F	0.004	--	--	--	0.009	0.100	0.105	0.001	--	--
All females		0.307	0.571	0.147	0.143	0.288	0.350	0.318	0.230	0.173	0.281 ± 0.133
Cubs		--	--	--	--	--	--	--	--	--	--
B11	M	--	--	--	--	--	--	--	--	0.008	--
B16	M	--	--	--	--	0.020	0.018	0.039	0.019	--	--
B25	M	0.021	0.015	0.001	0.017	0.021	0.021	0.021	0.021	0.021	--
B27	M	--	--	0.018	0.031	0.011	--	--	0.027	0.031	--
B41	M	0.004	--	--	--	0.008	0.099	0.105	0.001	--	--
All males		0.025	0.015	0.019	0.048	0.042	0.138	0.165	0.068	0.060	0.064 ± 0.053
All bears		0.332	0.586	0.166	0.191	0.330	0.488	0.483	0.298	0.233	0.345 ± 0.145

[a] Subunit numbers, representing specific areas for research purposes, are listed in Fig. 6; they are different from Subunits of Game Management Units.

[b] Density represents bear per 2.59 km^2 (1 mi^2).

Table 17. Estimates of black bear densities in North America.

Location	Reference	km^2/bear
Alaska	Modafferi 1982	2.4
Alaska	This study	3.9-7.5
Alberta	Kemp 1972	2.6
Minnesota	Rogers 1977	4.5
Michigan	Erickson and Petrides 1964	8.8
Montana	Jonkel and Cowan 1971	2.1-4.4
Washington	Poelker and Hartwell 1973	2.6-3.6
	Lindzey 1976	0.7-0.9
Idaho	Beecham 1977	2.1-2.3

Table 18. Den entrance and emergence time for black bears in the MRC study area, Kenai Peninsula, 1977-1981.

Bear No.	Sex	1977 In	1978 Out	1978 In	1979 Out	1979 In	1980 Out	1980 In	1981 Out	1981 In
B1	F	16 Oct	--	8 Nov[a]	25 Apr	--	--	--	--	15 Oct
B2	F	--	17 Apr	18 Oct[b]	19 Apr	28 Oct	9 May	2 Nov	27 Apr	15 Oct[b]
B9	M	--	--	18 Oct	25 Apr	18 Oct	9 May	16 Oct	22 Apr	--
B10	M	--	--	18 Oct	25 Apr	18 Oct	23 Apr	1 Nov	--	15 Oct
B11	M	--	--	--	--	--	--	11 Oct	22 Apr	27 Oct
B12	F	--	--	18 Oct[b]	25 Apr	28 Oct	23 Apr	2 Nov	14 Apr	24 Oct[b]
B13	F	--	--	18 Oct[b]	25 Apr	28 Oct	9 May	--	--	--
B14	F	--	--	31 Oct	19 Apr	28 Oct	9 May	10 Oct	27 Apr	27 Oct
B15	F	--	--	24 Oct	27 Apr	18 Oct[b]	9 May	16 Oct	27 Apr	15 Oct
B16	M	--	--	24 Oct	19 Apr	--	--	16 Oct	22 Apr	27 Oct
B18	F	--	--	18 Oct[b]	25 Apr	--	--	--	--	--
B19	M	--	--	--	1 May	--	--	--	--	--
B20	F	--	--	--	--	11 Oct[b]	9 May	2 Nov	22 Apr	27 Oct[b]
B21	F	--	--	--	--	28 Oct	--	--	--	--
B23	F	--	--	--	--	18 Oct	--	--	--	--
B24	F	--	--	--	--	18 Oct[b]	9 May	10 Oct	7 May	15 Oct[b]
B25	M	--	--	--	--	18 Oct	23 Apr	10 Oct	27 Apr	--
B30	F	--	--	--	--	18 Oct	23 Apr	--	--	--
B31	F	--	--	--	--	18 Oct	9 May	10 Oct	22 Apr	--
B34	M	--	--	--	--	18 Oct	--	--	--	27 Oct
B35	F	--	--	--	--	--	--	--	--	27 Oct[b]
B38	F	--	--	--	--	--	9 May	7 Nov	22 Apr	27 Oct
B39	M	--	--	--	--	--	23 Apr	7 Nov	7 May	27 Oct
N		1	1	10	11	14	14	14	13	15
Mean, all bears		--	--	21 Oct	24 Apr	21 Oct	3 May	21 Oct	25 Apr	22 Oct
Mean, all females		--	--	22 Oct	24 Apr	22 Oct	6 May	20 Oct	25 Apr	21 Oct
Mean, all males		--	--	20 Oct	25 Apr	18 Oct	27 Apr	23 Oct	26 Apr	23 Oct

[a] Bear was in den on day 312; previous flight made on day 297. Time lapse between flights was too great to accurately predict den entrance.

[b] Pregnant female.

Table 19. Bedding material, habitat type, and den excavation type for 49 black bear dens from the MRC study area, Kenai Peninsula, 1977-1981.

Bear No.	Date	Bedding material	Habitat[a]	Den excavation type
B1	1978-79	Spruce	MH-MS	Into hillside
B2	1978-79	Spruce & leaves	RS-RH	Under base of aspen tree
B15	1978-79	Spruce	RS-RH	Into hillside
B18	1978-79	Ledum, vaccinium, moss, grass, sticks	MH-MS	Into hillside
Unid	1978-79	Vaccinium, moss, grass	MH-RS	Under leaning aspen tree
B13	1978-79	Vaccinium & spruce	RS-RH	Under upturned birch tree
B7	1977-78	Vaccinium & birch sticks	R-H	Into hillside
B12	1978-79	Vaccinium & spruce	RS-MH-MS	On flat ground
B16	1978-79	None	RS-RH	Into hillside
B14	1978-79	Vaccinium & sticks	MH-MS	Under base of spruce tree
B21	1979-80	Vaccinium & spruce	RS-RH	Into hillside
B15	1978-79	Vaccinium (dug out of den)	RS-RH	Into hillside
B23	1979-80	Spruce	RS-RH	Into hillside
B30	1979-80	Leaves & sticks	RS-RH	Into hillside
B13	1979-80	Grass	MH-MS	Into hillside
B2	1979-80	Grass	RS-RH	Into hillside
B12	1979-80	Grass & vaccinium	MS-MH	Under birch tree
B25	1979-80	Spruce	RH-RS	Into hillside
B9	1979-80	Vaccinium, sticks, & leaves	RH-RS	Into hillside
B24	1979-80	Moss, vaccinium, leaves	MH	Into hillside
B14	1979-80	Vaccinium, spruce	RS-RH	Under upturned tree
B1	1980-81	Grass, leaves, sticks, spruce	MH-MS	Under leaning birch tree
B2	1980-81	Vaccinium, spruce, sticks, leaves	RH-RS	Under large boulder

Table 19. Continued.

Bear No.	Date	Bedding material	Habitat[a]	Den excavation type
B11	1980-81	Spruce, sticks, vaccinium, leaves	RS-RH	Into hillside
B12	1980-81	Vaccinium, leaves, ledum, moss	MH	Under leaning aspen tree
B14	1980-81	Vaccinium, grass, ledum	RS-BOG	Under rootmass of rotten tree stump
B14	1980-81	Spruce, vaccinium leaves & sticks	RH-RS	Into hillside
B16	1980-81	Spruce, grass, leaves, sticks, moss	MS-MH	Under birch tree
B20	1980-81	Spruce, vaccinium, sticks, moss	RS	On flat ground
B24	1980-81	Vaccinium, leaves, sticks, moss	MH-MS	Under tree stump next to old den
B25	1980-81	Spruce, vaccinium, sticks	RS-RH	Into hillside
B31	1980-81	Vaccinium, grass, leaves, spruce, moss, sticks	RS-RH	Into hillside
B38	1980-81	Vaccinium, leaves, moss	RS, RH	Under fallen spruce tree
B39	1980-81	Spruce, vaccinium, grass, leaves, ledum, moss	RS-RH	Under fallen spruce tree
B1	1981-82	Grass, spruce, sticks	MH-MS	On flat ground
B2	1981-82	Moss, leaves, sticks, vaccinium, spruce	MH-MS	Under leaning spruce tree
B11	1981-82	Vaccinium, spruce, moss, sticks	MH-RS	Under leaning aspen tree
B12	1981-82	Spruce & leaves	RS-RH	Into hillside under spruce tree

Table 19. Continued.

Bear No.	Date	Bedding material	Habitat[a]	Den excavation type
B14	1981-82	Grass	RS-RH	Into hillside
B15	1981-82	Moss, leaves, vaccinium, sticks	RH-RS	Into hillside
B16	1981-82	Spruce, leaves	RS-RH	Under large boulder
B20	1981-82	Spruce	RS-RH	Into hillside
B24	1981-82	Spruce, leaves, sticks	RS-RH	Into hillside next to old den
B27	1981-82	Sticks, moss, vaccinium, grass	RS, MH, MS	Under roots of leaning aspen tree
B34	1981-82	Vaccinium, leaves, moss, sticks	MH-MS	Under rootmass of rotten tree stump
B35	1981-82	Sticks, spruce, moss,	RS-RH	In hillside
B38	1981-82	Vaccinium, almost bare	RS-RH	In rootmass of rotten tree stump
B39	1981-82	Vaccinium	RS-RH	In rootmass of rotten tree stump
B47	1981-82	Vaccinium, leaves, moss, sticks	RS-RH	On flat ground

[a] R = Regrowth, M = Mature, H = Hardwood, and S = Spruce.

Table 20. Average dimensions (cm) of 49 black bear dens on the MRC study area, Kenai Peninsula, 1977-1981.

Cohort	N	Entrance		Approx. area	Tunnel	Chamber			Approx. volume
		Width	Height	(m^2)	length	Length	Width	Height	(m^3)
All bears	49	52 ± 13	44 ± 10	0.23	78	103 ± 29	109 ± 23	77	0.86
All females	35	41 ± 10	53 ± 13	0.22	79	102 ± 33	107 ± 22	75	0.82
Subadult females	5	47 ± 15	36 ± 5	0.16	63	82 ± 28	91 ± 25	56	0.42
Barren adult females	8	52 ± 7	40 ± 7	0.21	62	103 ± 37	110 ± 20	79	0.89
Females w/cub(s)	12	58 ± 12	48 ± 11	0.28	87	111 ± 28	103 ± 21	76	0.87
Females w/yearling(s)	9	53 ± 16	36 ± 75	0.19	94	102 ± 40	116 ± 21	80	0.94
All males	13	48 ± 15	47 ± 8	0.23	77	105 ± 15	117 ± 25	81	0.99
Subadult males	3	36 ± 11	40 ± 4	0.14	103	86 ± 8	111 ± 45	69	0.65
Adult males	10	52 ± 14	49 ± 7	0.26	69	111 ± 12	118 ± 19	85	1.12

Table 21. Serial body weights from adult female black bears in the MRC study area, Kenai Peninsula, 1977-81.

Bear No.	Age (months)	Date weighed	Weight (kg)	Comments on serial data
B1	42	8 Oct 1977	79.5	34% weight loss during winter/spring
	51	31 May 1978	52.2	with cubs born in 1978.
	88	9 Jun 1981	61.8	
B2	32	15 Oct 1977	64.4	8% weight loss during winter/spring
	40	9 Jun 1978	59.0	without cubs or yearlings; no weight
	59	10 Jan 1980	54.4	change from January (den) to June
	64	8 Jun 1980	54.4	with yearlings born in 1979; 32%
	76	8 Jun 1981	62.3	weight gain during summer with cubs.
	79	17 Sep 1981	90.9	
B13	40	19 May 1978	49.9	No weight change from 3 to 5 years of
	52	5 Jun 1979	79.9	age during June; 37% weight gain during
	58	3 Oct 1979	79.4	summer with cubs.
	64	6 Jun 1980	40.0	
B15	37	17 Mar 1979	62.2	12% weight loss from March to June;
	40	8 Jun 1979	54.5	no weight change from 3 to 5 years of
	52	1 Jul 1980	50.0	age during June.
	64	11 Jun 1981	55.0	
B24	123	7 Jun 1979	61.3	No weight change from 10 to 12 years of
	148	13 Jun 1981	60.5	age during June.
B30	52	25 Jun 1979	59.0	24% weight gain during summer with no cubs
	56	9 Oct 1979	77.3	or yearlings; 22% weight loss during winter
	64	8 Jun 1980	60.4	spring.
B31	40	25 Jun 1978	56.8	No significant weight change from 3 to 5
	52	28 Jun 1979	54.5	years of age during June.

Table 22. Serial body weights from adult male black bears on the MRC study area, Kenai Peninsula, 1978-81.

