HUMAN IMPACT ON THE BLACK BEAR IN MICHIGAN'S LOWER PENINSULA

By

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ABSTRACT

HUMAN IMPACT ON THE BLACK BEAR IN MICHIGAN'S LOWER PENINSULA

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Thirty-five black bears (Ursus americanus) were captured (22 males, 13 females), 25 were radio-collared, and 1,112 radio triangulations were made from ground and air between September 1977 and March 1980 in connection with a study of the interactions between humans and black bears in Michigan's Lower Peninsula, located mainly in Crawford, Kalkaska, Missaukee, and Roscommon counties. The objectives of the project were to determine the minimum requirements of the species with respect to habitat needs, home range size, the extent of individual movements, and den site selection; to assess the effects of human encroachment and hydrocarbon development on the bear habitat and population; to establish the extent of the nuisance bear problem; to evaluate the effects of hunting pressure; to estimate the size of the bear population in the 4-county unit; and to learn more about basic bear biology.

In a positive sense, effects of humans on bears included changes in hunting regulations which probably resulted in an increasing bear population; oil pipeline rights-of-way, oil well service lanes, and lumber roads used by bears as travel routes; roadside cutting, commercial lumbering, forest clear-cutting, and controlled burns all planned to benefit wildlife

by inducing the growth of early successional vegetational states; and bee-keeping practices providing bears with supplementary food. Negative effects included losses of habitat due to human encroachment, accident dangers and movement impedance from heavy automobile traffic, hunting aided by service roads, research and resource losses where marked bears and females with cubs were shot, and bears caused to flee their dens when approached. Questionable impacts included human activity possibly affecting the location of bear dens, the permanent closure of sanitary landfills, and possible disturbing effects of small-game and deer hunters.

The effects of oil wells and snowmobile trails on the average bear remain unknown. Denning close, however, to active wells were 2 males ($\bar{X}$=0.32 km) and to snowmobile trails ($\bar{X}$=0.09 km) were 2 females.

A surprisingly high incidence of periodontal disease (13 of 35 bears, with varying degrees of severity) was found. The total effects of even seemingly-serious conditions on the animals could not be fully assessed. The infections, however, obviously caused losses of teeth and atrophied jaw and gum tissues. The teeth of 7 bears also contained dental cavities.

Twenty-three marked animals were sighted and reported 63 different times by the public. On the study area, 46 nuisance and damage complaints were reported between August 1977 and July 1980. For animals with at least 6 months of telemetric data, and including several with extended summer movements, the average home range for males using convex

polygons was 150.3 km^2 (SD=96.6 km^2) and for females, 60.1 km^2 (SD=53.6 km^2). Six adult males made prolonged seasonal treks of 140, 105, 50, 47, 42, and 32 km during the summer months. They returned to their fall-winter-spring center of activity before denning.

Rapid increases in resident human populations in the northern resort districts of Michigan's Lower Peninsula are causing perhaps a great threat to local bear populations through losses of habitat to homesite and commercial development, and disturbances due to human activities.

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INTRODUCTION

The northern Lower Peninsula of Michigan has been a popular resort area for many years, and is becoming heavily populated with permanent residents. Private and commercial development, human encroachment, oil field expansion, and habitat destruction are of increasing significance and threaten the black bear population in the area. Central in the Lower Peninsula are the large and beautiful Higgins and Houghton lakes which, with the surrounding lands, form one of Michigan's largest and most popular resort areas. Adjacent to and immediately west of these 2 lakes is the Dead Stream Swamp, the largest wetland and roadless tract in the Lower Peninsula (Blouch 1960) and a major habitat of the black bear. The major emphasis of this study was to evaluate the impact of an increasing human population and related human activities on the bear population.

A steadily-increasing human population inevitably results in a loss of bear habitat (Cardoza 1976, Willey 1978). Missaukee County, immediately west of the Higgins and Houghton lakes, grew in resident population from 6,784 in 1960 to 7,126 (5%) in 1970, and by 1976 had increased to 9,200, a further 29%.

Roscommon County, center of the resort areas, had even more dramatic growth from 7,200 in 1960 to 9,892 (37%) in 1970, to 15,100 (a further 53%) by 1976. The population is expected to double by 1980's end (Houghton Lake Chamber of Commerce pers. commun.). The current population in the immediate Houghton Lakeshore vicinity alone is 8,500 residents. With increasing human densities and a moderately high level of bear nuisance and damage complaints, the Higgins-Houghton lakes area seemed appropriate for a study of bear-human interactions.

In addition to the increase in resident populations, recreational services are numerous. Around Houghton Lake, subscribing members of the Houghton Lake Chamber of Commerce include 46 motels (40 of which are open year-round), 3 trailer parks, 3 state and private recreational areas, 14 restaurants, 8 food and beverage stores, 7 sporting goods stores, and some 75 other businesses and professional services (Houghton Lake Chamber of Commerce 1980). Since not all commercial establishments in the area subscribe to the Chamber of Commerce, the actual figures are even higher. In addition to permanent residents, the lakes region receives heavy year-round use by vacationers. Sail and power boating, bow and rifle hunting, fishing, trail-biking, camping, hiking, snowmobiling, and cross-country skiing are popular sports, all attracting many participants and occasionally bringing humans into contact with bears.

In addition to human encroachment and private and commercial development, destruction of bear habitat is further

threatened by oil-field operations throughout the Peninsula's remaining prime bear habitat. Seven oil and gas fields, with some 694 wells, are located in the lakes region. In addition, approximately 141,750 ha of land have been approved for further oil exploration. Oil areas include the Norwich Oil Field, west of Higgins Lake and on the north end of the Dead Stream Swamp (106 wells); the Enterprise Oil Field, west of Houghton Lake and on the southwest end of the Swamp (35 wells); the Camp Grayling Oil Field, northwest of Higgins Lake (65 wells); the Cranberry Lake Oil Field, southwest of Houghton Lake (154 wells); the Winterfield Oil Field, west-southwest of Houghton Lake (197 wells); the Headquarters Oil Field, south of Houghton Lake (46 wells); and the St. Helen Oil Field, east of Higgins Lake (91 wells). The Norwich Oil Field has been active for more than 45 years. New wells were drilled in at least 3 of these oil fields during this study.

In addition to the above factors, another variable influencing the bear population is the extent to which bear hunting is regulated by the State. There is evidence that the number of black bears rapidly declined in the northern Lower Peninsula between 1930 and 1975 (Harger 1974a, Manville 1978a). Since 1975, however, bears in the Lower Peninsula seem to have become more numerous (E. Harger, MI DNR biologist, pers. commun.). It is possible that this increase may be due to changes in the bear-hunting regulations.

Prior to 1965, hunters in the Lower Peninsula could shoot a bear as a bonus on their deer tag (only 1 bear per calendar

year allowed; MI Dept. Conserv. 1957). The average annual harvest of bears in the Lower Peninsula, 1936-1946, was 374 animals (SD=124.6) (Erickson 1964b), virtually all taken in connection with deer hunting. This was true despite the fact that most bears had denned-up prior to the mid-November opening of the 2 week gun season on deer (Odocoileus virginianus).

In 1939, the Michigan Department of Conservation (now the DNR) opened the Dead Stream Swamp in Missaukee County to bear hunting with dogs (MI Dept. Conserv. 1957). Three hundred permits were issued to hunters in the Dead Stream Swamp on a first-come first-served basis. A Lower Peninsula harvest of 839 bears was recorded in 1947. Between 1946 and 1963, bear hunting in the Dead Stream Swamp and adjoining areas included large organized hunts (185 or more people) with packs of dogs exceeding 20 animals (F. Kellum, DNR field notes). The popularity of organized hunts with dogs continued until 1965 when an apparently-reduced bear population caused the entire Lower Peninsula to be closed to bear hunting from 1965 to 1968. Since 1969, bear hunting has been allowed in the Lower Peninsula only under special permits. The Dead Stream Swamp west of US-27 in Roscommon County (since 1973), however, and all of Missaukee County (since 1965) remained closed to bear hunting. Between 1969 and 1972, 850 gun permits (bow hunting for bears was permitted, but not during the gun season) were issued annually for a 5-to-7 day bear season in the Lower Peninsula. In 1973, 1,500 permits were allocated for a 7-day season. In 1974, 2,000 permits were allowed during a 10-day

season, and from 1975 to 1980, 3,000 gun permits were released for a 10-day season. From 1977 to 1980, 1,000 bow permits also were allotted for a separate 10-day bow-hunting season.

The focus of this study has been the examination and evaluation of the effects of these factors on the bear population of the Higgins and Houghton lakes region in Michigan's Lower Peninsula.

PROJECT OBJECTIVES

The objectives of the project were to: 1) determine the minimum requirements of the species with respect to habitat needs, home range size (and the extent of individual movements), and den site selection; 2) assess the effects of human encroachment and hydrocarbon development on the bear habitat and population; 3) establish the extent of the nuisance bear problem; 4) evaluate the effects of hunting pressure; 5) estimate the size of the bear population in Crawford, Kalkaska, Missaukee, and Roscommon counties; and 6) contribute to the overall knowledge and understanding of basic bear biology.

PROJECT APPROACH

The approach taken in conducting this research involved initially capturing, measuring, marking, and radio-tagging a portion of the local bear population, and periodically tracking the seasonal activities of the collared population over a two-and-one-half year period.

A variety of means were used in this tracking, which employed the use of radio collars attached to 71% of the research population. The major tracking approach relied on the

use of radio telemetry techniques (Mech 1974, Rogers 1977, Alt et al. 1980), using ground-based mobile receiver antennas as well as aerial tracking using receiver antennas mounted on the aircraft. Data were collected using various modes of travel. Tracking was undertaken using continuously received radio signals during the period of time a bear was being observed, or intermittent radio triangulations were plotted during shorter tracking periods. Observations were made during all seasons of the year.

In addition to the initial capture (for collaring and/or marking), 14 of the 28 marked bears were recaptured at least once for replacement of radio collars and/or ear tags, removal of collars, and additional measurement and examination.

In the process of this research, particular attention was given to collecting information in relation to the project's 6 main objectives and the overall impact of humans on bears in the research area.

ORGANIZATION OF THE DISSERTATION

This dissertation has been organized into 9 major sections. After the basic introductory information there are 7 self-contained chapters, followed by recommendations, a summary, the literature cited, and an appendix.

The chapters can be divided into 2 groups: the first two chapters (Capture, Immobilization, and Handling; and Radio Telemetry) address the research techniques used in this project and present information on some of the objectives of the research. As with all of the chapters, pertinent literature

and methods and materials are first discussed, and then a section on the results and a related discussion are provided.

The remaining 5 chapters address major topic areas of interest. Within these topic areas the other specific objectives of the project are discussed. Habitat needs, home range size, and individual bear movements are discussed in Chapter II since they relate to the tracking information. Den site selection is addressed separately as the self-contained Chapter V.

The effects of human encroachment as an overall topic of interest are discussed in Chapter III. Within this chapter the specific impacts of hydrocarbon development (objective 2) and hunting pressure (objective 4) are addressed. The nuisance bear problem; bear population estimation; and parasitology, pathology, and hematology are presented as individual topics in Chapters IV, VI, and VII, respectively.

Because this dissertation has been designed around stand-alone chapters, there is some repetition of information in various sections. As much as practical, efforts have been made to limit this by collecting basic reference data in the set of tables contained in the Appendix.

STUDY AREA

CENTER OF RESEARCH

The study centered in the Higgins-Houghton lakes region of Missaukee and Roscommon counties, although some bears were

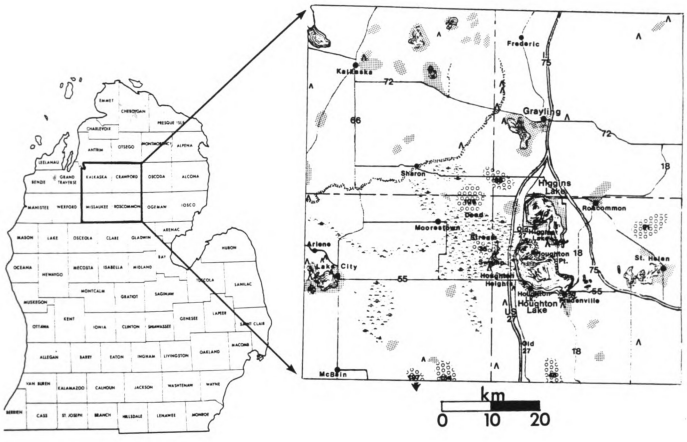
captured and others made seasonal movements outside this area.

The Dead Stream Swamp and adjoining wetlands in Roscommon and Missaukee counties comprise about 130 km^2 (Figure 1) and that portion west of US-27, has been closed to bear hunting since 1965. The Swamp itself is unique for several reasons. Although heavily lumbered in the early 1900's, it contains a nearly-continuous, thick stand of white cedar (Thuja occidentalis), ideal for winter denning.

Resort development is mainly to the east and northeast of the Swamp. Heavily-populated resorts are situated both on Higgins and Houghton lakes, east of the Swamp. Six popular public campgrounds also are located near the Swamp. Farming, though light, is heaviest to the west and southwest. The Swamp is nearly surrounded by oil wells. Two major highways (M-55 and US-27) pass through portions of the Swamp.

VEGETATION TYPES IN THE NORTHERN LOWER PENINSULA

The northern Lower Peninsula contains 3 dominant vegetation types: bog conifer, Great Lakes pine forest, and northern hardwoods (Kuchler 1964). The bog conifer type, found in the upper-northern and extreme-northern Lower Peninsula, is dominated by larch (Larix laricina), black spruce (Picea mariana), and white cedar. Other components include balsam fir (Abies balsamea), red maple (Acer rubrum), leatherleaf (Chamaedaphne calyculata), Labrador tea (Ledum groenlandicum), and sphagnum moss (Sphagnum spp.). Approximately 5% of the Lower Peninsula vegetation north of Houghton Lake



LEGEND

Λ = **Camping facility**

25 = **Oil field** (Number indicates no. wells per field)

— = **Principal paved road**

= **Resort or residential community**

= **Swamp**

• = **Town**

Fig. 1. The Dead Stream Swamp (west of Houghton and Higgins lakes) and adjacent wetlands in Roscommon, Missaukee, and adjoining counties in the study area.

is of this type (Figure 2). The Great Lakes pine forest, characterized by jack pine (Pinus banksiana), red pine (P. resinosa), and white pine (P. strobus), comprises approximately 35% of the Lower Peninsula vegetation north of Houghton Lake. Also found in the pine forest vegetation type are big-tooth aspen (Populus grandidentata), quaking aspen (P. tremuloides), scarlet oak (Quercus coccinea), jack oak (Q. ellipsoidalis), red oak (Q. rubra), and black oak (Q. velutina). Northern hardwoods occupies approximately 60% of the lands north of Houghton Lake. Dominant trees are sugar maple (Acer saccharum), yellow birch (Betula allegheniensis), beech (Fagus grandifolia), and hemlock (Tsuga canadensis). Other woody species include red maple, mountain maple (Acer spicatum), white ash (Fraxinus americana), white pine, black cherry (Prunus serotina), American basswood (Tilia americana), and American elm (Ulmus americana).

CLIMATE, TOPOGRAPHY, AND SOILS OF THE NORTHERN LOWER PENINSULA

The climate is cool and humid. There are less than 100 clear days per average year. In most years snow stays on the ground over 120 days and the growing season is short, averaging 80 to 120 days. The average annual temperature ranges between 4.4 and 10 C, with temperatures in summer averaging 15.6 to 21.1 C, and in winter -28.9 to -17.8 C. Average annual precipitation is 71.15 to 81.3 cm. Average relative humidity in the northern Lower Peninsula is 50-60% in July; in the extreme northern Lower Peninsula, 60-70% (US Dept. Interior 1970, Lehr et al. 1975).

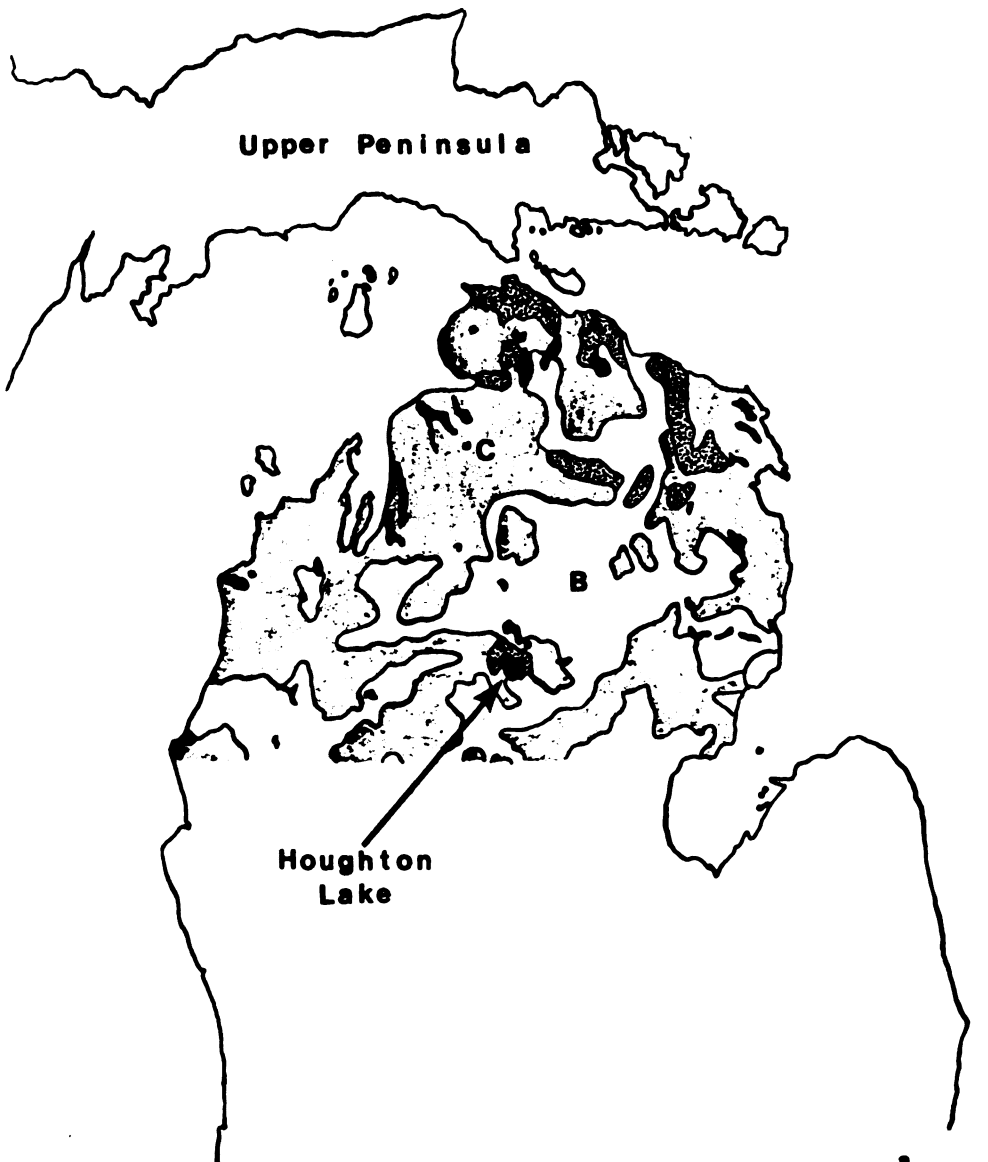


Fig. 2. Vegetation cover types in Michigan's northern Lower Peninsula (revised from Kuchler 1964).

The topography of more-northern areas varies from lowland swamps to rolling, glaciated hills. In the western and northwestern parts, some hills extend 230 m or more above the surrounding landscapes. Except for a few hills under 73 m, the topography near Higgins and Houghton lakes is relatively flat. The elevation at the Houghton Lake Airport is 350.5 m above sea level. North of Houghton Lake, ponds and lakes are more numerous than in the 2-lakes area.

The Lower Peninsula was covered by the Wisconsin glaciation of the Pleistocene epoch (Leet and Judson 1965). In consequence, soils are sands and sandy-loams to rocky, with various quantities of glacial drift.

CHAPTER I

CAPTURE, IMMOBILIZATION, AND HANDLING

Rogers (1977) described trapping and handling of black bears in Minnesota as did Manville (1976) in Wisconsin. In Tennessee, prebaiting and snaring techniques were discussed in detail by Johnson and Pelton (1980a). Immobilization techniques were detailed by Seal et al. (1970) and Harthoorn (1976).

METHODS AND MATERIALS

CAPTURE METHODS

Bears were captured along trails and roads, in swamps and uplands, and near human developments. They were taken in barrel traps, culvert traps, Aldrich foot snares, and in dens by darting or hand injection of drugs. Eleven barrel traps with removable portable wheels (a modified version of traps designed by Rogers 1977) averaging 60.3 kg in weight were constructed. Grocery store meat-scraps were placed in 30 x 45 cm burlap bags, scented with anise oil extract and Wrights Liquid Smoke, and tied in the upper far end of each trap. Several DNR-owned, trailer-mounted culvert traps and 6 Aldrich foot snares[1] were

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[1]Aldrich Animal Trap Co., P. O. Box 244, Clallam Bay, WA 98326

also employed. The latter were tied to drag logs by swiveled cables to prevent kinking. In one case, where a female had previously eluded recapture at its den, the den was located by radio triangulation and bear-dogs released nearby. They treed the bear, enabling darting.

To recapture radio-collared bears in dens, they were first located from the air (see beyond). Ground surveillance was then conducted to be certain that the animal was indeed immobile and in a den.

IMMOBILIZATION

Weights of bears in traps were estimated and the animals originally injected intramuscularly with Cap-Chur[2] darts containing 0.44 to 0.88 mg/kg body weight of succinylcholine chloride (Sucostrin[3]) fired from a CO_2 Cap-Chur[2] pistol. Bears were dragged from traps when immobile but fully conscious. Intraperitoneal injections of sodium pentobarbital[4] (0.43 mg/kg body weight) then were given in order to maintain immobilization. Unfortunately, early in the study, one denned family group of 4 bears (female and 3 yearling cubs) died after jabstick drugging with minimal doses of succinylcholine chloride. Thereafter, with DNR approval, combined doses of ketamine hydrochloride (Vetalar[5]; 2.3 mg/kg body weight) and promazine

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[2]Nasco, 901 Janesville Ave., Ft. Atkinson, WI 53538

[3]E. R. Squibb and Sons, Inc., New York, NY 10022

[4]Haver-Lockhart Labs, Div. of Bayvet Corp., Shawnee, KA 66201

[5]Parke, Davis and Co., Detroit, MI 48232

hydrochloride (Sparine[6]; 0.1 mg/kg body weight) were injected successfully with hand-held jab sticks.

Bears in dens were immobilized with ketamine hydrochloride at a reduced dosage (1.2 mg/kg body weight) plus promazine hydrochloride (0.1 mg/kg body weight). They were injected either with a hand-held syringe, a hand-held jab stick, or with a 0.22 caliber Cap-Chur dart rifle depending on the bear's activity as it reacted to being disturbed. A CO_2 dart pistol proved inoperable due to the cold.

HANDLING PROCEDURES

After immobilization, procaine hydrochloride[7] was injected as a further desensitizing agent and a first premolar (P1) tooth was extracted from each animal for age determination by counting cementum annuli. Tooth-extraction wounds were checked for proper healing in recaptured bears. Linear measurements taken from each immobilized animal included nose to ear, nose to tail, and paw-and-pad lengths and widths.

To determine each bear's stress reaction and body temperature, heart rate and rectal temperature were recorded. Admittedly, ketamine hydrochloride tends to depress the heart rate and body temperature slightly. These measurements, therefore, only approximated normal conditions. Each animal was weighed using a spring scale attached to rope looped around a forepaw

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[6]Wyeth Laboratories Inc., Philadelphia, PA 19101

[7]Bio-Ceutic Laboratories, Inc., St. Joseph, MO 64502

and the opposite hind paw. About 30-cc of blood was extracted from the femoral artery. This sample was used for isoelectric focusing to assess serum protein patterns and serum selenium determination in periodontal-diseased animals, and for parasite analysis. Three blood-smear slides were prepared to test for analysis of parasitism by Dirofilaria ursi microfilariae. A fecal sample was taken and a search was made for collected ectoparasites.

To augment data from a previous study in northern Wisconsin (Manville 1978b), bears were examined carefully for evidence of dental caries and periodontal disease. Bacterial samples were taken of caries and diseased periodontal tissues using Cepti-Seal Culturettes.[8] These contained modified Stuart's bacterial transport medium. Photographs were taken of diseased tissues, wounds, and such other abnormalities as broken bones, missing digits, and chipped or missing teeth. Winter dens also were photographed.

Bears recaptured while denned were checked for continuing proper collar fit and replaced or removed when necessary. Body measurements and weights, rectal temperatures, and dental diseases also were noted, 30-cc blood samples extracted, and bears photographed. Dens were measured and den materials identified. Bears which ran from the dens were returned to their respective den-sites after capture unless they went considerable distances from the dens before being immobilized. In the latter instances, new dens were fabricated. Newborn

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[8]Scientific Products, Am. Hospital Supply Co., McGraw Pk., IL 60085

or recently-born cubs were kept warm under the shirts and sweaters of assistants until work on their mother bears was completed.

MARKING

Each released bear was marked with numbered, metal cattle ear-tags placed in the dorsal, proximal portion of each ear. Seven bears also were each marked with 1 plastic colored, numbered cattle ear tag[9], in addition to the 2 metal tags. Plastic fluorescent red, orange, green, and chrome streamers[10] 15 cm long were attached to each ear tag, using combinations of 2 colors. Radio-transmitter collars were color-coded using from 1 to 4 plastic streamers glued to the collars with epoxy or sewn on with monofilament fishing line.

STATISTICAL ANALYSIS

One-way analysis of variance (ANOVA; LaMont et al. 1977) was used to examine the difference between spring, summer, and fall (full dosage) immobilization times for bears with ketamine hydrochloride versus winter drugging (half dosage) with this analgesic. The test also was used to examine differences in seasonal use of succinylcholine chloride. Statistical tests of differences in the effects of the two drugs at full and half dosages also were made.

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[9]Nasco, 901 Janesville Ave., Ft. Atkinson, WI 53538

[10]Saflags, Safety Flag Co., PO Box 1005, Pawtucket, RI 02862

RESULTS AND DISCUSSION

CAPTURE DATA

Between 9 September 1977 and 26 January 1980, 13 female and 22 male black bears were captured; 25 were radio-collared and ear-marked, 3 were ear-marked only, and the remaining 7 were released unmarked (Appendix A-1). Six of the unmarked bears were cubs (see beyond). Fourteen collared bears were later retrapped or examined in dens (Appendix A-2). Of the 35 bears captured during the study, 26 were trapped, 20 (77%) in barrel traps, and 3 (12%) each in culvert traps and foot snares. Seven bears were trapped twice, while one was trapped 3 times.

Nine unmarked bears were initially immobilized in dens. Four recently-born cubs also were examined there but were neither drugged nor tagged. Nine bears initially captured in traps and subsequently radio-collared were later examined one or more times in dens (5 bears once, 3 bears twice, and one bear 4 times).

During 3 winters, 17 successful and 28 unsuccessful attempts were made to immobilize bears in winter dens (Table 1). Eleven different bears were successfully drugged in dens on 17 separate occasions, 10 individuals ran from dens but were not drugged on 22 occasions during our approaches, and on 6 occasions 5 bears were darted but not immobilized. Five bears were successfully approached in dens 6 times without disturbing them.

Table 1. Types and numbers of reactions for 16 denned bears in response to darting approaches, winters of 1977-78, 1978-79, and 1979-80, in the Higgins-Houghton lakes area (Crawford, Missaukee, and Roscommon counties).

Individual bears	Bear ran from den -- not darted	Bears approached closely in dens: Darted but not immobilized	Successfully drugged in den	No drugging attempted[b]
MALES				
SB	-	-	-	1
DH	1	-	-	-
LS	2	1	1	1
LA	2	1	2	-
OC	-	-	2	-
BK	2	-	1	-
LV	1	-	-	-
Go	-	1	1	-
MP	2	-	1	-
FEMALES				
Ge	-	1	-	1
ML	-	-	1	-
An	-	-	1	-
DM	4	2	2	1
Rh	1	-	-	-
Lu	6	-	1 [a]	-
Ta	1	-	4	2
TOTALS	22	6	17	6

a = captured with aid of pack of hunting dogs
b = den located, bear's condition checked

Numerous attempts to anesthetize one adult female (Lu) at the den site failed. During the winters of 1978-79 and 1979-80, she and her cubs invariably ran from the den during our approaches. On 5 March 1980, a pack of bear-hunting dogs finally was recruited to assist in her capture. The dogs were released near the den site and in 5 minutes managed to corner and later tree the animal, enabling darting.

SEASONAL IMMOBILIZATION TIMES

Spring, summer, and fall ketamine hydrochloride immobilization times (N=27) varied between 2 and 46 minutes, averaging 10.4 minutes (Appendix A-3). In winter, ketamine immobilization times (N=15) ranged from 1.5 to 45 minutes, with an average of 13.8 minutes.

The extended reaction times to ketamine hydrochloride injections ($\bar{X}$=15.6 minutes) (Appendix A-3) during January, February, and March 1980 were probably random variations, since mild winter temperatures (-9.4 to 7.2C) and lack of deep snow cover (30.5 to 45.7 cm) prevailed. In the first four 1980 drugging attempts, the recommended winter dosage of ketamine hydrochloride was insufficient to immobilize animals quickly.

To examine the difference in drugging times with ketamine hydrochloride and succinylcholine chloride, reaction times for full dosages of both drugs (spring-summer-fall dosages) were compared with immobilization times for half dosages (in winter). Based on one-way ANOVA tests to examine the relation between ketamine immobilization times at full dosage versus times at

half dosage, there was no statistical difference. When the succinylcholine chloride immobilization times at full dosage were compared with half dosage times, however, there was a significant difference (at $F_{.01}(1,9)=10.56$). Since the winter drug dosage was half the spring-summer-fall dosage, it was not known whether the decreased mean winter immobilization time was due to depressed body metabolism, increased sensitivity to succinylcholine chloride, or other variables.

Immobilization times also were tested between ketamine and succinylcholine for all seasons at both dosages, using one-way ANOVA. There was a significant difference in immobilization times between ketamine (all seasons) and succinylcholine (all seasons) (at $F_{.01}(1, 40)= 7.31$), possibly due to difficulties with injection and unfamiliarity with succinylcholine chloride. Testing winter immobilization times between ketamine and succinylcholine resulted in no significant differences, but spring-summer-fall ketamine immobilization times were significantly different than corresponding succinylcholine immobilization times (at $F_{.01}(1,32)= 7.50$).

Three of 7 bears immobilized with succinylcholine chloride during summer and fall had to be given artificial respiration, while 4 of 5 bears drugged in the winter required this. The unfortunate winter loss of these 4 bears ultimately resulted in the use of the safer drug, ketamine hydrochloride.

RECTAL TEMPERATURES

Rectal temperatures of immobilized bears (N=28) captured during the spring, summer, or fall varied between 36.67 and

40.56 C (mean=38.24 C) (Appendix A-3). For 18 bears captured in dens during the winter, temperatures ranged between 33 and 37.44 C (mean=34.73 C).

