To the Graduate Council:

I am submitting herewith this thesis written by Carmen A. Lombardo entitled "Population Ecology of Black Bears on Camp Lejeune, North Carolina." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Michael R. Pelton, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Associate Vice Chancellor
and Dean of The Graduate School

POPULATION ECOLOGY OF BLACK BEARS ON CAMP LEJEUNE, NORTH CAROLINA

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Carmen Anthony Lombardo

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DEDICATION

"Ever since the appearance of their ancestors on earth, man and bear have been at odds. Beginning in the Pleistocene when giant cave bears towered over every other predator-of which man must be reckoned as one-our low browed grandfathers were forced to cope with shaggy haired beasts who stood twice as tall and out-weighed them ten to one. For a half million years it was the bear, not man, who dominated the wilds, and it continued to hold the upper edge until the development of high-powered rifles within the past two hundred years. In this short period-the blink of an eye in time-some bears have not adjusted their thinking to man's sudden supremacy. Some of them still believe they can whip any man in a fair fight, and that they have every right to run him out of the dwindling wilderness."

Frank Dufresne, *in* The Bear Book, 1979
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ABSTRACT

Fifteen black bears (*Ursus americanus*) were captured 24 times on Marine Corps Base Camp Lejeune, North Carolina, during 1988 and 1989. Females dominated the capture sample, but age did not differ between the sexes (P=0.31). No subadult males were captured during the study. Mean litter size was 2.2 (n=6) with females attaining primiparity at age 4. Breeding may occur at age 3; den observations and teat development suggested previous parturition in a four-year-old. Estimated annual survival rates were 0.77 for males, 0.69 for females, and 0.53 for cubs. Causes of mortality included vehicle collisions (n=8), research (n=1), and legal kill (n=1; outside the study area). Population density for the study area was estimated by 4 techniques at 0.16-0.30 bears/km^2, or 21-40 bears. Twenty three bears were known to inhabit the base as residents or seasonal migrants.

Denning ecology was described for 14 bears (12F, 2M). Winter activity was recorded for 5 of 7 bears in 1989 and 3 of 7 bears in 1990. Two bears (1 adult male, 1 subadult female) used multiple den locations. Bears denned exclusively on ground nests in three habitat types; pocosin (n=11), lowland pine-hardwood (n=2), and an area of forest regeneration (n=1). Vegetation density at the hibernacula (x=94%) was greater (P<0.001) than random locations. Prescribed burns resulted in 4 den abandonments (50% of all

human disturbance) and overall den abandonment was high (36%). Parturient females generally denned earlier (Dec. 23 ±10.4d) than all other bear groups.

Male home ranges (60.5 km^2) were larger on average than female ranges (20.4 km^2). Annual home range size for solitary females, subadult females, and females with cubs were not different (P=0.34). Annual home range overlap was extensive for females; considerable overlap was present between males and females during both years of the study.

Habitat utilization was determined by plotting telemetry locations on Camp Lejeune Forest Compartment maps. Bears used pocosin habitat more than expected based on random availability during all seasons except late summer. Mesic and xeric hardwoods were important habitats during late summer and early fall with the latter also disproportionately selected in late fall. Pine-hardwood habitats were used during summer and early fall; pure pine habitats were avoided throughout the year. Salt marsh and the landfill were selected habitats during late summer. Use of artificial foods was opportunistic in nature. Female bears were located farther from Class I roads during late fall than any other season. The distribution of bears to Class I roads suggested a relationship to habitat position. Bears were located closer to Class II roads than Class I roads throughout the year.

Factors indirectly associated with the military

mission, such as increased traffic volumes and urban development off Base property, impact the black bear population to a greater degree than military training itself. Abnormally high mortality rates for females and lack of dispersal information for subadult males indicates a need for further study. Genetic relationships between resident bears on Camp Lejeune and bears in the surrounding areas of Great Sandy Run Pocosin, Hoffman Forest, and Croatan National Forest warrant investigation to determine the degree of isolation and genetic variability within and among black bear populations in southeastern North Carolina.

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CHAPTER I

INTRODUCTION

Historically, black bear populations were found throughout the Eastern United States, but have declined in response to habitat destruction and exploitation (Carlock et al. 1983, Pelton 1985). The modern distribution of the species in the Southeast is only 5 to 10% of its historic range and is considerably fragmented (Maehr 1984). Dramatic changes in the environment resulting from land use shifts and human encroachment have negatively impacted the survival of the species in the Southeast.

Black bears were once numerous throughout North Carolina and were utilized to a great extent by settlers and Native Americans for food and clothing (Lawson 1967). Since the turn of the century, settlement and industrialization in the Piedmont physiographic province have largely eliminated the species from this portion of the state. Surviving populations now exist in the rugged western mountains, the nucleus of which is Great Smoky Mountains National Park. The pocosins and swamps of the Coastal Plain provide the last stronghold of desirable habitat for the coastal population (Monschein 1981; Fig.1, after Collins 1990).

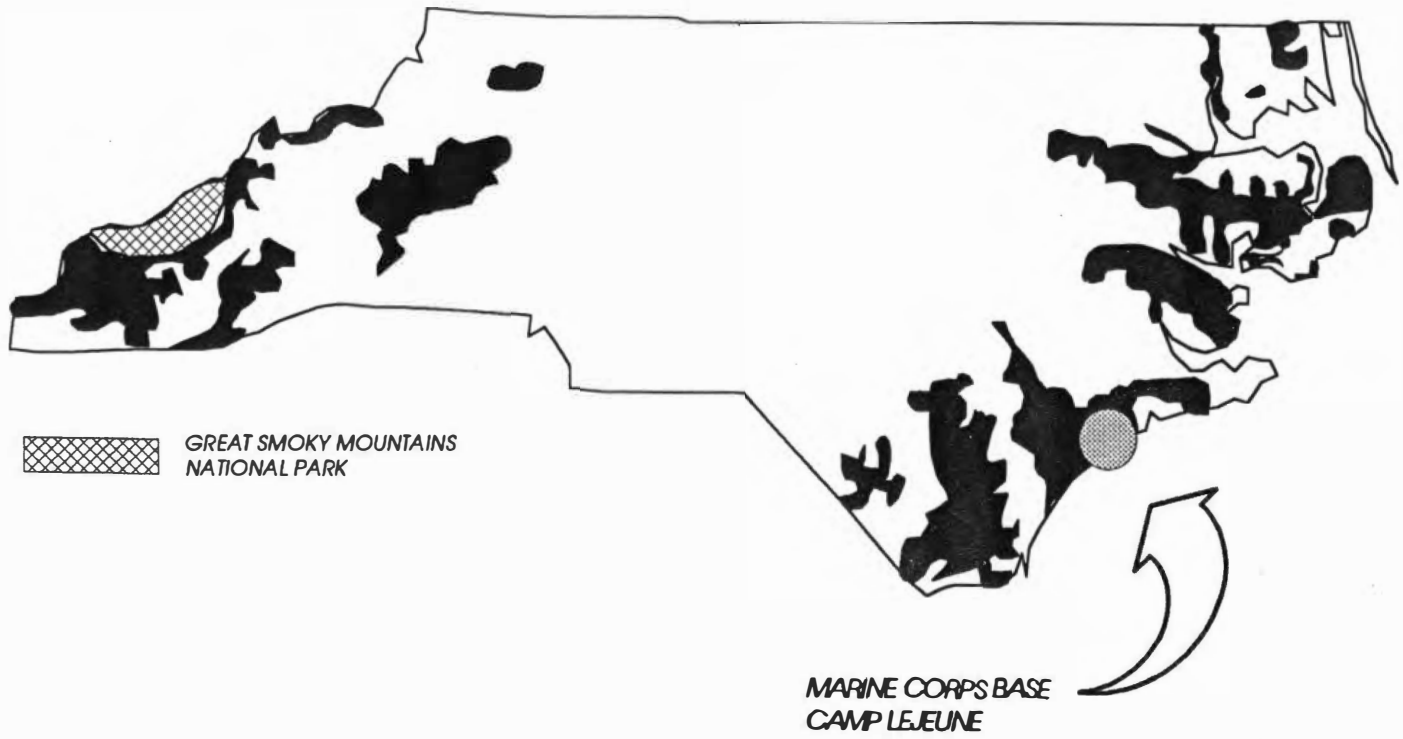


Figure 1. Distribution of black bears in North Carolina (after Collins 1990).