Bear No.	Age (months)	Date weighed	Weight (kg)	Comments on serial data
B9	51	17 May 1978	99.8	16% weight gain from 4 to 5 years of age
	64	19 Jun 1979	115.8	during May.
	64	25 Jun 1979	115.8	
B11	124	12 Jun 1980	102.3	No significant weight change from 10 to 11
	136	8 Jun 1981	103.2	years of age during June.
B16	84	2 Jun 1978	136.1	No weight change from 7 to 9 years of age
	112	15 Jun 1980	136.0	during June.
B25	75	8 Jun 1979	84.0	42% weight gain from 6 to 7 years of age
	87	28 Jun 1980	145.4	during June.
B34	32	9 Oct 1979	75.0	40% weight loss during winter/spring;
	40	8 Jun 1980	44.5	25% weight gain from 2½ to 4½ years of age
	57	16 Sep 1981	100.0	during fall.
B27	28	16 Jun 1979	52.3	35% weight gain from 2 to 4 years of age
	40	14 Jun 1980	61.4	during June.
	52	5 Jun 1981	50.4	
B29	40	21 Jun 1979	50.8	35% weight gain from 3 to 4 years of age
	52	8 Jun 1980	68.2	during June.

Table 23. Serial body weights from subadult black bears on the MRC study area, Kenai Peninsula, 1979-81.

Bear No.	Sex	Age (months)	Date weighed	Weight (kg)	Comments on serial data
B21	F	14	14 May 1979	20.4	100% weight gain during summer as yearling.
		23	9 Jan 1980	40.9	
		28	1 Jul 1980	46.3	
B32	M	8	9 Oct 1979	34.1	24% weight loss during winter/spring as yearling.
		16	3 Jun 1980	25.9	
B38	F	11	10 Jan 1980	13.7	55% weight gain from yearling to 2 years of age during June; 36% weight gain during summer as 2-year-old.
		16	9 Jun 1980	20.5	
		28	12 Jun 1981	31.8	
		33	18 Sep 1981	50.0	
B41	M	7	30 Sep 1980	21.8	No significant weight change during winter/spring as cub; 81% weight gain during summer as yearling.
		15	5 Jun 1981	20.5	
		18	24 Sep 1981	36.5	

Table 24. Body weights (kg) from adult black bears by season from the MRC study area, Kenai Peninsula, 1978-1981.

	Adult					
	Females			Males		
Seasons	$\bar{x}$	SD	N	$\bar{x}$	SD	N
Postdenning (May)	52.9	4.5	6	104.2	14.4	6
Summer (Jun, Jul)	59.1	6.5	23	90.0	33.8	19
Fall (Aug, Sep, Oct)	74.8	15.9	7	--	--	--
Denning (Nov-Apr)	58.3	5.5	2	--	--	--

Table 25. Serial morphometric measurements (cm) from adult female black bears on the MRC study area, Kenai Peninsula, 1978-1981.

Bear No.	Age (mo.)	Month sampled	Body lngth	Hind foot lngth	Hind foot wdth	Shoulder ht.	Chest girth	Neck circum-ference	Skull lngth	Skull wdth	Upper left canine lngth	Lower left canine lngth	ULC[a] AP	ULC[b] LL	LLC[c] AP	LLC[d] LL
B14	42	Oct	161	17	9	91	98	51	25.0	12.5	2.6	2.6	--	--	--	--
	51	May	141	17	9		92	44	26.0	14.0	2.8	2.6	--	--	--	--
	88	Jun	156	17	9	81	90	47	27.2	15.0	2.6	2.1	1.1	1.6	1.1	1.5
B2	32	Oct	156	16	9	--	85	48	24.0	14.5	2.5	2.4	--	--	--	--
	40	Jun	136	17	9	75	84		27.0	14.5	2.7	2.5	--	--	--	--
	59	Jan	160	17	9	73	88	48	25.6	15.4	2.8	2.3	1.0	1.8	1.1	1.4
	64	Jun	154	16	9	81	74	45	26.2	15.5	2.6	2.4	1.0	0.7	1.4	1.5
	76	Jun	158	17	9	81	85	48	26.5	16.0	2.9	2.3	1.0	0.7	1.4	1.5
	79	Sep	155	17	9	90	102	56	26.9	16.2	2.7	2.5	1.0	1.8	1.0	1.8
B13	40	May	137	15	9	72	79	40	23.5	13.5	2.2	2.1	--	--	--	--
	52	Jun	158	17	8	68	81		21.7	15.1	2.5	2.3	--	--	--	--
	52	Jun	163	19	10	83	76	44	26.5	15.0	2.5	2.3	1.4	0.9	1.4	1.2
	58	Oct	162	18	9	80	104		24.8	15.1	2.4	2.2	1.0	1.5	1.1	1.5
	64	Jun	148	17	9	83	84		25.0	16.0	2.5	2.2	0.9	1.6	0.9	1.5
B15	28	May	145	17	9	70	72	41	24.0	13.0	2.5	2.4	--	--	--	--
	37	Mar	132			84										
	40	May	142	19	9	78	78	43	24.9	14.7	2.1	2.0	--	--	--	--
	52	Jun	142	17	8	96	75	43	26.0	14.3	2.3	2.2	1.0	1.4	0.9	1.5
	64	May	155	17	9	81	74	42	25.3	15.0	2.5	2.2	1.2	1.5	1.0	1.5
B24	123	Jun	144	18	9	75	84	46	25.2	16.2	2.7	2.1	1.5	1.0	1.5	0.9
	148	Jun	151	17	9	79	84	52	25.4	15.4	2.7	2.3	1.5	1.0	1.5	1.0
B30	52	Jun	152	19	9	77	90	50	26.3	15.6	2.5	2.3	1.0	1.4	1.1	1.4
	56	Oct	156	17	10	80	103	59	25.4	15.0	2.5	2.4	1.6	1.8	1.1	1.5
	64	Jun	134	18	9	82	88	50	24.6	15.5	2.9	2.4	0.9	1.6	0.9	1.2
B31	40	Jun	148	17	--	79	95	44	25.0	15.0	--	--	0.9	1.6	0.9	1.3
	52	Jun	153	18	--	69	84	46	23.7	14.5	--	--	0.9	1.4	0.9	1.6

[a] Upper Left Canine, Anterior/Posterior.
[b] Upper Left Canine, Lingual/Libial.
[c] Lower Left Canine, Anterior/Posterior.
[d] Lower Left Canine, Lingual/Libial.

Table 26. Serial morphometric measurements (cm) from adult male black bears on the MRC study area, Kenai Peninsula, 1978-1981.

Bear No.	Age (mo.)	Month sampled	Body lngth	Hind foot lngth	Hind foot wdth	Shoulder ht.	Chest girth	Neck circum-ference	Skull lngth	Skull wdth	Upper left canine lngth	Lower left canine lngth	ULC[a] AP	ULC[b] LL	LLC[c] AP	LLC[d] LL
B9	51	May	178	20	12	100	98	55	20.5	17.5	3.0	2.8	--	--	--	--
	64	Jun	186	21	11	87	106	55	29.0	19.2	3.2	2.6	2.0	1.2	1.8	1.3
B11	124	Jun	179	20	11	104	100	66	28.8	18.6	3.0	2.7	1.2	1.9	1.2	1.7
	136	Jun	179	20		107	104	65	26.4	18.2	3.1	2.5	1.3	2.1	1.2	2.1
B16	84	Jun	165	21	12	117	120	79	29.0	16.5	2.9	2.8	--	--	--	--
	112	Jun	177	21	12	115	112	61	29.5	20.0	3.1	2.7	1.1	1.7	1.1	1.8
B25	75	Jun	177	19	12	86	96	62	28.0	18.0	3.2	2.8	1.9	1.4	1.7	1.2
	87	Jun	175	19	11	111	101	61	29.8	18.6	3.0	2.8	1.3	2.0	1.2	1.7
B27	40	Jun	149	20	10	95	80	52	26.5	16.0	3.0	2.8	1.1	1.8	1.2	1.8
	52	Jun	129	20	10	85	83	55	26.1	17.2	2.7	2.6	1.2	1.6	1.1	1.6
B29	40	Jun	155	17	10	79	87	47	24.3	14.5	2.9	2.7	1.2	1.5	1.2	1.5
	52	Jun	155	20	10	93	88	49	26.5	15.9	2.8	2.6	1.2	1.7	1.1	1.6
B34	40	Jun	145	18	9	82	75	42	27.2	14.8	2.8	2.6	1.2	1.7	1.5	1.8
	57	Sep	154	20	10	91	99	57	28.5	16.8	2.9	2.6	1.2	1.8	1.1	1.8

[a] Upper Left Canine, Anterior/Posterior.
[b] Upper Left Canine, Lingual/Labial.
[c] Lower Left Canine, Anterior/Posterior.
[d] Lower Left Canine, Lingual/Labial.

Table 27. Serial morphometric measurements (cm) from subadult female black bears on the MRC study area, Kenai Peninsula, 1978-1981.

Bear No.	Sex	Age (mo.)	Month sampled	Body lngth	Hind foot lngth	Hind foot wdth	Shoulder ht.	Chest girth	Neck circum-ference	Skull lngth	Skull wdth	Upper left canine lngth	Lower left canine lngth	ULC[a] AP	ULC[b] LL	LLC[c] AP	LLC[d] LL
B21	F	14	May	107	16	7	64	59	30	19.0	11.0	--	--	--	--	--	--
		23	Jan	135	17	8	64	78	40	23.4	13.0	2.4	2.4	1.2	1.4	1.3	1.5
		28	Jul	130	16	9	91	81	43	24.5	13.8	2.4	2.4	1.0	1.5	1.0	1.7
B32	M	8	Oct	126	13	8	64	77	41	21.0	12.2	--	--	--	--	--	--
		16	Jun	122	15	8	66	68	33	21.4	12.2	1.8	1.7	0.8	1.1	0.8	1.0
B38	F	11	Jan	98	12	6	51	57	32	18.2	10.2	--	--	--	--	--	--
		16	Jun	111		7	61	55	32	18.2	11.3	1.4	1.2	0.6	0.8	0.6	0.7
		28	Jun	123	10	8	62	63	37	22.2	13.2	2.4	2.0	1.0	1.3	0.9	1.2
		33	Sep	135	14	11	83	94	43	22.3	14.1	2.5	2.2	1.1	1.5	0.8	1.2
B41	M	7	Sep	99	11	7	54	54	32	18.1	10.0	--	--	--	--	--	--
		15	Jun	111	13	8	56	55	33	17.6	11.2	1.6	1.5	0.8	1.0	0.8	0.8
		18	Sep	123	15	8	74	73	35	22.0	12.4	2.6	2.4	1.4	1.3	1.0	1.1
B42	F	7	Oct	97	11	6	50	56	36	17.8	10.5	--	--	--	--	--	--
		15	Jun	113	14	7	49	61	31	18.6	10.8	1.4	1.2	0.7	0.7	0.6	0.6
		18	Sep	125	15	7		78	40	22.0	12.0	2.2	2.4	0.9	1.4	0.9	1.3

[a] Upper Left Canine, Anterior/Posterior.
[b] Upper Left Canine, Lingual/Labial.
[c] Lower Left Canine, Anterior/Posterior.
[d] Lower Left Canine, Lingual/Labial.

Table 28. Body measurements influenced by season of adult black bears from MRC study area, Kenai Peninsula, 1978-1981.

Measurement (cm)	Season: Postdenning (May)			Summer (Jun, Jul)			Fall (Aug, Sep, Oct)			Denning (Nov-Apr)		
	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N	$\bar{x}$	SD	N
Body length												
Female	149.8	12.2	6	152.3	9.1	20	157.0	12.9	7	149	19.8	2
Male	173.2	16.7	6	162.9	16.6	17	--	--	--	--	--	--
Shoulder height												
Female	79.5	7.9	4	80.3	6.9	20	86.2	5.7	5	78.5	7.8	2
Male	103.0	6.3	6	95.2	13.9	17	--	--	--	--	--	--
Chest girth												
Female	83.8	5.3	5	83.8	6.8	20	101.0	2.8	5	88.0		1
Male	106.3	6.5	6	94.4	13.9	17	--	--	--	--		--
Neck circumference												
Female	43.0	2.8	6	46.6	3.5	18	49.5	7.9	6	48.0		1
Male	64.3	5.4	6	57.2	10.6	17	--	--	--	--		--

Table 29. Morphometric measurements potentially useful for sex differentiation in adult black bears, MRC study area, Kenai Peninsula, 1977-81.

Measurement (cm)	Female $\bar{x}$	Female SD	Female N	Male $\bar{x}$	Male SD	Male N	Significant Level difference ANOVA
Hind foot length	17.6	1.8	34	20.2	2.0	26	0.0000
95% c.i. for $\bar{x}$ [a]	(17.0 to 18.3)			(19.3 to 21.0)			
Hind foot width	9.2	0.7	33	10.8	0.8	26	0.005
95% c.i. for $\bar{x}$	(8.9 to 9.4)						
Skull length	25.6	1.5	34	27.9	2.9	27	0.002
95% c.i. for $\bar{x}$	(25.1 to 26.1)			(26.7 to 29.0)			
Skull width	15.1	0.8	32	17.1	2.0	27	0.0000
95% c.i. for $\bar{x}$	(14.8 to 15.4)			(16.3 to 18.0)			
Upper left canine length	2.5	0.2	34	2.9	0.3	26	0.0000
95% c.i. for $\bar{x}$	(2.4 to 2.6)			(2.8 to 3.0)			
Lower left canine length	2.3	0.2	34	2.6	0.2	26	0.0000
95% c.i. for $\bar{x}$	(2.2 to 2.3)			(2.6 to 2.7)			
Upper left canine anterior/posterior width	10.8	1.8	21	13.2	2.8	17	0.005
Upper left canine lingual/labial width	14.6	2.9	21	16.5	2.8	17	0.1
Lower left canine anterior/posterior width	10.5	1.9	21	13.3	2.4	17	0.001
Lower left canine lingual/labial width	14.0	2.2	21	16.2	2.6	17	No significant difference

[a] 95% confidence interval for the mean (not available for all measurements).