MEASUREMENTS

The measured weights of 22 males and 13 females ranged from 0.2 to 169.9 kg (Appendix A-4). Two denned bears, an adult male (LS) and an adult female (Ge) each weighed an estimated 227 kg, but were not captured during the winters of 1977-78 and 1978-79, so the estimates were based on visual observations of both in their dens. The average weight of all 35 bears at the time of their initial capture was 63.7 kg; average weight of males (N=22), 67.9 kg; average weight of females (N=13), 56.5 kg. The average weight of bears (N=16) at the time of their last recapture was 87.2 kg, representing an average increase of 23.5 kg from the time of initial capture. The average weight of males (N=13) at time of last recapture was 94.9 kg, a 27 kg average increase in weight since time of initial capture. Weight gains generally indicate normal growth and fall and winter fat index increases.

The average nose-to-tail length (tip of nose to fleshy end of tail) for 27 bears at time of initial capture was 146 cm (Appendix A-4); average male (N=17) length, 151 cm; average female (N=10) length, 137.4 cm. The average nose-to-tail length for bears (N=14) at time of final recapture was 166.4 cm, representing an average increase of 20.4 cm. The average nose-to-tail length of males (N=11) at the time of final recapture was 169.9 cm, an 18.9 cm average increase in length

since time of initial capture. Growth of marked bears appeared normal.

Ages of bears known alive as of February 1980 ranged from a few days old to 8 years (Appendix A-4). The average age of bears (N=20) known alive as of this date was 4.4 years; average age of males (N=13), 4.46 years; average age of females (N=7), 4.29 years.

The average ages of males and females known to be alive as of February 1978 (including those that died later of hunting, car-kill, drug, strangulation, or nuisance-related causes) were 2.6 years for males (N=20) and 3.09 for females (N=11). When examining only those bears later shot by hunters (legally, illegally, or nuisance animals), the average age of males (N=6) backdated to February 1978 was 2.33 years; average age of females (N=4), 3.75 years. The average age of males (N=8) that died of hunting, nuisance, and car-related causes was 3.9 years; the average age of comparable females at time of death, 5.28 years. In tentative conclusion (due to small sample size), either males were more vulnerable to hunting and nuisance elimination than females or the males were more vulnerable to later destruction because they also were more vulnerable to capture.

Michigan data reveal a disproportionate number of males than females in the population, including sex ratios of cubs (E. Harger, DNR Biologist, pers. commun.). Willey (1978) concluded that male black bears in Vermont were more vulnerable to hunting than females.

SEX AND AGE RATIOS OF CAPTURED BEARS

More males than females were captured during the study and they tended to be younger. Barrel traps captured predominantly young bears, principally males. Thirteen males (mean age=2.77 years, backdated to February 1978) were barrel-trapped, while 7 females (mean age=3.0 years, backdated to February 1978) were trapped in this manner. Two males and a female were initially captured in culvert traps. Only males (N=3) were captured in foot snares. In the Upper Peninsula, Erickson and Petrides (1964) found that culvert traps were selective toward older-aged males. Data in this study were insufficient to make statistical comparisons between groups according to methods of capture.

The sex ratio of all trapped bears (N=26) was 18♂♂:8♀♀. The mean age ratio of this same group was 2.94 years for ♂♂, 3.38 years for ♀♀ (ages determined by backdating to February 1978). The sex ratio in cubs of the year was 2♂♂:2♀♀, and in yearling cubs, 2♂♂:1♀. The sex ratio of all bears captured in traps and dens (N=35) was 22♂♂:13♀♀. The sample size was small and there was also a greater propensity of males to wander widely and presumably to encounter traps. There was only a limited basis, therefore for evaluating the sex and age composition of the captured population, and no adequate revelation of ratios in the unmarked population, although Michigan data indicate a disproportionate number of unmarked males to females in the population (E. Harger, DNR biologist, pers. commun.).

EAR TAGS

Six of the 28 ear-tagged bears (21% of the marked population) were known to have lost one or both metal cattle ear tags between time of initial capture and final recapture. Four bears lost 1 and 2 lost both metal tags. Seven bears were each successfully marked with 1 numbered plastic tag (Ge, Cl, ES, SB, DH, OM, and ML). Only one bear was known to lose its plastic tag.

CHAPTER II

RADIO TELEMETRY

The historical impacts of humans on black bears in the East were reported by Pelton and Burghardt (1976). Although no estimates of precolonial population levels were given, they concluded that the disappearance of large, protected, relatively uninhabited tracts of land was the primary reason for the decline of the black bear from precolonial population levels. They also concluded that heavy logging and the growth of human populations hastened the bear's decline, but provided no supportive evidence. Raybourne (1978) mentioned that black bears were "common" throughout Virginia in colonial times but a population estimate was not indicated. Increasing human populations and land development eliminated much of the bear's habitat he advised, so by the 1970's the bear was confined to a fraction of its former range in that state. Jonkel and Cowan (1971) reported that sheep herders and commercial trappers earlier in the century shot considerable numbers of black bears in Montana, decimating the population. Intensive logging was reported as a further threat.

Collins (1978) reported that the decline of the black bear in North Carolina was due to encroachment by man with resulting habitat loss. He related this specifically to the draining of thousands of hectares of swamps and bays, clearing and transforming this habitat into agricultural lands and areas for further human development. Pulpwood cutting, draining, chopping, clearing of large pine site areas, poaching, encroachment by man, lack of available habitat, and human disturbance were reported by McDaniel (1974a and 1974b) as responsible for the precarious state of the black bear in Florida. It was added to Florida's list of threatened wildlife in 1974.

In areas where logging has occurred and where black bear populations still exist, logging effects were discussed. Lindzey and Meslow (1977) reported effects of logging on black bears in Long Island, Washington. Bears were found to select areas logged between 1963 and 1968, over areas logged in 1935, probably because of the greater availability of berry-producing shrub species. It is important to note that these areas were not overharvested and loss of habitat due to logging was not a major factor. Timbered areas were important to bears, however, since they apparently offered security when chased by humans or by other bears (Lindzey and Meslow 1976).

Loss of habitat as a result of encroachment by humans was reported in Arkansas (Conley 1978) and in Tennessee (Conley 1978).

Streeter et al. (1979) reported that increasing needs and demands for energy, coal, oil shale and uranium mining will

continue to create sizable impacts on bears as well as other wildlife. These impacts not only included loss of habitat due to construction, but pressure from workers through hunting, poaching, snowmobiling, etc.

Comparable home range information on black bears presented in the literature included data from Michigan, Minnesota, Montana, and Washington. Erickson and Petrides (1964) stated that Michigan's Upper Peninsula bears had a minimum summer range of 15.5 km^2 and an average annual range of 38.9 km^2. By recapture techniques, they estimated home range areas of 51.8 and 25.9 km^2 for male and female bears. Rogers (1977) in Minnesota estimated ranges for mature radio-tagged females averaged 9.6 km^2; mature radio-tagged males used much larger areas that included territories of 7-15 females. Jonkel and Cowan (1971) estimated home range areas of 30.8 and 5.2 km^2 for male and female black bears in Montana. Poelker and Hartwell (1973), using radiotelemetry techniques, found that 2 male black bears in Washington occupied ranges of 82.6 and 87 km^2; average home range area of females was only 5.3 km^2, however. Amstrup and Beecham (1976) felt that the quantity, quality, and distribution of food, as influenced by topography and climate, probably set minimums on the sizes of bears' home ranges. Lindzey and Meslow (1977) felt that the differences in range sizes of bears, both within and between different regions, was likely due to differences in resource availability.

METHODS AND MATERIALS

VEGETATION COVER TYPES AND HABITAT ALTERATION

Either during or after aerial and ground tracking operations, locations of collared bears were plotted with respect to vegetation cover types. In cases where bears were tracked at close quarters, or actually seen, vegetation types were recorded. The technique for determining habitat utilization merely involved plotting bear movements or single triangulated locations through or in various vegetation, then summarizing those types used during each tracking period. The radiolocations of the 25 collared bears tracked between September 1977 and March 1980 were plotted on USGS quadrangle maps and transcribed to respective vegetation cover types.

Although the ratio of captured males to females was a disproportionate one (16♂♂:9♀♀), no adjustment was made to convert bear usage of habitat types to an even sex ratio. No attempt was made, either, to determine the amount of time each bear spent in each habitat type.

Often during continuous ground tracking, bears were approached closely (see ground tracking, beyond). Although these approaches often were made apparently without disturbing the animal, there was no way of knowing whether bears may have used certain vegetation cover types as protection or escape cover to avoid close approaches. Even though the analysis is a subjective one, an attempt was made to estimate the percentage of habitat used as escape cover by bears which fled during continuous tracking, aerial reconnaissance, and

wintertime den site approaches. Reports by the public of sightings of fleeing bears also were considered. Regardless of uncertainties, bears did indeed use these habitat types as an integral part of their ranges, in this case while attempting to avoid direct contact with humans.

In recently-cut vegetation (3-15 years), particularly along roadsides, where signs of feeding by bears were evident (scats, tracks, broken branches, downed trees, digging, etc.), vegetation types were recorded and incidence of feeding noted. Particular attention was given to the presence of the following plant species important as food sources for black bears (Martin et al. 1961): choke cherry (Prunus virginiana), pin cherry (P. pennsylvanica), blackberry (Rubus allegheniensis), blueberry (Vaccinium spp.), serviceberry (Amelanchier spp.), hawthorne (Crataegus spp.), and apple (Pyrus malus). The relative amounts of available food were estimated for each fruiting species based on the potential size of each crop (Gysel and Lyon 1980).

The vegetation in the major habitat types of the study area was classified according to the following DNR Forestry cover types: A: aspen (Populus spp.), and white birch (Betula papyrifera); C: white cedar, more than 50%; E: lowland hardwoods; G: grass uplands, weeds, bracken fern (Pteridium aquilinum), and sweetfern (Comptonia peregrina); g: lowland sedges; I: lowland balsam fir (Abies balsamea); J: jack pine; L: lowland brush: alder (Alnus spp.), dogwood (Cornus spp.), willow (Salix spp.), huckleberry

(Gaylussacia spp.), blueberry, and cranberry (Vaccinium spp.); M: upland northern hardwoods; O: oak: red (Quercus rubra) or black (Q. velutina); Q: swamp conifers; R: red pine; S: black spruce, more than 50%; U: upland brush: cherry, hazel (Hamemelis spp.), serviceberry, and willow; W: white pine; and m: marsh: submersed and emergent aquatics. Whenever a radio-tagged bear was found using or travelling through these vegetation types, locations were plotted in these cover types.

Loss of bear habitat by human encroachment, residential and commercial development, clear-cutting, land-filling, dredging, building construction, digging, etc. was noted. The approximate amounts of altered habitat were recorded.

RADIO TRACKING EQUIPMENT

Both fitted and expandable radio collars were used. Initially, collars were purchased from AVM Instrument Co., Champaign, IL 61820. Use of the expandable AVM collar was discontinued after it was found to function improperly. Following problems with premature battery failure and large collar size, smaller collars were acquired from Telonics, Inc., Mesa, AZ 85201. The signal frequencies of all collars were set between 150.8 and 151.5 MHz. Radio signals were received with 3-element Yagi antennas either on an AVM LA12 15-channel receiver or a Telonics TR-2 20 receiver. For continuous ground tracking, a Telonics hand-held, collapsible 2-element Yagi antenna (26.75 cm length, 93.5 cm receiving-boom width, 100.5 cm reflector-boom width) was most convenient. Larger AVM 3-element Yagi antennas (113 cm length, 92.5 cm receiving-boom

width, 97.5 reflector-boom maximum width) were used for aerial tracking, and were occasionally employed on the ground. One of these was mounted on the right and another on the left wing strut of the various aircraft (Super Cub, Callair A-2, or Beaver) used. On one occasion aerial tracking was conducted from a helicopter. The principal axis of each antenna was mounted at a 45° angle out and down from the body of the aircraft. A right-left switch box was used so as to receive signals from either antenna separately. Though tests were made with an 8-element AVM null-peak Yagi antenna (containing 2 4-element antennas), the 3-element Yagi was found to be equally successful.

Signals from both AVM and Telonics collar-transmitters were received at distances up to 6.3 km on the ground (average of perhaps 1.6 km) and up to 56.3 km in aircraft flying 2.4 km above the ground. Motion-sensitive radio-collars were not used in the study.

GROUND AND AIR TRACKING

During flights, radio signals from bears were located at altitudes up to 2.4 km above ground. Once a signal was located, a gradual descent was made toward the point of the strongest pulse. Finally, the aircraft circled approximately 50 m above ground in an attempt to pinpoint the animal's location by differences in pulse volume or by sight. On frequent occasions a test radio collar was placed atop the van before flight departure; then from the air, antenna reception, receiver function, and frequency drift was checked while

close to, and at increasing altitudes and distances from that transmitter.

Ground tracking was conducted from automobile, truck, van, trail-bike, snowmobile, and foot. Radio-collared bears were located by means of 2 or more radio "fixes" resulting in a "triangulated location." A fix is defined as a single azimuthal bearing taken from a known point toward the direction of a transmitting radio-tagged bear. A triangulation consisted of 2 (occasionally more) radio fixes from different points, plotted so as to determine the position of a collared bear.

Both intermittent and continuous ground tracking operations were undertaken. During intermittent ground tracking, a radio fix was obtained from a given point, the radio receiver was disengaged, and another fix was then obtained from a different point after re-activating the receiver. This resulted in a triangulation. The distance between those fixes was determined by the need to produce a pronounced angle between the first and subsequent fix or fixes. This, in turn, was affected by the distance from the bear being tracked. The sites selected for triangulation fixes were also influenced by factors such as local observable landmarks and terrain.

In order to maximize the opportunity for obtaining fixes, continuous tracking was employed. This involved the constant or nearly-constant listening to the input of radio signals into headphones or ear plugs, plotting bearings with a compass, and determining a series of mapped locations.

At the beginning of most continuous tracking operations, one or more triangulations enabled the plotting of a bear's location. Thereafter, during continuous tracking operations, triangulations were made from mapped landmarks, where possible, at least once every half-hour. Although continuous tracking usually was undertaken only with one receiver, it was felt that the acquisition of numerous radio fixes (an average of some 24 per hour) resulted in a more accurate appraisal of a bear's location and activity than did intermittent tracking. Because the interpreted input of signals was nearly continuous, it was possible to maximize the input of radio data (fixes); to obtain a more detailed, explicit understanding of bear proximity (due to signal strength and bear movement, expressed by single strength fluctuation) and to learn to interpret the accuracy, or inaccuracy of signals as affected by atmospheric (e.g. static) or environmental conditions (e.g. frequency drift due to temperature variation).

The varying qualities of the audio radio signal were used to judge the nature of bear activity, if any (Amstrup and Beecham 1976, Lindzey and Meslow 1976, 1977). A bear was considered to be moving if the signal rapidly changed in tone or strength or frequently fluctuated between strong and weak input. The use of signal quality as an indicator of activity was biased toward activity since radio interference or temperature fluctuations also might cause signal-strength changes (Garshelis and Pelton 1980).

During nearly all continuous tracking operations, a test collar was placed in the field vehicle, enabling the testing of equipment, coordination of tracking locations, and subsequent return to the vehicle following completion of continuous tracking. Also during tracking, temperature, rainfall, cloud cover, snow, and insect presence were recorded.

Often during continuous ground tracking, bears were approached closely to determine their specific locations, activity patterns, and physical condition. During summertime, approaches often could be made within sight of a bear apparently without disturbing the animal (i.e., it did not run). During a few instances, however, animals did flee or actively attempt to avoid close proximity (e.g., by circling, doubling back, etc.). During wintertime, my impact on denned or resting bears apparently was more marked. Although a machete was used frequently during den approaches, and although attempts to approach dens quietly when within approximately 0.4 km of the site, environmental conditions appeared to allow sounds to be projected further than during summertime. The requirement for additional field equipment (e.g. snowshoes, backpack, dart rifle, etc.) in winter was unavoidable, and increased noise may have contributed to some bears fleeing their dens during approaches.

SIGHTINGS OF BEARS AND THEIR SIGNS

Color markings enabled visual identifications during tracking operations. The bears were color-marked and tagged also to enable visual identification by the public and in the

hope that hunters sighting color-marked bears would spare them for research. When bear traps were being checked on the Pole Bridge Road at the south end of the Dead Stream Swamp, tracks were counted on that county dirt road. Tracks were counted also on the gas line right-of-way at the west end of the Swamp, and on roads in the Jackson's Corners area at the northeast corner of the Swamp to determine frequency of use by bears. Tracks were measured and photographed when possible. Scat locations were mapped and the droppings were examined for gross identification of food items. The locations of bear trails and clawed marker trees were logged.

HOME RANGE DETERMINATION

Burt (1943) defined "home range" as the area an animal covers in its day-to-day travels. Occasional sallies outside this area usually are excluded from calculations of home ranges (Jonkel and Cowan 1971). In this human impact study, however, calculations of home ranges were made inclusive of all travels in order to include all areas of potential impact. Where extensive seasonal travels were made by 2 bears to different habitat types, areas between fall-winter-spring and summer ranges were not included in home range calculations. Following Southwood (1966), this study employed the "convex polygon method" of home range calculation wherein only those points on the perimeter of the area were plotted which resulted in convex boundaries (as viewed from outside the area). Such convex polygon boundaries which omitted minor indentations seemed most suitable for inclusion of areas of possible impact

by humans on bears. Therefore they were used as the major emphasis of the home range portion of this study. Convex polygons also were used to determine home range shape, geographical range boundaries, and range overlap, much like the work done by Garshelis and Pelton (1981).

For purposes of comparison, home ranges also were calculated using the minimum area method (Mohr 1947, Stickel 1954). This procedure consists of connecting sites of capture and radio triangulations by straight lines, forming a polygon representative of the range, and measuring the enclosed area. In a radio telemetry study conducted on grizzlies (Ursus arctos horribilis) in the vicinity of Yellowstone National Park, Judd and Knight (1980) concluded that the minimum area home range method, of the 4 techniques they tested, provided the best representation of the grizzly's home range size, shape, and habitat preferences. The next most representative method they felt was the convex polygon one, but it appeared inflationary in the area used.

There are home range techniques other than the previous two which are, perhaps, more suitable for determining black bear ranges. The covariance matrix estimate is one such technique (which does not assume a circular home range, provides a confidence region, and is statistically unbiased) (Jennrich and Turner 1969, Alt et al. 1976) but this method was not used because radio triangulations were not coded as X and Y coordinates on the Universal Transverse Grid System (Kordek 1973) nor were locations coded on computer cards. In

some home range studies on black bears (Alt et al. 1980, Garshelis and Pelton 1981), "centers of activity" were calculated for individual animals. The center of activity is purely a mathematical concept, the center of all points at which an animal has been trapped (Hayne 1949, Harrison 1958). The calculation and use of this technique were beyond the scope of this study.

Home range calculations using both convex polygons and minimum areas were made for all bears and seasons for which adequate data were available. Where possible, home range data includes spring and summer feeding and breeding ranges, late summer and fall feeding habitats, and winter denning areas. For those bears whose signals were received over limited periods, habitat utilization and home range calculations also were included. Peripheral points for the determination of convex and minimum polygon home ranges in this study varied from few to many triangulations, capture site locations, and points of sightings. Although greater numbers of peripheral points resulted in more reliable boundary calculations, convex polygons seemed more appropriate for including areas of potential impact by humans on bears.

STATISTICAL ANALYSIS

The randomization test for 2 independent samples (Siegel 1956) was used to test the statistical significance of differences between sexes with regard to the number of vegetation types used by each sex. To adjust for sexes, the percentage that each sex used a specific vegetation type was multiplied

by the number of times each vegetation type was visited per month.

RESULTS AND DISCUSSION

RADIO COLLAR RECOVERY

Eight radio collars were either known or presumed to cease functioning while attached to bears. Four collars were found with batteries dying during the study (weakened signal, erratic pulse), 3 of which were recovered (bears DH, OM, and BK). Two collars found to be inoperative were recovered from bears shot as nuisance animals (DH above and LV), and an inoperative collar in which the battery had expanded and possibly exploded was retrieved from a female (A1) shot by a hunter. Two of the collars with inoperative batteries recovered from dead bears (OM and LV) were identified by radio frequency, since ear tags were missing from both bears, and the metal identification plate on each collar had been lost.

Twenty-three of the 25 tagged bears had radio transmitters removed by the end of the study, including the report by local residents of a collared bear (Gr) being loaded into the trunk of a car in November 1978. Two presumably inoperative collars were unrecovered (SB and Du).

Two large AVM collars that remained on bears DH and LV for 33.6 and 12.7 months, respectively, were removed. Collars caused skin erosions into the dermis around the necks of both bears. An AVM expandable collar failed to expand properly on bear BK, also causing skin erosion into the dermis around the

neck. Later attempts to remove a replacement Telonics collar fitted to this male failed, and the collar was found to have caused skin erosion around the back of the neck when the animal was examined again after being shot in September 1980. Another Telonics collar caused slight skin erosion around the neck of bear Ta. Otherwise, all bears except Ta were in excellent condition (the female had serious caries and periodontal disease problems). Bear ES, attempting to remove his collar, died of apparent strangulation as the collar was not loose enough to slip freely over his head. Two bears, however, were able successfully to remove their collars (Ge and ML).

HOME RANGES AND MOVEMENTS

Radio Fixes

Some 1,112 radio triangulations (277 aerial observations during 44 flights, 835 ground triangulations taken during intermittent and continuous ground tracking) were made on 25 collared bears between September 1977 and March 1980, enabling calculations of home ranges for those animals. A total of 297.5 hours was spent in continuous ground tracking. In addition to radio triangulations and fixes, bear positions were verified by 117 other locations representing capture sites, sightings, and kill sites. The duration of signals received from individual bears varied from 0.1 to 21.5 months.

Home Ranges

Home range areas of bears with 6 or more months of telemetric data varied from 6.0 to 308.2 km^2 using convex polygon calculations (Table 2). Home ranges for males with $\geq$ 6 months telemetric data (N=11) averaged 150.3 km^2 (range 6 to 308.2 km^2, SD=96.6 km^2); ranges for females with $\geq$ 6 months data (N=5) averaged 60.1 km^2 (range 11 to 141.3 km^2, SD=53.6 km^2). Convex polygon home ranges which were calculated for all radio-collared males (N=15) averaged 128.4 km^2; for all females which were calculated (N=8), 60.7 km^2 (Figures 3 and 4). These latter calculations excluded ranges of 2 males (BK and LA) encompassing habitat located between fall-winter-spring range and summer range, and 2 females (Rh and Lu) which both had home ranges with a calculated portion based on only 1 sighting each.

Using the minimum-area home range method, bears with 6 or more months of telemetric data varied from 3.7 to 210.5 km^2 (Table 2). Home ranges for males with $\geq$ 6 months telemetric data (N=11) averaged 101 km^2 (range 3.7 to 210.5 km^2; SD=62 km^2); ranges for females with $\geq$ 6 months data (N=5) averaged 42.7 km^2 (range 15.5 to 108.9 km^2; SD=39.9 km^2). The home ranges of all radio-collared males which were calculated (N=15) averaged 95.5 km^2; for all females which were calculated (N=5), 41 km^2.

The lengths of home ranges for bears with $\geq$ 6 months of telemetric data (N=16) varied from 4.8 to 139.7 km (Table 2). The average length of range for males with $\geq$ 6 months data

Table 2. Radio tracking, bear location, and home range data for 25 radio-collared bears captured between September 1977 and July 1979.

Bear desig.	Radio tracking record: Tracking dates	No. months radio tracking	No. hours spent continuous grnd. tracking[a]	Total no. radio trianguls.	No. aerial trianguls.	No. ground trianguls.	No. other locations (capture sites, sightings, kill sites)
MALES							
Cl	Se 77-Oc 77	0.6	-	1	1	-	3
ES	Se 77-Ma 78 b	6.0	-	5	5	-	2
SB	Oc 77-Se 78 c	11.5	1.9	24	16	8	4
DH	Oc 77-Fe 79 d	16.0	1.5	22	17	5	8
OM	Oc 77-Oc 78 e	11.9	1.0	5	1	4	2
LS	My 78-Ma 80	21.5	16.1	64	23	41	6
JJ	My 78-My 78 f	0.1	-	1	1	-	2
LA	My 78-Fe 80	20.8	20.3	70	14	56	5
Du	Ju 78-Au 78	1.7	-	9	9	-	2
OC	Ju 78-Fe 80	20.3	9.9	54	29	25	5
Gr	Ju 78-Jl 78	0.7	-	4	4	-	2
BK	Ju 78-Ma 80	20.3	17.6	53	9	44	4
LV	Jl 78-Fe 79 g	7.4	0.8	14	11	3	13
Go	Ju 79-Ja 80	7.0	42.3	118	7	111	4
Be	Ju 79-No 79 h	4.3	-	3	3	-	3
MP	Jl 79-Ma 80	8.0	12.3	43	4	39	1
FEMALES							
Ge	Se 77-Au 78 i	10.9	13.6	61	20	41	8
ML	Fe 78-Ap 78 j	2.2	-	3	3	-	3
An	Fe 78	0.2	-	1	-	1	2
DM	Ju 78-Ja 80	19.7	49.4	160	23	137	3

Table 2. (cont'd.)

Bear desig.	Tracking dates	Radio tracking record: No. months radio tracking	No. hours spent continuous grnd. tracking[a]	Total no. radio trianguls.	No. aerial trianguls.	No. ground trianguls.	No. other locations (capture sites, sightings, kill sites)
FEMALES (cont'd.)							
Al	Ju 78-Jl 80 k	1.2	-	7	7	-	6
Rh	Ju 78-Se 79	15.2	15.4	81	23	58	5
La	Ju 78-Se 78	3.1	9.8	20	7	13	4
Lu	Jl 78-Ma 80	19.3	50.8	142	21	121	5
Ta	Au 78-Fe 80	18.4	34.8	147	19	128	15

Bear desig.	Convex polygon home range estimate (km^2)	Minimum area home range estimate (km^2)	Greatest length of home range (km)
MALES			
Cl	15.5	12.8	10.1
ES	6.0	3.7	4.8
SB	130.8	86.8	18.9
DH	282.0	120.8	29.5
OM	217.6	210.5	46.7
LS	308.2	181.3	42.2
JJ	-	-	1.2
LA	137.3 1	99.1	105.4

Table 2. (cont'd.)

Bear desig.	Convex polygon home range estimate (km^2)	Minimum area home range estimate (km^2)	Greatest length of home range (km)
MALES (cont'd.)			
Du	26.9	18.2	14.5
OC	192.3	95.2	27.2
Gr	62.2	49.9	30.2
BK	120.0 l	81.8	139.7
LV	167.1	147.7	32.2
Go	63.5	55.7	14.2
Be	292.7	240.9	49.9
MP	29.0	28.4	9.0
FEMALES			
Ge	82.9	36.8	13.5
ML	2.6	2.6	5.2
An	-	-	-
DM	47.9	44.5	12.9
Al	152.8	86.0	22.8
Rh	11.0 m	7.8	5.8 m
La	29.8	25.7	10.1
Lu	141.3 m	108.9	19.6 m
Ta	17.4	15.5	6.9

Table 2. (cont'd.)

		Radio tracking record:					No. other locations (capture sites, sightings, kill sites)
		No. months radio tracking	No. hours spent continuous grnd. tracking	Total no. radio trianguls.	No. aerial trianguls.	No. ground trianguls.	
TOTALS	25	248.3	297.5	1,112	277	835	117
♂	=16	158.1	123.7	490	154	336	66
♀	= 9	90.2	173.8	622	123	499	51
AVERAGES		$\bar{X}$ = 9.9	$\bar{X}$ = 11.9	$\bar{X}$ = 44	$\bar{X}$ = 11	$\bar{X}$ = 33	$\bar{X}$ = 5
		$\bar{X}_{♂}$ = 9.9	$\bar{X}_{♂}$ = 7.7	$\bar{X}_{♂}$ = 31	$\bar{X}_{♂}$ = 10	$\bar{X}_{♂}$ = 21	$\bar{X}_{♂}$ = 4
		$\bar{X}_{♀}$ =10.0	$\bar{X}_{♀}$ = 19.3	$\bar{X}_{♀}$ = 69	$\bar{X}_{♀}$ = 14	$\bar{X}_{♀}$ = 55	$\bar{X}_{♀}$ = 6
TOTALS WITH ≥ 6 months data	16	234.2	287.7	1,063	242	821	90
♂	= 11	150.7	123.7	472	136	336	54
♀	= 5	83.5	164.0	591	106	485	36

Table 2. (cont'd.)

a = this figure represents the time spent in making ground triangulations and "continuously" received radio fixes.
b = died of apparent strangulation
c = radio battery failed Se 78; visually identified in Ju 79
d = bear shot Jl 80 while raiding bee hives; last signal received Fe 79
e = collar battery dying in Oc 78; bear car-killed Au 79
f = collar battery died shortly after installation; recaptured Jl 79 and dead collar removed
g = signal last received Fe 79; bear shot Au 79 while feeding on garbage at a Bible camp
h = bear shot illegally No 79 during deer season; last signal received early No 79
i = collar removed by bear in Au 78; bear shot Se 78
j = collar removed by bear in Ap 78; visually identified in Jl 78
k = collar battery died shortly after attachment; bear visually identified on 3 separate occasions (summer 78); shot Oc 79
l = calculation includes only that range used during summer 1979, and fall-winter-spring 1978, 1979, and 1980
m = calculation includes only range used on regular basis; a portion of total range was not included in calculation because of only 1 observation

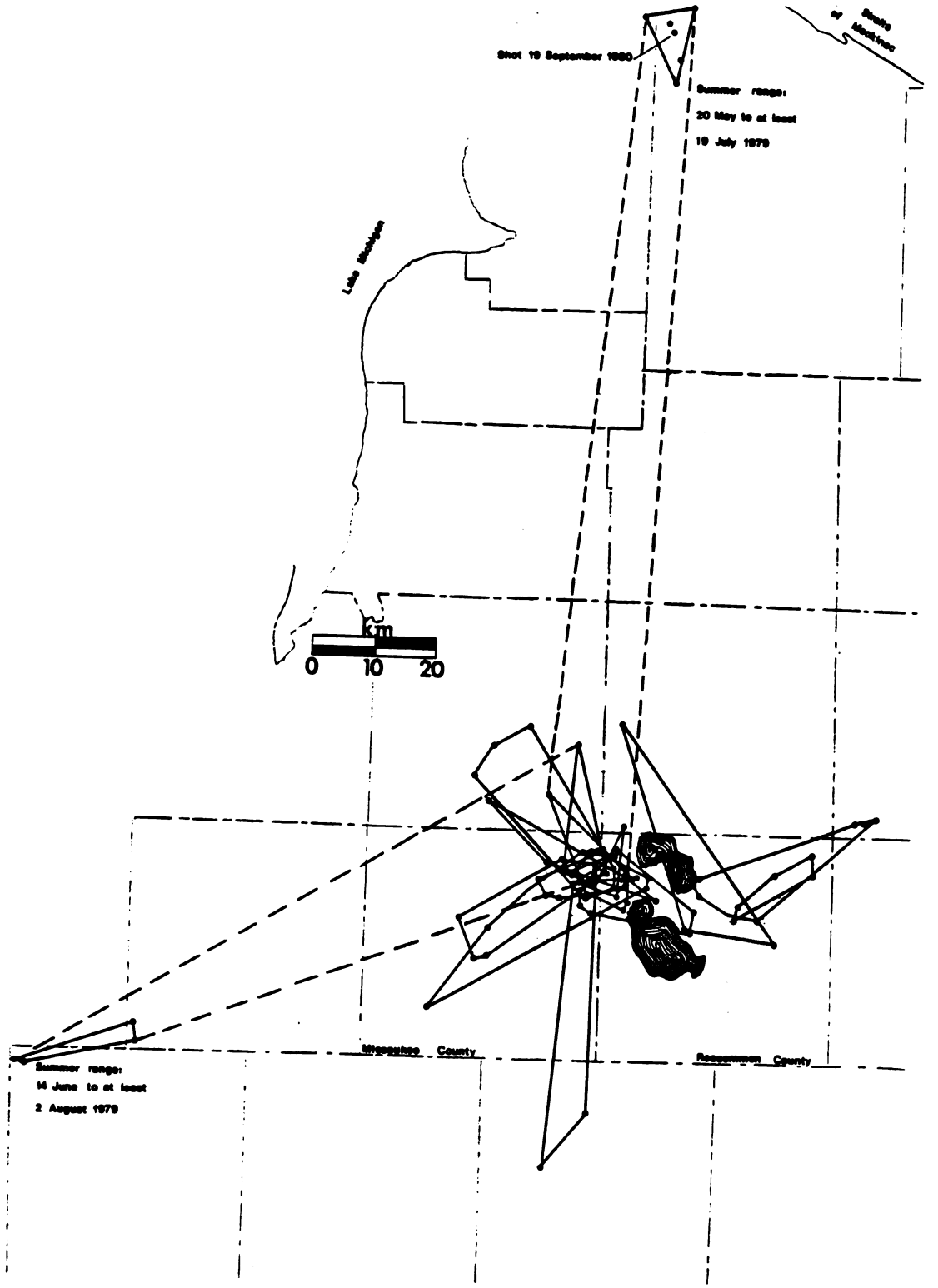


Fig. 3. Home ranges of 16 radio-tagged male bears captured between September 1977 and July 1979 in the Higgins-Houghton lakes area, Michigan. Ranges are delineated using convex polygons.