Black bear populations in the Coastal Plain are relegated to wetland habitat "islands" scattered among the eastern counties of the state (Monschein 1981). Thousands of hectares of prime wetland habitat within this region have been destroyed over the last few decades. Between 1962 and 1972, 33% (300,000 ha) of the pocosins in eastern North Carolina were altered by agriculture, forestry, and industrial land management practices (Richardson et al. 1981). Continued habitat destruction has further reduced the stability of coastal bear populations (J. Collins, North Carolina Resources Comm., pers. commun.).

In an effort to protect populations of breeding age female bears, the North Carolina Wildlife Resources Commission (NCWRC), established 28 black bear sanctuaries (364,000 ha total) throughout the state. The primary purpose of the sanctuary system is to provide a population core of breeding-age females whose offspring would disperse into surrounding areas (Sanders 1978). Sanctuaries in the western mountains of North Carolina appear to be successful in protecting such a breeding population (Beringer 1986, Seibert 1989).

Marine Corps Base Camp Lejeune (Camp Lejeune), Onslow County, North Carolina, became part of the sanctuary system in 1971 and remained so until 1984. Sanctuary status was lifted by the Environmental Management Department (EMD), because of an increase in bear-human interactions (C.

Peterson, pers. commun.). Bear-troop encounters increased near field mess tents because of food availability and artificial feeding (A. Henry, pers. observ. 1985). A concomitant increase in bear sightings at roadside sanitation bins was observed. Harvest levels of bears on Camp Lejeune for pre and post-sanctuary periods have remained low (≤6 per year). An increase in the number of female bears appearing in the harvest and rising vehicle-related mortalities caused concern. Hunting of bears on Camp Lejeune was stopped in 1988 and will be prohibited for an indefinite period, contingent upon findings from this study and future research endeavors.

The ecology of black bears on the Atlantic Coastal Plain of the United States has been the subject of limited study. The most recent study was conducted by Hellgren (1988) in the Great Dismal Swamp of Virginia-North Carolina. Hardy (1974) and Hamilton (1978) conducted studies in Dare County and Bladen County, North Carolina, respectively. Current investigations are underway on the Appalachicola National Forest in Florida (Seibert, pers. commun.).

A preliminary research project on Camp Lejeune was initiated in the spring of 1973 and ended in the autumn of 1974 with no formal findings presented.

The objectives of the present study were:

(1) To describe the population dynamics of black bears on Camp Lejeune,

(2) To determine recruitment and mortality rates;

(3) To describe the denning ecology of black bears on Camp Lejeune, and

(4) To determine habitat utilization, home range dynamics, and distribution of the species on the area.

CHAPTER II

STUDY AREA

Location

Marine Corps Base Camp Lejeune (64,000 ha) is located in Onslow County, southeastern North Carolina (Fig. 2). Camp Lejeune has approximately 56 km, 15 km, and 22 km of shoreline located on the New River, the intra-coastal waterway, and Atlantic Ocean, respectively. A 1992 purchase (Great Sandy Run Pocosin Acquisition) will increase the land area to approximately 82,000 ha.

The area is bounded on the northwest by the city of Jacksonville (population 68,000). The north, east, southwest, and west are bordered by the unincorporated townships of Hubert, Queens Creek, Sneads Ferry, and Verona, respectively (Fig. 3). Major highways include US Route 17, NC 24, and NC 172, which comprise the western, northern, and southern to eastern boundaries. NC 172, which transects the military base is subject to partial or total closure dependent upon range control priorities.

The primary drainage for Camp Lejeune is the tributary system of the New River. These tributaries are North East

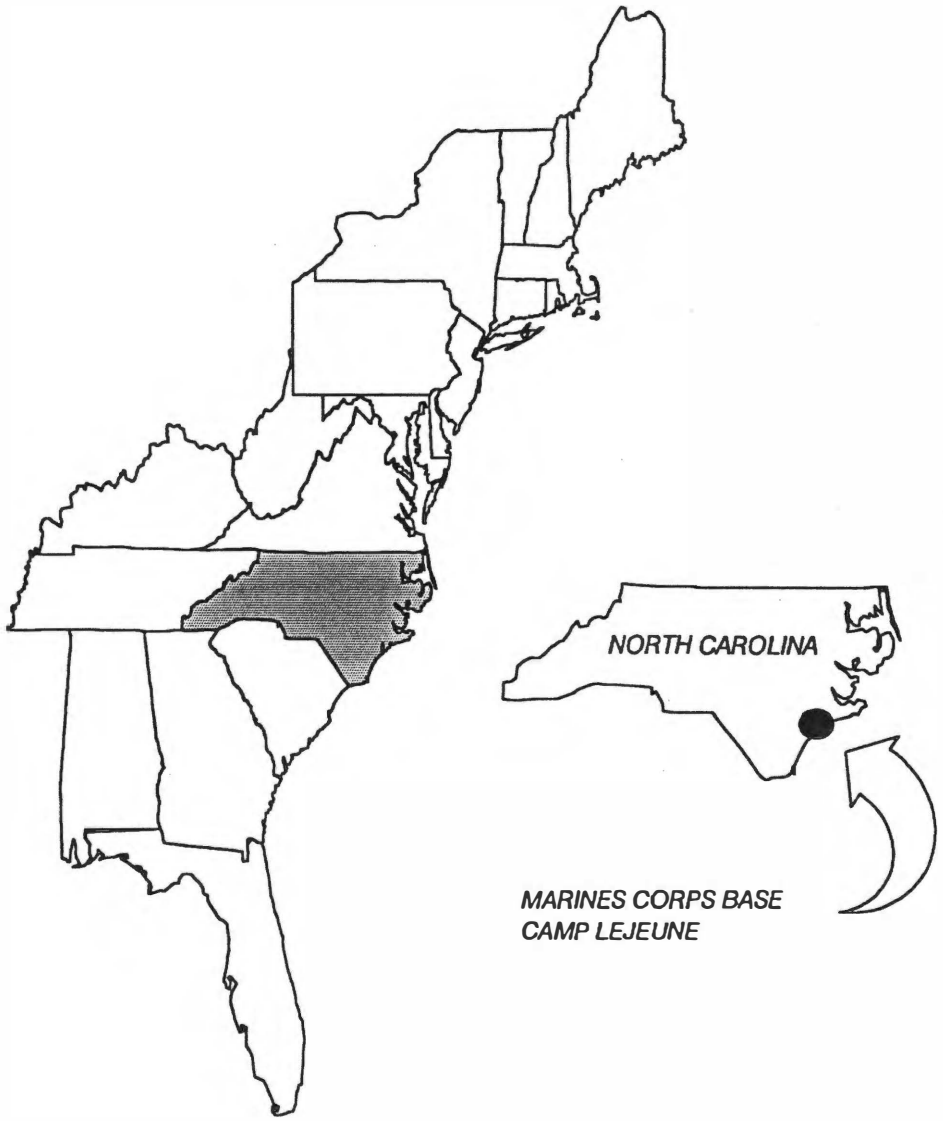


Figure 2. Geographic location of United States Marine Corps Base, Camp Lejeune, Onslow County, North Carolina.