Table 30. Blood parameters with significant differences between adult and subadult black bears at the MRC study area, Kenai Peninsula.

Blood parameter	Subadult				Adult				Significance level
	$\bar{x}$	SD	N	95% c.i.	$\bar{x}$	SD	N	95% c.i.	
Triglyceride mg/dl	247	94	30	(211 to 282)	298	110	57	(269 to 327)	0.033
SAP mg/dl	74	47	34	(58 to 90)	53	31	70	(45 to 60)	0.009
P mg/dl	5.7	1.9	34	(5.1 to 6.4)	5.1	1.2	70	(4.8 to 5.4)	0.050
Na mEq/L	144	5	30	(142 to 145)	142	3	57	(141 to 142)	0.027
Creatanine mg/dl	1.4	0.8	30	(1.1 to 1.7)	1.1	0.4	57	(1.0 to 1.2)	0.038
TSP mg/dl	6.3	0.7	34	(6.0 to 6.5)	7.1	0.7	69	(7.0 to 7.3)	0.000
Globulin g/dl	2.3	0.4	33	(2.2 to 2.5)	3.2	0.7	69	(3.0 to 3.3)	0.000
Alpha globulin g/dl	0.60	0.13	34	(0.55 to 0.64)	0.53	0.13	69	(0.50 to 0.57)	0.029
Beta globulin g/dl	0.74	0.20	34	(0.66 to 0.81)	1.15	0.40	69	(1.05 to 1.25)	0.000
Gamma globulin g/dl	0.54	0.20	34	(0.47 to 0.61)	0.88	0.47	69	(0.77 to 1.00)	0.001
A/G ratio	1.72	0.29	34	(2.63 to 1.82)	1.34	0.35	69	(1.26 to 1.43)	0.000
PCV %	43.0	6.9	32	(40.6 to 45.5)	45.7	6.27	67	(44.2 to 47.3)	0.055
MCHC %	42.9	3.7	32	(41.5 to 44.2)	39.8	5.0	66	(38.6 to 41.0)	0.003

Table 31. Seasonal influence on blood parameters black bears from MRC study area, Kenai Peninsula, 1978-1981.

Blood parameter	Subadult	Rank of seasons[a] (1 = postdenning, 2 = summer 3 = fall, 4 = denning) Low	Med	High	Adult	Rank of seasons (1 = postdenning, 2 = summer 3 = fall, 4 = denning) Low	Med	High
Glucose mg/dl	No				No			
Cholesterol mg/dl	No				Yes[b]	1, 4[c]	4, 2	2, 3
Triglyceride mg/dl	Yes	1	3, 4	4, 2	No			
LDH U/L	Yes	4, 3, 2		2, 1	Yes	4, 1, 3		3, 2
SGOT U/L	No				No			
SGPT U/L	No				No			
SAP U/L	Yes	4	3, 1	2	No			
P mg/dl	Yes	4, 3, 2		1	Yes	4, 3, 2		1
Ca mg/dl	Yes	3, 4	4, 1	1, 2	No			
Ca/P ratio	Yes	2, 1, 3		4	No			
Na mEq/L	Yes	1, 2		3, 4	Yes	2, 1, 4		4, 3
K mEg/L	No				Yes	3, 1, 4		1, 4, 2
Cl mEg/L	No				Yes	1, 4, 2		4, 2, 3
CO_2 mEg/L	No				No			
BUN mg/dl	No				No			
Creatanine mg/dl	Yes	2, 1	1, 3	4	Yes	2, 3	1	4
Bilirubin mg/dl	No				No			
Uric acid mg/dl	Yes	4, 3		2, 1	Yes	4, 3, 2		1
TSP g/dl	Yes	1, 2	2, 3	4	No			
Albumin g/dl	Yes	3, 2, 1		4	Yes	1	3, 2	4
Globulin g/dl	Yes	2, 1, 3		4	Yes	2, 4, 1		4, 1, 3
Alpha 1 globulin g/dl	Yes	2, 3, 1		1, 4	Yes	2, 1		1, 3, 4
Alpha 2 globulin g/dl	Yes	1, 2, 3		4	No			
Beta globulin g/dl	No				No			
Gamma globulin g/dl	Yes	2, 3		3, 1, 4	No			
A/G ratio	Yes	4, 1, 3		3, 2	No			

Table 31. Continued.

Blood parameters	Subadult	Rank of seasons[a] (1 = postdenning, 2 = summer 3 = fall, 4 = denning)			Adult	Rank of seasons (1 = post denning, 2 = summer 3 = full, 4 = denning)		
		Low	Med	High		Low	Med	High
Hb g/dl	Yes	1, 2		3, 4	Yes	1, 2		3, 4
PCV %	Yes	1, 2	2, 3	3, 4	Yes	1, 2, 4		4, 3
MCHC %	No				No			

[a] Postdenning = May; Summer = Jun, Jul; Fall = Aug, Sep, Oct; Denning = Nov-Apr.
[b] Parameters with Yes indicate a significant difference (*P* < 0.05) was detected with analysis of variance (SPSS Program).
[c] Rank as per Duncan's multiple range test (SPSS Program). Seasons grouped as either low, medium, or high were not significantly different.

Table 32. Baseline blood values of black bears that were not influenced by year, age, sex, or season, MRC study area, Kenai Peninsula.

Blood parameter	$\bar{x}$	SD	N	Minimum	Maximum	95% c.i.[a]
SGOT mg/dl	157	137	68	24	950	123 to 190
SGPT mg/dl	62	42	52	6	241	50 to 74
CO_2 mEq/L	16.8	3.8	57	5	24	15.7 to 17.8
BUN mg/dl	15.2	9.3	70	1	43	12.9 to 17.4
Bilirubin mg/dl	0.21	1.08	70	0	9.10	0.05 to 0.47
Beta globulin g/dl	1.15	0.42	69	0.20	2.50	1.05 to 1.25
MCHC %	39.8	5.0	66	26.5	53.8	38.6 to 41.0

[a] 95% confidence interval for the mean ($\bar{x}$).

Table 33. Serial blood chemistry and hematologic values from adult black bears at the MRC study area, Kenai Peninsula, 1978-1981.

Bear No.	Sex	Age (mo.)	Date sampled	Glucose mg/dl	Choles-terol mg/dl	LDH U/L	SGOT U/L	SAP U/L	P mg/dl	Ca mg/dl	Ca/P ratio	BUN mg/dl	TSP g/dl	Albumin g/dl	Glob-ulin g/dl	Beta globulin g/dl	A/G ratio	Hb g/dl	PCV %	Na mEq/L	Young	Capture method
B1	F	42	10/8/77	100	310	998	950	35	4.0	9.6	2.40	5	8.4	4.0	4.4	1.4	0.90	22.9	75	143	None	Snare
		51	5/31/78	66	202	601	251	58	7.5	9.3	1.24	5	7.3	3.6	3.7	0.6	1.00	17.0	46		2 cubs	Helic.
		88	6/21/81	93	262	989	465	60	4.8	9.1	1.90	34	7.6	4.6	3.0	0.8	1.53	15.0	39	137	2 yrlg	Trap
B2	F	32	10/15/77	71	225	995	555	14	7.3	8.2	1.12	7	7.0	4.6	2.4	1.0	1.80			146	None	Snare
		40	6/9/78	98	235	601	131	98	6.6	10.1	1.53	10	6.6	3.9	2.7	0.7	1.50	18.5	48		None	Helic.
		52	6/27/79	96	310	467	33	20	3.7	8.4	2.27	11	6.1	3.9	2.2	1.1	1.70	17.8	42	142	2 cubs	Trap
		59	1/10/80	64	275	588	82	4	4.0	8.9	2.23	10	8.0	4.4	3.6	1.1	1.20	25.0	52	143	2 yrlg	Den
		64	6/5/80	84	218	597	96	19	3.4	8.8	2.58	10	6.4	3.7	2.7	0.8	1.40	16.0	38	139	2 yrlg	Trap
		76	6/8/81	101	306	581	93	91	4.8	9.2	1.92	12	6.5	3.7	2.8	0.7	1.30	18.0	43	139	None	Trap
		79	9/1/781	96	400			17	4.3	8.2	1.90	15	9.2	4.2	5.0	2.5	0.84	28.0	62	147	None	Trap
B13	F	40	5/19/78	67	243	601	162	78	6.9	9.9	1.43	11	6.4	4.3	2.1	1.0	2.00	19.0	48		None	Helic.
		52	6/5/79	76	270	621	81	23	4.2	8.6	2.05	5	6.5	3.8	2.7	1.0	1.40	17.9	45	147	None	Trap
		52	6/14/79	47	360	771	88	23	3.9	9.3	2.38	7	6.7	3.9	2.8	1.2	1.40	18.0	46	144	1 cub	Trap
		52	6/15/79	76	316	970	112	39	5.0	8.5	1.70	13	7.3	3.8	3.5	1.6	1.10	18.0	60	138	1 cub	Trap
		58	10/30/79	98	293	428		29	3.9	8.3	2.13	9	7.2	4.0	3.2	1.0	1.30	19.5	53	144	1 cub	Trap
		64	6/6/80	91	303	580	72	38	5.2	8.9	1.71	26	6.5	3.8	2.7	1.0	1.40	18.0	41	141	1 yrlg	Trap
		64	6/12/80	69	321	816	113	28	4.3	9.0	2.09	10	6.2	3.8	2.4	1.0	1.60	19.8	43	141	1 yrlg	Trap
B15	F	28	5/30/81	119	212	601	161	94	7.3	10.5	1.44	15	7.0	3.9	3.1	0.8	1.30	18.0	45		None	Helic.
		37	3/17/79	117	246	366	24	18	2.7	10.0	3.70	4	8.3	4.7	3.6	2.2	1.30	18.0	46	141	None	Den
		40	6/8/79	61	281	776	101	43	4.6	9.4	2.05	11	6.9	3.9	3.0	1.8	1.30	15.8	47	139	None	Trap
		40	6/14/79	35	278	988	139	37	6.0	9.8	1.63	9	7.2	4.1	3.1	1.6	1.30	18.0	48	140	None	Trap
		52	7/1/80	57	300	624	69	13	4.1	8.6	2.09	15	6.7	4.3	2.4	1.0	1.80	18.6	48	145	2 cubs	Trap
		64	6/11/81	98	365	589	77	80	4.6	8.7	1.89	22	6.7	4.1	2.6	0.7	1.60	18.2	43	143	2 yrlg	Trap
B30	F	52	6/25/79	203	304	675	54	50	5.0	8.2	1.64	16	6.9	3.8	3.1	1.2	1.30	20.0	53	141	None	Trap
		56	10/9/79	112	259	538	59	15	3.5	9.3	2.65	15	6.8	3.8	3.0	1.0	1.30	22.0	54	145	None	Trap
		64	6/8/80	104	344	790	167	43	4.8	10.0	2.08	29	8.7	4.5	4.2	1.1	1.07	20.0	48	144	None	Trap

Table 33. Continued.

Bear No.	Sex	Age (mo.)	Date sampled	Glucose mg/dl	Cholesterol mg/dl	LDH U/L	SGOT U/L	SAP U/L	P mg/dl	Ca mg/dl	Ca/P ratio	BUN mg/dl	TSP g/dl	Albumin g/dl	Globulin g/dl	Beta globulin g/dl	A/G ratio	Hb g/dl	PCV %	Na mEq/L	Young	Capture method
B34	F	32	10/9/79	126	249	502	82	39	5.1	9.1	1.79	4	6.4	3.6	2.8	0.8	1.29	20.0	49	142	N/A	Trap
		40	6/8/80	87	274	606	675	72	5.5	9.7	1.76	14	6.5	3.7	2.8	0.8	1.32	19.5	47	139	N/A	Trap
		57	9/16/81	105	333	417	55	61	4.2	9.1	21.7	22	6.6	3.6	3.0	0.9	1.22	19.5	48	143	N/A	Trap

Table 34. Serial blood chemistry and hematologic values from subadult black bears at the MRC study area, Kenai Peninsula, 1978-1981.