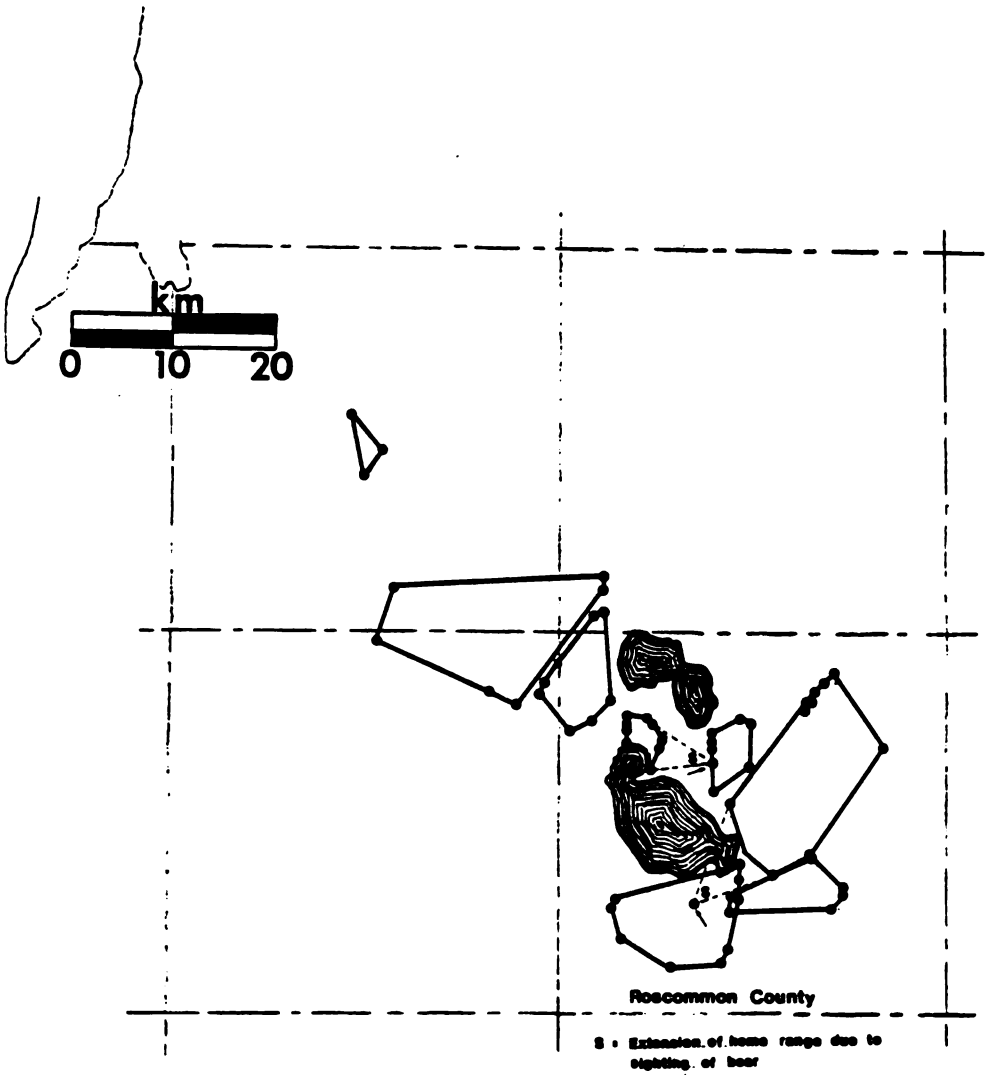


Fig. 4. Home ranges of 8 radio-tagged female bears captured between September 1977 and August 1978 in the Higgins-Houghton lakes area, Michigan. Ranges are delineated using convex polygons.

(N=11) was 42.8 km; average length of range for females (N=5), 11.7 km.

Home range calculations for bear ES, initially captured in September 1977, were calculated only through March 1978, although radio signals were received at later dates. Death of this animal appeared to have occurred by strangulation sometime in early to mid winter, as judged by its advanced state of decomposition when discovered in late June 1978. Although flights up to 28 March 1978 indicated that the bear was still in its den, 2 flights in April and 2 in May indicated that it had moved. The latter 4 flight locations were not included in home range calculations since inexperience early in the study may have led to faulty interpretation of den site locations from aircraft. Signal variation may also have increased the difficulty in locating this collar from the air. Beginning in the spring of 1978, experience with the installation of 2 antennas on the tracking aircraft led to improved capabilities of locating collared bears.

Extensive Movements and Seasonal Ranges

Six adult males, $\geq$ 3.5 years of age at the time of movement (bears BK, LA, Be, OM, LS, and LV) made seasonal treks of 140, 105, 50, 47, 42, and 32 km, respectively. The movements of BK, LA, and LS to the Straits of Mackinac area, the Manistee area, and the McBain area, respectively, occurred during the mating season. The movements of the third and sixth males, however, to the Harrison area, and Huron National Forest, respectively, occurred after the breeding season.

Hugie (1980) in Maine noted that 3 adult males moved extensively following the breeding season, returning just before denning. Rogers (1977) in Minnesota found that both males and females in late summer and early fall often left their usual ranges to exploit distant sources of seasonally abundant food. Some males and females there moved as far as 201 and 92 km, respectively, from their usual ranges; all returned for denning.

Bear BK was radio-located in the Straits of Mackinac area from 31 May until 19 July 1979, after which additional flights to this area had to be curtailed. The bear returned to the Dead Stream Swamp by 5 November 1979. On 19 September 1980 the bear was shot in the same Straits of Mackinac area. Bear LA was radio-located in the Manistee area from 14 June to 2 August 1979, flights also unavailable after this time. Bear LS was radio-located in the McBain area on 23 June 1978, but was found to have moved about seasonally from each end of his range both during and after the mating season. Bear OM was captured in October 1977 in the southwestern portion of his home range. In late October 1978 he was radio-located in the northwestern portion of his range. On 30 August 1979, the animal was car-killed in the extreme southeastern portion of his range, some 47 km distance from the previous October location. Bear Be was trapped and collared in late June 1979 in the northwest portion of his range. Between 2 and 30 August 1979, the animal was radio located west and northwest of Harrison, some 46 and 36 km, respectively, from his initial point of capture.

On 5 November 1979, bears BK, LA, and LS, along with 3 other collared bears, were radio-located within a 13 km^2 area in the Dead Stream Swamp. All appeared to have returned to the Swamp in preparation for denning. Of the 6 males, 2 (BK and LA) had seasonal summer ranges which could explicitly be differentiated from fall-winter-spring ranges (Figure 5). The former had a summer range of 36.3 km^2, using convex polygons, and a fall-winter-spring range of 83.7 km^2, while the latter had a summer range of 28.5 km^2, and a fall-winter-spring range of 108.8 km^2. It is difficult to explain the reason for extensive movements of these 2 males. Weights of the 2 bears in decreasing order of distance travelled were 65 and 82 kg, respectively. Since movements occurred during the breeding season, migrations may have resulted because of competition from more dominant males. The much larger male LS (145 kg initial capture weight, spring 1978), for example, had a home range which encompassed portions of both these male ranges. An even larger, possibly more-dominant 223 kg unmarked male was car-killed on expressway US-27 in October 1979, again in an area encompassing portions of the home ranges of the 2 males. At the time of initial capture, bear BK ranked only 17th in weight compared to the 18 adults and subadults captured during this study, while bear LA was tied (3 ways) for 13th in weight compared to the other bears (Appendix A-4). Lack of food was not likely the causative agent for movement of these 2 males since berry crops were abundant in the study area at this time.

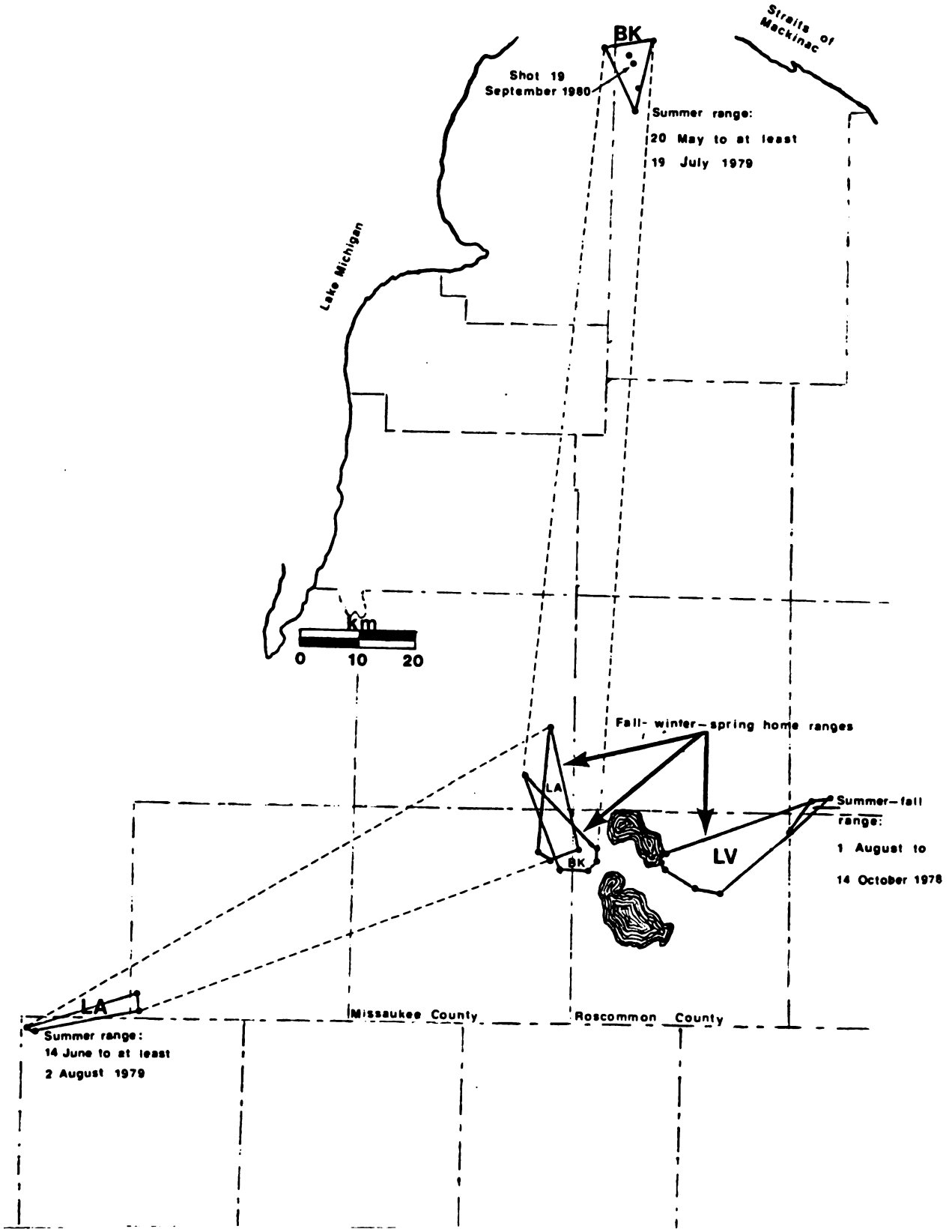


Fig. 5. Seasonal home ranges of 3 adult males, bears BK, LA, and LV, during the summers of 1978 and 1979, and the fall-winter-spring of 1978 and 1979, northern Lower Peninsula, Michigan.

The late summer-early fall home range of bear LV was different from his late fall-winter-spring range (Figure 5). Between 1 August and 14 October 1978 the animal resided in his summer home range, up to 32 km from his winter range. This bear made one apparent trip of 23 km from summer to winter range on 4 October, however, returning to summer range by 14 October. The size of the summer range was calculated to be only 6.7 km^2, but its small size probably was an artifact of insufficient data. It is difficult to explain the reason for these movements between ranges since food appeared to be less plentiful in the area of summer immigration consisting of xeric jack pine forest. These seasonal movements occurred after the mating season.

HABITAT USE BY BEARS AND IMPACTS BY HUMANS ON BEARS

Vegetation Types

In decreasing order of use (unadjusted for an even sex ratio), collared bears were located (Table 3) in the following vegetation cover types: 1) swamp conifers (Q; 312 locations of bears in this cover type; 51% males, 49% females); 2) lowland brush (L; 171 locations; 43% males, 57% females), including speckled alder, dogwood, willow, black huckleberry, blueberry, and cranberry; 3) lowland hardwoods (E; 154 locations; 50% of each sex); 4) upland northern hardwoods (M; 91 locations; 26% males, 74% females); 5) stands of more than 50% white cedar (C; 33 locations; 73% males, 27% females); 6) upland brush (U; 26 locations; 46% males, 54% females), including cherry, common witchhazel, serviceberry, and

Table 3. Sum total of monthly use of major habitat types by 25 black bears radio-tracked between September 1977 and March 1980, in Michigan's northern Lower Peninsula. Number indicates time(s) bear(s) located in each respective vegetation cover type during periods of aerial and ground tracking.

Vegetation cover type	Sex	Monthly use by bears of major habitat types: Se	Oc	No	De	Ja	Fe	Ma	p	My	Ju	Jl	Au	Row Total
	M	0	0	2	0	0	0	0	0	0	2	1	0	5
A	F	0	0	0	0	2	3	2	1	0	3	0	1	12
	M&F	0	0	2	0	2	3	2	1	0	5	1	1	17
	M	0	0	1	0	4	6	2	2	3	2	2	2	24
C	F	0	1	0	1	0	0	2	0	2	3	0	0	9
	M&F	0	1	1	1	4	6	4	2	5	5	2	2	33
	M	0	11	14	2	4	11	3	3	1	6	10	12	77
E	F	12	7	5	5	2	5	4	3	6	9	7	12	77
	M&F	12	18	19	7	6	16	7	6	7	15	17	24	154
	M	0	1	4	0	0	1	0	0	0	1	2	1	10
G	F	3	3	0	0	0	0	0	0	0	0	3	3	12
	M&F	3	4	4	0	0	1	0	0	0	1	5	4	22
	M	0	0	0	0	0	0	0	0	0	0	0	0	0
g	F	0	0	0	1	0	0	0	0	0	0	0	0	1
	M&F	0	0	0	1	0	0	0	0	0	0	0	0	1
	M	0	0	0	0	1	1	0	0	0	0	0	0	2
I	F	0	0	0	0	0	2	2	1	0	0	0	0	5
	M&F	0	0	0	0	1	3	2	1	0	0	0	0	7
	M	0	0	1	0	0	0	0	0	0	0	0	1	2
J	F	0	1	0	0	0	0	0	0	0	0	0	0	1
	M&F	0	1	1	0	0	0	0	0	0	0	0	1	3
	M	1	8	14	2	3	5	5	2	0	9	13	12	74
L	F	17	11	4	5	3	2	1	5	8	11	16	14	97
	M&F	18	19	18	7	6	7	6	7	8	20	29	26	171

Table 3. (cont'd.)

Vegetation cover type	Sex	Monthly use by bears of major habitat types: Se	Oc	No	De	Ja	Fe	Ma	Ap	My	Ju	Jl	Au	Row Total
	M	0	3	5	1	0	0	0	2	2	5	3	3	24
M	F	5	16	4	2	4	3	0	1	3	10	12	7	67
	M&F	5	19	9	3	4	3	0	3	5	15	15	10	91
	M	0	4	0	0	0	0	0	0	0	0	0	0	4
O	F	1	0	0	2	2	1	1	0	0	0	0	1	8
	M&F	1	4	0	2	2	1	1	0	0	0	0	1	12
	M	5	16	32	15	21	14	7	3	4	18	16	7	158
Q	F	14	21	16	8	8	2	5	7	13	20	23	17	154
	M&F	19	37	48	23	29	16	12	10	17	38	39	24	312
	M	0	0	0	0	0	0	0	0	0	2	0	0	2
R	F	0	0	0	0	0	0	0	0	0	0	0	0	0
	M&F	0	0	0	0	0	0	0	0	0	2	0	0	2
	M	0	0	0	0	0	0	0	0	0	0	0	0	0
S	F	1	0	0	0	0	0	0	0	0	0	0	0	1
	M&F	1	0	0	0	0	0	0	0	0	0	0	0	1
	M	0	1	7	0	0	2	0	0	1	0	1	0	12
U	F	3	1	2	2	0	0	0	1	0	4	0	1	14
	M&F	3	2	9	2	0	2	0	1	1	4	1	1	26
	M	0	0	0	0	0	0	0	0	0	0	0	0	0
W	F	0	1	0	1	0	0	0	0	0	0	0	0	2
	M&F	0	1	0	1	0	0	0	0	0	0	0	0	2

Table 3. (cont'd.)

Vegetation cover type	Sex	Monthly use by bears of major habitat types: Se	Oc	No	De	Ja	Fe	Ma	Ap	My	Ju	Jl	Au	Row Total
	M	0	0	0	0	0	0	0	0	0	0	0	0	0
m	F	1	0	0	0	0	0	0	0	0	0	0	0	1
	M&F	1	0	0	0	0	0	0	0	0	0	0	0	1
	M													394
	F													461
	M&F										Grand Total			855

Legend

A : Aspen, white birch
C : White cedar, more than 50%
E : Lowland hardwoods
G : Grass upland: grass, weeds, bracken fern, sweet fern
g : Lowland sedges
I : Lowland balsam fir
J : Jack pine
L : Lowland brush: alder, dogwood, willow, huckleberry, blueberry, cranberry
M : Upland northern hardwoods
O : Oak: red or black
Q : Swamp conifers
R : Red pine
S : Black spruce, more than 50%
U : Upland brush: cherry, hazel, serviceberry, willow
W : White pine
m : Marsh: sedges, submersed and emergent aquatics

willow; 7) grass uplands (G; 22 locations; 45% males, 55% females), including grass, weeds, bracken fern, and sweetfern; 8) aspen and white birch (A; 17 locations; 29% males, 71% females); 9) oaks (O; 12 locations; 33% males, 67% females); 10) lowland balsam fir (I; 7 locations); 11) jack pine (J; 3 locations); 12) red pine (R; 2 locations); 13) lowland sedges (g; 1 location); and 14) stands of more than 50% black spruce (S; 1 location).

Males and females varied slightly in their use of vegetation cover types (Table 3). For radio-tagged males, vegetation was inhabited in the following decreasing order of importance: Q, E, L, C, M (C and M values equal), U, G, A, O, I, R, and J (I, R, and J values equal), while for females, decreasing order of use included: Q, L, E, M, U, A, G (A and G values equal), C, O, I, W, g, J, S, and m (g, J, S, and m values equal).

Bears used 15.3 percent of the habitat they traversed as escape cover; males used 7 different cover types 43 times (5% used as escape cover), while females utilized 11 vegetation types 88 times (10.3% used as escape cover; Tables 4a and 4b). Escape attempts were classified as such only when animals were seen fleeing, appeared to be fleeing, or actively avoided the researcher or observer during continuous tracking, aerial reconnaissance, den site approaches, and observations made by local residents. In decreasing order of use, bears employed the following habitat types as escape cover (no accounting was made for bears already in some of these types before fleeing;

Table 4a. Use of various habitat cover types as escape cover by 16 bears during continuous tracking (c), den site (d), and aerial approaches (f), November 1977 to March 1980. Reports of sightings (s) of fleeing bears also are included. Initial cover type listed indicates habitat bear was in at time of sighting and/or radio location.

Bear design.	No. times fled	Cover types used during escape and/or avoidance (dash indicates movement of bear from one type to another; slash between types indicates ecotone)	Percentage of habitat types used as escape cover by each bear during tracking or sightings
MALES			
DH	1	Q(d)	4.3
LS	5	Q(c), Q-E-Q-E(d), L-E(d), E-Q(d), R(f)	23.8
LA	5	Q-L-Q(c), Q-E-L-C(d), Q(d), M(s), M(s)	21.7
OC	1	C(c)	2.0
BK	1	L/Q(d)	6.3 a
LV	1	Q-C-L-E-Q(d)	26.3
Go	4	E-L-U-L(c), Q(c), Q-L-E-Q (d), C-Q(d)	16.7
MP	1	E-L-Q(d)	9.4
FEMALES			
Ge	2	Q(c), E-L(c)	5.8
ML	1	E/Q(s)	25.0 a
DM	9	L-M-U(c), Q(c), Q(d), Q(d), Q(d), M(d), M/U(d), O-E-Q(d), M-Q(d)	23.4 a
Al	3	U(f), G-M(s), M(s)	30.8
Rh	3	E-Q(c), Q(s), L/Q(s)	9.1 a
La	1	M(s)	4.8
Lu	10	E-Q-E-L-Q-E(c), Q(c), L-Q-L-Q(c), M-L-Q-L-Q(c), Q(c), L-E(d), C-Q(d), E-L-E-A(d), Q-C-L-E(d), C-Q-g-E-G-W-Q-L(d)	31.9
Ta	8	M(c), M(c), L-Q-M-L-Q-L-Q(c) M-U-M(c), M(c), M(c), M-G-M-U-L-Q(c), E(d)	20.6

Total cover types used by males = 7
Total cover types used by females = 11
Total cover types used by both = 12

a = for purposes of calculation, vegetation types found in ecotones were treated separately

Table 4b. Use by bears of various habitat types as escape cover, November 1977 to March 1980.

Habitat type	No. times used by males	No. times used by females	Total no. times used
Q: Swamp conifers	17	27	44
L: Lowland brush, alder, dogwood, willow, huckleberry, blueberry, cranberry	9	16	25
E: Lowland hardwoods	9	13	22
M: Upland northern hardwoods	2	17	19
C: White cedar, more than 50%	4	3	7
U: Upland brush: cherry, hazel, serviceberry, willow	1	5	6
G: Grass uplands: grass, weeds, bracken fern, sweet forn	-	3	3
A: Aspen, white birch	-	1	1
g: Lowland sedges	-	1	1
O: Oak: red or black	-	1	1
R: Red pine	1	-	1
W: White pine	-	1	1
TOTALS	43	88	131

cover types within ecotones were treated as separate habitat types): Q, L, E, M, C, U, G, A, g, O, R, and W (Table 4b). Whether bears specifically selected certain vegetation types as escape cover (e.g., thick, dense vegetation) or simply fled there through convenience or random choice is unknown.

Statistical Analysis of Vegetation Use By Sex

No statistical differences between sexes (adjusted for unbalanced sex ratio of captured bears) were found for uses of vegetation types Q (swamp conifers) and E (lowland hardwoods) using the randomization test for 2 independent samples. For vegetation type L (lowland brush), however, there was a statistically significant difference in use of this type between sexes ($P<0.1$, df=22, -1.74), as well as a statistically significant difference in use of vegetation type M (upland northern hardwoods) ($P<0.01$, df=22, -3.47) and vegetation type C (more than 50% cedar) ($P<0.01$, df=22, 3.48).

Females were found to utilize upland northern hardwoods more extensively than males (67 times; 73.6% versus 26.4% for males). This was true even though there was a greater number of males in the sampled population. Use of this type was heaviest during periods of fruit and mast production (June, July, and August) and during periods of active fall weight gain (October and November). Males utilized cedar swamps (24 times; 72.7% compared to 27.3% female use). Winter concentrations of males in cedar swamps were related to denning (January, February, and March), while spring activities by

both sexes (April, May, and June) may have been related to active feeding, perhaps on carrion, sedges, tubers, etc. Females also used lowland brush more extensively (97 times; 56.7% compared to 43.3% male use). Aside from use as escape cover (16 times), females were located most in lowland brush during September, October, June, July, and August, possibly related to feeding. Males used this vegetation type as escape cover 9 times, and were likely feeding there in October, November, June, July, and August.

Human Impact

If the collared bear population was representative of other bears in the area, and if radio collars did not alter bear behavior, habitat selection and use by uncollared bears should have been comparable throughout the year. The four most heavily used and probably-critical habitat types for Lower Peninsula bears were swamp conifer, lowland brush, lowland hardwoods, and upland northern hardwoods.

The rapid increase in resident human population in the Higgins-Houghton lakes area (the Roscommon County population was estimated to double between 1976 and 1980) provides perhaps the greatest direct threat to the area bear population, due to further loss of habitat. Although much of the land in the area is presently State-owned (Figure 6), residential development continues to increase. A 40-ha wastewater treatment facility, constructed in oak uplands, was recently built between Higgins and Houghton lakes. Residential land development caused swamp and marsh habitats to be land-filled.

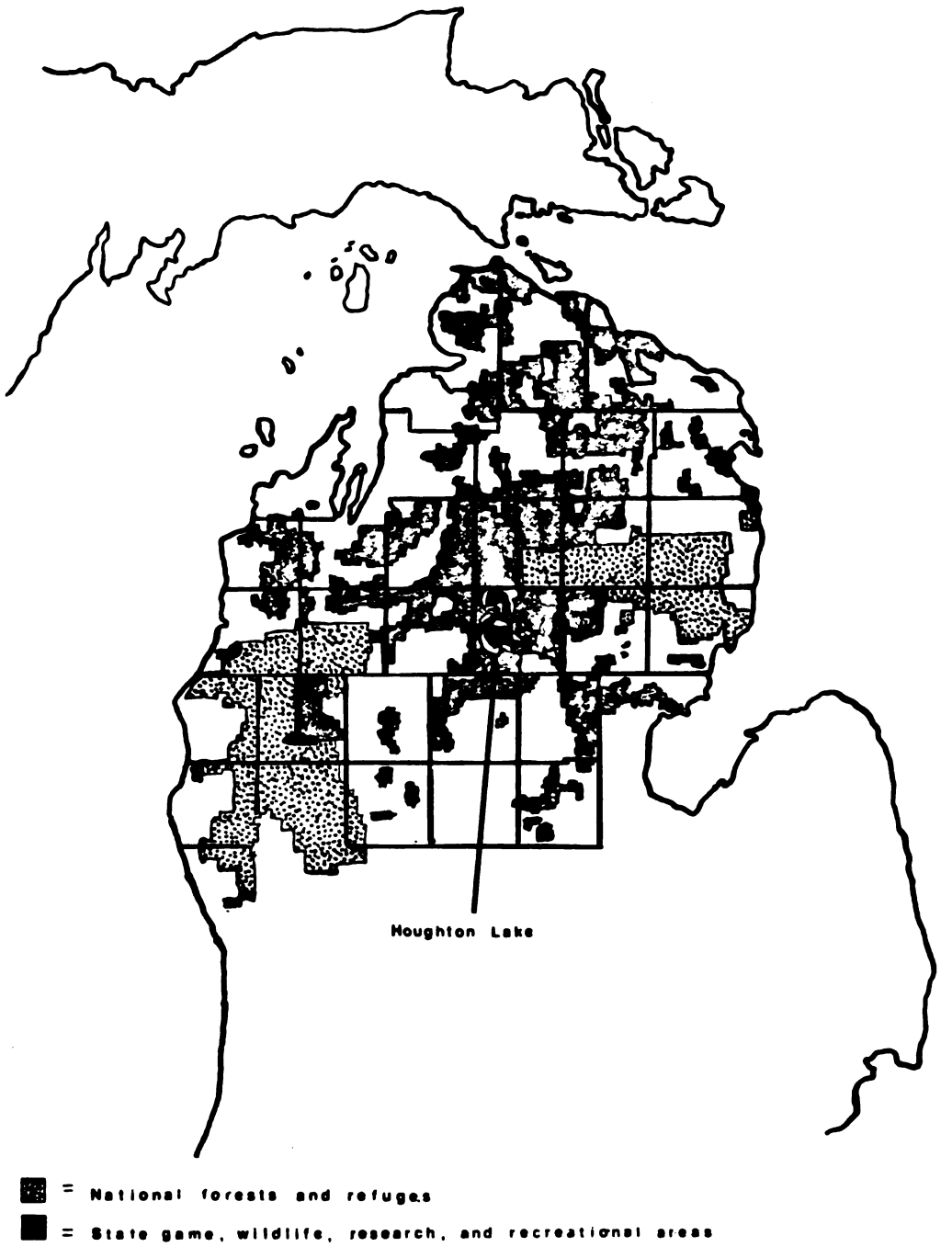


Fig. 6. State and federally-owned land in the northern Lower Peninsula, Michigan (revised from Michigan DNR public lands map, 1969).

Canals were dredged, especially around Houghton Lake. New houses were built between Houghton and Higgins lakes, in the area southwest of Houghton Lake, and north, east, and south of Higgins Lake. A large, operational gravel pit located in prime oak habitat southeast of Higgins Lake increased in size during the study. Such encroachment is depleting remaining prime bear habitat.

BEAR SIGHTINGS

Sightings by the Public

The bright, colorful Saflag ear streamers and collar markings, as well as the radio transmitter collars themselves, proved very effective for visual identification. Between September 1977 and September 1980, local residents reported seeing 16 collared and color marked, 2 ear marked (which were later identified individually) plus 5 sightings of unidentified, radio-collared bears. These 23 bears were seen and reported on 63 separate occasions (Table 5).

Ten of the sightings were made by hunters who saw the collared bears before shooting them, or by individuals who saw the animals being illegally harvested and loaded into vehicles, or who found carcasses. One car-killed bear was included in the list. The color markings did not appear to deter hunters from shooting marked bears as was previously hoped. Nine marked bears (32% of the marked population) were hunter-killed, 6 legally and 3 illegally.

Adult female Ge was seen on 6 separate occasions by a couple living south of Prudenville, Roscommon County, before

Table 5. Sightings by the public of 16 radio-collared, 2 ear-marked, and perhaps 5 unidentified collared bears. Sightings include 11 marked bears shot and 1 bear car-killed.

Sex	Year	Month sighted: Se	Oc	No	My	Ju	Jl	Au	Row totals
M	1977		1						1
	1978	2					1		3
	1979			1	1	3	3	11	19
	1980	1					5		6
F	1977	3	1					3	7
	1978	3				1	7		11
	1979	5			1		2	3	11
	1980								0
Unknown	1977								0
	1978			1		1			2
	1979		1	1				1	3
	1980								0
Column totals:		14	3	3	2	5	18	18	63

the bear was captured, marked, and radio-tagged in September 1977. Hand-feeding of cookies and bird suet may have accounted for the presence of this bear. After capture, the animal was not sighted again on the couple's property, but the following month was sighted on property adjacent to theirs. In early July 1978, the bear was observed behind a restaurant northeast of Prudenville, and later that month was seen feeding from a dumpster behind another restaurant just south of Prudenville. A fluorescent green collar and white plastic ear tag with a large red number "20" aided in identification. In late July 1978 the bear managed to remove her radio collar. The following September, she and one of her 2 surviving cubs were shot over a bait by a local resident.