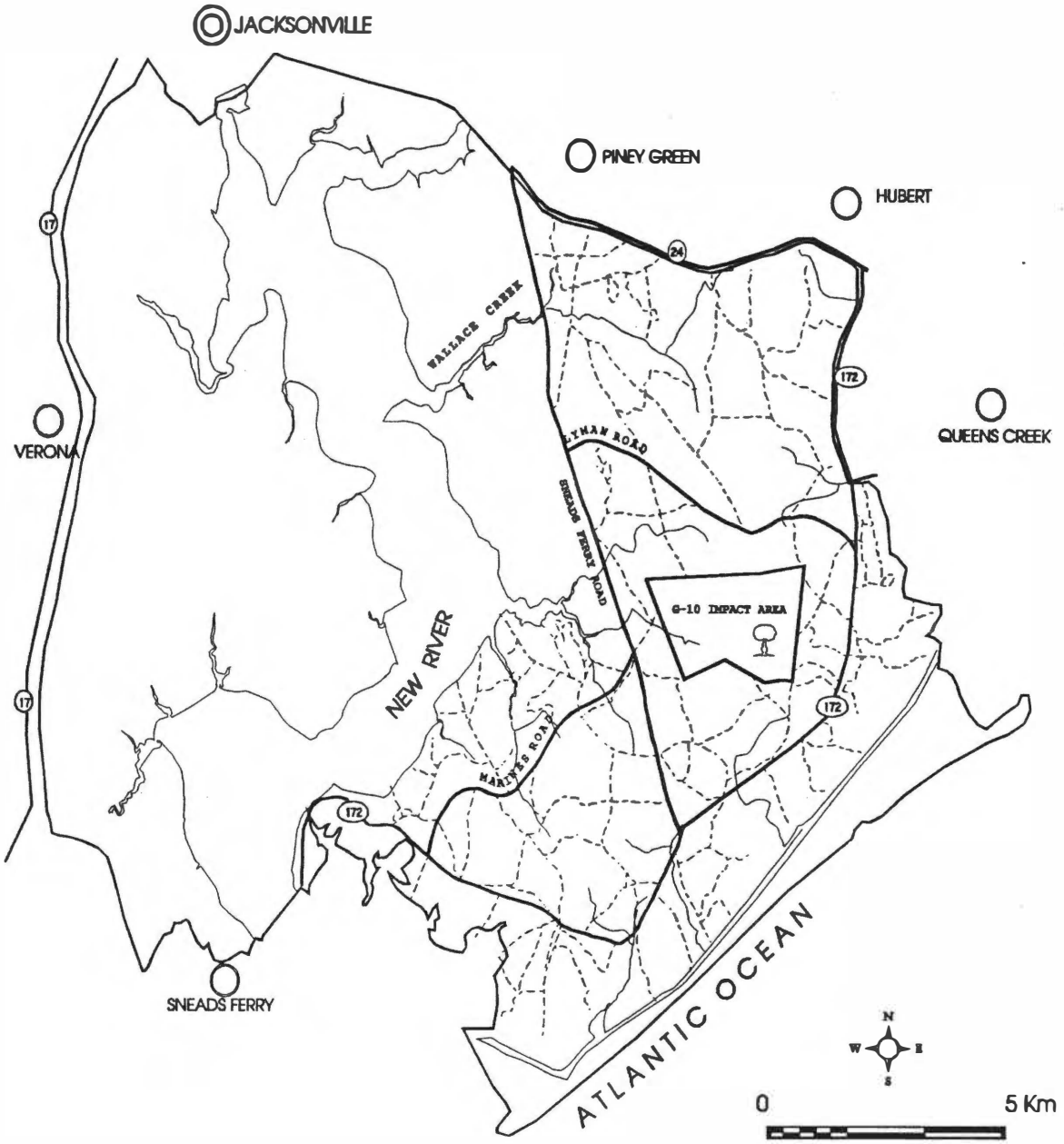


Figure 3. Locality map for Camp Lejeune, North Carolina.

Creek, Duck Creek, Southwest Creek, Mill Creek, Stones Creek, Wallace Creek, Bell Swamp, Cowhead Creek, French's Creek, and Everett Creek. These creeks have wide estuarial flood plains, are slow moving, and are influenced by tidal fluctuations. Brackish water can be found up to 5 km inland along these stream systems (Barnhill 1984). There are a myriad of shorter stream courses which empty directly into the intra-coastal waterway.

The eastern portion of the base (Mainside), which comprises 25,000 ha, was selected as the study area. The western section of the base (Verona) was excluded from any analysis due to lack of fresh sign and no response from bears to either prebaiting or trapping. These areas will be included in discussion of potential bear habitat and in relation to their juxtaposition to the Great Sandy Run Pocosin Acquisition.

Geology and Physiography

Camp Lejeune lies on the eastern edge of the Coastal Plain Physiographic Province. The coastal plain is a geosynclinal wedge of alluvial and marine sediments that comprise much of the landscape from the mid-Atlantic States southward across the Gulf States (Murray 1961). Soils derived from these sediments often are siliceous and nutrient poor (Christensen et al. 1988).

The area contains portions of three geomorphic surfaces, representing periods of "recent" land emergence (after Barnhill 1984; Fig. 4). The Pamlico Surface (0 to 7.7 m) lies in a narrow coastal strip and extends into constricted areas of the New River and its tributaries. A greater portion of the military base lies on the Talbot Surface (7.7 to 13.7 m). The Wicomico Surface (13.7 to 21.3 m) is represented by areas on the western edge of the installation.

Climate

The climate has been classified by Thornthwaite (1948) as mesothermal "humid". A classification of sub-tropical, warm-temperate moist forest is derived by application of the Holdrigde System (Sawyer and Lindsey 1964). Winters are short with relatively mild temperatures ($\bar{x}$=8.6°C). Cold spells are of limited duration. Summers are hot and humid with maximum temperatures occurring in July (31.1°C). The mean annual temperature is 23.1°C. Potential evapotranspiration is in excess of 75 cm (Watt 1971). Precipitation in the form of rainfall is greatest in July ($\bar{x}$=20.3 cm) and least during November ($\bar{x}$=6.7 cm). Afternoon thundershowers are frequent during July and August. Snowfall generally does not exceed 8.0 cm for the year; however, a 38 cm snowfall occurred in December 1990.