Bear No.	Sex	Age (mo.)	Date sampled	Glucose mg/dl	Cholesterol mg/dl	LDH U/L	SGOT U/L	SAP U/L	P mg/dl	Ca mg/dl	Ca/P ratio	BUN mg/dl	TSP g/dl	Albumin g/dl	Globulin g/dl	Beta globulin g/dl	A/G ratio	Hb g/dl	PCV %	Na mEq/L	Capture method
B21	F	14	5/14/79	77	217	823	119	93	6.6	8.9	1.35	5	5.4	3.4	2.0	1.2	1.70	17.5	43	138	Helic.
		23	1/9/80	132	288	482	65	21	3.6	8.2	2.28	9	7.3	4.6	2.7	0.7	1.70	22.0	49	144	Den
		28	7/1/80	34	300	763	97	136	8.3	9.6	1.15	42	5.2	3.0	2.2	0.8	1.40	16.0	41	140	Helic.
B32	M	8	10/9/79	97	268	633	142	74	4.4	9.1	2.07	1	6.3	3.9	2.4	0.9	1.60	20.0	48	144	Trap
		16	6/3/80	48	381	731	85	71	10.1	10.4	1.03	25	5.8	3.8	2.0	0.8	2.00	14.0	38	147	Trap
B38	F	11	1/10/80	56	249	541	55	12	2.2	8.5	3.86	21	7.0	4.2	2.8	0.7	1.50	20.0	46	148	Den
		16	6/9/80	78	247	739	67	176	7.1	10.0	1.40	14	5.7	3.7	2.0	1.0	1.90	19.5	43	133	Trap
		28	6/12/81	96	302	593	48	69	5.7	9.5	1.67	7	5.7	4.1	1.6	0.6	2.58	17.0	41	137	Trap
		33	9/18/81	110	253	553	81	48	4.8	8.4	1.75	6	6.0	3.7	2.3	0.6	1.55	22.0	47	147	Trap
B41	M	7	9/30/80	71	329	508	68	80	5.4	7.9	1.46	33	6.1	4.2	1.9	0.7	2.16			146	Trap
		15	6/5/81	32	361	890	110	126	8.3	10.1	1.22	9	5.8	4.0	1.8	0.6	2.23	17.0	37	146	Trap
		18	9/22/81	106	269	601	51	34	4.7	9.3	1.98	21	6.1	4.0	2.1	0.7	1.97	19.8	47	144	Trap
B42		7	10/1/80	79	332	440	52	84	6.4	9.5	1.48	30	6.3	3.9	2.4	0.8	1.60	16.0	39	143	Trap
		15	6/9/81	81	335	853	111	138	7.5	9.8	1.31	21	5.7	3.6	2.1	0.5	1.70	16.0	37	141	Trap
		18	9/24/81	5	309	695	104	72	5.5	6.5	1.18	46	6.6	4.3	2.3	0.7	1.81	22.0	46	143	Trap

Table 35. Condition-related blood parameters[a] from serial samples of 2 adult female black bears which demonstrate the extreme.

Blood parameter[a]	Black bear B1 Fall peak (no young)	Black bear B1 Spring low (2 yearlings)	Black bear B2 Fall peak (no young)	Black bear B2 Spring low (2 yearlings)
PCV %	75[b]	39	62	38
HB g/dl	22.9	15	28.0	16.0
Ca mg/dl	9.6	9.1	8.2	8.8
P mg/dl	4.0	4.8	4.3	3.4
TSP g/dl	8.4	7.6	9.2	6.4
Glucose mg/dl[c]	100	93	96	84
Albumin g/dl	4.0	4.6	4.2	3.7
Globulin g/dl	4.4	3.0	5.0	2.7
Beta globulin g/dl	1.4	0.8	2.5	0.8
Cholesterol g/dl[d]	310	262	400	84
Na mEq/L[e]	143	137	147	139

[a] Blood parameters are based on those useful for moose (Alces alces) condition assessment (Franzmann and LeResche 1978).

[b] Underlined values are highest or lowest for serial samples taken (Table 33).

[c] Values below dotted line were influenced by excitability in moose (Franzmann and LeResche 1978).

Table 36. Blood parameters from individual denned black bears and the total population from MRC study area, Kenai Peninsula, Alaska, 1978-1981.

Blood parameter	B15♀ 37mo	B2♀ 59mo	B21♀ 23mo	B23♀ 25mo	B36♀ 11mo	B38♀ 11mo	B37♂ 11mo	B39♂ 11mo	Denned adult ♀ $\bar{x}$(N = 2)	Denned adult ♀ $\bar{x}$(N = 4)	Denned adult ♂ $\bar{x}$(N = 2)	Total for all black bears sampled during study $\bar{x}$	SD	N	95% C.I.
Glucose mg/dl	117	64	132	96	60	56	98	69	90.5	86.0	83.5	89.6	31.8	104	83.4 to 95.8
Cholesterol mg/dl	246	275	288	302	293	249	301	252	260.5	283.0	276.5	277.3	53.5	104	266.9 to 287.7
Triglyceride mg/dl	215	199	226	178	352	195	457	242	207.0	237.8	348.0	280.1	106.8	87	257.3 to 302.9
LDH U/L	366	588	482	454	688	541	175	699	477.0	541.3	687.0	705.1	172.5	104	671.5 to 738.6
SGOT U/L	24	82	65	62	107	55	55	77	53.0	72.3	66.0	144.5	124.6	102	120.1 to 169.0
SGPT U/L	6	22	9	6	27	8	14	8	14.1	12.5	11.0	62.8	74.6	81	46.3 to 79.3
SAP U/L	18	4	21	24	11	12	13	16	11.2	17.0	14.5	60.0	37.8	104	52.6 to 67.3
P mg/dl	2.7	4.0	3.6	2.2	3.2	2.2	2.6	3.3	3.4	2.8	3.0	5.3	1.5	104	5.0 to 5.6
Ca mg/dl	10.0	8.9	8.2	10.1	9.3	8.5	8.3	9.0	9.5	9.0	8.7	9.2	0.7	104	9.0 to 9.3
Ca/P ratio	3.7	2.2	2.3	4.6	2.9	3.9	3.2	2.7	3.0	3.4	3.0	1.85	0.6	104	1.7 to 2.0
Na mEq/L	141	143	144	142	156	148	150	148.0	142.1	147.5	149.0	142.3	3.9	87	141.4 to 143.1
K MEq/L	4	5	4	4	4	4	4	4	4.5	4.0	4.0	5.1	4.9	87	4.1 to 6.1
Cl mEq/L	99	102	100	96		106	104	105.	101.1	101.7	104.5	103.6	3.4	86	102.1 to 104.3
CO_2 mEq/L	15	18	14	15	16	16	13	14	16.5	15.3	13.5	16.3	3.8	87	15.5 to 17.1
BUN mg/dl	4	10	9	3	25	21	20	24	7.0	14.5	22.0	16.0	10.2	104	14.0 to 18.0
Creatanine mg/dl	2.1	3.1	3.7	3.2	2.7	2.9	2.7	2.1	2.6	3.1	2.4	1.2	0.6	87	1.1 to 1.3
Bilirubin mg/dl	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.17	0.89	104	0.00 to 0.34
Uric acid mg/dl	0.7	1.2	1.0	1.2	0.8	1.0	1.1	1.2	1.0	1.0	1.2	1.7	0.7	102	1.6 to 1.8
TSP g/dl	8.3	8.0	7.8	7.3	7.7	7.0	7.4	7.4	8.2	7.5	7.4	6.9	0.8	103	6.7 to 7.0
Albumin g/dl	4.7	4.4	4.8	4.6	4.4	4.2	4.5	4.5	4.6	4.5	4.5	4.0	0.4	103	3.9 to 4.0
Globulin g/dl	3.6	3.6	3.0	2.7	3.3	2.8	2.9	2.9	3.6	3.0	2.9	2.9	0.7	102	2.8 to 3.0
Alpha 1 globulin g/dl	0.7	0.7	0.7	0.7	0.9	0.7	0.7	0.7	0.7	0.8	0.7	0.55	0.14	103	0.53 to 0.58
Alpha 2 globulin g/dl	0.4	0.8	0.8	0.7	0.9	0.6	1.0	0.7	0.6	0.8	0.9	0.58	0.25	103	0.53 to 0.63
Beta globulin g/dl	2.2	1.1	0.7	0.6	0.7	0.7	0.6	0.9	1.7	0.7	0.8	1.01	0.41	103	0.93 to 1.09
Gamma globulin g/dl	0.3	1.0	0.7	0.8	0.9	0.6	0.6	0.6	0.7	0.8	0.6	0.77	0.43	103	0.68 to 0.85
A/G ratio	1.3	1.2	1.6	1.7	1.4	1.5	1.6	1.6	1.2	1.55	1.6	1.47	0.37	103	1.40 to 1.54
Hb g/dl	18	25	25	22	24	20	22	19	21.5	23.0	20.5	18.3	2.7	99	17.7 to 18.8
PCV %	46	52	59	49	48	46	50	44	49.0	50.5	47.0	44.9	6.6	99	43.6 to 46.2
MCHC %	39.1	48.1	44.1	44.9	50.0	43.5	44.0	43.2	43.6	45.6	43.6	40.8	4.8	98	39.8 to 41.8

Table 37. Hair element mean values (ppm) from black bears at the MRC study area, Kenai Peninsula.

Element	Spring 1979			Spring 1980			Spring 1981			Fall (combined sex and age)		
	Ad female N = 13	Ad male N = 4	Juvenile N = 7	Ad female N = 6	Ad male N = 7	Juvenile N = 5	Ad female N = 6	Ad male N = 4	Juvenile N = 5	1979 N = 4	1980 N = 2	1981 N = 8
Zn	124(38)[a]	99(33)	170(26)	121(39)	135(30)	136(48)	124(25)	102(17)	86(20)	85(14)	135(20)	82(30)
Cu	20(5)	11(2)	19(6)	15(6)	14(6)	18(6)	9(2)	11(4)	111(43)	18(3)	9(2)	110(37)
Ca	591(192)	634(290)	412(168)	449(149)	488(313)	559(111)	434(77)	581(137)	611(172)	627(148)	644(315)	780(197)
Mg	86(32)	112(39)	87(47)	79(12)	86(20)	94(27)	111(22)	87(14)	117(17)	88(17)	95(45)	85(22)
K	1,254(241)	1,647(578)	1,706(670)	1,490(180)	1,384(303)	1,338(407)	911(337)	1,427(267)	1,368(339)	1,197(124)	1,204(32)	1,173(176)
Na	3,469(643)	3,722(630)	3,128(794)	2,612(320)	2,468(401)	2,424(397)	1,733(639)	2,037(751)	1,337(419)	1,843(539)	1,989(496)	1,771(445)
Fe	85(18)	82(26)	80(33)	75(12)	52(12)	69(21)	96(10)	76(36)	99(22)	63(12)	133(42)	109(27)
Co	1.4(0.7)	1.8(0.7)	1.6(1.0)	1.9(0.7)	2.2(0.5)	1.6(0.5)	1.2(0.1)	1.2(0.1)	1.3(0.3)	1.9(0.5)	0.7(0.1)	1.3(0.6)
Cd	1.1(0.5)	1.2(0.6)	1.1(0.4)	1.3(0.6)	1.3(0.4)	1.4(0.3)	2.2(1.5)	1.7(0.5)	1.5(0.5)	1.6(0.2)	1.7(0.1)	1.4(0.5)
Pb	5.3(4.6)	4.2(3.2)	4.8(3.6)	4.5(1.5)	6.6(2.6)	5.4(2.1)	4.7(3.0)	6.7(2.3)	6.1(1.7)	6.1(3.1)	4.0(4.8)	6.7(2.3)
Mn	1.0(0.8)	0.9(0.2)	1.2(1.5)	3.6(2.9)	2.3(0.7)	3.0(0.9)	1.9(1.1)	2.6(2.7)	1.6(0.3)	7.2(5.2)	3.4(4.0)	3.9(3.6)
Cr	0.9(0.9)	0.9(0.4)	1.7(2.0)	0.9(0.4)	1.2(0.5)	1.5(0.3)	1.1(0.5)	1.8(0.1)	0.9(0.4)	1.6(0.3)	0.8(0.6)	1.4(1.3)
Hg	----------	< 0.05 ppm	--------	----------	< 0.05 ppm	--------	----------	< 0.05 ppm	--------	----------	< 0.05 ppm	--------
Mo	1.4(0.2)	1.6(0.2)	1.5(0.3)	1.4(0.2)	1.2(0.3)	1.8(0.6)	1.7(0.6)	1.4(0.3)	1.6(0.3)	1.9(0.6)	1.5(0.4)	1.5(0.6)
Se	2.3(2.3)	2.5(2.6)	1.5(0.4)	1.4(0.7)	1.3(0.4)	1.8(0.5)	3.8(2.7)	2.8(2.8)	3.6(3.6)	1.4(0.2)	19(0.1)	1.9(0.5)
Al	1.2(0.8)	1.8(0.8)	1.6(0.3)	1.5(0.3)	1.6(0.1)	1.6(0.2)	2.6(1.5)	2.6(2.3)	4.3(2.3)	1.8(0.5)	2.9(2.4)	3.2(2.3)

[a] Standard deviations in parenthesis.

Table 38. Hair element values (ppm) from serially sampled black bears on the MRC study area, Kenai Peninsula.