Subadult male C1, captured September 1977, was shot the following October over a bait. Adult male DH, first captured in October 1977, was sighted on 4 separate occasions in July 1980 in Kalkaska County, moving during daylight hours along the Manistee River. The bear was shot 12 July 1980 while raiding a bee hive. Collar and ear tags enabled identification. Adult male OM, first captured in October 1977, was car-killed in August 1979. Ear tags were missing from the animal and the metal collar identification plate had been removed; the radio-collar was identified by frequency.

Fluorescent chrome on the collar of adult female A1, captured in June 1978, proved very effective for identification. In July 1978, the female was seen by an oil company employee as she crossed Missaukee County Road 104, in the

company of 2 other unmarked, "adult-sized" bears. The 3 stood in the road, apparently in "no big hurry." Later that month the bear was seen in Kalkaska County 1.2 km west of Military Road, but no other bears accompanied her at that time. In August, however, the female was seen on Fletcher Road, near the town of Sharon, in Kalkaska County, again with 2 unmarked "adult-sized" bears. The female was shot in Kalkaska County in September 1979.

In October 1979, a local deer bow-hunter spotted a group of 3 bears, 2 adults and a cub. The unmarked female swatted the cub with her paw, while the collared male was no further than 18 m from the cub. When the hunter, seated in a tree stand, exclaimed "boo", the collared male stood up momentarily before running away, enabling the hunter to sex him. This male with a "cream-colored collar" was never identified to number.

Adult female Rh was nearly hit by a car while crossing old US-27, Roscommon County, in July 1979. The driver, travelling approximately 67 kph, had to slam on his brakes to avoid hitting the bear. A chrome collar patch was clearly visible. In August, the bear was sighted 0.8 km west of The Cut (a river), Roscommon County, and the chrome collar was reported. The following September the animal was shot over a bait.

Adult female La, captured in June 1978, was seen wearing a brightly-colored, fluorescent orange collar behind a restaurant just south of Prudenville. Reports of the bear being

shot in September, some 4.8 km south of Prudenville, were confirmed when the transmitter was detected in downtown Prudenville. Attempts to retrieve the collar and illegally harvested bear failed as the collar was apparently dismantled by a local resident during a search by Conservation Officer C. Johnson and myself before radio location could be pinpointed.

Subadult male Ru, captured in June 1978 in Roscommon County, was shot the following September in Kalkaska County. Adult male LV, captured in July 1978, was seen 12 times over a 2-week period in August 1979 at a Bible camp in Roscommon County. The animal was finally shot while feeding on garbage.

Adult male Be, captured in June 1979, was illegally shot during deer rifle season, November 1979.

An eyewitness reported seeing a collared bear (probably adult male Gr) being loaded into the trunk of a car in Roscommon County, November 1978. No arrest was ever made.

Adult male SB was sighted in September 1978 wearing a fluorescent red collar and white ear tag in Roscommon County, along the Dead Stream Swamp. Adult female ML, with 2 cubs, was captured and radio-tagged in her den in February 1978. Although able to remove her collar while still in the den, she and her cubs were identified the following July 5.2 km from the den site. Ear tags aided in identification.

Thanks to sightings by several individuals, 2 far-ranging bears were later located from the air by radio signals. Adult male LA was first sighted 37 km west of Cadillac, Wexford County, on 14 June 1979. The following day the bear was again

sighted 2.4 km south of the previous location. Red flagging from the right ear aided in identification. In May 1979, far-ranging adult male BK was sighted at the north end of Burt Lake, Cheboygan County, immediately south of the Straits of Mackinac. The red on its collar and the red ear flagging aided in identification. On 19 September 1980 the animal was shot in Cheboygan County.

Adult female Lu was sighted on 3 separate occasions. The first probable sighting, in July 1979, involved the collared bear breaking into a dog pen, southwest of Prudenville on County Road 401, Roscommon County. In August, a lumber company employee had to brake his truck sharply to avoid hitting the collared female with a red ear streamer; 4 cubs followed her. In early September, a State patrolman had to scare a collared bear with a "red collar and cloth flagging" from his yard after the bear stood up. The location and identifying marks aided in classifying this animal.

Adult male OC was probably visually identified 1.2 km east of 7-Mile Road, Missaukee County. The description of the collar and size of the animal aided in identification.

While driving to Roscommon, DNR pilot J. Selesky sighted a collared bear with a bright fluorescent red collar crossing M-76, Roscommon County, in July 1978. It likely was subadult Du.

The small adult female Ta was sighted several times. In September 1978, a "possible yearling with blaze orange and yellow tags" (actually red and blaze orange) was sighted just

west of M-18, Roscommon County. In May 1979, a "probable yearling with red and yellow ribbons" was sighted next to The Cut, and in August and September 1979, a woman spotted a small collared bear on 4 separate occasions along The Cut.

Information on three of the collared bears was insufficient to identify them. One was sighted west of US-27 on County Road 104, Roscommon County in June 1978, another was seen in August 1979 in Missaukee County west of the Dead Stream Swamp, and a third was seen at close range, 6 to 9 m distance from a deer rifle-hunter in the Dead Stream Swamp in November 1979. The third animal was accompanied by a larger unmarked bear.

Project Sightings

During continuous tracking, I and/or my assistants saw 4 males 6 times, and 4 females 12 times. Two unmarked bears also were spotted. During 44 flights from September 1977 to February 1980, I only saw 2 different bears 3 times (a male twice, a female once) during numerous attempts to locate bears visually from aircraft.

FATES OF MARKED BEARS

Of the 35 bears captured, 28 were marked and released between September 1977 and July 1979 (Table 6); 25 were radio-collared for up to 22 months. Seventeen bears, including a family group of 3 unmarked denned animals (49% of the total captured population) died during the study, while 13 collared bears (52% of the collared population) died. Of the latter,

Table 6. Mortality causes and telemetry data for 28 black bears marked and released between September 1977 and July 1979.

Bear	Date captured												
MALES													
Cl	9	16	77	r	t	h							y
ES	9	29	77	r	t					x			y
SB	10	6	77	r	t						u	e	-
DH	10	9	77	r	t		n					e	z
OM	10	29	77	r	t				c			e	y
LS	5	15	78	r	t								z
JJ	5	23	78	r	t							e	y
LA	5	25	77	r	t								z
Du	6	13	78	r	t						u	e	-
OC	6	14	78	r	t								z
Gr	6	20	78	r	t	hi'						e	y
BK	6	26	78	r	t	h						ef	z
Ru	6	29	78	-	t	h							none
LV	7	4	78	r	t		n					e	y
Zo	7	5	78	-	t						u		none
Go	6	27	79	r	t								z
Be	6	27	79	r	t	hi							y
MP	7	3	79	r	t								z
FEMALES													
Ge	9	9	77	r	t	h							y
ML	2	7	78	r	t						u		y
An	2	23	78	r	t			d					y
DM	6	5	78	r	t								z
Al	6	7	78	r	t	h						e	y
Rh	6	15	78	r	t	h							y
La	6	28	78	r	t	hi							y
Lu	7	27	78	r	t								z
Ta	8	3	78	r	t								z
NN	6	19	79	-	t						u		none
TOTALS:		28		25	28	9	2	1	1	1	5	9	23
	♂	18		16	18	5	2		1	1	3	8	14
	♀	10		9	10	4		1			2	1	9

c = car-killed
d = died of drugs
e = collar ceased functioning before end of study
f = replaced with new collar
h = shot by hunter
i = illegally harvested
i'= probable illegal harvest
n = shot as nuisance
r = marked with radio collar
t = marked with ear tags
u = fate unknown
x = apparent strangulation
y = collar removed prior to end of study
z = collar removed at end of study

8 were shot by hunters (3 illegally), 2 were shot as nuisance animals, 1 died of a succinylcholine chloride drug problem, 1 was car-killed, and 1 died of an apparent strangulation. An ear-tagged bear also was shot by a hunter.

CHAPTER III

IMPACTS OF HUMANS ON BEARS

Since 1954, research on bears has increased tremendously. Five international conferences on bear biology and management and 6 regional conferences or workshops have been held since 1970 (Dean and Tracy 1979). In 1977, The Bear Biology Association was established. Yet the effects of human impacts on bears have only recently been examined in any detail.

McCaffrey et al. (1974) discussed bear conflicts with people in the Catskills, New York, and concluded that if the bear population there increased without suitable available habitat, human-bear conflicts would likely increase.

Hunting was listed as the greatest recent impact on bears in Pennsylvania (Alt 1978). The one-day season resulted in the record harvest of 605 bears. Because of the heavy kill, the season was closed during the following 2 years to allow the population to recuperate.

Until this study was undertaken, black bear research in Michigan had been conducted only in the Upper Peninsula (Erickson 1964a, Marks 1964, Rogers 1975, Rogers et al. 1976a and 1976b) with the exception of some early research by

Erickson (1964a) in the Dead Stream Swamp. No human impact studies specifically related to habitat alteration and hydrocarbon development had been published on the black bear in the Great Lakes region. The only published bear investigations anywhere in the United States that relate to gas and oil exploration were conducted with respect to the grizzly bear (Harding and Nagy 1980, Schallenberger 1980). Jonkel (1977a) reported 4 grizzlies using livestock grazing and oil-gas leasing areas in Montana. Fuller and Keith (1980) reported that ongoing development of the Athabasca Oil Sands in northeast Alberta was subjecting the black bear to increased human disturbance there. The effects of these disturbances, however, were not reported.

In Michigan's Lower Peninsula, Harger (1974b) stated that the greatest threat to bears was people. He believed that, as a result of overdevelopment and commercialization, people were pushing the bear out of its range.

METHODS AND MATERIALS

IMPACT CATEGORIES

The impacts of humans on bears were classified into 4 categories: positive, negative, questionable, and unknown. Positive impacts were those which appeared to benefit individual bears or the local population. Negative impacts were those determined or assumed to be detrimental to individual bears or the resident population. Questionable impacts included those in which supportive evidence was not sufficient

to objectively evaluate the impact. In the unknown impact category, supportive evidence was lacking to determine effects.

DAMAGE AND HUMAN IMPACT ASSESSMENTS

Whenever possible, persons reporting nuisance bears and property damage were interviewed. Property damage was photographed for documentation purposes. Traps, when available, were set at sites where damage had occurred. Estimates of monetary damage were acquired when possible.

Where bears were car-killed, carcasses were examined and animals checked for ear tags, dental caries, and periodontal disease. When collared bears were killed, most transmitter collars were retrieved to check function. Hunters who legally harvested tagged or collared bears were interviewed for details of the hunt.

Den site distances from human activity centers were calculated to determine possible impacts of humans on bears. A human activity center was defined as an area with daily or at least triweekly human use (e.g. snowmobiles present, vehicular traffic on state or county road, or road to an oil well, etc.) When bears were shot, the distance from the known point of harvest to the nearest improved public road (accessible with a 2-wheel drive vehicle) was calculated.

During all continuous tracking exercises, any possible impacts of humans on bears were recorded. These included: 1) the number of cars or trucks seen or heard per 10-minute period, 2) the number of trail bikes, snowmobiles, and

off-the-road vehicles (ORV's) seen or heard per hour, 3) the number of canoeists seen on The Cut, Roscommon County, 4) traffic congestion on interstate, expressway, and state highways, 5) the number of hunters seen per hour, per km of road checked, or per unit area examined, 6) the number of shots heard per hour, 7) the number of hikers seen per km or trail or per unit area, 8) the number of dogs heard barking per hour, and 9) the number of oil wells heard operating per unit area.

The one sanitary landfill in use in Roscommon County, at Nine-Mile Hill, was checked intermittently for evidence of bear activity. Track counts were conducted there on perhaps a biweekly basis.

MONITORING HUNTING IMPACT

During small game, bear (both bow and rifle), and deer (bow and rifle) seasons, service roads in areas opened to hunting were spot-checked for numbers of hunters by making head counts and counting parked cars. Bear locations were radio-plotted during the day, evening, and at night to ascertain possible hunting pressure (hunter presence and gun noise) on bear behavior and movements. During these continuous tracking periods, numbers of gun shots were logged per hour and distance of shots from researcher estimated. During nighttime tracking, the numbers of jacklighters/shiners seen were tabulated. A citizen's band (CB) radio also was intermittently monitored during bear gun season in attempts to determine hunter success, sightings, or poaching. Hunters

also were questioned over the CB during deer gun season regarding possible bear sightings. Hunters knowing the whereabouts and circumstances involved in the poaching of bears also were interviewed.

STATISTICAL ANALYSIS

The randomization test for 2 independent samples (Siegel 1956) was used to test the statistical significance of differences between sexes in several regards, including measurements of several distances and numbers of locations. To adjust for an uneven sex ratio, the percentage of each sex in the sample was multiplied by the distances or numbers of locations involved.

The Pearson product moment correlation (Sokal and Rohlf 1973) was used to determine correlations between the distance from point of harvest to an improved road, the age of a bear when shot, and the bear's estimated weight at time of harvest. Correlations were made for each sex and for the sexes combined. Product moment correlations also were employed to determine statistical relationships between numbers of shots fired during small game and deer seasons and distances moved by bears.

RESULTS AND DISCUSSION

POSITIVE IMPACTS

Changes in Hunting Regulations

1) Evidence (sightings, nuisance complaints, road kills, etc.) indicates that the bear population in the Higgins-Houghton lakes area (Crawford, Kalkaska, Missaukee, and Roscommon

counties) has increased since 1975 (E. Harger, biologist, Mich. Dept. Nat. Resour., pers. commun.). This may be a result of a change in the hunting regulations as the Dead Stream Swamp and all of Missaukee County were closed to bear hunting in 1965, and a permit system was implemented in 1969.

Bear hunting regulations for Michigan's Lower Peninsula have varied considerably over the years (MI Dept. Conserv. 1957). Prior to 1925, bears were unprotected and could be taken by any means. From 1925-1934, bears could be taken in most of the northern Lower Peninsula during deer season, 15-30 November, but trapping bears was not permitted. From 1935-1938, bear hunting during the northern Lower Peninsula deer season (15-30 November) also was permissible, but trapping and the use of dogs were prohibited. Beginning in 1937, it became lawful to take bears with bow and arrow during a special deer bow season. Between 1939 and 1952, most of the northern Lower Peninsula was open to bear hunting during deer season, while dogs and traps were allowed in Leelanau, Missaukee, and Ogemaw counties (and in Benzie County in 1939). In 1952, Otsego and Montmorency counties were open to bear hunting both during deer season and during a special fall bear season of 15 October-5 November (dogs were allowed but cubs were protected). From 1953-1958, all of the Lower Peninsula was open to bear hunting during deer season and during the special fall bear season. Between 1959-1964, the same regulations applied to the northern Lower Peninsula except that the dates of the special bear season varied (1-15 October

1959, 1-7 October 1962-63, 3-5 October 1964).

Between 1965 and 1968, all of the Lower Peninsula was closed to bear hunting. Beginning in 1969, bear hunting in the northern Lower Peninsula (except Arenac, Gladwin, Clare, Missaukee, Grand Traverse, Leelanau, and counties west and south of these) was open only to holders of bear permits (1969 permit season 10-14 September). Permit hunting has continued to the present (8-14 October 1970, 15-19 October 1971, 13-19 October 1972, 21-27 September 1973, 20-26 September 1974, etc.). And beginning in 1973, permit holders were only allowed to hunt in Roscommon County east of US-27.

Prior to closure, hunts organized by the Michigan United Conservation Clubs were conducted in the Dead Stream Swamp and surrounding area. From 1946 to 1963, 33 organized, single-day hunts (with up to 185 persons per party) resulted in the reported harvest of 16 (hunting parties successfully shooting bears during 49% of their hunts) and the reported wounding of 1 bear. Hunting was conducted almost exclusively with dogs (F. Kellum, Mich. DNR, pers. field notes). From 1939 to 1952, Missaukee County was open year-round to bear hunting. Deer hunters also hunted in this area in November, killing bears through 1964. Bears were trapped in the Dead Stream Swamp as well, and over 100 bears were taken this way between the 1930's and 1940's (E. Harger, DNR biologist, pers. commun.). Closure of hunting in all of the Lower Peninsula in 1965, elimination of the use of dogs in packs greater than 6 in 1976, the registration of dog packs in 1976, termination of non-permit

bear hunting in the Lower Peninsula, and declines in hunting pressure following permit implementation appear to have benefited the bear population.

Although bear harvest data prior to 1975 in the Higgins-Houghton lakes area were unavailable, records for Crawford, Kalkaska, and Roscommon counties were maintained by county unit regarding harvests from 1975 to 1979 (Table 7). Although harvests in the 3-county area fluctuated between 1975 and 1979, cropping did not appear to be detrimental to the population. Since an average of 11 unmarked bears were shot in the 3-county unit between 1975 and 1979, and since the average of 2 population estimates placed the "rough" number of uncaptured bears at 99 in the 3-county area during this time (see population estimation beyond), an 11% average annual harvest is well below the 15-20% that Poelker and Hartwell (1973) considered possible for sustained yield management. Furthermore, although no detailed records of sightings of unmarked bears were kept, sightings of unmarked bears were commonly reported during spring, summer, and fall 1978 and 1979. Some 23 marked bears were sighted 63 times between 1977 and 1980. The closed hunting area probably benefited the population since no legal hunting occurred there. Additional factors that might have influenced a population increase included weather conditions (e.g., a moist mild spring in 1979, and a mild winter of 1979-80) and resultant food abundance.

Table 7. Black bear kills by hunters in Crawford, Kalkaska, and Roscommon counties, Michigan, falls 1975 to 1979.

Fall of year	County: Crawford	Kalkaska	Roscommon	Total known harvest	Gun permits issued	Bow permits issued
1975	0	1	5	6	3,000	none
1976	0	3	5	8	3,000	none
1977 a	2	5	14	21	3,000	1,000
1978 b	0	8 c	5 d	13	3,000	1,000
1979 b	1	3	12 c	16	3,000	1,000

a = 1 radio-collared bear harvested.

b = 3 radio-collared bears harvested.

c = includes 1 illegal kill.

d = includes 2 illegal kills.

Service Roads as Travel Lanes

2) Track counts, scats, and radio-monitoring of 14 bears disclosed the use by bears of oil pipeline right-of-ways, oil well service roads, and lumber roads as travel lanes. Off-road use by bears, particularly swamp and forest bear trails, stream banks, and river bottoms, however, were traversed probably 95+% of the time. During periods of low human presence or activity (less than 5 persons hiking per day, no camping, no trapping, no hunting), the Pole Bridge Road, a travel lane into the Dead Stream Swamp, was used by at least 6 different bears. Yet until 1979, portions of this road were impassable to most motorized traffic, except ORV's, 4-wheel drive vehicles, and motorcycles. Following grading, the road became readily passable with 2-wheel drive vehicles. At least 5 different bears frequented an unmaintained but drivable lumber road in the northeast portion of the Swamp. Another unimproved but drivable lumber road in the same vicinity was used by at least 4 different bears.

A main pipeline right-of-way-road was traveled by at least 6 different bears during the fall 1978. A service road to an oil well was used as a travel lane by at least 4 different bears. Next to this road, a plastic and fiberglass wellhead cover was chewed and clawed by bears in October 1979. After replacement in late October, bears again damaged the cover in November. Nineteen of perhaps 30 poplars (Populus sp.) were broken by bears in the clearing around the wellhead, but only 2 of these trees were chewed by bears. Extensive digging

by bears was noted next to the wellhead. Although there were rumors that the area had been baited by oil company employees, these could not be substantiated. Chewing and clawing could have been signs of objections by bears to intrusions into their territories (E. Harger, DNR biologist, pers. commun.), but might also be a normal marking of bear territories on home ranges.

Successional Changes

3) Man-induced early plant successional states evidently have benefited bears; fruiting plant species were more abundant in areas clearcut by humans. In Roscommon County during the summer and falls of 1977, 1978, and 1979, 31 roadsides contained early plant successional species induced by mowing and/or cutting and which were fed upon by bears. Roadside-cut areas contained choke cherries, pin cherries, blackberries, blueberries, serviceberries, hawthorns, and apples that obviously had been fed upon by bears. Cherry trees had broken limbs and had been knocked over or clawed; serviceberry bushes and hawthorns were broken. Bear scats laden with cherry pits, blackberry seeds, and partially digested blueberries were found among these fruiting species. Scats were also found around hawthorn and apple trees and tracks often were present. In Missaukee County, 21 roadside areas were seen during 1977, 1978, and 1979 which contained fruiting plant species that had been fed upon by bears.

Other habitat changes which influenced the state of plant succession included commercial lumbering, clear cutting for

deer management, controlled burns for Kirtland's warbler (Dendroica kirtlandii) management and construction of new service roads to oil wells. Between January 1970 and July 1978, an estimated 2,776,334 cords of timber were cut in the northern Lower Peninsula (Region II). During this same period in Region II, approximately 31,716 ha of habitat were cut for game (mostly deer) management. Between January 1973 and July 1978, 4,109 ha of habitat were burned, mostly for Kirtland's warbler habitat improvement (N. Hussain, Mich. DNR For. Div., pers. commun.). In the northwest sector of the Dead Stream Swamp, Missaukee County, 8 new service roads to oil wells alone were constructed between 1978 and 1979.

Apiaries

4) Bee-keeping provided bears with additional, supplementary foods. Damage to hives was extensive; 14 of 46 (30%) bear nuisance or damage complaints reported between September 1977 and July 1980 involved damage to bee hives. In Missaukee County, for example, apiarists maintained at least 1,000 hives in the field in 1980. Yet between May 1975 and September 1980, one bee keeper completely lost 63 hives to bears ($6,300 investment) while 200 other hives were knocked over and partially damaged. In the past 12 years, bee keepers in Missaukee County have lost 230 hives to bears (estimated $23,000 loss) (D. Byrne, apiarist, pers. commun.). Clearly, the impact of humans on bears from a supplementary food standpoint has been positive. The reverse effect on bee keepers, though, has been economically serious.

NEGATIVE IMPACTS

Loss of Habitat

1) The greatest threat to bears in the study area was loss of habitat due to human encroachment. Swamps were landfilled for residential and commercial development in the Prudenville (east-south-east end of Houghton Lake) and North Shore areas between 1977 and 1980, decimating approximately 40 ha of prime bear habitat. Two collared bears (females Ge and Lu) used this swamp, as did an unmarked bear (sighted on a paved road by a state patrolman) which was suspected of harassing dogs in Prudenville (C. Varner, DNR Cons. Off., pers. commun.). More significantly, construction of pipe and pumping facilities for wastewater treatment around Houghton Lake resulted in the loss of several hundred hectares of swamp habitat. The construction of a 40-ha wastewater treatment facility, dug in an oak upland, eliminated part of a prime feeding area for bears. Another wastewater treatment facility, already in use southwest of Houghton Lake eliminated some 50 ha of abandoned farmland. A 16-ha gravel pit between Higgins and Houghton lakes, situated in oak and northern hardwoods uplands, continued to increase in size, disrupting potential denning and feeding areas. Residential development continued to increase in the Houghton Lake area, especially along the north and northeastern shores of the lake.

Recreational activities were encouraged at Houghton Lake, particularly by subscribing members of the Houghton Lake Chamber of Commerce. These included 46 motels, 40 of which

were open year-round, 3 trailer parks, 3 recreational areas, 14 restaurants, 8 food and beverage stores, 7 sporting goods stores, and 75 businesses and professional services (Houghton Lake Chamber of Comm. 1980). Numerous other non-subscribing establishments also were present, but not included in this count. Two motels and 2 State public campgrounds were located on the shores of Higgins Lake.

Highways

2) Heavy traffic on 3 State highways restricted movements of 4 females, marking their home range boundaries. Heavy southbound traffic on US-27 restricted movement of subadult female DM in September 1978. Radio-locations from distances as close as 0.3 km indicated that the bear moved south 0.5 km parallel to the highway, then turned north 0.2 km, again moving parallel to the highway before moving west-northwest away from US-27, the eastern boundary of her home range. US-27 also marked the western boundary of adult female Rh's home range, and heavily traveled M-55 delineated the northern boundary of adult female La's home range. M-18 marked the eastern home range boundary of the fourth adult female Ta. Apparently, however, the movements of male bears were not blocked by major highways as they readily crossed them. Adult male OM was car-killed while crossing I-75. Eight unmarked bears were reported hit by cars in the study area and 7 were killed.

Service Roads Aiding Hunting

3) Bear hunting was likely aided by service roads to oil wells. Hunting pressure on bears was heavier in areas that contained extensive service road systems. These areas provided easy access and with citizen band (CB) radio contact between hunters, chances of shooting a fleeing bear were enhanced. Access, however, appeared to be more significant than CB radio use (E. Harger, Biologist, Mich. DNR, pers. commun.).

Few data are available (Table 8) but the average distance from the nearest all-weather road to the points of harvest for 9 marked bears was 0.46 km. The average distance from a road to point of harvest for males (N=5) was 0.59 km; for females (N=4), 0.30 km (Table 8).

Results of the randomization test for 2 independent samples indicated no significant difference between sexes regarding the distance from point of harvest to the nearest improved road. The Pearson product-moment correlation used to determine relationships between distance from point of harvest to improved road (hereafter referred to as "distance"), between age when shot, and between estimated weight at time of harvest resulted in 2 negative correlations. The negative correlation between distance for both sexes and respective ages for both sexes was significant ($r=-0.63$, $P<0.1$, $df=7$, 0.582); a negative correlation between distance for both sexes and respective weights was also significant ($r=-0.70$, $P<0.05$, $df=7$, 0.666). These data indicated that as the ages and weights of males and females together increased, the distances from point of harvest

Table 8. Distance bears were shot from nearest light duty road with an all-weather improved surface, drivable with a 2-wheel drive passenger vehicle, Oct. 1977 to Jly. 1980.

Bear	Distance shot from nearest road (km)	Age when shot (yrs)	Estimated weight at time of harvest (kg)
MALES			
Cl	0.96	2.75	90.6
DH	0.25	5.5	135.9
Ru	0.80	1.75	67.4
LV	0.01	4.63	142.2
Be	0.91	3.88	61.2
FEMALES			
Ge	0.08	6.75	135.9
Al	0.84	4.75	78.2
Rh	0.10	4.75	79.3
La	0.17	3.75	90.6

$\bar{X} = 0.46$

$\bar{X}_{♂} = 0.59$

$\bar{X}_{♀} = 0.30$

to nearest improved road decreased, suggesting decreased fear and/or increased tolerance of man with greater bear age and weight.

Hunting and Related Gun Impacts

4) The impact of hunters on marked bears proved to be significant to the detriment of the animals involved. Of 28 animals marked (25 radio-tagged), 11 (39%) were shot. Three were shot over baits, 1 was shot as a nuisance over garbage, 1 was shot as a nuisance while destroying bee hives, 2 were shot by hunters using dogs, 1 was taken only with a gun, and the harvest technique for 3 illegally-shot bears was not known. Colorful collar and ear markings appeared to make marked animals more vulnerable to hunting, since 9 bears were shot by hunters (not including 2 nuisance-killed animals; 32% of the marked population hunter-killed) between 1977 and 1980. This rate of kill occurred while during this same period, 16.7, 17.4, 18.2 and 10%, respectively, of the marked (ear-tagged) population known or suspected of being alive each year were shot by hunters. A 39% harvest during this study (including 2 nuisance-shot bears) was a sizable loss in the marked population since, in contrast, an average of 11% of unmarked bears was shot in Crawford, Kalkaska, and Roscommon counties between 1975 and 1979 (Table 7). With 11 unmarked bears shot, a "rough" population estimate of 99 bears for these counties would indicate an 11% average annual harvest of unmarked bears (see population estimation beyond).

Hunting females accompanied by cubs is legal in Michigan while shooting cubs of the year is not. Of the 4 females (Ge, Al, Rh, and La) shot between fall 1978 and 1979, 2 (Ge and Rh) were shot in the company of 2 and 3 cubs, respectively. One of the cubs of the former female was also shot and later tagged as a legal kill.

Den Approaches

5) My impact on denned bears often was negative; 48.9% of the time when attempting to examine bears in dens, they fled the site before I actually arrived. Forty-five attempts were made to immobilize bears in dens. One bear (LS) ran in conditions as cold as -28.9 C and with as much as 1.22 m of snow on the ground. Where data were recorded, 5 marked bears ran from dens in temperatures between -9.4 and -12.2 C, with from 0.61 to 1.2 m of snow on the ground; 2 bears ran in temperatures of -6.7 and -8.9 C, with 0.3 to 0.9 m of snow; 5 ran in temperatures of -3.9 to -6.1 C, with 0.05 to 1.2 m of snow; and 3 ran in temperatures of -2.2 to -3.3 C, with 0.3 to 1.1 m of snow. These observations included marked bears that ran from dens more than once. Of the 10 animals that fled their dens 22 times, 82% left before being sighted, but usually were heard escaping through the brush. These evasions were made while I was only 70 to 125 m from the den sites. Bears probably heard and/or smelled me before fleeing. Only 4 bears on 5 occasions were successfully approached in dens, were not drugged, and did not flee. The requirement for additional field equipment (snowshoes, machete, backpack,

dart rifle, etc.) caused undesirable but unavoidable noise. These noises may have contributed to the flights of some bears. The wariness of bears under cold, snowy conditions was greater than had been expected.

QUESTIONABLE IMPACTS OF HUMANS ON BEARS

Den Sites and Human Activity Centers

1) The average den site distance from a human center of activity (area with daily or at least triweekly winter human use; Table 9) was classified under the questionable category of human impact on bears. The average distance for males in dens from a center of human activity was 1.26 km (N=10, range 0.16 to 2.74 km); for females, 0.55 km (N=7, range 0.01 to 1.17 km); for both sexes, 0.94 km. There was a statistically significant difference between sexes regarding the average distance of dens from centers of human activity ($P < 0.01$, df=15, 2.951) using the randomization test for 2 independent samples. Females (even those with cubs) tended to den closer to centers of human activity than males. This may have been due, in part, to the selection by females of upland den sites which were closer to centers of human activity than the swamp sites selected by males.

Sanitary Landfills

2) The closure of most sanitary landfills, and the centralization and proper maintenance of dumps in the Higgins-Houghton lakes area affected bears questionably, possibly negatively impacting them. At least 6 bears appeared to feed

Table 9. Total number of dens used, average number of dens per winter, distance of dens from centers of human activity, and average distance of dens from centers of human activity for bears in Michigan's Lower Peninsula, winters of 1977-78 to 1979-80.

Bears desig.	Winter den used (years)	Total number of dens used	Average number of dens per winter	Distance (km) of den sites from center of human activity	Average distance (km) of den sites from center of human activity
MALES					
ES	77-78	1	1	1.53	1.53
SB	77-78	1	1	2.57	2.57
DH	77-78	3	3	2.74, 1.24, 0.42	1.64
	78-79	3		0.98, 2.38, 2.11	
LS	78-79	3	2	1.32, 1.43, 2.11	1.26
	79-80	1		0.16	
LA	78-79	3	3	0.15, 1.0, 2.2	1.11
	79-80	3		1.45, 0.72, 1.11	
OC	78-79	2	2	0.8, 1.71	1.13
	79-80	2		0.48, 1.51	
BK	78-79	1	1	0.56	1.09
	79-80	1		1.63	
LV	78-79	1	1	0.51	0.51
Go	79-80	2	2	0.49, 0.65	0.57
MP	79-80	1	1	1.29	1.29
FEMALES					
Ge	77-78	2	2	0.38, 0.24	0.31
ML	77-78	1	1	0.68	0.68

Table 9. (cont'd.)