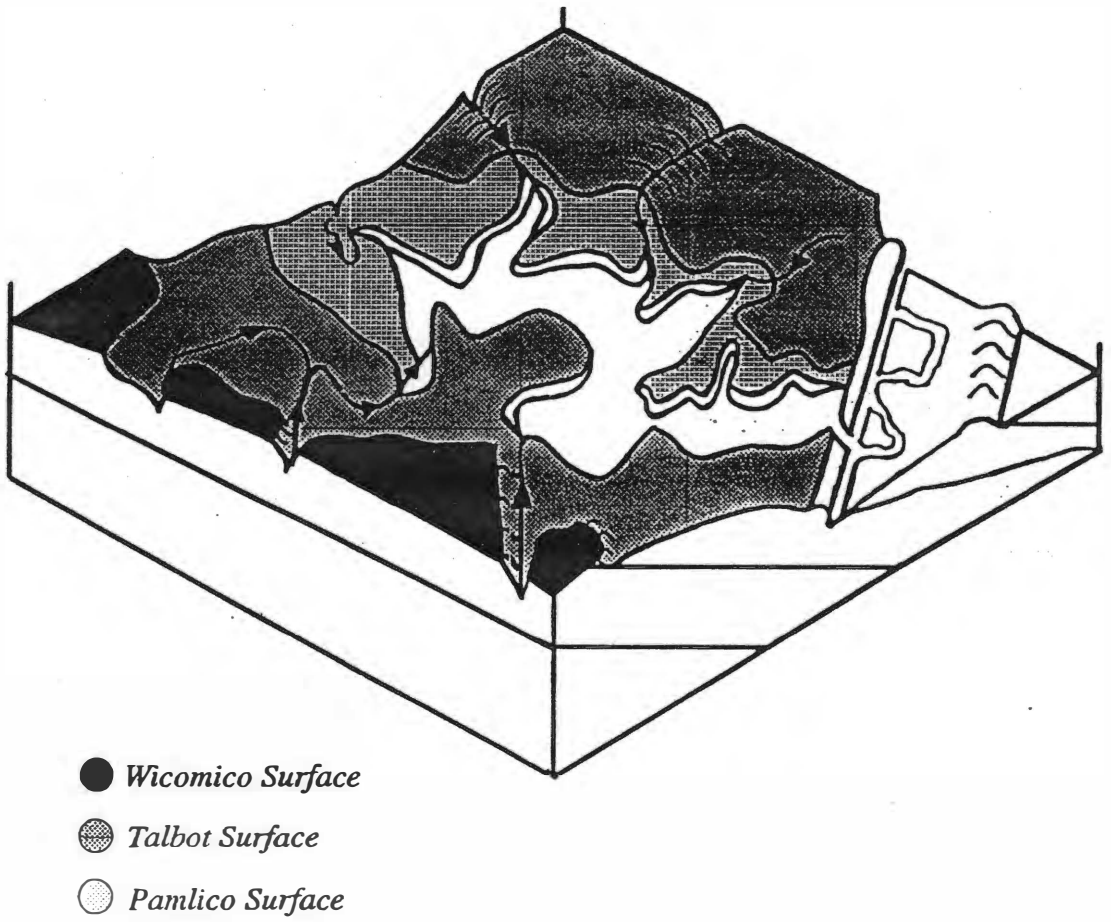


Figure 4. Geomorphology of United States Marine Corps Base Camp Lejeune, North Carolina.

Fauna

A variety of furbearing mammals can be found including beaver (*Castor canadensis*), mink (*Mustela vison*), river otter (*Lutra canadensis*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*), opposum (*Didelphis virginiana*), gray fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), and striped skunk (*Mephitis mephitis*). Small game mammals include the cottontail rabbit (*Sylvilagus floridanus*), marsh rabbit (*Sylvilagus palustris*), gray squirrel (*Scurius carolinensis*), and the fox squirrel (*Scurius niger*). Southern flying squirrels (*Glaucomys volans*) also are endemic. The only resident big game animal, other than the black bear, is the white-tailed deer (*Odocoileus virginiana*). Upland game birds include the eastern wild turkey (*Meleagris gallopavo sylvestris*) and bobwhite quail (*Colinus virginiana*). The fresh, brackish and saline waters associated with Camp Lejeune boast more than 80 species of fish.

Approximately 80 species of birds inhabit the area with a minimum of 8 migratory waterfowl species, 4 owls, 5 hawks, and 6 species of woodpeckers including the red-cockaded woodpecker (*Picoides borealis*) which is listed by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1979) as federally endangered. At least 20 species of reptiles and 16 species of amphibians inhabit the area.

Flora

Plant communities on Camp Lejeune are diverse and range from beach and barrier island communities to longleaf pine (*Pinus palustris*) savannas to upland hardwood types. Dune communities are located landward of beach zones and are dominated by salt tolerant perennial grasses. Typical species include American beech grass (*Ammophila brevigulata*), bitter panic grass (*Panicum amarum*), salt-meadow cordgrass (*Spartina patens*), sea oats (*Uniola paniculata*), and broomes (*Andropogon spp.*). Maritime shrub thickets (salt spray communities; Wells 1928) are typically found landward of dune communities and grade into tidal marshes or extend into maritime forest communities. Trees in the maritime forest are dominated by live oak (*Quercus virginiana*). Extensive salt marshes are present along bay heads and creek outlets.

EMD Forestry Division has inventoried the entire base, exclusive of impact areas, and partitioned the area into forest compartments. Stands within each compartment are designated by dominant and co-dominant overstory species. The remainder of the stocking in each stand is not categorized. For the selected study area (Mainside), there are 56 distinct stand types (Table 14)[1] that represent 8 major cover types and two additional categories: pure pine,

[1] Tables 14-17 and Figures 16-23 are found in the appendices.

mixed pine, pine-hardwood, mesic hardwood, xeric hardwood, hardwood-pine, pocosin, salt marsh, landfills, and wildlife openings (Table 1). Seventy-six percent of Camp Lejeune occurs in 6 pine cover types.

History and Land Use

Prior to 1940, the land area was privately owned with tracts ranging in size from one to several thousand hectares. Approximately 3,000 hectares were in open farmland. Camp Lejeune, established in 1940, was envisioned primarily as an amphibious training installation and hails today as the worlds largest amphibious training center. During Camp Lejeune's construction, nine million board feet of timber were harvested (Camp Lejeune et al. 1987).

Today, most of Camp Lejeune is commercial forestland. Managing a forestland used primarily for military training provides a unique opportunity for foresters to integrate many silvicultural practices. Portions of the base, such as the G-10 and K-2 Impact Areas, are exclusively used for military training; controlled burning is the only forest management application (Camp Lejeune et al. 1987). The Endangered Species Act of 1973 has had a significant effect on forest husbandry because of the presence of the red-cockaded woodpecker. Longer rotation lengths for loblolly, longleaf, and pond pine were recommended for the ecological

Table 1. Major forest cover type groupings for the selected study area (Mainside), excluding residential and industrial areas on Camp Lejeune, North Carolina.

Cover Type	Coverage in hectares	% of Study Area
Pure Pine	3388	24.9
Mixed Pine	1402	10.3
Pine-Hardwood	3361	24.7
Pocosin	2004	14.7
Mesic Hardwood	1715	12.6
Xeric Hardwood	871	6.4
Hardwood-Pine	286	2.1
Marsh	191	1.4
Landfill	231	1.7
Wildlife Openings	175	1.3
Total	13,624	100.0

stability of woodpecker colonies (U.S. Fish and Wildlife Service 1987a).

Natural Resource Management within the Camp Lejeune complex is carried out as a multiple-use system with primary and secondary land uses. The primary use of any given tract of land or water area is, with minor exceptions, directly related to the military mission. All natural resource activities are conducted in coordination with Range Control to avoid conflicts with scheduled military training exercises.

The harvest of game animals on Camp Lejeune is closely monitored by EMD Wildlife Division. Hunting seasons are directed by a wildlife biologist and enforced by civilian game wardens. State mandated regulations provide the basis for most wildlife laws with minor changes in season lengths. Special organized hunts for white-tailed deer are scheduled during fall and winter to manage the herd on a zone by zone basis. As noted, black bear hunting is prohibited for an indefinite period.

CHAPTER III

MATERIALS AND METHODS

Trapping and Handling

Trapping was conducted during the months of June through October for 1988 and 1989. Trapsites were located in areas adjacent to wetland habitats (pocosins and swamps) and probable feeding areas (i.e., soft and hard mast producing vegetation, sanitation bins, and the sanitary landfill). The majority of trap sites were established within close proximity to roads. Prebaiting was conducted in areas distant to artificial food sources (Johnson and Pelton 1980a).

Heat constraints became a factor during late July and August when daily temperatures could exceed 38.8°C. Black bears lack true sweat glands, therefore trapsites were checked during early morning hours to reduce the possibility of heat stress on captured bears.

Bears were captured with modified Aldrich foot snares (Johnson and Pelton 1980a), a barrel trap constructed from a 90cm galvanized rain culvert, and two steel cages box traps mounted on boat trailers (Black 1958). Captured bears were immobilized with intra-muscular injections of a mixture of

Ketaset (Ketamine Hydrochloride, Bristol Laboratories, Syracuse, NY), Rompun (Xylazine Hydrochloride, Haver-Lockhart, Inc., Shawnee, KS), and Carbocaine V (Mepivacine Hydrochloride, Winthrop Laboratories, New York, NY) at a concentration of 200 mg/100 mg/20 mg, respectively. Initial dosage rate was 1 cc per 45 kg estimated body weight. The drug was administered using a hand held jab-stick and syringe. A CO_2 powered dart pistol (Capchur, Palmer Chemical Company, Douglasville, GA) was used only when approach was hazardous to the researcher or animal.