Bear No.	Age (yrs)	Sex	Date sampled	Zn	Cu	Ca	Mg	K	Na	Cd	Co	Fe	Pb	Mn	Cr	Hg	Mo	Se	Al
B2	4	F	6/27/79	138.3	18.3	538.0	86.0	1,383.0	3,561.0	0.5	2.2	93.4	5.6	1.5	1.5	L	1.2	1.9	1.5
B2	5	F	6/5/80	184.4	12.8	381.0	96.5	1,229.0	2,235.0	1.6	1.4	73.0	3.6	3.6	0.5	E	1.6	2.1	1.8
B2	6	F	6/8/81	107.6	6.6	582.0	139.5	973.0	1,629.0	2.2	1.2	83.3	2.3	3.0	1.3	S	1.3	1.7	1.8
B2	6.5	F	9/17/81	82.3	108.7	1,042.0	62.0	981.0	1,525.5	1.8	1.6	125.4	9.9	4.7	1.6	S	1.6	2.2	0.6
B15	3	F	3/17/79	107.4	19.0	462.0	82.5	1,681.5	3,281.0	1.2	1.4	90.6	7.1	1.2	0.6	T	1.7	3.8	1.7
B15	3	F	6/8/79	173.9	14.9	848.0	82.0	1,562.5	3,085.5	1.2	1.2	107.0	2.8	2.8	1.2	H	1.9	1.2	1.8
B15	4	F	7/1/80	132.3	17.2	727.5	82.0	1,663.0	2,348.5	1.2	2.3	76.4	2.8	6.5	0.8	A	1.2	2.2	1.1
B15	5	F	6/18/81	130.5	8.2	436.0	128.5	832.5	1,056.0	1.0	1.2	95.2	8.2	0.8	1.3	N	1.7	4.7	4.8
B41	0.5	M	9/30/80	148.6	8.3	421.0	63.5	1,182.0	2,340.0	1.8	0.8	163.2	1.6	6.2	1.2	0	1.8	2.0	4.6
B41	1	M	6/5/81	74.3	126.7	442.0	108.0	1,286.0	1,347.0	1.2	1.2	86.2	6.2	1.6	0.6	.	1.8	3.0	2.8
B41	1.5	M	9/22/81	92.8	115.8	860.0	120.0	1,062.0	1,082.5	1.0	1.0	136.0	8.0	1.5	0.8	0	1.6	2.0	1.4
																5			
B42	0.5	F	10/1/80	120.3	11.2	866.0	126.5	1,227.0	1,638.0	1.6	0.6	102.6	7.4	0.6	0.4	P	1.2	1.8	1.2
B42	1	F	6/9/81	105.4	140.6	473.0	123.0	1,024.0	1,239.0	1.3	1.0	102.6	5.6	1.2	0.9	P	1.2	2.3	3.7
B42	1.5	F	9/24/81	73.7	63.2	893.0	103.0	1,240.5	1,739.0	1.2	1.2	103.0	8.0	1.2	0.4	M	1.2	2.8	4.0

APPENDIX A. The number of times each study area bear was captured and processed in the MRC study area, Kenai Peninsula, Alaska, 1977-81.

Bear No.	1977	1978	1979	1980	1981	1977-81 Total
1	1	1	-	-	1	3
2	1	1	1	2	2	7
3	-	1	-	-	-	1
4	-	1	Dead	-	-	1
5	-	1	-	-	-	1
6	-	2	Dead	-	-	1
7	-	1	Dead	-	-	1
8	-	1	Dead	-	-	1
9	-	1	3	-	-	4
10	-	1	-	-	1	2
11	-	-	-	1	1	2
12	-	1	1	2	1	5
13	-	1	3	2	Dead	6
14	-	1	3	-	1	5
15	-	1	3	1	2	6
16	-	1	-	1	-	2
17	-	1	Dead	-	-	1
18	-	1	-	-	-	1
19	-	1	Dead	-	-	1
20	-	-	1	-	-	1
21	-	-	1	2	-	1
22	-	-	-	1	-	1
23	-	-	1	1	-	2
24	-	-	1	-	1	2
25	-	-	1	1	-	2
26	-	-	2	-	-	2
27	-	-	1	1	2	4
28	-	-	1	Dead	-	1
29	-	-	1	1	Dead	2
30	-	-	2	1	Dead	3
31	-	-	1	1	Dead	2
32	-	-	1	2	Dead	3
33	-	-	-	1	-	1
34	-	-	1	1	1	3
35	-	-	-	-	1	1
36	-	-	1	1	-	2
37	-	-	-	1	-	1
38	-	-	-	2	2	4
39	-	-	-	1	1	2
40	-	-	-	2	Dead	2
41	-	-	-	2	2	4
42	-	-	-	2	2	4
43	-	-	-	-	1	1
44	-	-	-	-	1	1
45	-	-	-	-	1	1
46	-	-	-	-	1	1
47	-	-	-	-	2	2
Totals	2	19	30	33	27	111

Appendix B. Characteristics of 49 black bear dens from the MRC study area, Kenai Peninsula, Alaska, 1978-82.

Bear No.	Sex	Reproductive Status	New or Used Den	Year	Dimensions (cm) (according to Figure 15 text) A	B	C	D	E	F	G	Entrance Area (m^2)	Chamber Volume (m^3)	Slope (Degrees)	Aspect (Degrees)
B1	F	2 yearlings	Used	1978-79	33	76	56	18	107	104	162	0.25	0.82	15	325
B2	F	2 cubs	New	1978-79	53	66	76	8	91	101	254	0.35	0.77	1	115
B15	F	Barren	Used	1978-79	43	63	70	3	130	132	163	0.27	1.25	28	345
B18	F	2 cubs	Used	1978-79	30	60	75	-	150	150	160	0.18	1.69	26	5
Unid.	U	Unkn.	New	1978-79	76	67	-	18	-	-	163	0.51	-	-	61
B13	F	1 cub	New	1978-79	58	81	53	20	79	172	282	0.47	0.99	08	35
B7	F	2 cubs	New	1977-78	36	51	61	20	109	175	175	0.18	1.54	10	245
B12	F	2 cubs	Used	1978-79	53	63	41	25	107	107	172	0.33	0.76	7	95
B16	M		New	1978-79	43	63	56	0	89	124	124	0.27	0.62	21	275
B14	F	Barren	Used	1978-79	38	56	61	15	101	69	182	0.21	0.53	1	25
B21	F	Barren	New	1979-80	34	43	33	04	89	74	112	0.15	0.24	28	175
B15	F	2 cubs	Used	1979-80	47	63	70	-	120	130	159	0.30	1.09	27	345
B23	F	Barren	New	1979-80	30	62	51	5	97	67	122	0.19	0.36	17	225
B30	F	Barren	?	1979-80	40	60	66	8	125	68	153	0.24	0.62	17	335
B13	F	1 yearling	New	1979-80	54	53	78	16	136	106	215	0.29	1.36	18	225
B2	F	2 yearlings	?	1979-80	34	39	78	7	89	63	131	0.13	0.48	38	195
B12	F	2 yearlings	?	1979-80	31	78	63	9	135	100	210	0.24	0.97	1	205
B25	M		New	1979-80	48	65	-	-	-	96	140	0.31	-	29	295
B9	M		Used	1979-80	49	49	85	2	133	121	208	0.24	1.40	27	85
B24	F	2 cubs	Used	1979-80	53	70	71	13	100	79	152	0.37	0.66	12	330
B14	F	2 cubs	New	1979-80	64	52	-	-	104	106	266	0.33	-	1	190
B1	F	2 yearlings	Used	1980-81	30	64	69	18	147	203	391	0.19	2.56	7	360
B2	F	Barren	New	1980-81	41	46	53	20	84	109	145	0.19	0.67	1	70
B11	M		New	1980-81	41	46	69	13	109	107	137	0.19	0.96	21	56
B12	F	Barren	New	1980-81	51	43	71	13	89	74	229	0.22	0.55	4	340
B14	F	2 yearlings	New	1980-81	36	33	56	41	114	81	175	0.12	0.90	1	184
B15	F	2 yearlings	?	1980-81	33	43	66	8	112	89	150	0.14	0.74	30	15
B16	M		?	1980-81	61	48	81	-	132	118	282	0.27	1.26	14	325
B20	F	2 yearlings	?	1980-81	33	48	46	5	86	79	145	0.16	0.35	9	100
B24	F	2 yearlings	New	1980-81	42	45	60	21	120	93	186	0.19	0.90	10	350
B25	M		New	1980-81	46	56	79	15	91	112	118	0.26	0.96	15	285
B31	F	Barren	New	1980-81	33	48	46	3	135	91	110	0.16	0.61	33	107
B38	F	Barren	New	1980-81	33	31	43	8	71	71	178	0.10	0.26	23	360
B39	M		New	1980-81	43	48	48	18	160	84	190	0.20	0.89	1	270
B1	F	Barren	New	1981-82	50	62	77	13	135	98	154	0.31	1.19	5	350
B2	F	2 cubs	New	1981-82	48	46	64	11	110	96	154	0.22	0.79	4	320
B11	M		Used	1981-82	61	51	70	5	119	103	225	0.31	0.92	2	3
B12	F	2 cubs	New	1981-82	35	57	64	8	119	98	181	0.20	0.84	15	195
B14	F	Barren	New	1981-82	35	52	82	20	103	137	165	0.19	1.44	30	280
B15	F	2-2 year olds	Used	1981-82	38	44	91	6	122	94	160	0.17	1.11	20	55
B16	M		New	1981-82	41	77	82	8	135	129	164	0.32	1.57	20	240
B20	F	1 cub	New	1981-82	33	42	63	-	87	-	120	0.14	-	25	70
B24	F	2 cubs	Used	1981-82	44	42	55	12	71	89	229	0.18	0.42	16	130
B27	M		Used	1981-82	49	35	88	9	138	103	196	0.17	1.38	8	340
B34	M		New	1981-82	50	30	88	8	120	95	200	0.15	1.09	1	300
B35	F	3 cubs	New	1981-82	62	50	60	9	94	92	241	0.31	0.60	18	200
B38	F	Barren	New	1981-82	38	34	62	0	69	67	152	0.13	0.29	1	264
B39	M		New	1981-82	36	26	60	8	71	79	165	0.09	0.38	7	230
B47	M		New	1981-82	40	34	62	10	101	95	212	0.14	0.69	4	140

APPENDIX C. DEN SITE CHARACTERISTICS OF PRINCE WILLIAM SOUND BLACK BEARS.

Sterling Miller, Dennis McAllister, and Charles C. Schwartz, Alaska Dept. of Fish and Game, Anchorage. August, 1982.

Black bear dens utilized in winter 1980/81 and 1981/82 by bears radio-collared in connection with population identity studies in Prince William Sound (Modafferi, in prep.) were located, marked and measured. The purpose of this work was to provide baseline data on characteristics of Prince William Sound black bear den sites. Such data are valuable in light of increased developmental activities anticipated in the area, especially logging. These observations also provide comparison data to that being collected on the Kenai Peninsula (Schwartz and Franzmann 1981) and along the upper Susitna River (Miller and McAllister 1982).

Mark Chihuly provided valuable assistance in this project in 1982 as did Chuck Schwartz in 1981. Julius Reynolds also assisted the project in various ways. Ron Modafferi provided historical data and his cooperation was essential and appreciated.

All radio-collared bears were in dens when bears were located by fixed-wing aircraft on 15 April 1981. However, 2 bears, both males, had left their dens by 23 April 1981 when dens were marked; only approximate locations and elevations are available for the dens of these 2 males. One 1981/82 den was also only approximately located because of radio failure. Nine bears, all females, were still in dens on 23 April 1981 and these dens were marked with radio-collars, flagging and/or evident topographic features. In 1982, 6 new dens were located and marked on 9-13 April.

Marked dens were visited in the summers of 1981 and 1982 and their characteristics were noted and the dens measured. The measurements followed those outlined by Schwartz and Franzmann (1981) with the addition of a subjective characterization of relative quality on a scale from 1 (poor) to 5 (excellent). These data are presented in Table 1.

Of the 15 measured dens, 8 were in mature hemlock (*Tsuga* spp.) forests, a forest type likely to be heavily exploited by increased logging efforts. Hollow trees were used as dens by 3 bears denning in hemlock forests (Table 1).

Interestingly, 14 of the 15 dens examined were in natural cavities (3 in hollow trees, 4 in rock caves, 2 under hemlock roots and 5 under large boulders on talus slopes) (Table 1); only 1 den was completely excavated by a radio-collared black bear.

In 12 cases, a determination or reasonable guess could be made on whether an examined den had been previously used by a black bear. In 9 of these, previous use by black bears was evident or suspected (Table 1).

Frequency of reuse of the same den by the same individual appeared low, although individual bears tended to den in the same general vicinity in successive years. One of the dens visited in 1981 was reused by a radio-collared bear in 1982 (den #5). Den #1 was occupied by a nonradio-collared bear in 1981/82, but Den #6 was not occupied in 1981/82. The other dens found in the first year of the study were not revisited so occupancy in the second year was not determined for these dens (Tables 2, 3). The mean distance between the different dens used by 7 individuals in 1980/81 and 1981/82 was 1.1 ± 0.6 miles.