Bears desig.	Winter den used (years)	Total number of dens used	Average number of dens per winter	Distance (km) of den sites from center of human activity	Average distance (km) of den sites from center of human activity
FEMALES					
An	77-78	1	1	0.51	0.51
DM	78-79	5	4	0.14, 0.14, 0.85, 0.01, 1.11	0.47
	79-80	3		0.56, 0.15, 0.82	
Rh	78-79	2	2	0.61, 1.06	0.84
Lu	78-79	2	3	1.04, 0.68	0.5
	79-80	4		0.32, 0.23, 0.34, 0.37	
Ta	78-79	1	1.5	0.37	0.84
	79-80	2		1.17, 0.98	
TOTALS	17	51	AVERAGES	$\bar{X}$ = 0.94	
	♂ = 10	♂ = 28		$\bar{X}_{♂}$ = 1.26	
	♀ = 7	♀ = 23		$\bar{X}_{♀}$ = 0.55	

at a landfill in northwest Roscommon County, and after its closure in 1978, only 1 other landfill remained open in the County. Two bears were eventually captured at this new landfill in 1978 and track counts and triangulations in 1978 and 1979 indicated that possibly no other bears were using the site. Nuisance complaints in the study area increased from 6 during the fall 1977, to 9 in 1978 and to 22 in 1979. These dropped to 9 in 1980 but were tallied only through July. Food was plentiful in the study area during spring, summer, and fall 1979 (carrion, berry crops, acorns, etc.). Questions arise: were dump closures responsible for the increase in nuisance and damage complaints in 1979, were nuisance complaints due to population increases, or were the statistics only circumstantially correlated?

Small Game and Deer Gun Hunters and Recreational Activities

3) The effects of small game and deer gun hunters, jacklighters, trail bikers, canoeists, and ORV's on bears were generally questionable. Five bears moved 10 times ($\bar{X}$ = 1.50 km, range 0.5 to 5.06 km) possibly due to disturbances caused by nearby gunshots (N=9) or loud 2-cycle trail bikes (N=1) as bears appeared to move immediately or shortly after the disturbances. A Pearson product moment correlation was conducted between the number of shots fired during continuous tracking per unit area (or trail bike noise), and between the movement of bears from previous locations as an apparent result of disturbances. The result was not statistically significant.

The movements of 5 bears (SB, Rh, DM, Lu, and Ta) were monitored in September 1978, while movements of 3 (Rh, Lu, and Ta) were followed in September 1979, 4 (DM, Go, Lu, and Ta) in October 1979, and 8 (DM, MP, Go, LA, BK, LS, Lu, and Ta) in November 1979 to assess the impacts of small game and deer gun hunters on bears. All 9 bears tracked during the hunting seasons were located in swamps 33 times during the day; 6 were located 8 times in upland and lowland habitat. During evening hours, 7 bears visited apparent feeding areas (upland and lowland hardwoods, upland shrubs) 19 times, while 7 bears (5 from the previous group) remained in swamps 19 times. Three bears moved into swamps 7 times during evening hours. It would appear that hunter-related disturbances (23 jacklighters seen in October 1979, 70 some hunters and numerous gun shots detected in November 1979) may have resulted in bears spending the majority of their time in thick, protective swamps during daylight, then moving out into more open feeding areas at night. In some cases, perhaps when disturbances occurred in the evenings, bears remained in or retreated into swamps. In only one case, however, was evidence conclusive that bear LA moved along the edge of the Dead Stream Swamp, rather than continuing to follow an abandoned railroad right-of-way, in order to avoid some 12 deer gun hunters, and perhaps 5 gunshots heard in the immediate vicinity.

The noise from a party of canoeists and a loud ORV at The Cut Bridge in September 1979 may have forced female Ta to avoid the immediate area.

UNKNOWN IMPACT OF HUMANS ON BEARS

Hydrocarbon Development

1) The total effects of oil wells on bears during this study were uncertain. Oil well development and related road construction in the mid to late 1940's had opened up the area to hunters with a resultant decline in the bear population (E. Harger, DNR Biologist, pers. commun.). During this study, six adult males were located 0.09 to 0.3 km from active oil wells whose exhausts were audible up to 2.4 km or more. Adult male LA denned within 0.16 km of an active well in December 1978, easily within hearing distance of the exhaust, but moved into a cedar swamp out of the oil field in January 1979. Adult female DM was radio-tracked 6 separate times close to different oil wells (0.11, 0.16, 0.16, 0.16, 0.21, and 0.39 km distance). Whether the noise and the H_2S odor indeed bothered bears, or whether they learned to acclimate to these disturbances was unknown.

Snowmobiles

2) Females Ta and DM denned extremely close to actively-used snowmobile trails, 0.07 and 0.09 km, respectively. The first bear remained in her 1978-1979 den all winter, even though snowmobiles passed within 70 m of the den. The second female stayed in her den during periods of snowmobile activity in December but moved in late December when I attempted to anesthetize her at night.

Loss of Fear of Humans by Bears

3) Contact between humans and bears may have resulted in some bears partially losing any fear of people that they once possessed. In this study, there were 63 sightings of marked bears and numerous sightings of unmarked animals. Increased nuisance complaints, particularly of animals threatening or scaring humans (N=18 complaints) may have resulted from loss of fear of humans.

The behavior of several marked bears was reported as being "very bold". Female Ge placed her paws on a large picture window, and was hand fed suet and cookies. Female Al stopped in the middle of the road when sighted by an oil company employee. Female Lu was seen breaking into a dog pen, eating dog food, later was almost hit by a lumber truck while walking across a highway, and was seen by a State patrolman who had to frighten the bear from his yard.

Male LV visited a Bible camp for nearly 2 weeks, frightened campers, and walked in front of the spotlights by the main lodge. Female Ta was radio-triangulated next to a public golf course and near a group of trail bikers, while a large unmarked male extensively damaged 3 cabins, frightening the residents in the process. An unmarked bear frightened a deer hunter who yelled at the animal without scaring it, and another unmarked bear possibly harassing dogs was seen by a State trooper walking down a street in Prudenville "bold as brass" (C. Varner, DNR Cons. Off., pers. commun.).

RESEARCH IMPACTS

Tight-fitting radio-collars caused neck wounds and infections in a few animals. Unfortunately, at the time this study was initiated, breakaway radio-collars had not yet been perfected. Unexpected premature battery failure occurred among several of the first group of AVM collars used and made it impossible to locate the denned bears for collar replacement. Three of these bears were eventually either recaptured (JJ), shot (LV), or car-killed (OM) but two collars were never retrieved (SB and Du). Radio collars were found to cause skin erosions on the necks of LV, DH, BK, and Ta. A collar fitted too loosely but not sufficiently loose to slip completely over the animal's head resulted in the apparent strangulation of bear ES.

INDIVIDUAL BEARS AND THEIR PROXIMITY TO HUMANS AND HUMAN DEVELOPMENT

Bears were radio-tracked near, next to, or in areas of human development on numerous occasions (Table 10). Two females denned close to snowmobile trails ($\bar{X}$=0.09 km) while 2 males denned close to active oil wells ($\bar{X}$=0.32 km). Nine males were radio-located close to oil wells ($\bar{X}$=0.26 km) 24 times; 2 females were located near oil wells ($\bar{X}$=0.22 km) 10 times. Six males were radio-triangulated near houses ($\bar{X}$=0.3 km) 10 times; 7 females were located near houses ($\bar{X}$= 0.21 km) 22 times. Two males and 1 female were located near the Roscommon County Airport ($\bar{X}$=0.28 km), 2 females were tracked near gravel pits ($\bar{X}$=0.23 km), 2 males and 2 females

Table 10. Bear proximity to humans and human development, northern Lower Peninsula, September 1977 to September 1980.

Bear	Average den site distance (km) from snowmobile trail	Average den site distance (km) from active oil well	Number times bear located next to house(s)	Average distance bear radio-located from house(s) (km)	Number times bear located next to active oil well(s)	Average distance bear radio-located from active oil well (km)	Average distance bear radio-located from public airport (km)	Distance bear radio-located from actively used gravel pit (km)	Average distance bear radio-located from town or resort (km)	Average distance bear radio-located from sanitary landfill(km)	Number towns, residential communities, and resorts in bear's home range	Total times bear located near or next to houses, active oil wells, an airport, a gravel pit, a golf course, sanitary landfill, or town/resort
MALES												
SB					1	0.27	0.32			0.24	5	5
DH					3	0.31			0.88		3	7
LS			4	0.25	1	0.18					2	5
LA		0.15	2	0.49	1	0.15					2	3
Du					2	0.19				0.14	1	3
OC		0.48	1	0.56	4	0.32					3	5
Gr											0	0
BK					2	0.24				0.15	4	4
LV			1	0.02					0.02	0.14	5	14
Go					6	0.20					0	6
Be											1	0
MP			1	0.39	4	0.36					0	5
OM			1	0.06		0.16					6	2
FEMALES												
Ge			3	0.31					0.29		1	4
DM	0.1		3	0.35	7	0.22					0	10
Al			1	0.4	3	0.22					1	4
Rh			2	0.13				0.29			1	4
La			1	0.05							0	1
Lu			7	0.14							5	7
Ta	0.07		5	0.18			0.31	0.16	0.08		0	11
$\bar{X}$	-	-	2.5	0.24	3.1	0.25	0.28	-	0.22	-	2.0	5
$\bar{X}_{♂}$	-	0.32	1.7	0.3	2.7	0.26	0.27	-	0.45	0.16	2.46	4.5
$\bar{X}_{♀}$	0.09	-	3.1	0.21	5	0.22	0.31	0.23	0.12	-	1.14	5.9

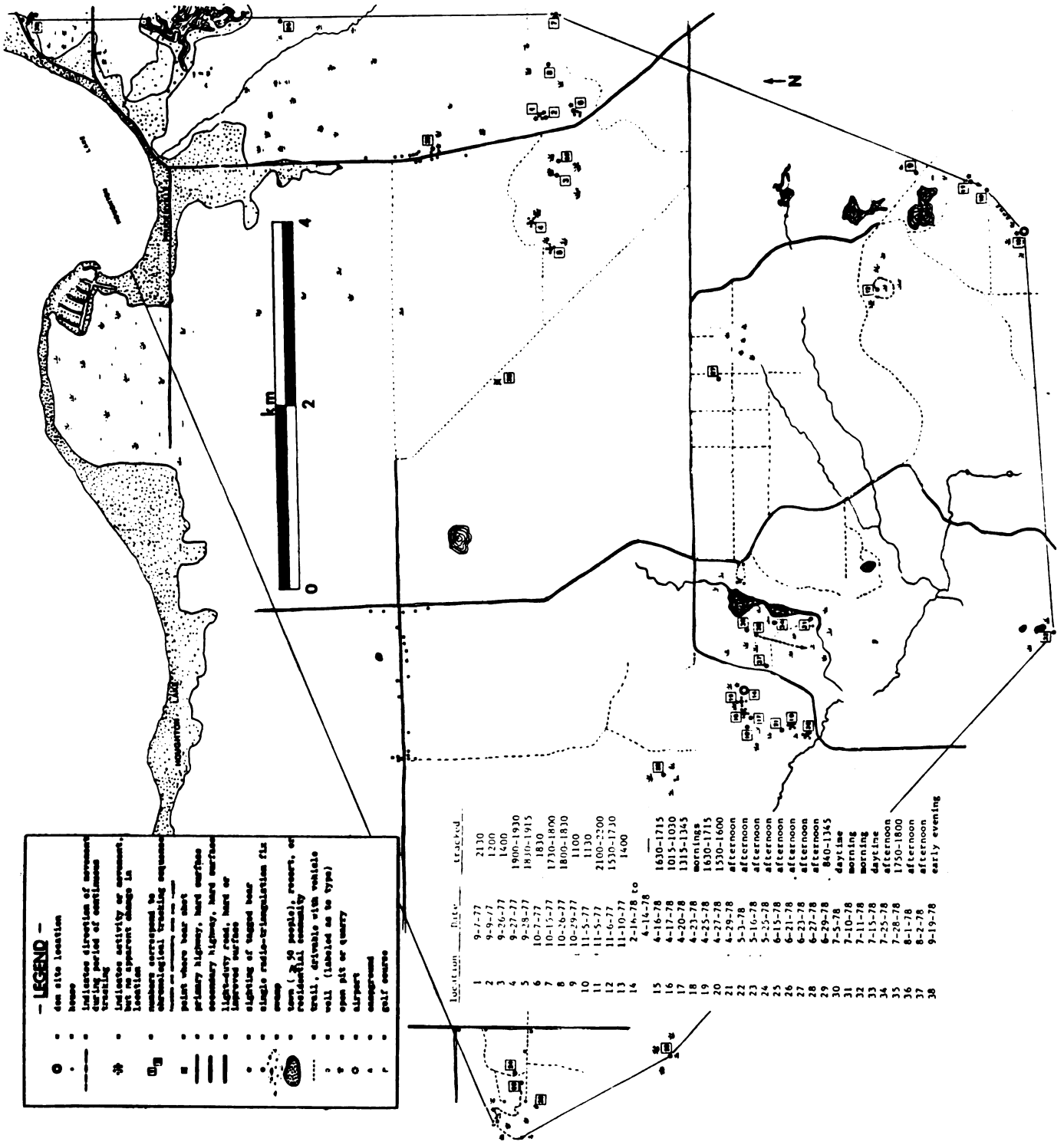


Fig. 7. Home range boundary of female bear Ge, chronological sequence of radio-locations in numbered order, and areas of human development within her home range.

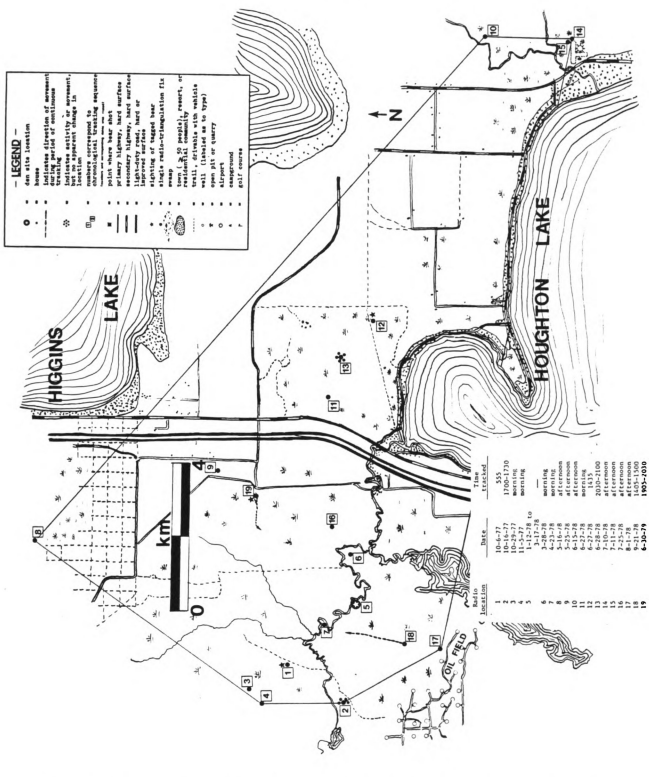
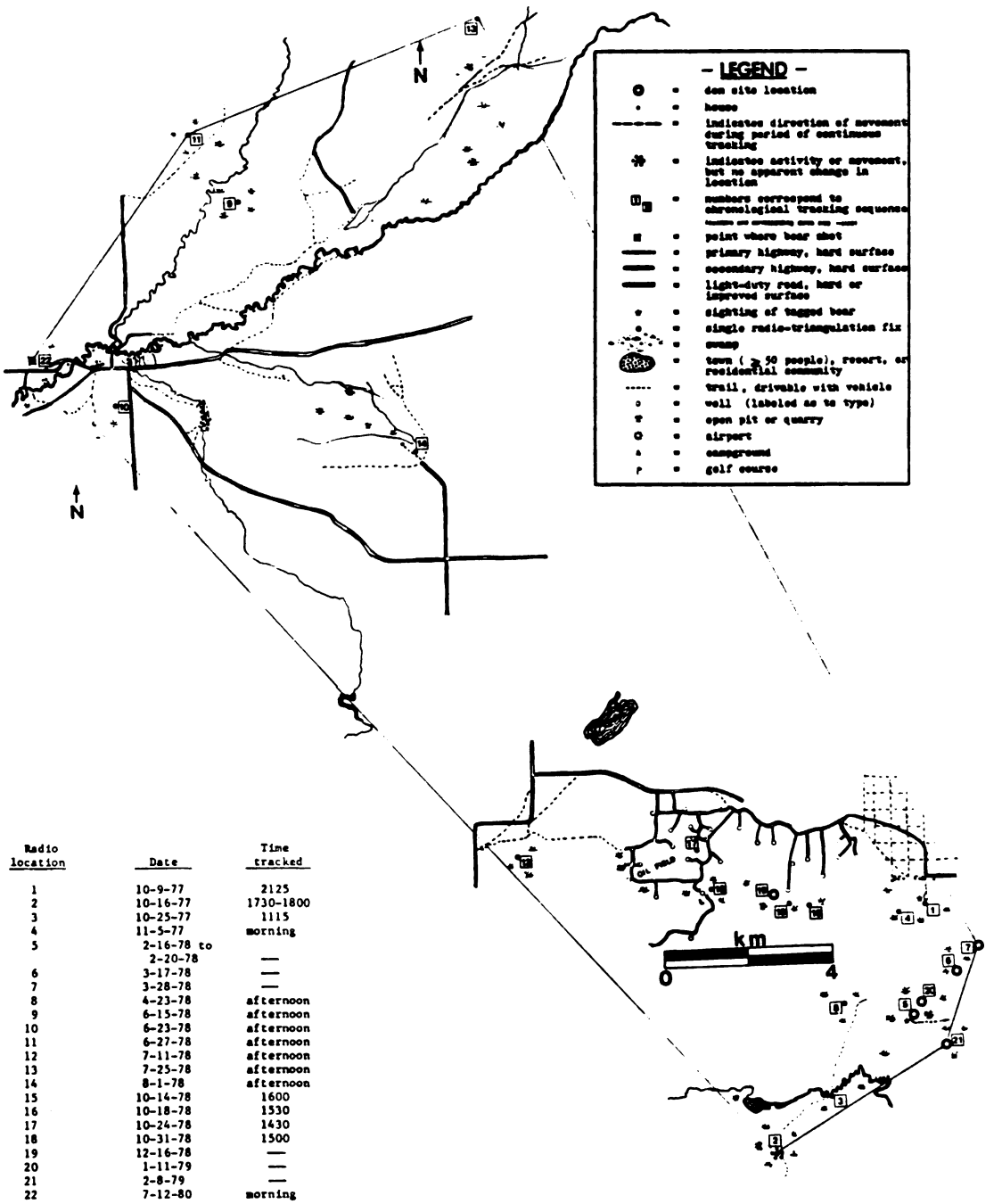


Fig. 8. Home range boundary of male bear SB, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.



Radio location	Date	Time tracked
1	10-9-77	2125
2	10-16-77	1730-1800
3	10-25-77	1115
4	11-5-77	morning
5	2-16-78 to 2-20-78	—
6	3-17-78	—
7	3-28-78	—
8	4-23-78	afternoon
9	6-15-78	afternoon
10	6-23-78	afternoon
11	6-27-78	afternoon
12	7-11-78	afternoon
13	7-25-78	afternoon
14	8-1-78	afternoon
15	10-14-78	1600
16	10-18-78	1530
17	10-24-78	1430
18	10-31-78	1500
19	12-16-78	—
20	1-11-79	—
21	2-8-79	—
22	7-12-80	morning

Fig. 9. Home range boundary of male bear DH, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.

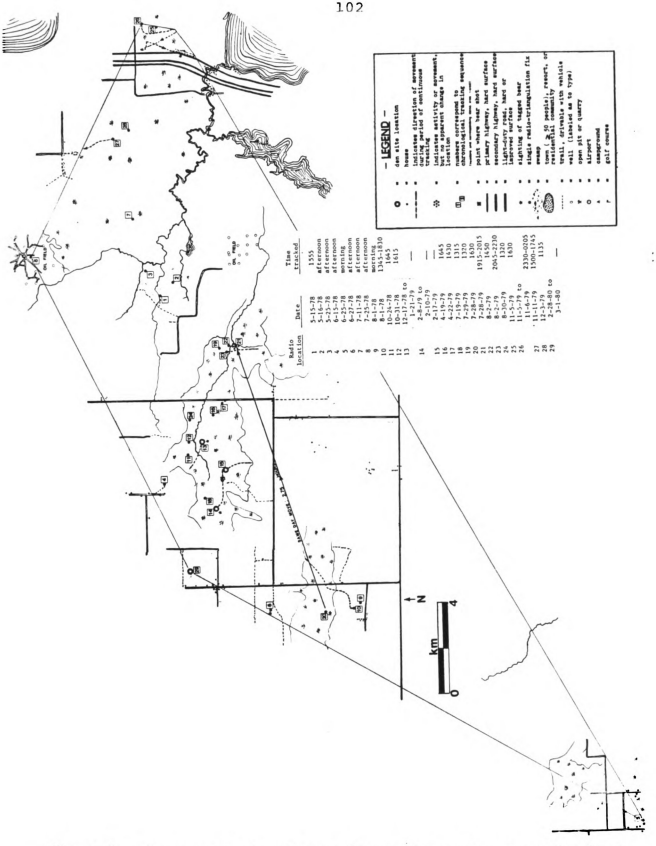
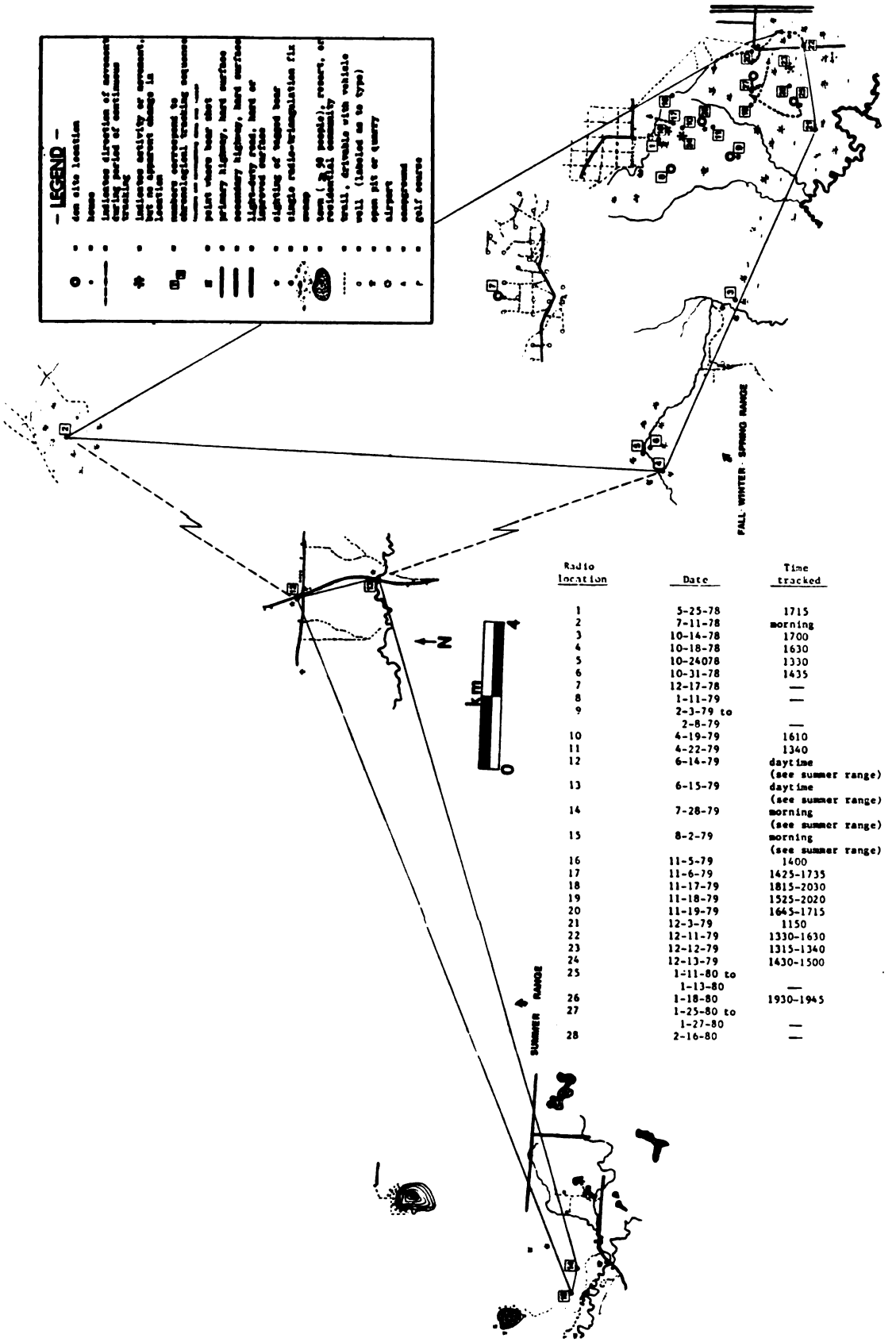
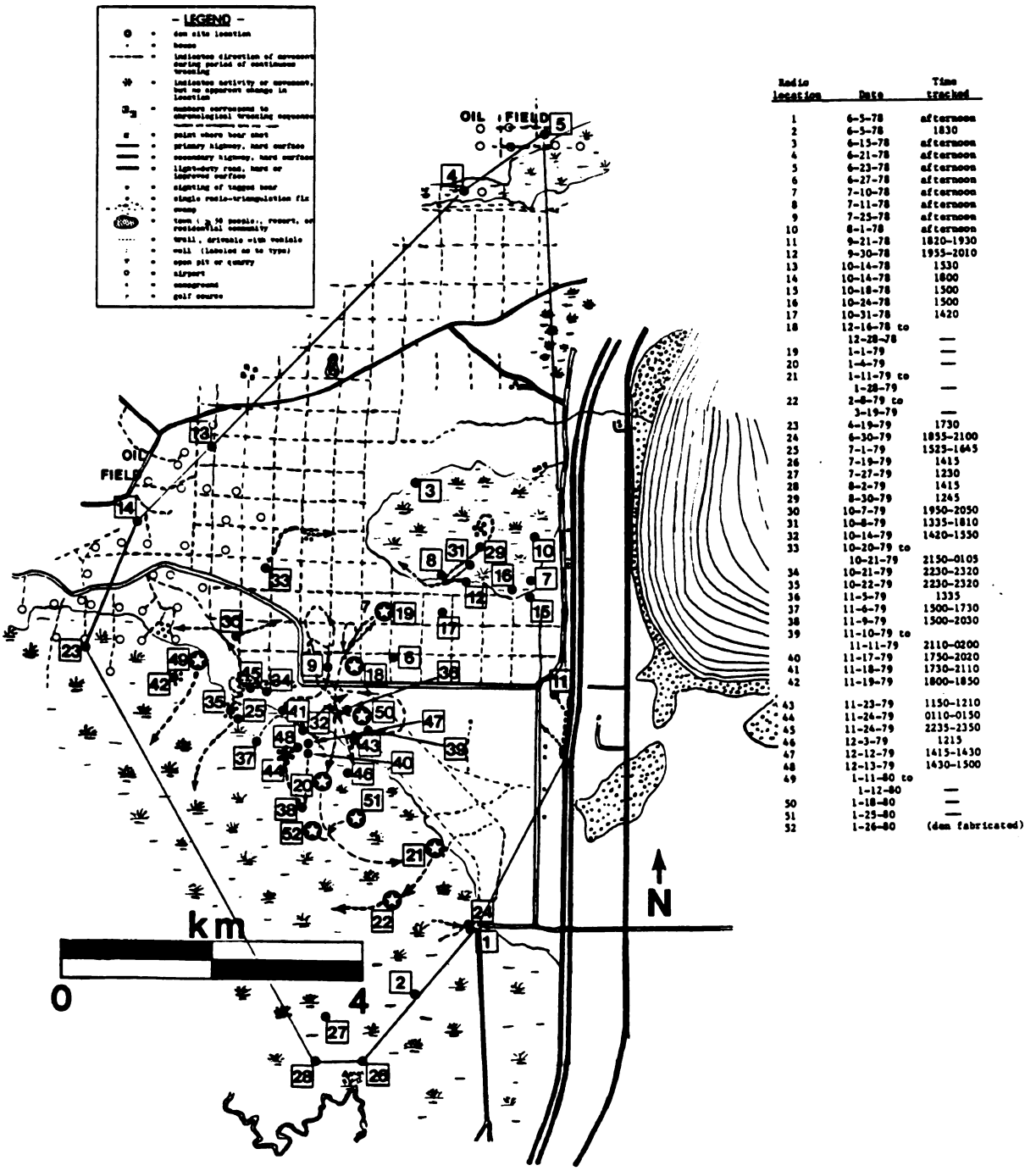


Fig. 10. Home range boundary of male bear LS, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.



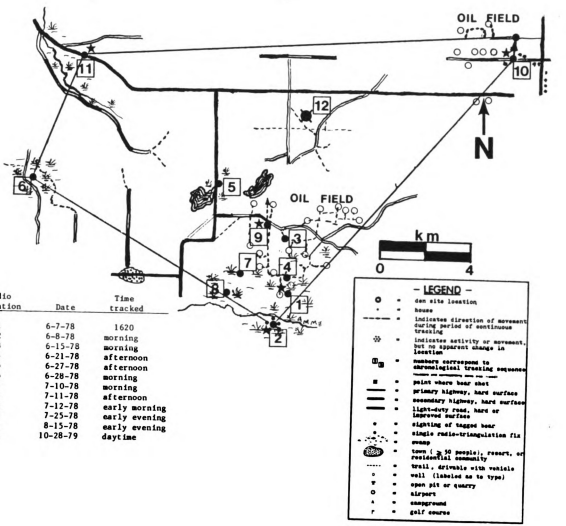
Radio location	Date	Time tracked
1	5-25-78	1715
2	7-11-78	morning
3	10-14-78	1700
4	10-18-78	1630
5	10-24078	1330
6	10-31-78	1435
7	12-17-78	—
8	1-11-79	—
9	2-3-79 to 2-8-79	—
10	4-19-79	1610
11	4-22-79	1340
12	6-14-79	daytime (see summer range)
13	6-15-79	daytime (see summer range)
14	7-28-79	morning (see summer range)
15	8-2-79	morning (see summer range)
16	11-5-79	1400
17	11-6-79	1425-1735
18	11-17-79	1815-2030
19	11-18-79	1525-2020
20	11-19-79	1645-1715
21	12-3-79	1150
22	12-11-79	1330-1630
23	12-12-79	1315-1340
24	12-13-79	1430-1500
25	1-11-80 to 1-13-80	—
26	1-18-80	1930-1945
27	1-25-80 to 1-27-80	—
28	2-16-80	—

Fig. 11. Home range boundary of male bear LA illustrating fall-winter-spring and summer ranges using convex polygons, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.