Immobilized bears were weighed and a number of morphological characteristics measured. A portable tripod, designed specifically for large mammals, was employed to weigh bears. Morphological characteristics included: head length (saggital crest to tip of nose), head width (greatest breadth between zygomatic arches), ear length (ear tip to ear notch), neck circumference (measured approximately 6cm behind ears), chest circumference (measured behind front fore-legs), shoulder height, forearm circumference (measured at widest point), front and hind foot pad length and width, tail length (measured on the underside of tail), and total length (measured from tip of nose, along back, to tip of tail).

Bears were ear tagged with numbered hog buttons (Nasco, Inc.) and a corresponding number was tattooed on the inner lip and groin for permanent identification. Selected

individuals were fitted with radio-collars (Telonics Inc., Mesa, AZ). First premolars were extracted for age identification (Willey 1974, Eagle and Pelton 1978). Liquamycin (Phizer Laboratories, New York, NY) was administered intra-muscularly and spray antibiotics applied locally to prevent infection from handling or trap related injuries. Lactating females were given 1 cc of Oxytocin (Burns Veterinary Supply, Oakland, CA) to counteract the milk inhibiting properties of Ketaset.

Radio Telemetry

The radio transmitters used in this study had a bimodal feature which allowed activity monitoring, although distinct behavior could not be determined by signal pulse (Quigley et al. 1979). A leather spacer was affixed to each collar which was designed to break away after 12 to 18 months of use (Hellgren et al. 1988). The leather spacer measured 12.5 cm by 4.0 cm with bracket holes to allow for individual adjustment.

A Telonics TR-2 receiver equipped with a roof mounted antenna (Wildlife Materials, Carbondale, IL) was used to monitor radio-tagged animals. A hand-held "H" antenna was used when conducting "walk-ins" and to determine direction when an animal was within 50 m.

Triangulation accuracy was tested by placing

transmitters at known locations (UTM Grid System, Zone 18). Transmitter location varied from open landing zones to dense vegetation along stream drainages and pocosins. The standard deviation of bearing error associated with handheld equipment was ± 3.1 (n=200).

Data Collection

Radioequipped bears were located 1-7 times weekly by standard ground triangulation techniques. Aerial telemetry was used on 2 occasions during October of 1988 to locate Bear 05 which had travelled off Base property. Transmitter direction was determined by the "null" and "peak" of signal strength (Springer 1979).

Up to 5 azimuths were taken from known receiver location points around the animal, with three being the minimum number of azimuths accepted for error polygon calculation (Mech 1983). A modification of Beringer's (1986) criteria was used to select azimuths. These criteria were: (1) the angle between any two azimuths was between 40 an 120 degrees, (2) the time between successive triangulations was less than 30 minutes, (3) selected azimuths had the shortest distance between the receiver and animal, (4) signal strength and integrity were good, and (5) there were no dense pockets of vegetation between the animal and the receiver. Criteria (2) and (5) were observed

conjunctively. A maximum of 20 minutes was needed to determine if a bear was within a dense stand of vegetation.

Home Range

Radiolocation stations, georeferenced on the Universal Transect Mercator (UTM) system, along with azimuth bearings were used as input for the computer program XY-Log (Dodge and Steiner 1986). XY-Log generated output was downloaded into the computer program MCPAAL (Stuwe and Blohiwiak 1986) to generated convex polygons. DISPOL (Display Polygons; ERDAS, 1990) was then used for plotting home range locations georeferenced to Base features.

Annual and seasonal home ranges were constructed for bears with a minimum of 14 locations per season. Seasonal home ranges were calculated for bears that were monitored for > 50% of a season and relocated on average at least once per week (Hellgren 1988). Seasons were based on changes in plant phenology and logistical contraints: summer (emergence to 16 July), late summer (17 July to 31 August), early autumn (1 September to 15 November), and late autumn (16 November to 1 January). Home ranges were calculated with the minimum convex polygon method (Hayne 1949). The convex polygon method was chosen because of its graphic simplicity (Clevenger 1986), although overestimation of actual area of activity can occur (Mykytka and Pelton 1988).

Seasonal and annual home range areas were tested for differences between female age and reproductive groups with nonparametric tests (Kruskal-Wallis tests, SAS Institute Inc. 1985). Data were pooled between years because of small sample sizes. Annual and seasonal home range overlap was measured with program Measure (ERDAS, 1990).

Habitat Utilization

Coordinates for radiolocations were overlaid on a cover map prepared by EMD, Forestry Division. These data were arranged by compartment (30 for the selected study area) and stands within compartments. The stands averaged 23 ha in size. Fifty-six specific stand cover types were grouped into 10 categories for analysis of bear habitat preferences. The detail and accuracy within stand compartments enabled habitat analysis to be conducted at the scale of major forest cover type groupings and individual stand types. Age class data and site index values (quantified as percentage of merchantable timber) were not uniformly available and were not included in the analysis.

To determine the percentage of habitats used, the habitat available to that individual must be quantified. Various methods of determining available habitat have been used. These include: areas which include the greatest quantity of bear locations (Quigley et al. 1979, Garris

1983), utilization distributions of all bears (Brody 1984, Hellgren 1988), and selection of a study area core as available habitat (Smith 1985, Hellgren 1988).

Habitat preference analyses were conducted on 3 scales. The relative availability of habitats over the entire study area (Mainside) was determined and compared to relative use of those habitats by radio collared bears. This comparison was used to estimate habitat selection by female bears at the macro scale. Considering the assumption that all habitats within an area should be available to bears regardless of sex and age, a second analysis was conducted using a composite range determined by the union of female bear home ranges. This composite range was considered available habitat and the habitat intersected by radiolocations of these bears was considered habitat used. An analysis comparing habitat availability to habitat use was then performed. A final analysis was performed at the scale of individual home ranges. Proportions of available habitat within individual home ranges were determined for females that were located > 100 times (n=6). Habitat use (based upon radiolocations) was then compared on an annual basis and throughout the year to habitat available within that individual's home range. This micro-analysis was meaningful in determining individual variations in habitat use so that generalizations about overall use would not downplay the importance of particular stand types.

Preference or avoidance of individual habitats was determined by the method of Neu et al. (1974) using χ^2 analysis and Bonferroni Z-statistics. The 0.10 level of significance was used because it appears to be appropriate for habitat management decisions (Wood 1988). Habitats were considered preferred or avoided if used proportionately more or less than ($P<0.10$) available. Similarly a χ^2 goodness-of-fit test also was performed to test the null hypothesis that the proportions of habitats within the composite female home range were comparable to proportions within the entire study area.

Distribution

Seasonal and annual locations of female bears (n=8) were compared to random locations (n=300) for distance to Class I (primary paved surfaces) and Class II roads (secondary access roads and tank trails) and to describe shifts in bear distribution. All radiolocations which met collection criteria were used for this analysis. The mean distance of bears to each class of road was determined for each bear during each season. Paired t-tests were performed using mean distance differences for each season relative to random distances (SAS Institute Inc. 1985). The apriori hypothesis was that mean distance differences was 0. Distances were partitioned into 5 categories for each road

class (<100m, 100-200 m, 200-400 m, 400-800 m, and >800 m). Comparisons of the distribution of radiolocation and random distances were then performed using χ^2 and Bonferroni Z-statistics. Male data were not available due to the difficulty of monitoring collared males.

A χ^2 analysis was conducted for female bears with artificial food sources within their home range comparing random points within home ranges to actual bear locations. Distances from artificial foods were classified into 3 categories for analysis; <200 m, 200-400 m, 400-800 m, and >800 m. An x,y grid was superimposed over home ranges for random point generation. Grid size was dependent upon actual home range size with individual grid cells equal to 10m on the ground. Data between seasons were pooled in many instances due to χ^2 cell size expectations. Visual observations of bears at artificial food sources were clumped into the <200 category.

Population Dynamics

Sex ratios were compared to a 1:1 ratio with a Z-test for binomial distributions. Differences in age between sexes were determined with the Kolmogorov-Smirnov test (SAS 1985). Litter size was determined by den observation and observation of family groups post-denning. Interbirth interval and age at primiparity were estimated using the

adult female capture sample. Survival and mortality rates were calculated using radio-telemetered bears, tagged bears, and offspring of collared females (Trent and Rongstad 1974). Small sample sizes prohibited the calculation of a maximum or minimum survival rate.