The time bears spent in 1980/81 dens could not be determined as the last flight in 1980 was on 29 September at which time all bears were still out. Emergence from dens seemed concentrated in the first 2 weeks of May for females and the last two weeks of April for the 2 males (Table 4). In 1982 data on time of entrance to and emergence from dens were not collected.

Aspects of known dens are illustrated in Figure 1. The mean slope of 15 dens was 38° ± 14 (Fig. 2).

The high frequency of dens in natural cavities probably contributed to the apparent absence of trends in the slope and aspect data; perhaps the bears select for good cavities and these are independent of slope or aspect.

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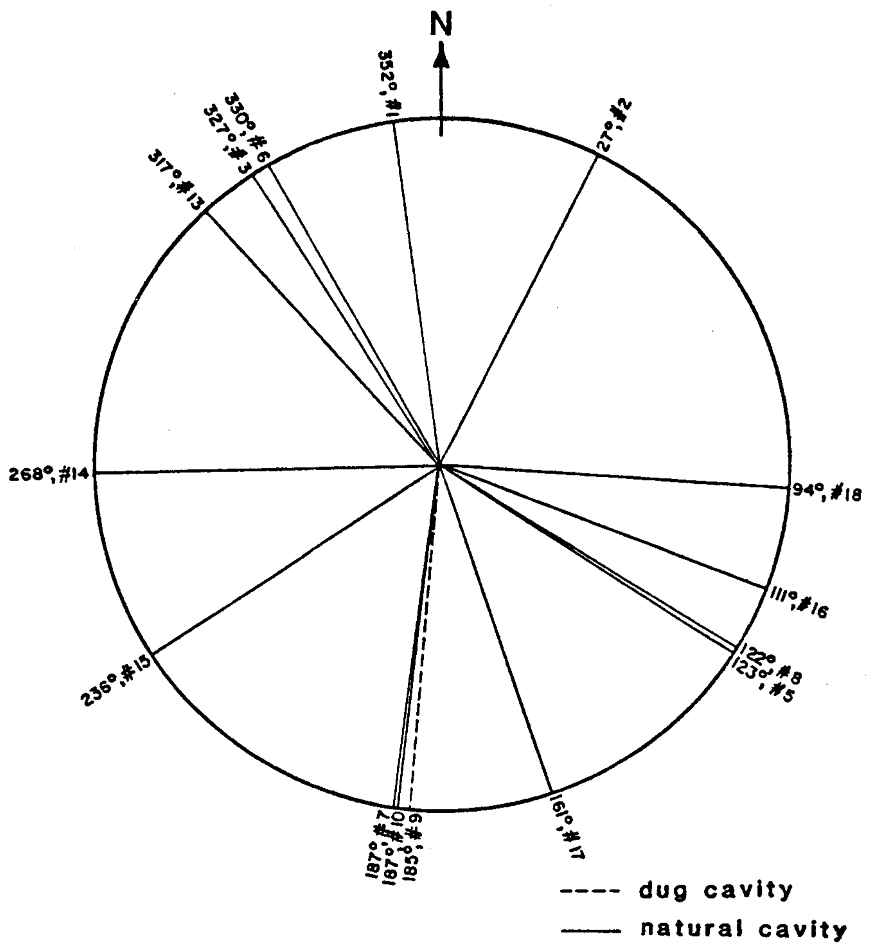

Figure 1. Aspect of all black bear study dens in northwestern Prince William Sound, Alaska. (1980-1981, 1981-1982)

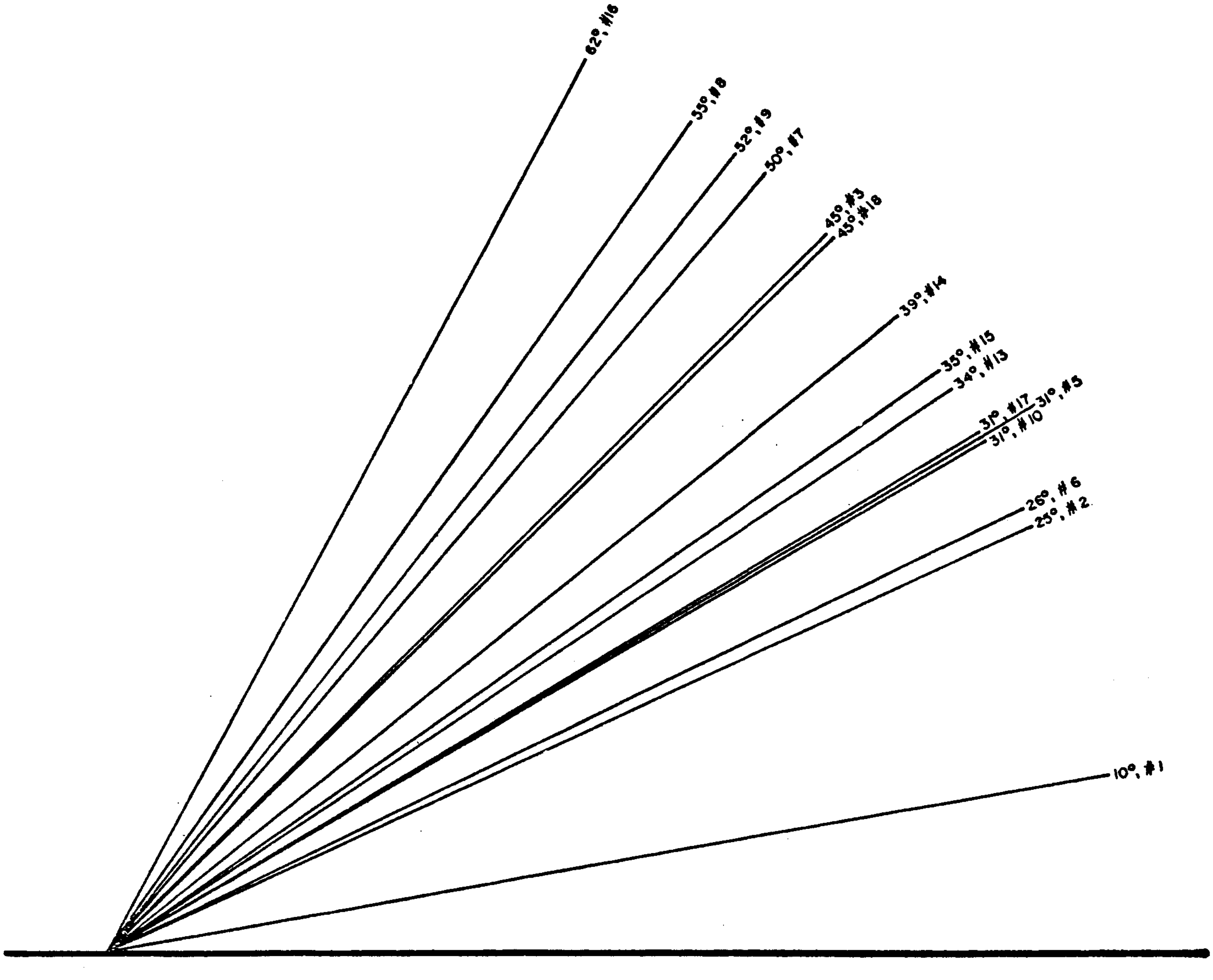

Figure 2. Slope of all black bear study dens in northwestern Prince William Sound, Alaska. (1980-1981, 1981-1982)

APPENDIX C. Table 1. Characteristics of black bear dens in Prince William Sound, 1980-82.

Den No.	Bear No.	Repro. Status & Age at Exit	Winter of Known Use	Elevation (Ft.)	Slope (degree)	Aspect (True North)	Vegetation	% Canopy Tree Cover	Entrance Ht. (cm)	Entrance Wt. (cm)	Chamber Ln. (cm)	Chamber Wt. (cm)	Chamber Ht. (cm)	Total Length (cm)	Prev. Use[a]	Relative Quality[a]	Location & Type
NATURAL CAVITIES																	
1	101	F@9 w/3@1[c]	1980-81 1981-82[d]	375	10	352	Alpine Tundra	0	38	47	216	160	96	800	Yes	3	Blackstone Bay Rock Talus
17	142	F@13 w/1@ C	1981-82	425	31	161	Hemlock	80	40	42	62	101	66	159	Yes	4	Cochrane Bay Hemlock Roots
2	106	F@19 w/0	1980-81	450	25	27	Hemlock	30	65	55	71	80	90	94	No?	4	Blackstone Bay Hollow Tree
3	143	F@4 w/0	1980-81	500	45	327	Hemlock	60	46	26	88	71	74	198	No?	2	Cochrane Bay Hollow Tree
5	144	F@ w/0 F@8 w/2@C	1980-81 1981-82	600	31	123	Hemlock	30	37	48	67	62	--	89	Unk.	4	Cochrane Bay Hollow Tree
6	169	F@14 w/0	1980-81 1981-82[e]	300	26	330	Hemlock	20	55	104	175	126	67	308	Yes	3	Cochrane Bay Rock Cave
7	148	F@3 w/0	1980-81	400	50	187	Alder/ Salmon Berry	0	34	71	73	134	65	122	Unk.	3	Culross Pass. Rock Cave
8	147	F@17 w/0	1980-81	900	55	122	Hemlock	80	178	42	128	114	118	980	Yes	3	Culross Pass. Rock Talus
10	149	F@11 w/0	1980-81	1,250	31	187	Alpine Tundra	0	43	59	86	86	53	268	Yes?	3	Cochrane Bay Rock Cave
13	101	F@10 w/unk.	1981-82	575	34	317	Alder	10	48	270	94	203	69	335	Yes	2	Blackstone Bay Rock Talus
14	169	F@15 w/unk.	1981-82	625	39	268	Salmon Berry	0	47	65	107	112	69	361	Yes	3	Cochrane Bay Rock Talus

APPENDIX C. Table 1. Continued.

Den No.	Bear No.	Repro. Status & Age at Exit	Winter of Known Use	Elevation (Ft.)	Slope (degree)	Aspect (True North)	Vegetation	% Canopy Tree Cover	Entrance Ht. (cm)	Entrance Wt. (cm)	Chamber Ln. (cm)	Chamber Wt. (cm)	Chamber Ht. (cm)	Total Length (cm)	Prev. Use[a]	Relative Quality[a]	Location & Type
15	148	F@4 w/unk.	1981-82	950	35	236	Hemlock	95	46	68	73	89	71	124	Unk.	4	Culross Pass. Hemlock Roots
16	147	F@18 w/unk.	1981-82	890	62	111	Hemlock	0	53	68	76	102	88	189	Yes	3	Culross Pass. Rock Cave
18	149	F@12 w/unk.	1981-82	700	45	94	Alder	60	49	56	70	98	57	324	Yes	3	Cochrane Bay Rock Talus
DUG CAVITIES																	
9	142	F@12 w/0	1980-81	1,300	52	185	Alder	0	36	52	70	129	92	80	No	3	Cochrane Bay Soil
UNKNOWN CAVITY TYPE (actual den not located on ground)																	
11	165	M @ 7	1980-81	250 Approx.	--	--	Spruce	--	--	--	--	--	--	--	--	--	Cochrane Bay
12	146	M @ 9	1980-81	350 Approx.	--	--	Alder (?)	--	--	--	--	--	--	--	--	--	Kings Bay
19	146	M @ 10	1982-83	300 Approx.	--	--	Spruce (?)	--	--	--	--	--	--	--	--	--	Kings Bay

[a] Same bear used the den in 1977-78 (w/1@1), and probably in 1978-80; not in same den in 1976-77, unknown den located in 1978-79.
[b] Subjective characteristics of quality, 1 = Poor and 4 = Excellent.
[c] F@9 w/3@1 = Female 9 years old with 3 offspring at 1 year of age; F@13 w/1@c = Female 13 years old with 1 offspring, cub.
[d] Den #1 was reused in 1981-82 by an unknown black bear.
[e] Den #6 was not occupied in 1981-82.

APPENDIX C. Table 2. Denning history of radio-collared black bears in Prince William Sound, Alaska (prioritized for dens by year, bear number, and reproduction status given).

Den No.	Year 1977-78	1978-79	1979-80	1980-81	1981-82
1	Bear #101 F@6 w/1@1[a]		Bear #101 F@8 w/3@c[a] (Prob.)	Bear #101 F@9 w/3@1	Unmarked Bear
2				Bear #106 F@19 w/0	Unk.
3				Bear #143 F@7 w/0	Unk.
5				Bear #144 F@7 w/0	Bear #144 F@8 w/2@c
6				Bear #169 F@14 w/0	Not occupied
7				Bear #148 F@3 w/0	Unk.
8				Bear #147 F@7 w/0	Unk.
9				Bear #142 F@12 w/0	Unk.
10				Bear #149 F@11 w/0	Unk.
11				Bear #165 M @ 7	Unk.
12				Bear #146 M @ 9	Unk.
13					Bear @101 F@10 w/unk.
14					Bear #169 F@15 w/unk.
15					Bear #148 F@4 w/unk.

APPENDIX C. Table 2. Continued.