Radio location	Date	Time tracked
1	6-5-78	afternoon
2	6-5-78	1830
3	6-15-78	afternoon
4	6-21-78	afternoon
5	6-23-78	afternoon
6	6-27-78	afternoon
7	7-10-78	afternoon
8	7-11-78	afternoon
9	7-25-78	afternoon
10	8-1-78	afternoon
11	9-21-78	1820-1930
12	9-30-78	1955-2010
13	10-14-78	1530
14	10-14-78	1800
15	10-18-78	1500
16	10-24-78	1500
17	10-31-78	1420
18	12-16-78 to 12-28-78	—
19	1-1-79	—
20	1-4-79	—
21	1-11-79 to 1-28-79	—
22	2-8-79 to 3-19-79	—
23	4-19-79	1730
24	6-30-79	1835-2100
25	7-1-79	1525-1645
26	7-19-79	1415
27	7-27-79	1230
28	8-2-79	1415
29	8-30-79	1245
30	10-7-79	1950-2050
31	10-8-79	1335-1810
32	10-14-79	1420-1530
33	10-20-79 to 10-21-79	2150-0105
34	10-21-79	2230-2320
35	10-22-79	2230-2320
36	11-5-79	1335
37	11-6-79	1500-1730
38	11-9-79	1500-2030
39	11-10-79 to 11-11-79	2110-0200
40	11-17-79	1750-2020
41	11-18-79	1730-2110
42	11-19-79	1800-1850
43	11-23-79	1150-1210
44	11-24-79	0110-0150
45	11-24-79	2235-2350
46	12-3-79	1215
47	12-12-79	1415-1430
48	12-13-79	1430-1500
49	1-11-80 to 1-12-80	—
50	1-18-80	—
51	1-25-80	—
52	1-26-80	(den fabricated)

Fig. 12. Home range boundary of female bear DM, chronological sequence of radio-locations in numbered order, and areas of human development within her home range.



Radio location	Date	Time tracked
1	6-7-78	1620
2	6-8-78	morning
3	6-15-78	morning
4	6-21-78	afternoon
5	6-27-78	afternoon
6	6-28-78	morning
7	7-10-78	morning
8	7-11-78	afternoon
9	7-12-78	early morning
10	7-25-78	early evening
11	8-15-78	early evening
12	10-28-79	daytime

Fig. 13. Approximate home range boundary of female bear A1, chronological sequence of radio-locations in numbered order, and areas of human development within her home range.

Radio location	Date	Time tracked
1	6-13-78	1530
2	6-15-78	morning
3	6-21-78	morning
4	6-23-78	morning
5	6-29-78	morning
6	7-10-78	morning
7	7-11-78	afternoon
8	7-25-78	afternoon
9	8-1-78	morning
10	8-4-78	morning

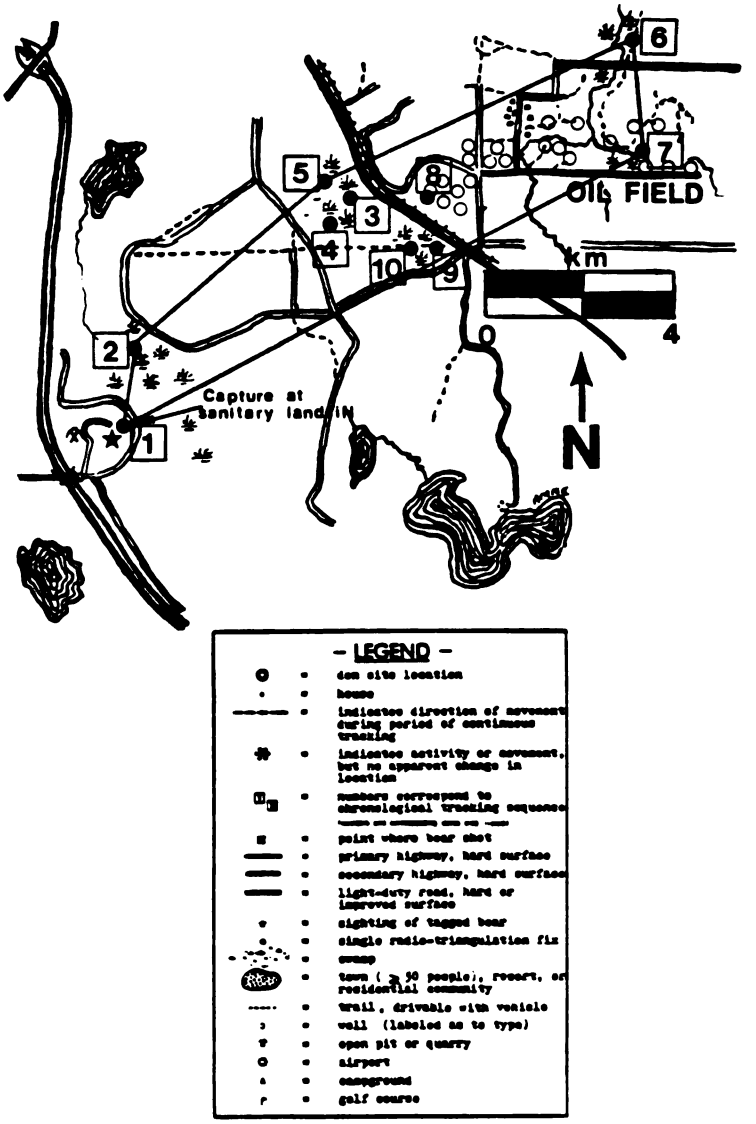


Fig. 14. Approximate home range boundary of male bear Du, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.

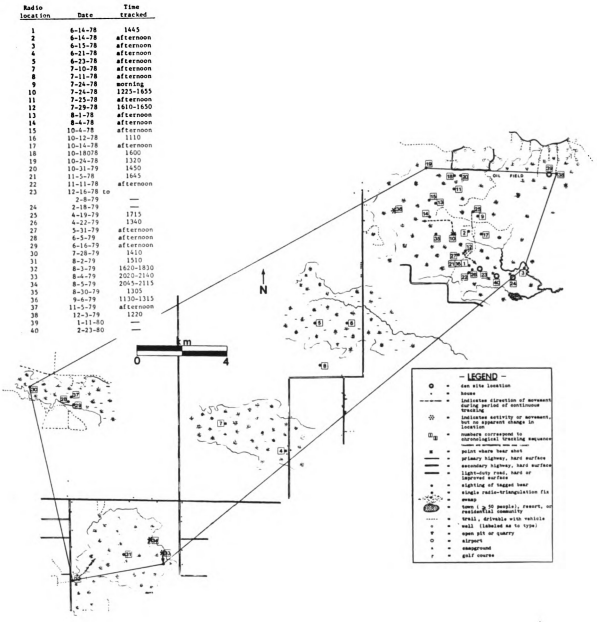


Fig. 15. Home range boundary of male bear OC, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.

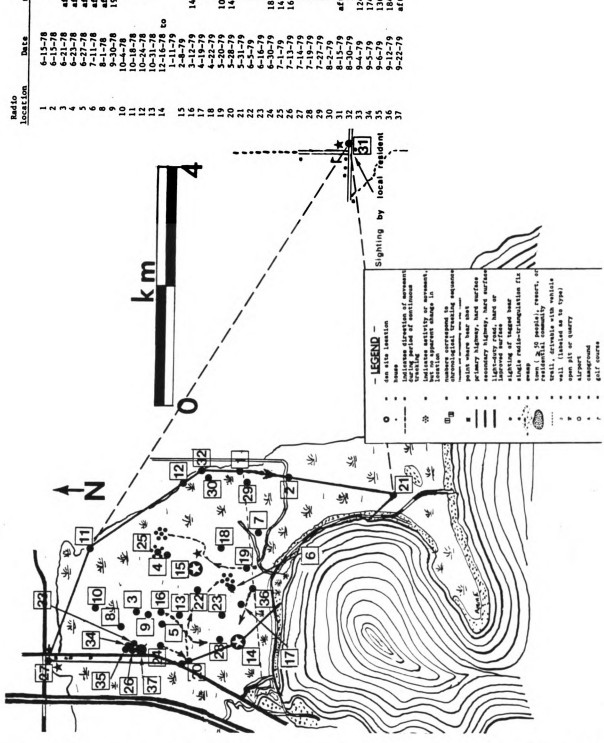


Fig. 16. Home range boundary of female bear Rh, chronological sequence of radio-locations in numbered order, and areas of human development within her home range.

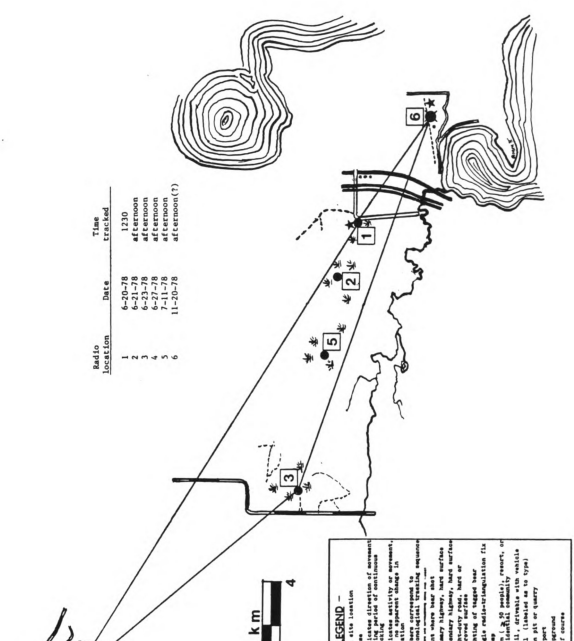


Fig. 17. Approximate home range boundary of male bear Gr, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.

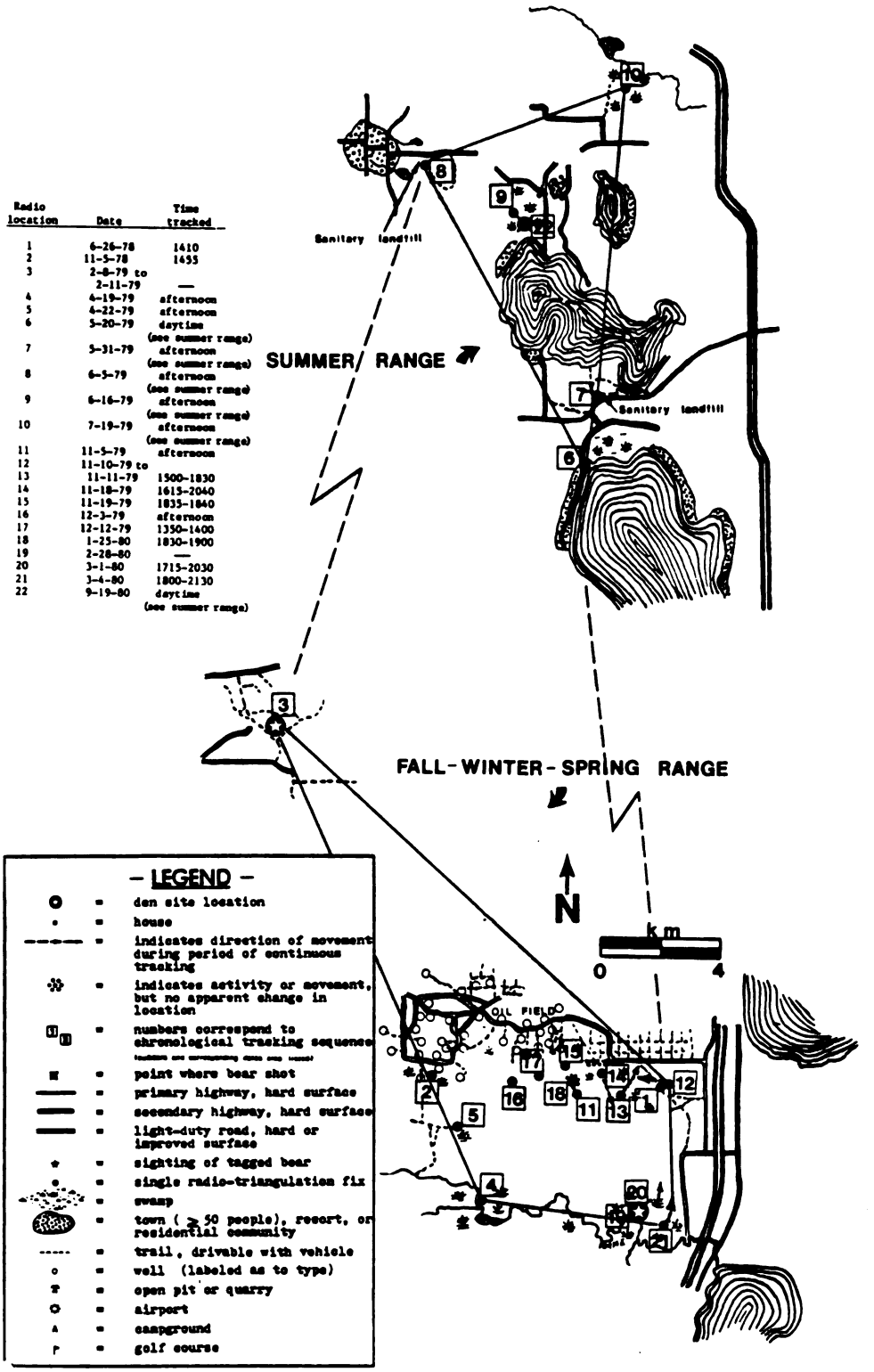
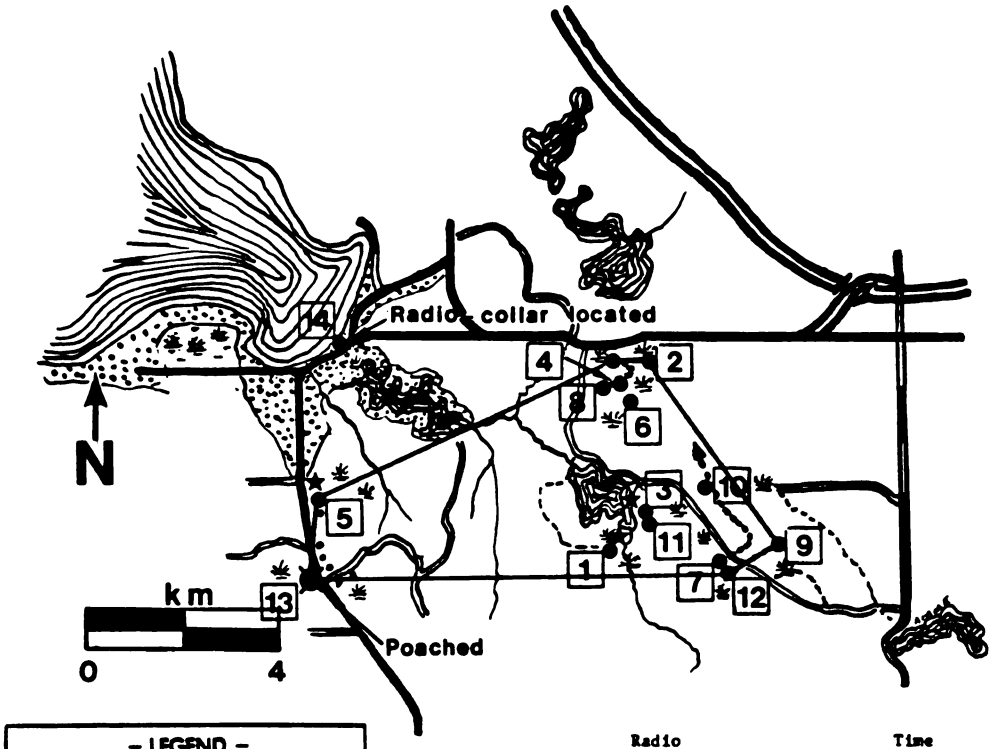
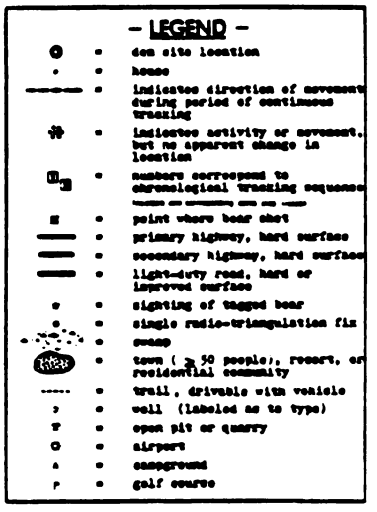


Fig. 18. Home range boundary of male bear BK illustrating fall-winter-spring and summer ranges using convex polygons, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.





Radio location	Date	Time tracked
1	6-28-78	1745
2	7-10-78	morning
3	7-10-78	afternoon
4	7-11-78	afternoon
5	7-15-78±	
6	7-20-78	morning
7	7-20-78	1730-2145
8	7-21-78	1130-1705
9	7-24-78	morning
10	7-25-78	morning
11	8-1-78	morning
12	8-4-78	morning
13	9-29-78±	daytime
14	9-30-78 to 10-1-78	—

Fig. 19. Home range boundary of female bear La, chronological sequence of radio-locations in numbered order, and areas of human development within her home range.

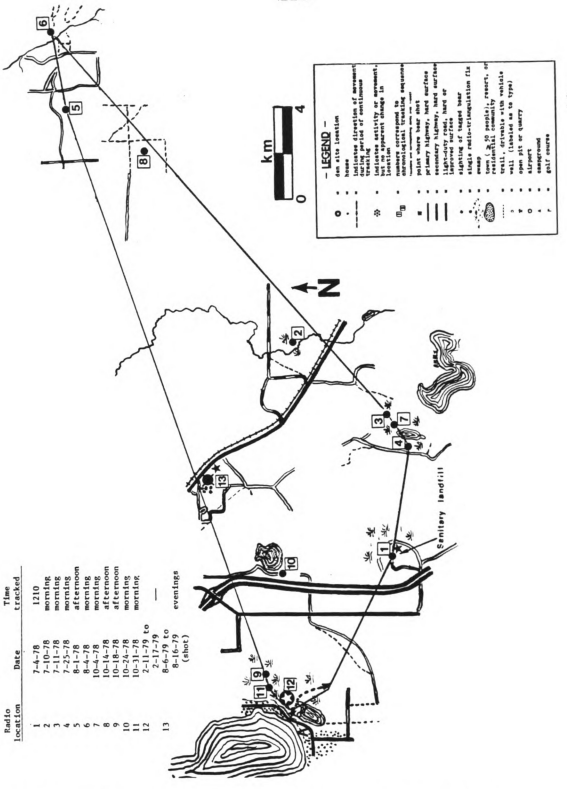


Fig. 20. Home range boundary of male bear LV, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.

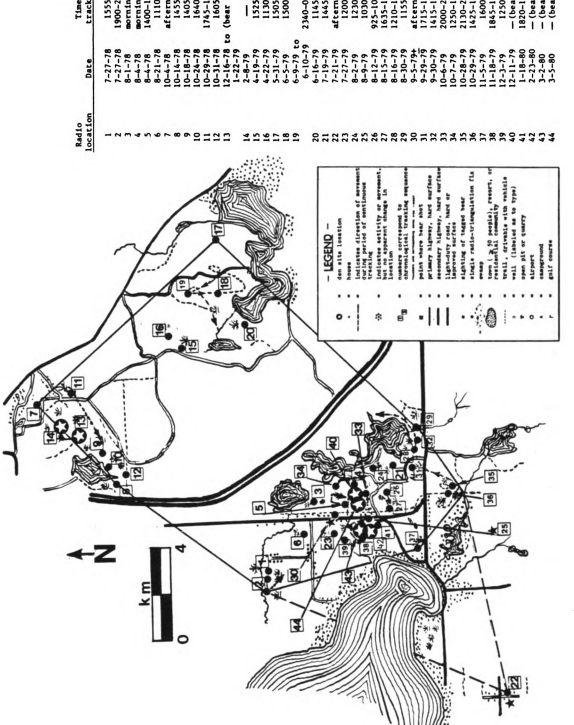


Fig. 21. Home range boundary of female bear Lu, chronological sequence of radio-locations in numbered order, and areas of human development within her home range.

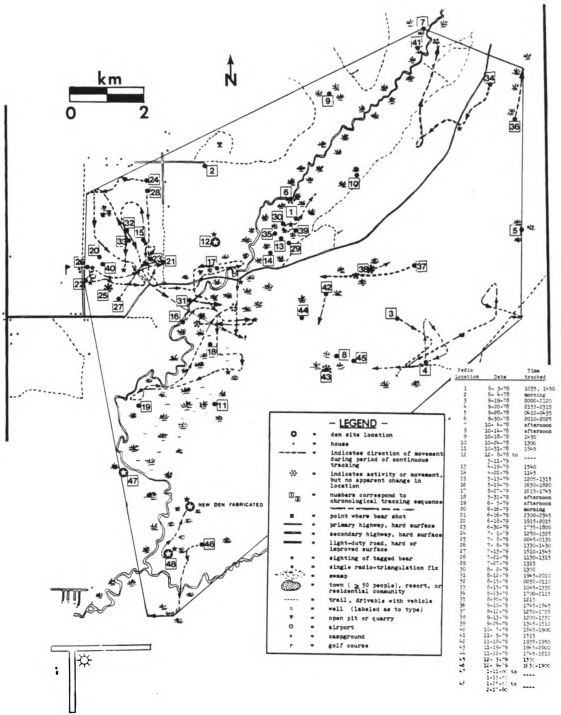


Fig. 22. Home range boundary of female bear Ta, chronological sequence of radio-locations in numbered order, and areas of human development within her home range.

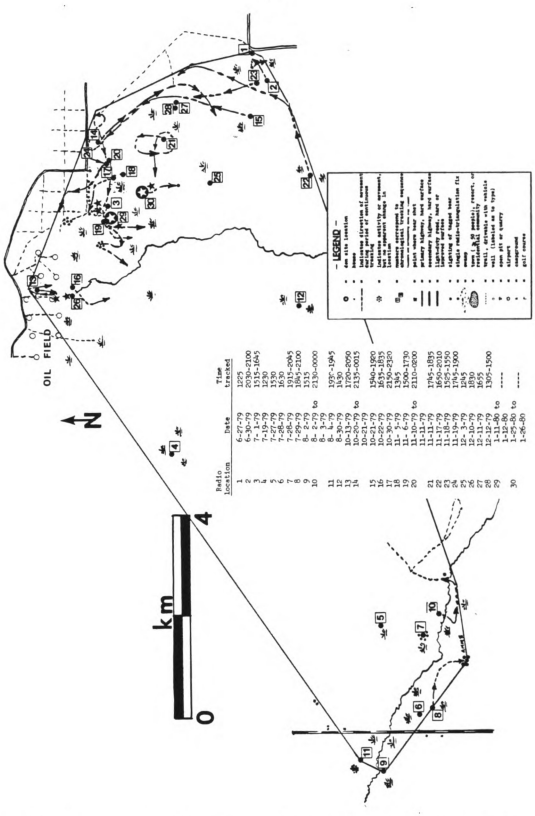
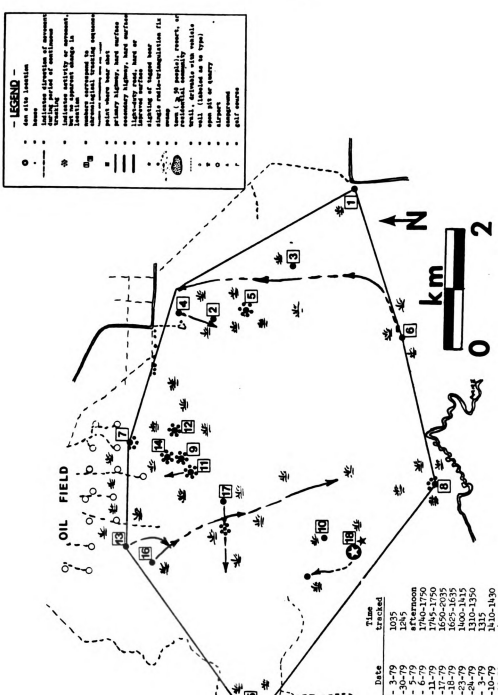


Fig. 23. Home range boundary of male bear Go, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.



Radio location	Date	Time tracked
1	7- 3-79	1905
2	8-30-79	1905
3	11- 5-79	afternoon
4	11- 6-79	1745-1750
5	11-16-79	1745-1750
6	11-17-79	1650-2035
7	11-18-79	1605-1635
8	11-23-79	1300-1345
9	11-24-79	1310-1350
10	12- 3-79	1335
11	12-15-79	1410-1430
12	12-15-79	1430-1500
13	1-12-80	1345-1430
14	1-25-80	1945-2000
15	2-14-80	1945-1955
16	2-24-80	1700-2030
17	2-27-80	1945-2130
18	2-28-80 to 3- 2-80	----

Fig. 24. Home range boundary of male bear MP, chronological sequence of radio-locations in numbered order, and areas of human development within his home range.

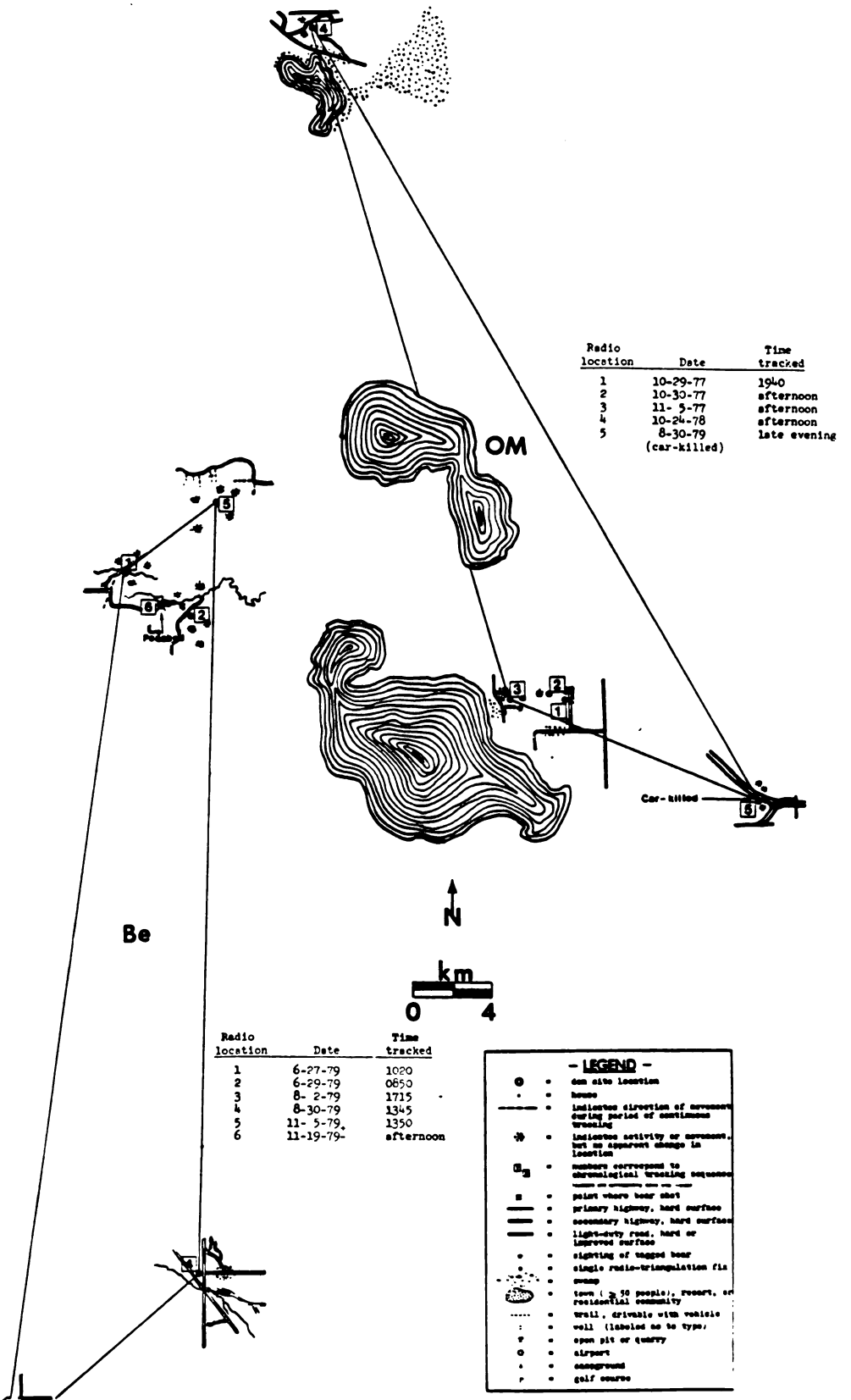


Fig. 25. Approximate home range boundaries of male bears Be and OM, chronological sequence of radio-locations in numbered order, and areas of human development within their respective home ranges.

were tracked to locations near towns or resorts ($\bar{X}$=0.22 km), and 4 males were triangulated near sanitary landfills ($\bar{X}$=0.16 km). Thirteen male home ranges contained 32 towns, residential communities, and resorts within their respective home range boundaries ($\bar{X}$=2.5), while 7 females had 8 ($\bar{X}$=1.1) (see Figures 7-25 for details of home range, radio-locations, and areas of human development for each radio-collared bear).

Statistical Analysis

The differences between sexes, corrected where disproportionate sex ratios existed, were tested using the randomization test for 2 independent samples. There was a statistically significant difference between sexes regarding the average distances bears were located from active oil wells ($P < 0.01$, df=9, 3.833) as well as a significant difference between sexes regarding the number of towns, residential communities, and resorts located within respective bear home ranges ($P < 0.05$, df=18, 2.185). The differences between sexes also were tested using the randomization test regarding the number of times bears were located next to houses, the average distances bears were radio-located from houses, and the number of times bears were located next to active oil wells. There were no significant differences here.

Males had a greater number of towns, residential communities, and resorts within their home ranges, probably due to larger home range size.

CHAPTER IV

NUISANCE PROBLEMS

Barnes and Bray (1967) conducted an extensive study of panhandler black bears in Yellowstone National Park and found that backcountry and roadside bears comprised 2 separate populations. Eager and Pelton (1978, 1980) and Pelton (cited in Harrison 1979) reported interactions between black bears and humans in Great Smoky Mountains National Park, Tennessee, and found that only about 5% of the marked bears in the Park were roadside panhandlers, often dominant males. Bears also learned to associate backpacks with food. There was reason to believe that enriched diets of adult female panhandlers increased cub production.

Rogers (1970) in Minnesota indicated that nearly every radio-tagged bear living within 9.7 km of a dump visited such a facility, especially when natural foods were scarce. Because of nuisance problems caused by bears tipping over garbage cans at nearby dwellings, at least 26 bears were reported killed in the vicinity of 2 small dumps. Rogers et al. (1976a) captured 126 black bears at garbage dumps, campgrounds, and residential areas in Michigan's Upper Peninsula during the summer 1968. Forty-two percent of these bears (excluding

cubs) captured in campgrounds or residential areas were males less than 4 years of age, indicating to Rogers et al. that young males exhibited less attachment to an area than did females or older males.

Cardoza (1976) reported that although most publicized nuisance bear encounters between bears and humans occurred in the national parks, problems in the Northeast included chronic dump confrontations in the Adirondacks, scavenger bears in some northern New Hampshire towns, and a bear in a Connecticut campground for 6 weeks. Peterson (1966 cited in Cardoza 1976) suggested that black bears have been responsible for more human injuries than any other North American predator, due probably to heedless human actions rather than innate bear viciousness.

Graber and White (1978) reported that a sharp increase in human-bear conflicts in Yosemite National Park, California, resulted in a comprehensive human-bear management plan including capture and relocation of nuisance animals, intentional elimination of some animals, elimination of human food sources, better law enforcement and public education, and further research and monitoring. As a result, property damage, human injury, and the proportion of human foods in the diet of black bears declined.