Several estimates were made of population size and density. A two-sample mark-recapture method or Lincoln Index (Skalski and Robson 1992) was used with an adjustment for bias (Chapman 1951). A modified estimate also was made by replacing a second capture sample with a re-observation period. Robson and Reiger (1964) provide justification for the use of Lincoln Index models when sample sizes are small. When the equation mu = n_1n_2/N is greater than 4 and m_2 is > 7 then it is reasonably certain ($P<0.05$) that the bias on the estimate is negligible. The equation in this study, using the number of bears known to be alive as the population estimate (N), yielded 5.6 and 8.7, for the Lincoln and modified Lincoln estimate, respectively. The high rate of female mortality prevented the number of marked bears in the second capture sample (n=6) to equal or exceed m_2 limitations (7).

A minimum known population estimate was made which gave similar results to the Mortality Rate Method. The estimate was derived by accounting for all bear observations and measuring all bear tracks encountered (Klien 1959). Although simplistic in form, this method produced results

observations and measuring all bear tracks encountered (Klien 1959). Although simplistic in form, this method produced results comparable to the other estimators.

Winter Den Surveys

Bears were radiotracked from one week after capture until den entrance and then once weekly to document possible winter movements. Dates of den entry were defined as the median of the last recorded movement and the first in a series of static signals (O'Pezio et al. 1983). Dates of den entry in 1989 were determined to the day by intensive radio telemetry.

Dens were located to within 50 m and flagged. A den characteristics form was completed at each den site regardless of actual handling or observation. Den measurements were obtained on site or after the bears emerged in spring and included den entrance height, den cavity height (measured from nearest vertical branch or object), den cavity width, and den cavity length. Bedding material was recorded as present or absent with the type of material used and mean depths under bear and on den sides. Analysis of variance procedures (Proc GLM, SAS Institute, Cary, NC) were performed on mean depth of bedding under the bear making contrasts between female cohorts. Males were excluded from analysis of den dimensions because of the

small sample size (n=1).

Cub production was recorded for reproductive females. Cub survivorship was determined by visual observations and "walk-ins" six to nine months post partum and by successive den visits.

Percentage vegetation cover around each den site was quantified with a density pole constructed from 3/4" PVC pipe, taped at 10cm intervals. Quantified measurements of vegetation were obtained from a distance of 4.5 m by reading the percentage of coverage at each interval from four random directions around the pole and then averaging them for the site. Vegetation coverage at 12 random locations was measured to describe selectivity.

CHAPTER IV

POPULATION DYNAMICS

Population Sex and Age Structure

A total of 24 captures of 15 bears (6M:18F) was made between June, 1988 and October, 1989 (Table 14). In 1988 (22 June-10 October) 846 trap nights produced 8 captures (105.8 trap nights per capture); females (n=7) dominated the capture sample. In 1989 (24 May-08 October), 1050 trap nights yielded 16 captures of 13 bears (65.5 trap nights per capture), including 6 recaptures from the 1988 season. Again, females (n=8, excluding intra-season recaptures) dominated the capture sample.

The sex ratio of initial captures was 50M:100F (N=15) and differed from 1:1 ($P<0.05$). Between year sex ratios varied considerably. In 1988 the ratio (1M:7F) was different from 1:1 ($P<0.001$), while in 1989 sex ratio (5M:8F) did not differ ($P>0.05$).

The mean age (±SE) of captured bears was 4.9±2.9 years (range=2 to 10 years)(Fig. 5). Ages of males (5.4±1.7) and females (4.7±2.7) were not different ($P=0.31$). Age extremes, 2.0 and 10 years, were represented by females. No sub-adult males or males greater than 8 years old were

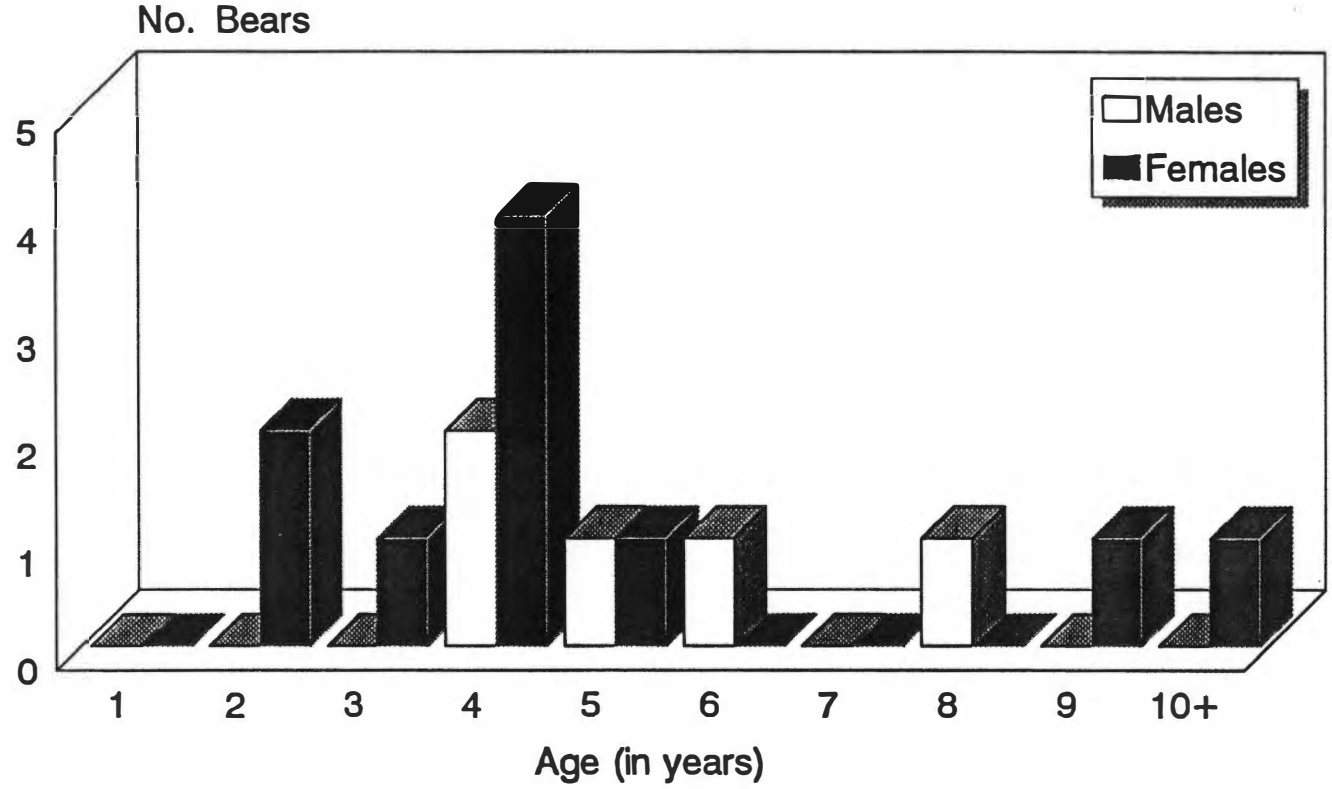


Figure 5. Age frequency distribution of black bears captured on Camp Lejeune, North Carolina during 1988-1989.

captured.

Reproduction

Two reproductive tracts from road-killed bears were examined for corpora lutea; each contained 2. Litters in 6 dens had a mean litter size of 2.2 (range=1 to 3). Mean litter size for Camp Lejeune did not differ ($F=1.63$, $P=0.20$) from other populations in the Southeast (Table 2).

The youngest observed breeding age for female black bears on Camp Lejeune was 3 years as determined from den observations. Only one of four bears that were 4 years of age had teat development suggesting previous parturition. This female was not observed with young and it is uncertain whether any offspring were successfully weaned. All female bears ≥4 years at the time of capture were either in estrus or lactating. All four 4-year-old females produced successful litters the denning season after their capture.