	Year				
Den No.	1977-78	1978-79	1979-80	1980-81	1981-82
16					Bear #147 F@18 w/unk.
17					Bear #142 F@13 w/1@c
18					Bear #149 F@12 w/unk.
19					Bear #146 M @ 10

[a] F@6 w/1@1 = Female 6 years old with 1 offspring at 1 year of age;
F@8 w/3@c = Female 8 years old with 3 offspring, cubs.

APPENDIX C. Table 3. Denning history of radio-collared black bears in Prince William Sound, Alaska (prioritized for dens by year, bear number, and reproduction status given).

Bear No.	Year 1976-77	1977-78	1978-79	1979-80	1980-81	1981-82
101	Den unk. F@5 w/1@c[a]	Den #1 F@6 W/1@1[a]	Den unk. F@7 w/unk.	Den #1 (Prob) F@8 w/3@c	Den #1 F@9 w/3@1	Den #13 F@10 w/unk.
106	Den unk. F@15 w/2@c	Den Not Meas. F@16 w/unk.	Den unk. F@17 w/unk.	Den not Meas. F@18 w/unk.	Den #2 F@19 w/unk.	
143		Den Not Meas. F@4 w/unk	Den unk. F@5 2/unk	Den unk. F@6 w/unk	Den #3 F@7 w/0	
144					Den #5 F@7 w/unk.	Den #5 F@8 w/2@c
169					Den #6 F@14 w/0	Den #14 F@15 w/unk.
148					Den #7 F@3 w/0	Den #15 F@4 w/unk.
147					Den #8 F@17 w/0	Den #16 F@18 w/unk.
142					Den #9 F@12 w/0	Den #17 F@13 w/1@c
149					Den #10 F@11 w/0	Den #18 F@12 w/unk.
165					Den #11 M @ 7	Den unk.
146					Den #12 M @ 9	Den #19 M @ 10

[a] F@5 w/1@c = Female, 5 years old, with 1 offspring, cub; F@6 w/1@1 = Female, 6 years old with 1 offspring, 1 year old.

APPENDIX C. Table 4. Den entrance and emergence dates of radio-collared black bears in Prince William Sound, winter 1980-81.

Bear ID	Sex	Age @ exit (yrs)	1980 entrance [a]	1981 emergence [b]
101	F	9	29 Sep - ?	29 Apr-14 May
106	F	19	29 Sep - ?	29 Apr-14 May
143	F	7	29 Sep - ?	27 Apr-29 Apr
144	F	7	29 Sep - ?	29 Apr-14 May
169	F	14	29 Sep - ?	14 May-22 May
148	F	3	29 Sep - ?	29 Apr-14 May
147	F	17	29 Sep - ?	29 Apr-14 May
149	F	11	29 Sep - ?	29 Apr-14 May
142	F	12	29 Sep - ?	23 Apr-?
165	M	7	29 Sep - ?	15 Apr-23 Apr
146	M	9	29 Sep - ?	15 Apr-23 Apr

[a] Last flight in fall was on 29 Sep when all bears were in their dens.

[b] Range represents last observation in den and first observation outside den.

APPENDIX D. STUDY DESIGN FOR CONTINUATION OF THE MRC BLACK BEAR STUDY.

Not for Publication
or Publication Reference

SIE No.: ______

Project No.: ______

State: Alaska

Job. No.: ______

Res. Class: ______

NOTICE OF RESEARCH PROJECT
SCIENCE INFORMATION EXCHANGE
Smithsonian Institution
U. S. DEPARTMENT OF THE INTERIOR
U. S. Fish and Wildlife Service
Division of Federal Aid

Study Title: Population ecology of the Kenai Peninsula black bear

Name and Title of Principal Investigators:

Charles C. Schwartz, Game Biologist II
Albert W. Franzmann, Game Biologist III

Name and Title of Co-investigators:

Ted H. Spraker, Game Biologist III

Name and Address of Game and Fish Agency:

Alaska Department of Fish and Game
Juneau, Alaska

Study Objectives:

To determine the population density, age structure, productivity, and survival of the black bear populations within the: (1) Moose Research Center (MRC), (2) Swanson River, and Finger Lakes study area.

To evaluate seasonal, temporal, and spatial aspects of bear movements as they relate to food abundance within the two study areas.

To determine bear food habits within the two study areas on a seasonal basis, and relate food habits to food availability.

Procedures:

Methods will follow Schwartz and Franzmann (1980). All resident bears within the two study areas will be fitted with radio collars. Movement and home range data will be obtained by monitoring radio-collared bears once a week by aircraft. Bear density will be calculated following the methods described by Schwartz and Franzmann (1981).

Food habits of bears will be determined by scat analysis. Scats will be collected, frozen, and analyzed on a seasonal basis for the two study areas. Each scat will then be thawed, sorted into visible food components, and washed through a series of soil screens to aid in material identification. Herbaceous materials, particularly graminoides, will be identified by the microscopic technique of (Baumgartner and Martin 1939, Dusi 1949) based on characteristics of epidermal tissues (Davis 1959, Croker 1959). No attempt will be made to quantify food intake from fecal analysis. Data will be used to rank foods in bear scats on a frequency and seasonal basis, and to compare bear foods between habitat types and study areas.

Food production, primarily lowbush cranberry (*Vaccinium vitis-idaea*) and devil's club (*Echinopanax horridum*) fruit, and highbush cranberry (*Viburnum edule*) where it occurs, will be sampled in selected habitats using techniques and sites described by Oldemeyer and Regelin (1981).

Status and Background:

The current bear research being conducted on the Kenai Peninsula is part of a cooperative comprehensive predator-prey project with the U. S. Fish and Wildlife Service, Kenai National Wildlife Refuge.

Major objectives of the bear study as outlined were : 1) to determine the impact of black and brown bear predations on moose calves, 2) to determine density and movement of bears into and around the moose calving area and assess the temporal, seasonal, and spatial aspects of bear movements, 3) to determine food habits of black and brown bears, particularly at calving time, 4) to integrate the bear study with concurrent wolf and moose calf mortality studies in an informational manner, and 5) to obtain movement and home range on bears in addition to that related to calving activity on the Moose River flats.

We have studied black bears for three field seasons (Franzmann and Schwartz 1978; Schwartz and Franzmann 1980; Schwartz and Franzmann 1981), and have learned a lot about black bears in the 1947 burn around the Moose Research Center. We have also generated several additional hypotheses regarding black bear population density, food abundance, plant succession, predation on moose, and potential habitat manipulations for moose management. These hypotheses can be best explained if we examine the major components of the Kenai Peninsula predator-prey system, namely the (1) vegetation, (2) the prey (moose), and (3) the black bear.

<u>The Vegetation</u>:

The vegetative component of the Kenai Peninsula ecosystem is very dynamic and probably the major controlling factor that ultimately determines moose and bear abundance. The Kenai Peninsula has a long history of fire, (Viereck and Schandelmeier 1980) and the fluctuation in moose numbers relative to fire history has been well documented (Spencer and Chatelain 1953, Peterson 1955, Spencer and Hakala 1964, Bailey 1978, Bailey and Bangs 1981).

Fire is the primary force which sets back primary and secondary plant succession. The revegetation sequence following fire in the boreal forest has been studied for selected species in Alaska (Zasada 1971, Zasada et al. 1979). An excellent review of these and other works was presented by Viereck and Schandelmeier (1980). Successional sequence after fire in the taiga is complex. It is related to a number of variables, which include preburn vegetation type and age, climate, fire severity, time of burn, parent material, presence and absence of permafrost, and the weather.

The Kenai Peninsula lowland is a typical interior forest, containing a mixture of white spruce (<u>Picea glauca</u>), black spruce (<u>Picea mariana</u>), poplar (<u>Populus balsamifera</u>), aspen (<u>Populus tremuloides</u>), and paper birch (<u>Betula papyrifera</u>). On dry upland sites, primarily south-facing slopes, the mature forest vegetation is white spruce, paper birch, aspen, or some combination of these species. The deciduous tree species represent successional stages of revegetation developing after fire (Figure 1). The understory associated with these successional stages likewise follows a pattern of regeneration. Shortly after the fire, a lush herb layer is established with fireweed (Epilobium angustifolium) and bluejoint (Calamagrostis canadensis) being most common. Depending on the severity of the fire, shrub species (Salix, Ledum, and Vaccinium) reinvade 6-25 years following the burn. As the overstory component matures, many of the understory species are shaded out leaving the more shade tolerant forbs like low and highbush cranberry. Finally, when white spruce forest matures, the major understory species are mosses and lichens.

Moose:

Moose evolved to utilize intermediate stages of vegetation succession. High densities of moose are keyed to those stages of plant succession which contain large quantities of available browse. On the Kenai, birch, willow, and aspen are the major browse species. Moose populations tend to peak 15-20 years following a burn (Spencer and Hakala 1964), and decline as the vegetative overstory changes to white-black spruce and/or the hardwood species grow out of reach of browsing moose.

Black Bears:

Black bears are creatures of the forest (Herrero 1972, 1978) and are reluctant to venture far from trees (Herrero 1972, Schwartz and Franzmann 1981, Erickson 1965). Changes in black bear density as they relate to vegetation succession are not documented in Alaska. However, certain generalizations can be made which probably reflect bear densities and habitat.

Lowbush and highbush cranberry and devil's club are three of the major foods of black bears on the Kenai lowlands (Schwartz and Franzmann 1980, Schwartz and Franzmann 1981). Lowbush cranberry is a staple food and is consumed in both spring and fall. Devil's club and highbush cranberry are fall foods. Both species are affected by fire. Lowbush cranberry has abundant brambled underground stems embedded about 2 to 3 cm in the humus. They are able to survive light fires, but are generally killed by moderate to heavy fires (Uggla 1958). Lowbush cranberry is therefore eliminated from the understory in all but very light forest fires. Elimination of the lowbush cranberry would probably reduce the carrying capacity of an area for black bears. Likewise old-growth forests which have a heavy moss layer on the forest floor do not contain an abundance of lowbush cranberry and have a reduced carrying capacity for black bears.

Devil's club and highbush cranberry are generally absent from earlier stages of plant succession. They become more apparent in late stages of succession when the hardwoods mature. These two species are important as fall bear foods, but are not consumed other times of the year. Therefore, old-growth forests can support a large number of black bears in the fall when these foods are abundant (Schwartz and Franzmann 1980, 1981) but cannot carry large numbers of bears on an annual basis.

Although we can only speculate, it appears that early stages of plant succession (<25 years) have a low carrying capacity for bears due to a lack of abundant food resources. These same areas have a high propensity to support moose. As vegetation succession continues (25-50 years), the overstory hardwoods begin to form a canopy, and lowbush cranberry begins to increase in density. The carrying capacity for black bears is increasing, while the carrying capacity for moose has peaked or started a downward trend (Figure 1). Once the forest reaches the mature hardwood stage (51-100 years), the carrying capacity for bears is at its highest, while that for moose is quite low. As the mature hardwood forest changes to a mature spruce-moss (100-250 years), the carrying capacity for black bears also declines due to the loss of the food producing species in the understory. At this time, moose carrying capacity is near zero.

Justification:

If black bear densities are keyed to plant succession following a fire in the manner we have just discussed, then management programs directed at black bears, moose, or vegetation manipulation should be keyed to this succession. Knowing the interrelationships of moose-bear habitats can enable us to more fully understand our management priorities regarding the two game species. In other words, it may be very impractical to manage moose in later stages of vegetation succession when, in fact, the habitat is more suitable to black bears than moose. This fact has been demonstrated in the 1947 burn where bear densities are high (Schwartz and Franzmann 1980, Schwartz and Franzmann 1981), bear predation rates on moose are high (Franzmann and Schwartz 1979, Franzmann et al. 1980) and moose numbers are declining (Spraker 1980a). An understanding of when habitat becomes more suitable for bears than moose can enable us to determine at what time (i.e., successional stage) habitat manipulation is necessary for moose.

These studies in conjunction with the proposed moose calf mortality study will enable us to more fully understand the dynamics of the Kenai Peninsula predator-prey system. Moose calf mortality studies conducted in the 1947 burn indicated that 34% of all calf deaths were caused by black bears. This fact has been abused, used out of context, and otherwise used to "point the finger" at black bears as the causative agent responsible for moose population declines in the 1947 burn. If our hypotheses are true, moose population declines in the 1947 burn are inevitable.

Our work in the MRC study area has indicated that it requires at least three years before an accurate estimate of bear density can be made. It takes this long to assure that all resident animals are radio-collared. We, therefore, propose to study bears in each area for at least three years.

We also believe that long-term ecological studies of black bears within the MRC study area are necessary because: 1) bears are long lived; 2) seasonal changes in food abundance occur at periodic but sporadic intervals (it is, therefore, necessary to study bears long enough to monitor changes in reproductive status, cub and yearling survival, seasonal movements, etc., when a "poor" food year occurs); 3) it is also important to look at population fluctuations on a long-term basis in light of increased hunting pressure (Spraker 1980b) and declining moose numbers; and 4) we need to understand the significance of various habitats to black bear welfare on a seasonal basis.