Black bear damage by girdling conifers in northwest Washington had a significant impact on conifer tree production in that state (Poelker and Hartwell 1973). Bray (1974) related black bear nuisance problems, in part, to lack of mast

production; in years when mast was low, bears moved out of their normal range creating problems for landowners by raiding chicken coops, farms, livestock, etc. As a result, this increased bear vulnerability to poaching or nuisance animal elimination.

Bear depredation of beekeeping operations was reported as a worldwide problem, with at least 5 bear species identified as bee pests (Ambrose and Sanders 1978). The largest loss estimate of black bear depredation to apiaries was reported in Alberta in 1973 where damage was set at $200,000 despite removal of 400 bears from the affected area (Gunson 1974, cited in Ambrose and Sanders 1978). The emetic compounds lithium chloride and cupric sulfate placed in honey baits were found unsuitable for producing taste aversions in free-ranging black bears; there was no evidence that the compounds reduced bear damage at fenced beeyards in Alberta (Dorrance and Roy 1978). In the past, hive depredation was controlled, in part, by either the "Florida" electric fence (Robinson 1965), flashing lights, radios, repellents, platforms, or trapping and harvesting of nuisance animals (Ambrose and Sanders 1978).

METHODS

Direct and step-wise two-group discriminant function analyses (Klecka 1975) were used to analyze 2 major categories of bears: nuisance and non-nuisance animals. Bears were classified as nuisance animals when they were 1) captured while causing property damage, frightening residents, or

threatening humans, 2) shot where causing property damage and frightening residents, or 3) reported as nuisance animals where they ate garbage or pet food, and frightened residents. The remaining bears were categorized as non-nuisance animals. Seven discriminating variables were used to measure characteristics on which the groups were expected to differ: 1) sex, 2) incidence of periodontal disease, 3) number of sightings by the public, 4) average distance of dens from nearest center of human activity, 5) estimate of home range size, 6) distance bear shot from nearest improved road, and 7) number of towns, residential communities, and resorts ($\geq$ 50 persons) within the bear's range. In view of the small nuisance group sample size (N=5), and possibility of lack of independence and mutual exclusion between the discriminating variables and the nuisance classification, the results may not have biological significance. The statistical results must be interpreted with caution.

RESULTS AND DISCUSSION

Using the direct method, the discriminant function model indicated that in decreasing order of significance, 1) nuisance bears were more likely, if shot, to be close to improved all-weather roads, 2) were more likely to be sighted by the public, and 3) were more likely to be shot than non-nuisance animals (N=19). When the Wilks stepwise method was used, however, the model predicted that nuisance bears 1) were more likely to be sighted than non-nuisance animals, and 2) would have more towns, residential communities, and resorts in their respective

home ranges than non-nuisance bears. Interestingly, the discriminating variables sex and periodontal disease were not significant according to the model. Because of the small sample size of the nuisance group (N=5), the results of both direct and stepwise analysis must be viewed with caution. To provide more meaningful results, a much larger sample size is needed.

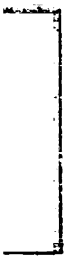
Nuisance and damage complaints reported in the study area between September 1977 and July 1980 were extensive (N=46 reports; Table 11). By far the greatest individual type of damage involved bear depredation of bee hives (14 of 46 complaints, 30.4%). Between May 1975 and September 1980, one beekeeper lost 63 complete hives to bears ($6,300 estimated loss) and had 200 others knocked over and partially destroyed. Apiarists in Missaukee County have totally lost 230 hives to bears in the past 12 years. Prior to 1967, beehive damage by bears in Missaukee County was negligible (D. Byrne, apiarist, pers. commun.).

The largest group of complaints involved bears frightening people (N=18). Nuisances caused by bears eating garbage from cans or popcorn at a drive-in theater were greatest (N=5), followed by sightings of bears in yards (N=4). Property damage comprised the third largest complaint/damage category. Damage to cabins (bears chewing gutters, eaves, main supports, walls, or window frames; breaking windows; or puncturing screens) was greatest (N=4 reports), followed by damage to oil wellhead covers (N=2 reports). The final

Table 11. Black bear nuisance and damage complaints in Cheboygan, Crawford, Kalkaska, Missaukee, and Roscommon counties, Michigan, September 1977 to July 1980.

Nature of complaint/damage	Group totals reported	No. reported
Bear damaged bee hives, ate honey	14	14
Bears harassed, injured, or killed animals	6	
Chased horses		1
Injured cattle		1
Injured leashed dog		1
Killed dog(s)		3[a]
Bear damaged property	8	
Tore clothes line		1
Tore up 3 hunting blinds, ate C-rations		1
Damaged cabin(s)		4
Damaged oil wellhead covers		2
Bear frightened people	18	
Frightened guests at restaurant		1
In camp		2
Put paws on picture window, ate suet		1
In yard		4
Ate garbage and/or popcorn		5
Broke into dog pen, ate dog food		1
In Bible camp		1
In tent		1
Female with cubs crossed golf course		1
In downtown Prudenville		1
		N = 46

a = dogs dying in all 3 instances, but apparently not killed by bears



complaint/damage category involved bears harassing, injuring, or killing animals (bees excluded). Tethered or penned dogs were reported harassed on 3 occasions (dogs dying in all 3 instances, but apparently not killed by bears), a leashed dog was reported injured, dairy cattle were injured by a bear, and horses were reported chased by a bear.

Bear damage complaints were examined by law enforcement district personnel in the Lower Peninsula from fiscal year 1972-73 (when they were initially maintained) to fiscal year 1978-79 (Table 12). In District 7, the center of the study area (Kalkaska, Missaukee, Crawford, Roscommon, Oscoda, Ogemaw, Alcona, and Iosca counties), reported bear damage complaints ranged from 4 in fiscal year 1976-77, to 85 in fiscal year 1974-75. When damage complaint locations were further divided into law enforcement areas for District 7 (Area 19: Kalkaska, Missaukee, and Crawford counties, Area 20: Roscommon and Ogemaw counties; Table 13), both areas 19 and 20 had record numbers of recorded damage complaints, 73 and 8 reported complaints for fiscal year 1974-75, respectively.

Snowfall during the winter of 1973-74 was slightly below average for November, December, January, and March, but above average for February. Precipitation levels for January, April, May, June, July, and August 1974 all were above average. During the winter of 1974-75, snowfall was considerably below average in November, but only slightly below average in December, February, and March. Precipitation for January, April, June, July, and August 1975 was above average, with

Table 12. Bear damage complaints[a] by law enforcement district, fiscal years 1972-73 to 1978-79 (MI DNR Law Division damage complaint records 1972-1979).

District	Counties	1978-79 Oct-Sep	1977-78 Oct-Sep	1976-77[b] Oct-Sep	1976-77 Jul-Jun	1975-76 Jul-Jun	1974-75 Jul-Jun	1973-74 Jul-Jun	1972-73 Jul-Jun	Totals[c]
5	Emmet, Charlevoix, Antrim, Cheboygan, Otsego, Presque Isle, Montmorency, and Alpena	11	9	8	6	31	39	42	36	176
6	Leelanau, Benzie, Grand Traverse, Manistee, Wexford, Mason, Lake, Oceana, and Newaygo	0	0	3	3	2	2	4	0	11
7	Kalkaska, Missaukee, Crawford, Roscommon, Oscoda, Ogemaw, Alcona, and Iosco	9	9	4	9	13	85	20	12	152
8	Osceola, Mecosta, Clare, Isabella, Gladwin, Arenac, Midland and Bay	3	6	19	15	16	11	5	7	67
	TOTALS	23	24	34	33	62	137	71	55	

a = only complaints reported to and handled by conservation officers
b = change in fiscal year period from July 1-June 30 to October 1-September 30
c = totals excluding July 1976-June 1977 totals

Table 13. Bear damage complaints[a] by law enforcement areas, fiscal years 1972-73 to 1978-79 (MI DNR Law Division damage complaint records 1972-1979).

Dist.	Areas	Counties	1978-79 Oct-Sep	1977-78 Oct-Sep	1976-77[b] Oct-Sep	1976-77 Jul-Jun	1975-76 Jul-Jun	1974-75 Jul-Jun	1973-74 Jul-Jun	1972-73 Jul-Jun	Totals[c]
5	13	Emmet, Charlevois & Antrim	5	1	1	2	6	11	0	1	25
5	14	Cheboygan, Otsego, & Presque Isle (W-½)	5	3	4	3	10	14	15	18	69
5	15	Presque Isle (E-½), Montmorency, & Alpena	1	5	3	1	15	14	27	17	82
6	16	Leelanau, Benzie, & Grand Traverse	0	0	0	0	1	0	2	0	3
6	17	Manistee & Wexford	0	0	2	2	0	1	0	0	3
6	18	Lake & Newaygo	0	0	0	0	1	1	0	0	2
7	19	Kalkaska, Missaukee, & Crawford	3	3	0	2	5	73	15	0	99
7	20	Roscommon & Ogemaw	6	2	3	4	1	8	0	5	25
7	21	Oscoda, Alcona, & Iosco	0	4	1	3	7	4	5	7	28
8	22	Osceola, Mecosta, & Isabella	0	0	9	6	1	1	1	3	15
8	23	Clare, Gladwin, & Midland	3	6	4	2	9	8	2	3	35
		TOTALS	23	24	27[d]	25[d]	56[d]	135[d]	67[d]	54[d]	

a = only complaints reported to and handled by conservation officers
b = change in fiscal year period from July 1-June 30 to October 1-September 30
c = totals excluding July 1976-June 1977 totals
d = discrepancy in tallied area totals from tallied district totals, Table 11

May levels only slightly below average. Drought, then, did not appear to limit mast production either in 1974 or 1975. At Houghton Lake, Roscommon County, low temperatures of -9.4 and -3.9 C on 8 April and 7 May 1974, and -10.6 and 0.6 C on 5 April and 13 May 1975 (U.S. Dep. Commerce 1974, 1975) and late May frosts (J. Duvendeck, DNR biologist, pers. commun.) may have resulted in killing frosts in the area which would have affected mast and fruit production. Otherwise, meteorological conditions appeared normal and record numbers of nuisance complaints for fiscal year 1974-75 were unexplainable.

CHAPTER V

DEN SITE SELECTION

Black bears show considerable flexibility in selecting winter dens (Lindzey and Meslow 1976). In Michigan's Upper Peninsula, Erickson (1964b) found that most bears favored dens dug beneath logs or stumps, or holes dug into hillsides. Bears there expended considerable effort constructing dens, lining them with leaves, bracken fern, and marsh grass. More adult females and juveniles lined dens than did adult males. Erickson theorized that adult males entered dens later than females and juveniles and that suitable nest material was thus less likely available at the time males entered dens. The earliest report of a denned bear in the Upper Peninsula (Erickson 1964b) was October 13, while in the Lower Peninsula it was October 27. Seven percent of denned Upper Peninsula bears were found in unsheltered depressions.

Manmade structures used by black bears as dens in Yellowstone National Park included storm drainage culverts (Barnes and Bray 1966) and foundations of old buildings (Skinner 1925). Jonkel and Cowan (1971) also reported bear dens in basements of abandoned buildings in Montana.

Cahalane (1954) reported black bears denning in caves, in hollow trees or fallen logs, under windfalls, roots, or thickets, in geyser-steam-heated caves, and in the open. Skinner (1925) even reported black bears denning in geyser openings and in an old hot spring in Yellowstone. In Montana, preferred den sites included bases of hollow trees, rock caves, and holes dug in the ground (Jonkel and Cowan 1971). On Long Island, Washington, Lindzey and Meslow (1976) found 10 bear dens associated with dead trees while the 2 remaining dens were associated with live trees. All dens of adult females except one were located in areas partially cut or clearcut prior to 1956. The principal function of dens in the Northwest appears to be protection from heavy winter rains. Craighead and Craighead (1972) attributed the selection of north-facing slopes for grizzly bear dens to the insulative qualities afforded by greater accumulations of snow on these slopes.

Tietje and Ruff (1980) conducted a comprehensive denning behavior study in east-central Alberta from 1975 to 1977. Bears were found to den in mixed stands of mature aspen and spruce or mature spruce stands. Thirty-five of 37 dens were dug beneath ground level or under root masses of fallen trees, and were lined with grasses and litter from the immediate vicinity of dens. Dens were constructed over a 5 to 10-day period. In 1975, bears entered dens during a 4-week period starting 7 October, while in 1976 bears denned over a 5-week period starting 1 October. Adult females and subadults denned first and adult males last.

In northern Maine, Hugie (cited in Allen 1978) reported several bears denning, one at the base of an old white pine lined with evergreen boughs, another underneath the root mass of a white pine, and a third in a shrub-protected opening. In Washington, Poelker and Hartwell (1973) tracked 3 radio-tagged bears to their respective dens. An adult female denned in 4 different locations, moving each time she was disturbed. Sites included 2 dens in hollow logs, 1 in an excavated cavity at the base of a large, rotten stump, and 1 in a natural cavity at the base of a maple tree; no bedding material was used. Bears reused vacated dens 3 times. Dense ground cover appeared to be preferred for denning. Three dens were within 91 m of forest access roads. Even during western Washington's relatively mild winters, some black bears had dormant periods of nearly 3 months. Fuller and Keith (1980) reported that at least 5 of 6 bears excavated dens in the Fort McMurray, Alberta area. Leaves were scraped into 4 of the dens.

The length of the denning period in the Great Smoky Mountains, Tennessee, ranged from 50 to 116 days ($\bar{X}$=90 days), but upon entering dens, bears did not intermittently leave and return (Johnson and Pelton 1980b). They found that 14 of 17 instrumented bears denned between the last week in December and the first week in January.

METHODS

Bears were tracked to dens in order to remove or replace radio collars, and also to determine site types, locations

and distances from centers of human activity. Lengths, widths, and heights of dens also were recorded, and denning materials were classified. All dens were photographed. Habitat types where dens were situated (upland, lowland, or swamp) were statistically compared between sexes using the χ^2 test for k independent samples (Siegel 1956).

RESULTS AND DISCUSSION

Ten radio-tagged males denned in 24 swamp (more than 50% white cedar, mixed swamp conifers, or more than 50% black spruce), 2 lowland (lowland hardwoods, lowland sedges, lowland balsam fir, or lowland brush), and 2 upland dens (upland northern hardwoods, oak, upland grass and weeds, or upland brush) during the winters of 1977-78 to 1979-80; 7 females denned in 11 swamp, 5 lowland, and 7 upland dens during this same period (Table 14). Den site locations were compared between sexes; there was a significant difference between sexes in the use of swamp, lowland, and upland habitats in den site selection ($P < 0.002$, df=2, $\chi^2=8.29$).

Of the 31 dens (16 of males and 15 of females) actually visited, males DH and LS denned in open snow "nests," unprotected by trees, shrubs, or root masses. Both dens were lined with vegetation from the immediate area (cedar and spruce bark, balsam fir and tag alder branches, etc.). Females Lu and Ta also denned in open snow nests. One of 2 dens of female Lu was an open nest lined with tag alder, spirea, and willow branches. Two cubs denned with her. The

Table 14. Den site locations for black bears by habitat type, winters of 1977-78 to 1979-80, Kalkaska, Missaukee, and Roscommon counties.

Bear	Winter of	Number dens in: Swamp habitat[a]	Lowland habitat[b]	Upland habitat[c]	Total
MALES					
ES	1977-78	1			1
SB	1977-78	1			1
DH	1977-78	3			3
	1978-79	3			3
LS	1978-79	2	1		3
	1979-80		1		1
LA	1978-79	2		1	3
	1979-80	3			3
OC	1978-79	2			2
	1979-80	2			2
BK	1978-79			1	1
	1979-80	1			1
LV	1978-79	1			1
Go	1979-80	2			2
MP	1979-80	1			1
		24	2	2	28
FEMALES					
Ge	1977-78		1	1	2
ML	1977-78			1	1
An	1977-78			1	1
DM	1978-79	2	1	2	5
	1979-80	1	1	1	3
Rh	1978-79	2			2
Lu	1978-79	1	1		2
	1979-80	4			4
Ta	1978-79			1	1
	1979-80	1	1		2
		11	5	7	23
					51

a = more than 50% white cedar, mixed swamp conifers, or more than 50% black spruce
b = lowland hardwoods, lowland sedges, lowland balsam fir, or lowland brush
c = upland northern hardwoods, oak, upland grass and weeds, or upland brush

other den also was open, next to a balsam fir tree, lined with twigs and branches of alder and willow. One of the dens of female Ta consisted of an open cup depression lined with sedges and bracken fern, located next to an elm tree. An unmarked female with 2 yearling cubs also was located in an open, unprotected snow nest, lined with tag alder branches. The bears were initially spotted from the air. Harger (1974b) also reported that bears denned in Lower Peninsula, Michigan sites that afforded absolutely no protection. He found that bears denned in leatherleaf bogs and, for 2 years in a row, a bear denned on top of a muskrat (Ondatra zibethicus) house in a cattail marsh.

Tietje and Ruff (1980) concluded that the proportion of bears excavating dens was correlated with decreasing winter temperatures and the need for increased insulation. In Alberta where the mean daily minimum temperature was -20 C, 35 of 37 dens were excavated. In Michigan's northern Lower Peninsula, average winter temperatures are -29 to -18 C (Lehr et al. 1975). Though protected and underground sites are extensively available, denning of Michigan bears in open conditions does occur.

Dens of other marked males included 5 depressions under downed trees or upended root masses, 5 chambers underneath downed trees or upended root masses, and 3 underground cavaties (2 under root masses and 1 dug into the north-facing slope of a hill). Only 1 den of the male LS was unlined, consisting only of a dirt bottom.

Dens of other marked females included 7 depressions under downed trees, shrubs, or upended root masses, 1 vegetation nest next to a white cedar tree lined with bracken fern, and 4 underground dens dug under stumps (2), root-masses (1), or underground burrows (1). Curiously, the bottom of the den of female Lu contained water several cm's deep. Dens of all females were lined with varying amounts of vegetation from the immediate vicinity.

Dens of both males and females were concentrated in the Dead Stream Swamp area (Figure 26).

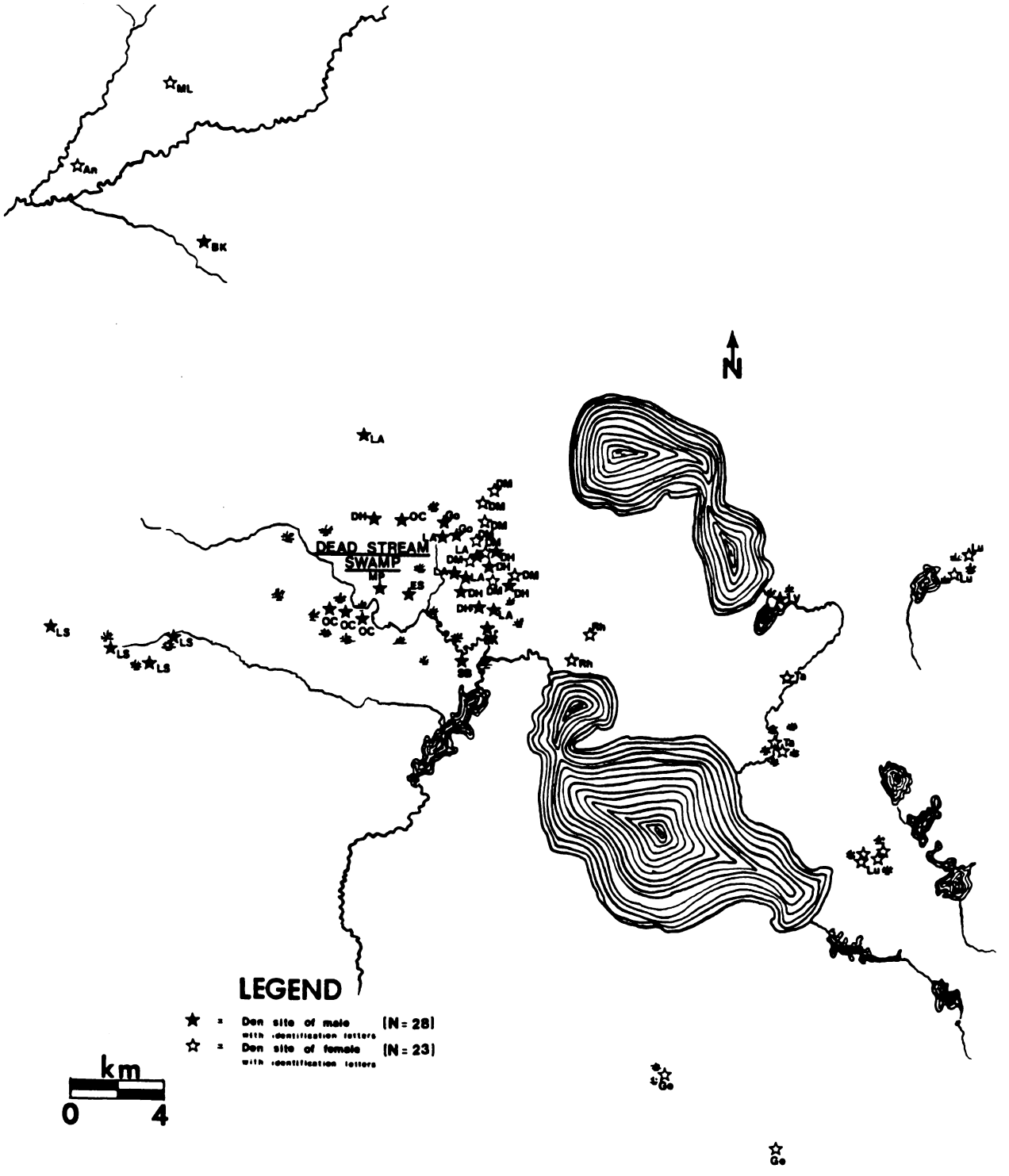


Fig. 26. Den site locations of 10 males (28 dens) and 7 females (23 dens) in Kalkaska, Missaukee, and Roscommon counties, winters of 1977-78 to 1979-80.

CHAPTER VI

POPULATION ESTIMATION

Black bear densities have been determined in only a few localities. In Michigan's Upper Peninsula, Erickson and Petrides (1964) calculated an average of 1 bear per 8.8 km^2 based on tagged-untagged ratios. They felt, however, that this estimate was lower than the amount of bear sign present indicated. In one case, they captured 23 bears within a single township (approximately 1 bear per 4.1 km^2) and presumably not all bears present were captured. In the Higgins-Houghton lakes area, Harger (1978) estimated that 1 bear was present per 16.2 to 32.4 km^2.

In western Montana, Jonkel and Cowan (1971) found that bear densities varied between 1 bear per 2.6 to 4.4 km^2. In western Washington during the spring of 1972, Poelker and Hartwell (1973) estimated 1 bear per 1.9 km^2 where a snare-trap line captured 25 bears in a 46.4 km^2 area. Levin (1954) judged bear densities in northeastern Washington to be as high as 1 per 0.65 km^2.

METHODS

Although one of the objectives of the present project was to estimate the size of the bear population in the

Higgins-Houghton lakes area, only 28 bears could be marked over 23 months. Though sample size was small, it was felt that it did provide some information on bear densities.

In this study, 3 census methods were utilized to calculate the size of the bear population for the 3 counties of Crawford, Kalkaska and Roscommon.

From the hunter-kill data of 1977-79 for Crawford, Kalkaska, and Roscommon counties, the average percentage of marked bears shot over the 3-season period was compared to the average total of bears shot during the same 3 seasons using a Lincoln index estimate (Davis and Winstead 1980). Colorful collar and ear markings appeared to make marked animals more vulnerable to hunting, since 16.7, 17.4, 18.2, and 10%, respectively, of the marked population known or suspected of being alive each year were shot by hunters between 1977 and 1980 in Crawford, Kalkaska, and Roscommon counties. Yet if it can be assumed that the marked and unmarked populations were equally vulnerable to hunting, a population estimate may be calculated from total kill data, including sport hunting, poaching, and control operations based on methods of Poelker and Hartwell (1973). In Washington, they assumed that 1) the population was stable, 2) natural mortality was replaced by hunting and nuisance-control mortality, and 3) the rate of population replacement was 20%.

As an alternate procedure, Poelker and Hartwell (1973) also used a mortality-rate population estimate based on 15% to 18% mortality rates derived from study data in Washington.

They assumed a stable population. In Michigan, Erickson and Petrides (1964) calculated from first-year recoveries of marked animals that there was a minimum annual mortality rate of 19% for Upper Peninsula bears.

RESULTS AND DISCUSSION

During 1977, 1978, and 1979, 20, 10, and 13 unmarked bears, respectively, were harvested during the bear hunting seasons in Crawford, Kalkaska, and Roscommon counties. There was thus an average annual harvest of 14.3 unmarked bears. During the same years, 16.7% (1 of 6), 17.4% (4 of 23), and 18.2% (4 of 22; $\bar{X}$=17.4%) of the marked population known or suspected of being alive each year were shot by hunters. Based on the usual Lincoln index assumptions (Davis and Winstead 1980), if the mean annual harvest of 14.3 bears equals 17.4% of the population, then 82 unmarked bears must have been present on the average in the 3-county unit during the 3-year period. Whether this figure is a true estimate is not known. Certainly, however, sightings of bears by the public were frequent and bear signs were abundant. And between 1977 and 1980, 35 bears alone were captured in the Dead Stream Swamp and surrounding swamp areas.

Where Poelker and Hartwell's (1973) harvest estimate of 20% is applied, then for every bear shot and car-killed there must exist 5 in the prehunting population. Since 21 bears were legally shot in Crawford, Kalkaska, and Roscommon counties in 1977, and 2 were car-killed in the Higgins-Houghton

lakes area, the kill of 23 bears reflects a 1977 prehunting population of 115 bears in the 3-county unit.

From these 2 population estimates, home range information, sightings and signs, and tracking data, my best fall 1977 population estimate is a judgement that 150 bears were present, or approximately 1 animal per 7.8 to 9 km^2 of available black bear habitat in the 3-county unit.

CHAPTER VII

PARASITOLOGY, PATHOLOGY, AND HEMATOLOGY

Coyler (1936) was perhaps the first to report dental variations and diseases in bears, including cavities and tooth eruption failures. He reported wild bears to be free of caries, but found dental cavities infrequently in captive bears. Hall (1940) found cavities in the teeth of 5 (3%) among 165 black bear skulls. He believed caries were most common in bears whose molars had low-rounded crowns and a topography of occlusal faces which, as in man, lead to penetration of enamel and decay of dentin. He also felt that bear diets high in honey, berries, and other carbohydrates could contribute to tooth decay. Erickson (1967) states that dental diseases in black bears were common, especially in older animals. He observed that canines often were broken, and that many other teeth were darkly stained and often decayed. Manville (1978b) found dental cavities in 9 (11%) of 86 bears in northern Wisconsin, though only 1 had extensive decay.

Erickson (1967) reported that periodontal disease, too, was often encountered in black bears, particularly among older animals. Eleven (79%) of 14 old-aged Alaskan black

bears examined by Rausch (1961) were noted to be infected with periodontal disease, while 7 (20%) of 35 prime-age bears also were positive for that ailment. Periodontal disease was discovered, however, only in 1 (1%) of 86 bears live-trapped in Wisconsin during 1974 and 1975 (Manville 1978b). Colyer (1936) felt that injuries to individual teeth led to infection, yet the teeth of the one infected Wisconsin bear were not injured (Manville 1976).

Erickson (1967) reported that, except for dental disorders, the diseases of black bears were remarkably few. He did find skeletal disorders, however, which appeared to have been caused mostly by injuries, some human-induced and some due to fighting. He stated that the black bear possesses a remarkable ability to withstand infection, to mend fractured bones, and even to recover from amputations. King et al. (1960) reported various wounds caused by gunfire and natural accidents in 9 New York bears. These included an amputated foot and healed broken bones.

Black bears were surveyed for ecto- and endoparasites in Michigan's Upper Peninsula and in northeastern Minnesota by Rogers (1975) and in northern Wisconsin by Manville (1978b). In other studies in the Great Lakes region, a survey in Wisconsin for Trichinella spiralis by Zimmerman (1975) found a 3.8% incidence. Anderson (1952) and Choquette (1952) also reported Dirofilaria ursi in southern Ontario.

King et al. (1960) reported calcium, magnesium, and phosphorus levels from the blood of 1 black bear in New York.

No published studies of blood selenium levels were found. Prior to this study, no parasite, disease, or hematological studies on the black bear had been conducted in Michigan's Lower Peninsula.

METHODS AND MATERIALS

About 30-cc of blood were extracted from each immobilized bear for parasite analysis by the DNR Physiology and Pathology Laboratory at the Rose Lake Wildlife Research Center, serum selenium determination by Michigan State's Animal Husbandry Department, and serum 2-dimensional isoelectric focusing protein preparation by MSU's Human Medicine Department.

For protein analysis, blood was centrifuged and serum separated from the hematocrit. The serum was then subjected to isoelectric determination as described by Pierce and Eradio (1979).

Three blood smears per bear were made for determination of Dirofilaria ursi microfilariae presence. Bacterial swabs for laboratory culture were taken from caries and diseased periodontal tissues. Cepti-Seal Culturettes which contained modified Stuart's bacterial transport medium were used for this purpose. All diseased tissues, caries, wounds, and other abnormalities were photographed.

Fecal samples, where present, were collected from live-trapped bears and checked microscopically for parasites. Slides of fecal material were prepared using the standard Sheather's flotation technique.

Black bear skulls in the National Museum of Natural History, Washington, D.C., were examined for dental caries and periodontal disease. Severe specimens were photographed.

RESULTS AND DISCUSSION

Periodontal Disease

Thirteen (37%) of the 35 bears captured had periodontal disease in varying degrees of severity, suffering tooth loss, infection, and jaw and gum atrophy.

The blood sera from 6 denned bears (2 females and 4 males) were examined for selenium values in relation to periodontal disease; the 2 females (Ta and Lu) had 0.066 and 0.074 μg Se/ml serum, respectively. If found in pigs, the 2 minimal values might indicate a beginning selenium-deficient problem, but no baseline values are known for black bears so that deficiency problems are difficult to predict (P. K. Ku, animal husbandry specialist, Mich. State Univ., pers. commun.). Since the Lower Peninsula is in a selenium-deficient belt, and since insufficient quantities of this element can cause periodontal disease in humans (Fredericks 1979), insufficient selenium is suspected of causing periodontal disease in Lower Peninsula bears.

Bacterial swabs were taken from teeth and gums from 11 different bears (7 males and 4 females) between June 1978 and March 1980 (Table 15). Specimens from all except 2 bears showed a presence of *Micrococcus* sp. This organism is normally considered to be only a skin contaminant, being associated

Table 15. Incidence of bacteria collected from gums and teeth of black bears handled between June 1978 and March 1980, Lower Peninsula of Michigan.

Bear	Periodt disease	Dental caries	Date sample collected	Bacterial presence and degree of infestation: α-hemolytic Streptococcus sp.	β-hemolytic Streptococcus sp.	nonhemolytic Streptococcus sp.	Acinetobacter sp.
MALES							
Du			6 13 78	light	-	-	-
Gr	+		6 20 78	heavy	-	heavy	-
LA	+		2 3 79	light	-	-	-
Go	+	+	1 26 80	-	light	-	-
OC	+		2 23 80	-	-	-	heavy
LS	+		3 1 80	-	-	-	-
MP	+		3 2 80	-	-	-	-
FEMALES							
Rh	+		6 15 78	light	-	-	-
Ta	+	+	3 11 79	moderate	-	-	moderate
DM		+	1 26 80	light	light	-	-
Ta	a +	+	2 17 80	-	-	-	-
Lu	+	+	3 5 80	-	-	-	-

a = second sample taken from this bear

Table 15. (cont'd.)