Survival and Mortality

Eleven mortalities were recorded during the course of this study, 9 were tagged bears or offspring of tagged females and two were of unknown origin (Table 3; Fig. 6). Known individuals included four radio-collared females, one collared male, one tagged male, and three offspring of

Table 2. Black bear litter sizes in southeastern United States.

Source	Geographic Location	Average Litter Size	Method[1]
Wathen 1983	GSMNP	2.58	FC, CR
Eiler 1982	GSMNP	2.60	FC, CR
Hellgren and Vaughn 1987	GDS	2.25	FC
Harlow 1961	Florida	2.20	FC
Collins 1974	North Carolina	2.17	PS, EC
This Study	North Carolina	2.20	FC

[1] FC=Field Count, CR=Cub Recording, PS=Placental Scar, EC=Embryo Count

Table 3. Black bear mortalities on Camp Lejeune, North Carolina, 1988-1989.

Date	ID#	Sex	Age in Months	Cause of Mortality	Location
24 Sept 88	02	F	<12	Roadkill	Lyman Road
18 Oct 88	07	F	48	Roadkill	Lyman Road
12 Dec 88	10	M	<12	Roadkill	US Route 17
08 July 89	14	F	<12	Roadkill	Lyman Road[a]
12 July 89	03	F	60	Natural[b]	Salliers Bay Area
16 July 89	12	M	48	Handling	Salliers Bay Area
14 Aug 89	20	F	<12	Roadkill	Albatross[c]
26 Oct 89	19	F	24	Roadkill	Bell Swamp
15 Nov 89	21	M	<12	Roadkill	Holcomb Boulevard[a]
20 Nov 89	15	F	48	Roadkill	Lyman Road
29 Nov 89	17	M	96	Legal Kill	Riggs Road

[a] Offspring of Bear 06, as determined by multiple observations of family group size post mortum.

[b] Bear 03 most probably succumbed to an infection from a badly broken forearm.

[c] Offspring of Bear 08, as determined by muiltiple observations of family group size post mortum.

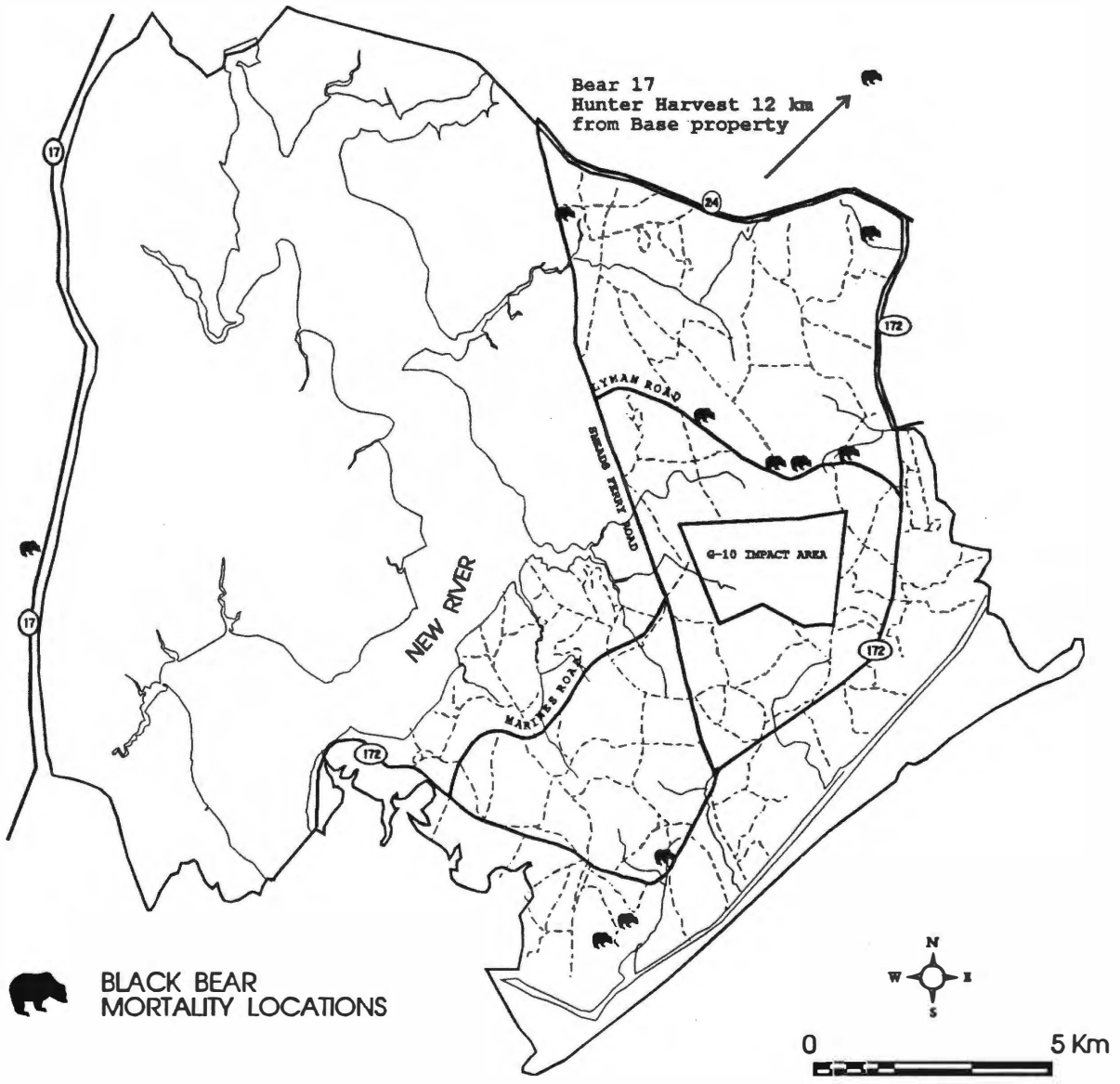


Figure 6. Location of black bear mortalities on Camp Lejeune, North Carolina 1988-1989.

radio-collared females. A collared male (Bear 12) apparently died from heat stress or post-traumatic shock related to the handling process. His death was not used in survival calculations. Data from ten radio-collared bears, three tagged males, and six cubs, totaling 7,090 radio-bear days, were used for calculating survival rates (Table 4).

Mortalities of marked bears were attributable to three causes: legal kill, handling (discussed above), and vehicle collision. Vehicle related mortalities (n=8) accounted for 72% of the total mortality. Seventy-five percent (n=6) of these occurred between 24 September and 12 December. One hunting related mortality was recorded for a tagged adult male bear. Bear 17 was shot in a corn field approximately 8 km off Base property, 12 km from his capture location. Another male bear, originally captured during the pilot research study in 1974, was shot in Hoffman Forest, nearly 40 km from Base property (Peterson pers. commun. 1989). No hunting related mortalities were known to have occurred on Base property during this study. As described earlier, the harvest of black bears on Camp Lejeune has been prohibited until the results of this and future studies on the ecology and demography of the species is complete. One female bear (Bear 03), when captured, had a right foreleg badly damaged from unknown causes. Her subsequent death was attributed to massive infection from this injury.

Cub mortality rates were determined by comparing changes

Table 4. Annual survival rates of black bears on Camp Lejeune, North Carolina as estimated by radiotelemetry[1].

Sex	Age (months)	N	Radio-Days Monitored	Mortalities	Annual Survival Rate[2] (95% CI)
Female	>18	10	3971	4	0.69(0.52-0.74)
Male	>36	4	1386	1	0.77(0.60-0.81)
Cubs	<12	6	1733	3	0.53(0.47-0.59)
Total		20	7090	8	0.66(0.56-0.74)

[1] (Trent and Rongstad 1974).