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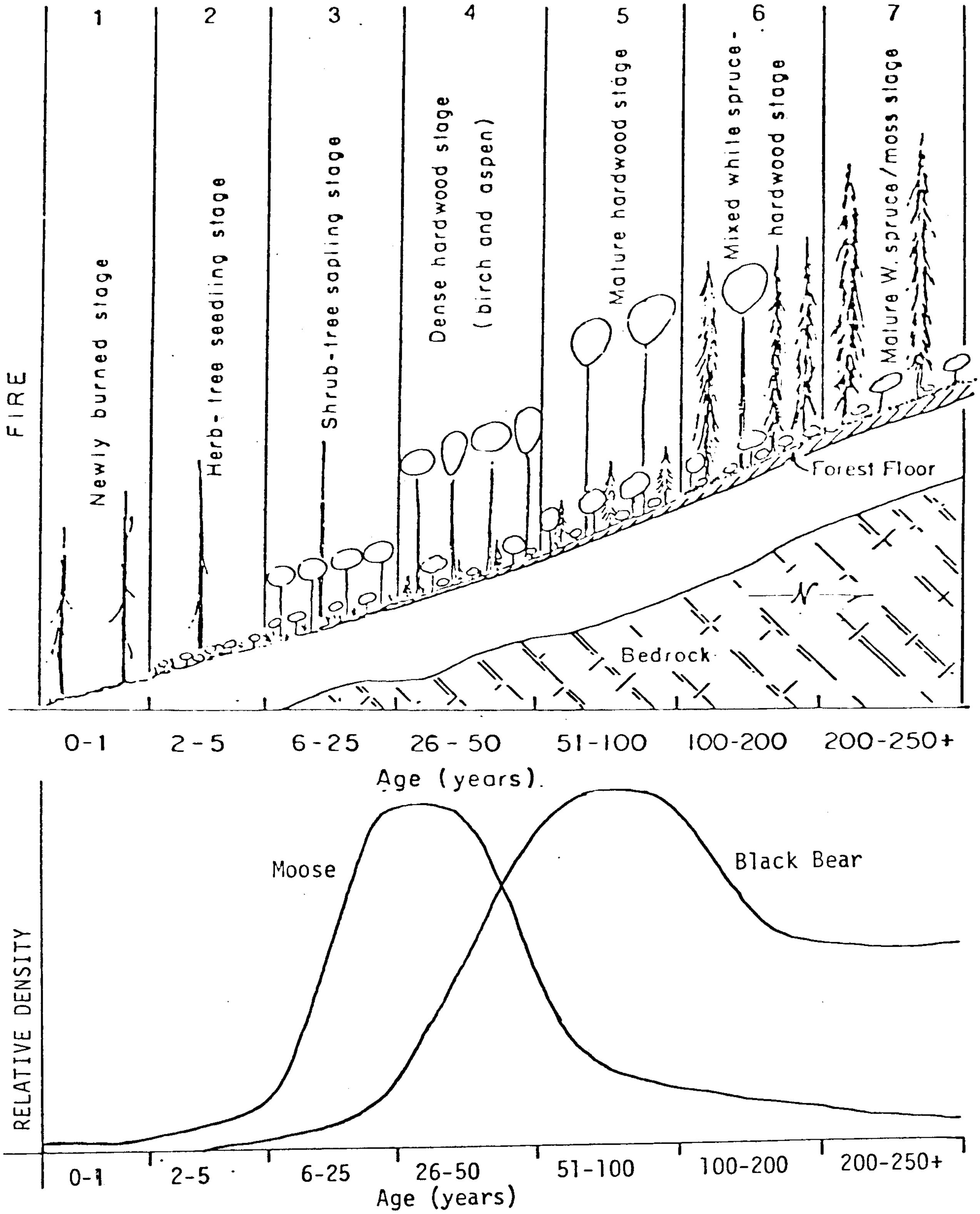

Figure 1. Theoretical biological succession which results from primary and secondary plant succession accompanied by interspecific competition.

APPENDIX E. STUDY DESIGN OF PAUL SMITH FOR MASTER OF SCIENCE DEGREE AT UNIVERSITY OF ALASKA, FAIRBANKS.

STUDY PLAN

Study Title: Kenai black bears and cranberries: bear food habits and density.

Background

Since 1976, the Alaska Department of Fish and Game and the U. S. Fish and Wildlife Service have been conducting a cooperative, comprehensive predator-prey study on the Kenai Peninsula lowlands, within the Kenai National Wildlife Refuge. The study focuses on habits and interrelationships of black bear (*Ursus americanus*), brown bear (*Ursus arctos*), moose (*Alces alces*), caribou (*Rangifer tarandus*), and wolf (*Canis lupus*). As part of this continuing study, the Alaska Department of Fish and Game has proposed, and received approval for, an intensive study entitled "Population ecology of the Kenai Peninsula black bear." This study involves, in part, a study of the food habits of black bear with particular emphasis on determining the importance of lowbush cranberry (*Vaccinium vitis-idaea*) as a bear food and its effect upon bear density. Through the University of Alaska, Fairbanks, and in cooperation with the Alaska Department of Fish and Game, I will undertake this portion of the overall bear study as the topic for an M.S. degree in Wildlife Management.

In addition to determining food habits, the abundance and density of lowbush cranberry within the study area will be determined to test the hypothesis that black bear population densities are highest in areas of high lowbush cranberry density. Food habits data will be related to data on lowbush cranberry abundance, and the resulting information will be in turn correlated with bear movement and density data obtained through radio telemetry studies being conducted by the Alaska Department of Fish and Game. Information generated will create a better understanding of the interrelationships between black bear and other species in the area, particularly moose. In addition, a better understanding of habitats used by these animals will enable wildlife biologists to make more sound decisions regarding the management of large predators, herbivores, and their habitat.

Study Area

The study area lies on the northwestern Kenai Peninsula lowlands within the Kenai National Wildlife Refuge. A wide variety of boreal vegetation types occur in the area interspersed with numerous lakes and bogs. Topography consists generally of low rolling hills.

Study efforts will be concentrated in two areas of the lowlands. The first is a 300,000-acre tract burned in 1947. The second is an 86,000-acre tract burned in 1969. Concentrating on these areas should allow good comparisons to be made between successional stages which should support different black bear densities. Additional sampling will be conducted in old-growth forests adjacent to the 1947 and 1969 burns for comparison. Detailed descriptions of the study area appear in Oldemeyer and Seemel (1976), Oldemeyer et al. (1977), and Sigman (1977).

Length of Study

Study completion is planned for the period of May to September, 1983. Black bear scats will be collected from May to October, 1982 and combined with other scats which Alaska Department of Fish and Game biologists have collected in the study area each year since 1978. Scat analysis will take place from approximately January 1982 to December 1982. Field work involving sampling of vegetation (lowbush cranberry) will also take place between May and October 1982. Telemetry studies conducted by the Alaska Department of Fish and Game to determine levels of black bear predation on moose and black bear population densities and movements began in 1978 and will continue through 1985. General planning for the food habits portion of the overall black bear study began during May 1981 and will be complete before May 1982. Synthesis and analysis of data collected during 1982, and the previous years mentioned, should be completed by or before May 1983 with thesis completion planned for sometime between May and September 1983.

Problem Statement

The Kenai Peninsula ecosystem is very dynamic with regard to vegetational succession. There exists a long history of fire on the Peninsula (Viereck and Schandelmeir 1980) and an accompanying history of vegetational change and setback. These changes ultimately determine the abundance and population density of various wildlife species; black bear is of special concern in this study.

Information on the seasonal food habits of black bear in various successional stages is lacking, and changes in the density of black bear as they relate to vegetation succession, have not been documented in Alaska. Movements of black bear in relation to food habits and food abundance are also poorly understood.

These aspects of black bear life history are of particular interest when examining the interrelationships of black bear and moose (Chatelain 1950). Moose calf mortality studies conducted on the Kenai Peninsula lowlands between 1977 and 1980 showed that 34% of all calf deaths were caused by black bear, the single highest cause of mortality (Franzmann and Schwartz 1980). However, biologists currently speculate that moose will not thrive in habitats ideally suited for black bear and vice versa. This is because black bear account for a high percentage of moose calf mortality only in habitats where black bear densities are high, i.e., the type of habitat in which a decline in the moose population is inevitable. Early stages of plant succession (6-25 years) are likely to support large numbers of moose but few bears due to lack of proper foods. On the other hand, mature hardwood stages (50-100 years) supposedly have the highest carrying capacity for black bear in this area, but a very low carrying capacity for moose, again due to food supplies.

A better understanding of the relationship between food habits and habitat preferences of black bears in different successional stages will enhance, and provide for, better management of not only black bears, but also of moose and the other species components of the Kenai Peninsula predator-prey system. For example, it may prove to be quite impractical to manage for moose in later successional stages of vegetation where, in fact, the habitat is far more suited to black bears than to moose. Being able to determine the successional stage at which a habitat's carrying capacity is best suited to black bears will enable biologists to determine when habitat manipulation is necessary either to maintain high black bear numbers or to obtain higher numbers of another species such as moose.

Objectives

The objectives of this study are: (1) to determine the food habits of black bears in selected areas of the Kenai Peninsula lowlands on a seasonal basis; (2) to determine the abundance and density of lowbush cranberries in various habitats and successional stages within the study area; and (3) to evaluate the relationship between black bear population densities and lowbush cranberry densities.

Hypotheses to be examined regarding food habits will involve differences and similarities in food consumption in various seasons and successional stages.

Berries of the genus Vaccinium (including lowbush cranberry) have been recognized by many investigators as a major food item in the diet of black bear (Hatler 1967, Tisch 1961, Rogers 1976). Lowbush cranberry is very abundant on the Kenai Peninsula lowlands (Oldemeyer and Seemel 1976) and general observations to date indicate that black bear in the study area rely heavily on this berry in both spring and fall (Schwartz, pers. commun.). Hypotheses testing for independence between bear population densities and lowbush cranberry densities, or testing to see if, when, and where lowbush cranberry consumption is significantly higher than consumption of other food items, will lend insight into the importance of this food to black bear. It is possible that the presence, absence, or abundance of these berries determines to a large extent the numbers and health of black bear in the study area.

Justification

The black bear is a major component of the Kenai Peninsula predator-prey system and is highly valued for recreational purposes of hunting and viewing, and as a food source. Today, the black bear is recognized as a superb game animal (Rue 1981). Under Alaska hunting regulations (1981) hunters may take 3 bears per year on the Kenai Peninsula (including the Kenai National Wildlife Refuge), and there is no closed season in the area. The proposed Alaska Wildlife Management Plans (1976) call for the provision of an optimum harvest as the primary management goal for black bear on the Kenai Peninsula.

Black bear-moose interrelationships are of special importance as moose receive even greater pressure than bear for both recreational and food purposes while their numbers are currently declining on the Kenai Peninsula (Spraker 1980).

The Kenai Peninsula's wildlife and habitat are receiving increasing amounts of human use pressure every year. The Peninsula's close proximity to Alaska's largest population center, Anchorage, as well as excellent road and trail access ensures that this trend will continue. And, as Modzyski (1981) points out, recent Alaska lands legislation will likely add to the increasing pressure as the Kenai Peninsula "absorbs" hunters who may have otherwise hunted in areas which are now heavily restricted or closed. Similarly, hunting pressure for black bear in particular can be expected to rise as hunters shift away from other species of big game where new and/or heavier restrictions now apply.

In order to successfully manage black bear and other wildlife under this increasing pressure, biologists need to have more information on the Kenai Peninsula's predatory-prey system; this study will provide an essential part of that information. The direction taken in management programs aimed at black bear, moose or their habitat depends directly upon our understanding of the relationships which exist between these animals and their habitat, with food habits being an extremely important factor in these relationships.

Materials and Methods

The food habits of black bears will be determined by analyzing scats collected throughout the study area. Over 200 samples from 4 years (1978 through 1981) have already been collected by Alaska Department of Fish and Game biologists. These samples, plus additional ones to be collected during the 1982 field season, will be kept frozen and sealed in plastic until analyzed. For analysis, scats will be thawed, soaked in water, and washed through a series of soil screens to sort visible food components. Water displacement tests will then be made to determine the percent volume of the scat each food item composes. Scat analysis techniques will be similar to those used by Tisch (1961), Hatler (1967), and Mealy (1975). Data obtained will be used to rank foods as they appear in the bear scats on a frequency and seasonal basis and to compare foods between successional stages the scats are collected in. No attempt will be made to precisely quantify the bear's actual food intake based on scat analysis. According to Hatler (1972)"... good collection of scats can justifiably serve as a base for nearly any bear food habits study."

Vegetation sampling to determine abundance and density of lowbush cranberry will generally follow the techniques of Martin (1980) and Halls and Dell (1966).

Data from past and ongoing radio telemetry studies in the area (Schwartz and Franzmann 1980) will be used to evaluate the relationships of food habits, lowbush densities, and black bear movements and population densities.

The Alaska Department of Fish and Game will (as part of their broader study, "Population ecology of the Kenai Peninsula black bear") provide all logistical support, field equipment, and miscellaneous other equipment needed for the study, as well as food and lodging while in the field. Other services such as laboratory and office space will be provided by ADF&G when and where possible.

The University of Alaska, Fairbanks will provide laboratory and office space, laboratory and other equipment and, when possible, logistical support.

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