Bear	*Actinomyces* sp.	*Bacillus* sp.	*Enterobacter* sp.	*Klebsiella pneumoniae*	*Micrococcus* sp.	*Proteus mirabilis*	*Proteus* sp.
MALES							
Du	-	-	-	-	light	-	-
Gr	-	-	-	-	heavy	-	-
LA	-	-	-	-	light	-	-
Go	-	-	-	-	light	-	-
OC	-	-	heavy	-	heavy	-	-
LS	light	-	-	-	light	-	-
MP	-	-	-	light	light	-	-
FEMALES							
Rh	-	-	-	-	light	-	-
Ta	-	-	-	-	moderate	-	-
DM	-	light	-	-	-	-	-
Ta	a -	-	-	-	moderate b	heavy c	light b
Lu	-	-	-	-	-	-	-

a = second sample taken from this bear
b = sample taken from dental caries
c = sample taken from periodontal diseased tissue

Table 15. (cont'd.)

Bear	Staphylococcus aureus	Staphylococcus epidermidis
MALES		
Du	-	-
Gr	-	-
LA	-	-
Go	-	-
OC	-	heavy
LS	-	-
MP	light	light
FEMALES		
Rh	light	-
Ta	-	-
DM	-	-
Ta a	light b	-
Lu	very light	-

a = second sample taken from this bear
b = sample taken from dental caries

with man and animals as a generally-harmless commensal (Carter 1979). Staphylococcus aureus and S. epidermidis, present in 4 and 2 bears, respectively, also commonly occur as commensals on the skin and mucous membranes of man and other animals. S. aureus, however, has been reported to cause abscesses in many animal species, and is a frequent secondary invader and opportunist in a wide variety of diseases (Carter 1979). S. epidermidis also has been implicated as causing abscesses and skin infections in various animal species.

Bacillus sp. was present in 1 bear swab and can cause abscesses in teeth (A. Grupta, veterinary microbiologist, Mich. State Univ., pers. commun.). Actinomyces sp. also has been known to cause infection on occasion. The Bacillus sp. was taken from a caries' infected tooth. Although these 2 organisms were present in swabs from 4 bears infected with periodontal disease, they probably were not responsible for the initial infection. Alpha-hemolytic Streptococcus sp. is a common throat organism, beta-hemolytic Streptococcus sp. has been implicated in potential primary and secondary infection problems, and nonhemolytic Streptococcus sp. is generally considered to be a commensal organism (A. Grupta, pers. commun.). Most other bacteria (Table 15) were probably present because of fecal contamination, since bears usually defecated in barrel and culvert traps.

There is insufficient evidence to indicate that any of the bacteria collected were the cause of periodontal disease in bears. Their presence may have been opportunistic,

possibly related to secondary infection. Colyer (1936) felt that periodontal disease was caused by injuries to individual teeth. In this study, most infected cases showed no indication of tooth injury or damage.

Both Erickson (1967) and Rausch (1961) indicated that periodontal disease in black bears examined in Alaska was age-dependent. In this study, such was generally not the case. Ages of bears inflicted with the disease at the time of capture ranged from 1.75 to 6.5 years. The age:disease-frequency was: 1.75 years (1 of 13 bears), 2.75 (1), 3.5 years (3), 4.5 (5), 5 years (1), 6.1 years (1), and 6.5 years (1). By far the most extreme case of the disease was in a 2.75-year-old male, DH (Figure 27). In that case, there was atrophy of the gum and jawbone, nearly complete exposure of the canine root, and infection. In a 4.5-year-old male, Gr, the disease was classed as serious with atrophy of buccal and lingual gum tissue, loss of premolars, and widespread infection (Figure 28).

In 7 cases, bears that had the disease at initial capture were found not to have evidence of it when recaptured 7 to 13 months later (Table 16).

In 2 cases, bears having the disease when initially captured continued to show presence of it when recaptured (Table 16). Bear JJ, captured 23 May 1978, had a light infection on 3 July 1979. Bear Ta, initially captured on 3 August 1978, had a moderately severe level of the disease at that time. In the den on 3 December 1978, Ta's disease had declined in

Fig. 27. Critical case of periodontal disease found in male DH, examined on 25 October 1977. Note nearly complete exposure of canine root, atrophy of gum and jawbone, and infection.

Fig. 28. Serious case of periodontal disease in male Gr, examined on 20 June 1978. Note atrophy of gum tissue, loss of premolars, and infection.

Table 16. Variations in the presence of periodontal disease in black bears examined between September 1977 and March 1980, Michigan's northern Lower Peninsula.

	Bear initially had disease; upon recapture, disease not evident		Had disease at initial capture and subsequent recapture		Disease not present at capture, present at subsequent recapture, not present at final capture		
BEAR	Initial capture date	Recapture date	Initial capture date	Recapture date	Initial capture date	Subseq recapt date	Final recapt date
MALES							
LV	7- 4-78	8-16-79					
OM	10-29-77	8-30-79					
Go	6-27-79	1-26-80					
MP	7- 3-79	3- 2-80					
LA	5-23-78	2- 3-79/ 2-16-80					
FEMALES							
Lu	7-27-78	3- 5-80					
Rh	6-15-78	9-22-79					
MALE							
JJ			5-23-78	7- 3-79			
FEMALE							
Ta			8- 3-78	12- 3-78/ 1-20-79/ 3-11-79/ 2-17-80/			
MALE							
OC					11- 5-78	2-18-79	2-23-80

severity and healthy gum tissue had replaced some diseased tissue, although scar tissue was evident. Yet by 20 January 1979, the disease had increased in severity and was even more severe when the bear was examined in the den on 11 March 1979. By 17 February 1980, the disease was classed "serious" (Figure 29). Bear LS did not have periodontal disease when first captured on 15 May 1978 but had a light infection when recaptured on 1 March 1980.

Male OC, when captured on 5 November 1978, did not have periodontal disease; in 18 February 1979 the bear had a mild infection. On 23 February 1980, the disease was not evident.

The museum skulls of 618 black bears from Canada, United States, and Mexico were examined for evidence of possible periodontal disease. In contrast to the 37% incidence of periodontal disease infections in Michigan bears, only 5 (4%) of 136 Alaskan black bear skulls showed evidence of bone atrophy and degeneration possibly indicative of the disease (Figures 30 and 31). One (3%) of 32 skulls from Arizona, 1 (8%) of 13 from Florida, 3 (16%) of 19 from New York, and 1 (4%) of 23 from Mexico showed evidence of the disease.

Serum protease inhibitors of turkeys and several mammals (not known to include bears) have been associated, due to their deficiency, with major diseases such as emphysema (Kueppers and Black 1974). Samples from 7 bears, 5 of which were known to have periodontal disease, were tested using 2-dimensional isoelectric focusing. All samples showed the expected 3 major protein bands, but the 5 samples from diseased

Fig. 29. Severe case of periodontal disease in denned female Ta, examined 17 February 1980.

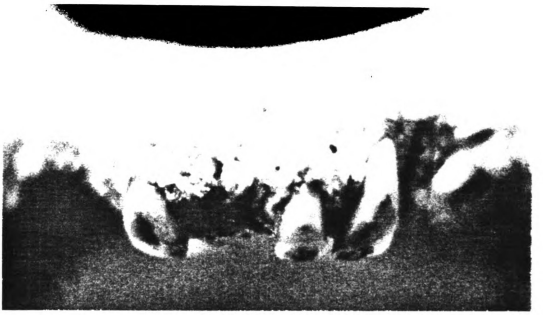


Fig. 30. Possible incidence of periodontal disease in male black bear (231461), captured 12 October 1918, Distna River, Alaska. National Museum of Natural History collection.

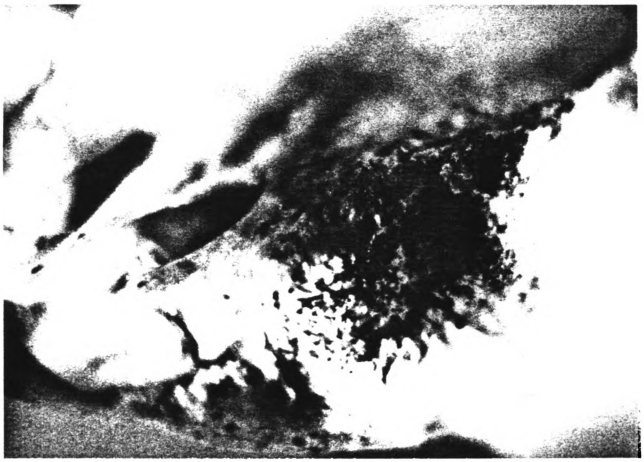


Fig. 31. Possible incidence of periodontal disease in female black bear (157629), captured White Mountains, Blue River, Arizona (no date listed). National Museum of Natural History collection.

bears also contained a minor additional band (Figure 32). Further tests on sera from other bears, both infected and disease-free, failed to duplicate the minor-band pattern. All protein samples showed normal alpha-1-antitrypsin activity (C. DeBussy, biochemist, Human Medicine Dept., pers. commun.). The additional protein band in the sera from infected bears is curious but needs to be examined further using this and other techniques before possibly linking periodontal disease to proteolytic enzyme causes.

Tooth Decay

Dental cavities found in 7 (20%) of the 35 bears examined, appeared to develop in older animals, ranging from 3.5 to 8.1 years of age. Caries incidence was as follows: 3.5-year-old (1 bear), 3.75-year-old (2), 4 years (1), 4.1 years (1), 4.5 years (1), and 8.1 years (1). A bear with a severe case of periodontal disease (Ta) did not show caries until between 3.1 and 4.1 years of age.

Parasites

Bears in the Lower Peninsula showed no evident ectoparasites. Some endoparasites were discovered. All blood smears collected from immobilized bears were negative for Dirofilaria ursi microfilariae. This was surprising since 17 (19%) of 90 black bears examined in northern Wisconsin contained microfilariae (Manville 1978b). Fecal samples from 20 bears contained various parasite eggs and larva. Six (30%) fecal samples were found to include eggs of the coccidian

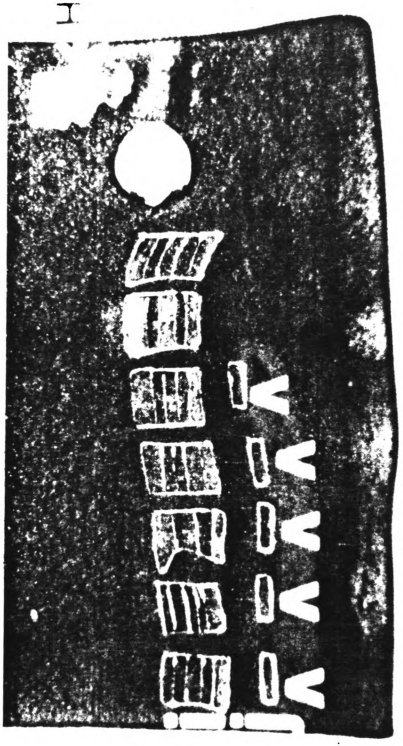


Fig. 32. Block of blue gel, showing the isoelectric drift of 7 samples of black bear blood serum using 2-dimensional isoelectric focusing. Samples 1-5 were from periodontal diseased bears, while 6-7 were from non-infected animals. H=human serum sample. Note the expected major protein bands (i), and the additional minor band (j) in the 5 diseased bears.

Eimeria sp., also reported from black bears in Alberta by Hair and Mahrt (1970). Five (20%) fecal samples contained eggs of the nematode parasite Baylisascaris transfuga, also commonly reported in Minnesota (Rogers 1975) and Wisconsin (Manville 1978b). The eggs and the larvae of the nematode parasite Capillaria sp. were discovered in the feces of 1 bear examined. This parasite, it is believed, has not previously been reported in black bears. Unknown larvae also were found in 3 fecal samples.

Injuries

Three bears had missing digits or healed broken bones. Male OC had lost the right rear fifth digit, the right front fifth claw, and all claws on the right rear foot except the fourth digit. Female Ta was missing the toe, claw, and pad on the left hind foot, and on the right hind foot, the outer 3 toes, pads, and claws. Male SB had a large calcareous growth between the right tibia and fibula, the result of healed broken bones.

Physiological Abnormality

Female Lu, captured on 27 July 1978, was lactating yet had a swollen vulva. Recaptured on 21 August 1978, the bear was still lactating, but no swelling was evident. Again recaptured on 5 March 1980, the 6 mammae were swollen and all looked like they had recently been suckled yet no milk was evident. The female, when captured, was denned with 2 cubs, one perhaps 15 kg heavier than the other (the cubs were not captured). No vulval swelling was evident.

PROJECT RECOMMENDATIONS

Techniques

1) Researchers should use plastic, snap-on, cattle ear tags rather than metal ear tags. Plastic tags are less irritating to ear tissue, less likely to cause infection, will not pull out as the ear grows, and are less likely to catch on vegetation and other objects.

2) The fluorescent-chrome color markers appeared more effective for visual identification than fluorescent orange, red or green markers because of their brightness and reflectiveness. Chrome could be used in combination with fluorescent red. Fluorescent orange markers were confused with yellow which was not used on bears.

3) Radio collars should be numbered with an electric etcher. They should be constructed of narrow, rubberized machine belting such as used by Telonics, Inc. products. Collars should be fitted with breakaway bolts such as those described by Larsen *et al.* (1980) for polar bears (*U. maritimus*). These will rust, corrode, or break off in approximately a year. In addition collars should be rolled with flexible rubber cushion foam, and taped (C. Jonkel, Univ.

Mont. bear biologist, pers. commun.; M. Pelton, Univ. Tenn. bear biologist, pers. commun.). The foam will rub off with time and wear, enabling the collar to increase in circumference as the bear's neck expands. This may alleviate problems of battery failure and inability to recapture marked animals, as the collar should eventually slip off when the foam wears down. Although dogs were used successfully only once during this study to corner female Lu, it seems reasonable that dog teams might be effectively employed to track and corner collared bears in winter which avoid recapture. They might also be used for initial capture and marking of animals, subject to the possibility of injuries to dogs inflicted by cornered bears refusing to tree.

Bear Management

1) Extensive continuous stands of swamp, lowland hardwoods, lowland brush, and adjacent upland hardwoods wherever found should be preserved as critical habitat for bears in Michigan's Lower Peninsula. No habitat management is being conducted specifically for the black bear there. If black bears are to be maintained in the Lower Peninsula, however, the lands around Higgins and Houghton lakes must be held in trust for this and other species and for the public. The State must continue to preserve the Dead Stream Swamp area, and when possible, to purchase additional critical swamp and adjacent upland habitats. Funds for additional land acquisition could be acquired, in part, from sales of bear hunting licenses.

2) Females with cubs should be protected by law from potential harvest. Although Erickson (1959) found that cubs as young as 5.5 months and as small as 8.2 kg may be self-sufficient in Michigan's Upper Peninsula, I hypothesize that cub survival is greatly enhanced in the company and protection of the mother.

3) Conscientious monitoring of age ratios in the kill of both sexes should disclose (and allow for prevention of) the occurrence of over-harvests, particularly if ratios are substantially altered.

4) Bears that cause property damage, display erratic behavior, or threaten people constitute a considerable potential danger. Such animals should be destroyed. Opening a limited hunting season in Missaukee County could remove some potentially-destructive bears.

5) All bears shot as nuisance animals should be reported to the DNR, and their sex, age (by cementum annuli analysis), and tooth condition recorded, to assist in population estimation and in seeking correlations between nuisance status and bear condition.

6) The meat from bears shot during control operations should be donated to local charities rather than discarded. Prime hides could be tanned and auctioned to the public, with any profits going to augment a general fund for possible future bear management.

7) Bears causing damage to beeyards should be trapped and removed at least 120 km from the area. If trapping is

unsuccessful, beehive depredators should be destroyed either by conservation officers or by apiarists under special authority. When possible, beeyards should be fenced with electrical shock wiring (Robinson 1965).

SUMMARY

Interactions between humans and black bears in Michigan's Lower Peninsula, particularly in developed portions of Crawford, Kalkaska, Missaukee, and Roscommon counties, were observed from the ground and from aircraft between September 1977 and March 1980. Thirty-five black bears were captured (22 males and 13 females), 25 were radio-collared for up to 22 months, and 1,112 radio-triangulations were made.

Humans seemed to benefit bears in several ways. Increased restrictions in hunting regulations (areas closed to hunting, a permit system, no bear harvest on deer tag registrations, and dog-pack restrictions) seemed likely to have induced the recently-observed increase in bear numbers in the study area. Bears were frequently observed using oil pipeline rights-of-way, oil well service lanes, and lumber roads as travel routes. Early successional vegetational states favorable to bears were induced by roadside cutting, commercial lumbering, clear-cutting deer-management projects, and controlled burns. Beekeeping practices provided food for bears.

Negative impacts of humans on bears included loss of habitat due to human encroachment and development, heavy

automobile traffic blocking movements of 4 bears, hunting aided by service roads benefiting bear hunters, 11 marked bears and females with cubs being shot, and bears which fled their dens when approached.

Bears were radio-tracked near, next to, or in areas of human development on numerous occasions. Two females denned close to snowmobile trails, while 2 males denned close to active oil wells. Nine males were located close to oil wells on 24 occasions and 2 females were located close to wells 10 times. Six males were found near houses 10 times, while 7 females were triangulated near dwellings on 22 occasions. Two males and a female were located near a local airport.

There was no evidence that oil wells, snowmobiles or people in the woods disturbed bears to any serious degree. Neither was there evidence that these factors were of no importance.

Of the 35 bears captured during the study, 17 (49%) died, including 14 collared bears (56% of the collared population). Of the latter, 9 were shot by hunters (3 illegally), 2 were shot as nuisances, and 1 was car-killed. In unfortunate study-related problems, 1 died from drugs and 1 died of an apparent strangulation.

Twenty-three marked bears were sighted and reported by the public on 63 separate occasions. Color markings did not appear to deter hunters from shooting marked bears as had been hoped.

Using convex polygons, males with greater than 6 months of telemetric data (N=11) had home ranges averaging 150.4 km^2 (SD=96.6 km^2) and females (N=5) averaged 60.1 km^2 (SD=53.6 km^2). Results from this study indicated that bears in the resort-developed areas of Michigan's Lower Peninsula required larger home range areas than in wilder localities of Minnesota, Maine, Montana, Washington, and elsewhere. During the summer of 1979, 6 adult males wandered 140, 105, 50, 47, 42, and 32 km from their fall-winter-spring home range areas but returned to those areas to den.

Ten radio-tagged males denned in 24 swamp, 2 lowland, and 2 upland locations, while 7 females denned in 11 swamp, 5 lowland, and 7 upland places. Unprotected snow nests were used by several bears. Males averaged 2.8 dens per winter; females, 3.3. Bears used the swamp conifer habitat most heavily on a year-round basis, while lowland brush was next most heavily utilized. Lowland hardwoods were third in use-importance while upland hardwoods were rated fourth.

Forty-six nuisance and damage complaints were reported in the study area between August 1977 and July 1980. Eighteen involved bears frightening people, 14 concerned damage to bee hives, while 8 involved other property damage. Data suggested a decreasing fear and/or intolerance of humans as bears increased in age and weight.

Based on ratio of marked to unmarked animals, the fall 1977 population was estimated at 82 unmarked bears for the

Dead Stream Swamp area (parts of Crawford, Kalkaska, Missaukee, and Roscommon counties).

Periodontal disease was found in 13 of 35 bears examined during this study and dental caries were present in 7. Bears suffered tooth loss, gum infection, and jaw and gum atrophy. There was insufficient evidence, however, to indicate that bacteria caused the disease. Using 2-dimensional isoelectric focusing, 5 samples of bear blood serum from diseased bears contained a minor protein band not present in disease-free samples. Results, however, were inconclusive. Selenium levels were low in bears examined, but since baseline values are not known for black bears, deficiency problems were difficult to appraise.

In view of expanding human populations and increasing uses of land areas in its natural range, the future of the black bear in Michigan's Lower Peninsula is uncertain. To insure its survival, habitat must be preserved and hunting must be carefully regulated.

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APPENDIX

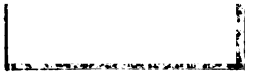

Table. A-1. Identification of marked black bears as discussed in the text of the dissertation, and as recorded during the field portion of the project.

Bear identification as used in the dissertation text	Ear tag identification as used during the project
MALES	
C1	50528-50529 C1
ES	50530-50531 ES
SB	50532-50533 SB
DH	50534-50535 DH
OM	50536-50537 OM
LS	7783-7784 LS
JJ	7785-7786 JJ
LA	7787-7788 LA
Du	7793-7794 Du
OC	7795-7796 OC
Gr	7799-7800 Gr
BK	50709-50710 BK
Ru	50713-50714 Ru
LV	50715-50716 LV
Zo	50717-50718 Zo
Go	51-52 Go
Be	50704-53 Be
MP	54-55 MP
FEMALES	
Ge	50526-50527 Ge
ML	5538-5539 ML
An	5540-5541 An
DM	7789-7790 DM
A1	7791-7792 A1
Rh	7797-7798 Rh
La	50711-50712 La
Lu	50719-50720 Lu
Ta	50721-50722 Ta
NN	76-77 NN

Table A-2. Capture, recapture, trapping, and den site information on 35 bears captured between September 1977 and January 1980.

Bear	Sex	Date Initial Capture	Date First Recapture	Date Second Recapture	Date Third Recapture	Date Fourth Recapture
Ge	F	9 9 77 a				
Cl	F	9 16 77 a	9 21 77 a			
ES	M	9 29 77 a				
SB	M	10 6 77 a	6 27 78 a			
DH	M	10 9 77 a	10 25 77 a			
OM	M	10 29 77 a				
ML	F	2 7 78 b				
Cub	M	2 7 78 b				
Cub	F	2 7 78 b				
Adlt	F	2 23 78 b				
Juv	M	2 23 78 b				
Juv	M	2 23 78 b				
An	F	2 23 78 b				
LS	M	5 15 78 a	3 1 80 c			
JJ	M	5 23 78 a	7 3 79 a			
LA	M	5 25 78 a	2 3 79 c	2 16 80 c		
DM	F	6 5 78 a	1 28 79 c	1 26 80 c		
Al	F	6 7 78 a				
Du	M	6 13 78 a				
OC	M	6 14 78 a	10 12 78 a	11 5 78 a	2 18 79 c	2 23 80 c
Rh	F	6 15 78 a				
Gr	M	6 20 78 a				
BK	M	6 26 78 a	11 5 78 a	2 11 79 c		
La	F	6 28 78 a				
Ru	M	6 29 78 a				
LV	M	7 4 78 a				

Table A-2. (cont'd.)

Bear	Sex	Date Initial Capture	Date First Recapture	Date Second Recapture	Date Third Recapture	Date Fourth Recapture
Zo	M	7 5 78 a				
Lu	F	7 27 78 a	8 21 78 a	3 5 80 d		
Ta	F	8 3 78 a	12 3 78 c	1 20 79 c	3 11 79 c	2 17 80 c
NN	F	6 19 79 a				
Go	M	6 27 79 a	1 26 80 c			
Be	M	6 27 79 a	6 29 79 a			
MP	M	7 3 79 a	3 2 80 c			
Cub	M	1 26 80 b				
Cub	F	1 26 80 b				
Total		35	14	6	2	2

a = capture or recapture in barrel, culvert trap, or foot snare
b = initial den site capture
c = den site recapture
d = capture with aid of dogs

Table A-3. Comparison of immobilization times and rectal temperatures for bears captured in the spring, summer, and fall, or in the winter, 1977 to 1980.

		SPRING/SUMMER/FALL CAPTURE				WINTER CAPTURE			
Bear	Sex	Date	Drug Used	Immobiliz Time (min)	Rectal Temp (C)	Date	Drug Used	Immobiliz Time (min)	Rectal Temp (C)
Ge	F	Se 77	S SP	115	37.33				
Cl	M	Se 77	P P a	20	37.22				
Cl	M	Se 77	S SP	20	37.94				
ES	M	Se 77	S SP	16	37.11				
SB	M	Oc 77	S SP	2	37.44				
DH	M	Oc 77	S SP	55	37.39				
DH	M	Oc 77	S SP	2	36.67				
OM	M	Oc 77	S SP	80	38.89				
ML	F					Fe 78	S SP	1.25	-
Adlt	F					Fe 78	S SP b	12.5	33.33
Juv	M					Fe 78	S SP b	3	33.61
Juv	M					Fe 78	S SP b	0.17	-
An	F					Fe 78	S SP b	-	33.89
LS	M	My 78	K P	4.75	39.56				
JJ	M	My 78	K P	3.7	38.67				
LA	M	My 78	K P	14	39.11				
DM	F	Ju 78	K P	4	38.11				
Al	F	Ju 78	K P	16	40.56				
Du	M	Ju 78	K	4	38.61				
OC	M	Ju 78	K	7	38				
Rh	F	Ju 78	K	3.5	38.11				
Gr	M	Ju 78	K P	11	38				
BK	M	Ju 78	K	46	38.94				
SB	M	Ju 78	K	25	38.44				
La	F	Ju 78	K	7.5	38.78				
Ru	M	Ju 78	K P	3	39.27				

Table A-3. (cont'd.)

		SPRING/SUMMER/FALL CAPTURE				WINTER CAPTURE			
Bear	Sex	Date	Drug Used	Immobiliz Time (min)	Rectal Temp (C)	Date	Drug Used	Immobiliz Time (min)	Rectal Temp (C)
LV	M	Jl 78	K P	5	37.83				
Zo	M	Jl 78	K	13	40.11				
Lu	F	Jl 78	K P	7	36.89				
Ta	F	Au 78	K P	3.5	38.11				
Lu	F	Au 78	K	2	-				
OC	M	Oc 78	K P	6	37.89				
BK	M	No 78	K	3	38				
OC	M	No 78	K P	8	37.81				
Ta	F					De 78	K	6	33.89
Ta	F					Ja 79	K P	5	33
DM	F					Ja 79	K P	21	34.67
LA	M					Fe 79	K P	37	35.89
BK	M					Fe 79	K P	1.5	34.17
OC	M					Fe 79	K	7	37.44
Ta	F					Mr 79	K	4	33.11
NN	F	Ju 79	K	7	-				
Go	M	Ju 79	K	20	-				
Be	M	Ju 79	K	8	-				
Be	M	Jl 79	K	18	-				
JJ	M	Jl 79	K	17	-				
MP	M	Jl 79	K	13	-				
DM	F					Ja 80	K P	45	37.44
Go	M					Ja 80	K P	20	36.56
LA	M					Fe 80	K P	20	33.33
Ta	F					Fe 80	K P	12	34.61

Table A-3. (cont'd.)

		SPRING/SUMMER/FALL CAPTURE			WINTER CAPTURE			
Bear	Sex	Date	Drug Used	Immobiliz Time (min)	Rectal Temp (C)	Date	Drug Used	Immobiliz Time (min)	Rectal Temp (C)
OC	M					Fe 80	K P	7	36.06
LS	M					Mr 80	K P	5	34.11
MP	M					Mr 80	K P	8	34.22
Lu	F					Mr 80	K P	8	35.78
TOTALS AND AVERAGES		55	35	$\bar{X}$ =16.9 $\bar{X}_{SSP}$=38.8 $\bar{X}_{KP}$ =10.4	$\bar{X}$=38.24	20		$\bar{X}$ =11.8 $\bar{X}_{SSP}$= 4.1 $\bar{X}_{KP}$ =13.8	$\bar{X}$=34.73

K P = ketamine hydrochloride and promazine hydrochloride (both injected intramuscularly)

P P = phencyclidine hydrochloride and promazine hydrochloride (both injected intramuscularly)

S SP = succinylcholine chloride (intramuscular) followed by sodium pentobarbital (intraperitoneal injection)

a = used after unsuccessful attempts with succinylcholine chloride and sodium pentobarbital

b = died from apparent reaction to succinylcholine chloride

Table A-4. Weights, ages, and measurements of bears captured between September 1977 and March 1980.

Bear	Date of initial capture	Radio-collared	Weight at time of initial capture (kg)	Nose-to-tail length (cm)	Date of last recapture	Weight at time of last recapture (kg)	Nose-to-tail length (cm)	Age as of Feb. 1980 (years)
MALES								
C1	9 16 77	+	89.2	157.5	9 21 77	90.6	157.5	5 a
ES	9 29 77	+	90.6	157.5	-	-	-	6 a
SB	10 6 77	+	126.8	176.5	6 27 78	92.9	69.5	6
DH	10 9 77	+	97.4	163.8	10 25 77	97.4	163.8	5
OM	10 29 77	+	72.5	148.6	8 30 79	106.5	159	5 a
Cub	2 7 78		0.3	-	-	-	-	2
Juv	2 23 78		27.2	97.8	-	-	-	3 a
Juv	2 23 78		27.2	94	-	-	-	3 a
LS	5 15 78	+	145	181	3 1 80	169.9	195.6	6
JJ	5 23 78	+	86.1	165.1	7 3 79	90.6	-	5
LA	5 25 78	+	61.2	152.4	2 16 80	93.3	172.7	5
Du	6 13 78	+	68	156.2	-	-	-	5
OC	6 14 78	+	58.9	149.2	2 23 80	83.8	166.4	5
Gr	6 20 78	+	74.7	165.7	-	-	-	5 a
BK	6 26 78	+	47.6	139.7	2 11 79	66.6	149.9	4
Ru	6 29 78		31.3	127.6	-	-	-	3 a
LV	7 4 78	+	104.2	161.9	8 16 79	142.2	189.5	5 a
Zo	7 5 78		99.7	172.7	-	-	-	6
Go	6 27 79	+	63.4	-	1 26 80	65.7	162.6	4
Be	6 27 79	+	61.2	-	6 29 79	61.2	-	4 a
MP	7 3 79	+	61.2	-	3 2 80	72.5	175.3	5
Cub	1 26 80		0.2	-	-	-	-	0.02

Table A-4. (cont'd.)

Bear	Date of initial capture	Radio-collared	Weight at time of initial capture (kg)	Nose-to-tail length (cm)	Date of last recapture	Weight at time of last recapture (kg)	Nose-to-tail length (cm)	Age as of Feb. 1980 (years)
FEMALES								
Ge	9 9 77	+	154	179.9	-	-	-	8 a
ML	2 7 78	+	116.4	158.8	-	-	-	8
Cub	2 7 78		0.3	-	-	-	-	2
Adlt	2 23 78		96	141	-	-	-	- a
An	2 23 78	+	22.7	94	-	-	-	3 a
DM	6 5 78	+	20.4	87.6	1 26 80	63.4	161.3	4
Al	6 7 78	+	63.4	153.7	-	-	-	5 a
Rh	6 15 78	+	52.1	139.7	-	-	-	5 a
La	6 28 78	+	66.6	154.3	-	-	-	5 a
Lu	7 27 78	+	58.9	153.7	3 5 80	65.7	167.6	7
Ta	8 3 78	+	27.2	111.8	2 17 80	47.1	132.1	4
NN	6 19 79		56.6	-	-	-	-	5
Cub	1 26 80		0.2	-	-	-	-	0.02
TOTALS AND AVERAGES	35	25	35	27	16	16	14	34
			$\bar{X}$=63.7	$\bar{X}$=146		$\bar{X}$=87.2	$\bar{X}$=116.4	$\bar{X}$=4.4 b
			$\bar{X}_{♂}$=67.9	$\bar{X}_{♂}$=151		$\bar{X}_{♂}$=94.9	$\bar{X}_{♂}$=169.9	$\bar{X}_{♂}$=4.5 b
			$\bar{X}_{♀}$=56.6	$\bar{X}_{♀}$=137.4				$\bar{X}_{♀}$=4.29b

a = age of bear had it been alive at this time; died before this date.
b = average calculated only from bears known alive as of Fe 80.