[2] Maximum and minimum estimates were not calculated.

in mean litter size from parturition to 9-12 months post-partum (Smith 1985, Bunnell and Tait 1985). The estimated cub mortality rate was 0.47, or conversely a survival rate of 0.53. Although this mortality rate is greater than many North American populations (Rogers 1977, Alt 1982, Smith 1985, Hellgren 1988), it is similar to estimates provided by researchers using radio-collared cubs as a study cohort (0.41 in Massachusetts, Elowe 1987 and 0.48 in Arizona, LeCount 1986). The causes of mortality in these areas (cannibalism, predation, den abandonment, disease, and hunting) were not observed during this study. All known deaths of black bear cubs on Camp Lejeune were vehicle related.

Population Size and Stability

The major problem encountered with population estimates for this study was violating the assumptions of closure, equal catchability, and to a lesser degree a small sample size. Reliable estimates of animal numbers can be obtained when the marked proportion of a population nears 50% (Bartmann et al. 1987). Based upon the marking of 15 black bears and estimates ranging from 21 to 39 bears, a mean of 55% of the population was marked. The estimators used in this study were the most practical under the given conditions.

Several estimates of population size and density were made for Camp Lejeune (Table 5). The small sample size of captured bears limited the use of many complex estimators such as Schnabel and Jolly-Seber methods. Petersen estimates, without modification, were calculated using the relationship of marked to unmarked bears during two capture periods (1988 and 1989 trapping seasons). These estimates were 21±3(SE) and 39±14(SE) for the Lincoln Index and modified Lincoln Index, respectively. The mean of Lincoln estimates was 30 bears.

A geometric distribution function applied to capture frequencies (Edwards and Eberhardt 1967) followed the formula:

$N = \frac{n}{1-(n/t)}$, where n = total number of individuals captured and t = the total number of captures, yielded an estimate of 40 bears. The geometric model is less sensitive to assumption violations of equal catchability and population closure. The estimate falls within the upper 95% confidence limit of the modified Lincoln estimate.

The Mortality Rate Method has been used by a limited number of researchers to estimate black bear densities (Erickson and Petrides 1964, Poelker and Hartwell 1973, Hamilton 1978) and has the general formula, $N = \frac{\bar{M}}{MR}$, where M = mean annual mortality rate and MR = mean annual bear mortalities. Hamilton (1978) reported this method provided a reasonable estimate of the black bear population

Table 5. Black bear population estimates for Camp Lejeune, North Carolina, 1988-1989.

Estimation Method	Population Estimate	Density[a] bears/100 km^2
Mean Lincoln Index	21±3	15
Modified Lincoln[b]	39±14	29
Mortality Rate	22	16
Geometric Model	40	29
Known To Be Alive[c]	23	17
Mean of all estimates ± (SE)		21±3

[a] Denisty estimates for the selected study area (13,624 ha).

[b] The sample n_2 was comprised of observations of marked bears.

[c] The estimate was based upon observations of individual bears and also on different track sizes found throughout the study.

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in Bladen County at the time of his study, although he used average mortality rates from outside his study area (Erickson and Petrides 1964, Poelker and Hartwell 1973) to derive the estimate. The average mortality rate for both sexes was 0.27 and corresponds to an estimate of 22 bears.

A minimum known population estimate was made which gave results comparable to the unmodified Lincoln Index. This method suggested that there were 23 bears on Camp Lejeune either as residents or seasonal migrants.

Discussion

Sex ratios for black bear cubs normally do not differ from 1:1 (Jonkel and Cowan 1971, Alt 1982, Carney 1985). Studies in other wetland habitats (Hamilton 1978, Smith 1985, Hellgren 1988) reported sex ratios of capture samples skewed towards males. The general belief is that males are more vulnerable to capture because of their large home ranges and broad travel behavior. Maximum home range size and maximum daily movements of adult male black bears are noted to occur during the breeding season (Alt 1980). These presumptions appeared valid for 1989 when male bears were captured with greater frequency during July. Barber and Lindzey (1986) described breeding season movements and dispersal of male bears on and off Long Island (21km^2), Washington; similar movements have been observed on Camp

Lejeune. Few adult male bears are known to be residents on the Base, the majority appear transient in relation to the breeding season.

The predominance of females in the capture sample for both years also may be related to the "recent" (1971-1984) sanctuary status of the Base which, in effect, has made the facility a habitat island for adult females. Female black bears are reportedly more susceptible to recapture (Roger 1977, LeCount 1980, Seibert 1990); this also appears to be demonstrated during this study. Previous indications were that site fidelity and small home ranges accounted for inflated recapture rates. Seibert (1990) reported recaptures of females near or at initial capture locations. In this study, only two females (09 and 15) were captured near their initial capture sites. The remaining recaptures were all made greater than 2000 m from initial capture locations. Annual differences in home range size and individual feeding behavior may be responsible for these incidents.

Age structures of unexploited populations have been reported to favor adults (Beecham 1980, LeCount 1982, Smith 1985, Hellgren 1988). Heavily exploited populations, in contrast, are characterized by age distributions favoring younger bears (Idaho-Beecham 1980, Maine-Hugie 1982, North Carolina-Carlock et al. 1983). Two exploited black bear populations in the Southeast (North Carolina-Hamilton 1978,

Georgia-Abler 1985) favored younger aged cohorts.

The exploitation rate of Camp Lejeune black bears is difficult to ascertain. The post-sanctuary harvest of bears on Camp Lejeune is to small to draw inferences about exploitation rates based upon harvest sex ratios. The high percentage of adults (87%) in the capture sample would suggest little or no exploitation. This is supported by the degree of scars and wounds found on adult males. Scars and wounds on the head and neck of males appear to be related to the number of older adult males in a population (LeCount 1980). The date of capture and the prevalence of "fresh" wounds on captured males suggested an appreciable amount of competition for receptive females, characteristic of an unexploited population (Pearson 1975, Beecham 1980).

Female black bears on Camp Lejeune appear to be lightly exploited. The age distribution of female bears reflects a stable cohort with both old and young bears present. The exploitation rate of females will remain relatively static, held at the current level by a fairly high mortality rate.

Sub-adult males are characteristically more vulnerable to harvest and capture (Collins 1973, Alt 1980, Rogers 1977). They also would be more abundant locally in the absence of a legal harvest. No sub-adult males were captured during the course of this study or recorded during pre-study harvests. Two male cubs (one offspring of a collared female and one unknown) were obtained as roadkills,

but were too young to provide any information about dispersal. The fate of 2 additional male bears, last observed as yearlings, has not been determined. It is uncertain if normal patterns of male dispersal are present within the population.

Most of the available data concerning population dynamics for black bears has been collected in mountainous or upland habitats (Hellgren 1988). Current data for southeastern wetland populations is limited, but increasing (Smith 1985, Hellgren 1988). These studies indicate that wetland habitats are resource rich and provide for early sexual maturity. These data suggest that females bears on Camp Lejeune may breed at age three, but attain primiparity at age 4, as is similar to female bears in GDS (Hellgren 1988). No data were available to suggest that breeding occurs at an earlier age.

Natural causes of black bear mortality are poorly understood (Rogers 1983). Human related mortalities, especially hunting and vehicle collisions, are the major forms of mortality in black bears over one year of age. During the course of this study all known mortalities that occurred on Camp Lejeune were human related.

Annual mortality rates (calculated from harvest data) for black bears >1 year of age in several exploited populations averaged 0.17±0.002(SE) and 0.26±0.004(SE) for females and males, respectively (Bunnell and Tait 1985).

The average mortality rate of male bears on Camp Lejeune (0.23)(Table 4) is similar to average rates described by Hamilton (1978) for Bladen County, North Carolina and approximate rates reported by Abler (1985) for southeastern Georgia. Hellgren (1988) reported a 0.42 male mortality rate in GDS, which is substantially higher than reported in this study. He attributed this higher male mortality rate to factors such as depredation permit kills and vehicle collisions.

The average female mortality rate of 0.31 is much higher than reported for other southeastern populations (Hamilton 1978, Smith 1985, Hellgren 1988). Abler (1985) reported similar differences in mortality rates for black bears in southeastern Georgia. In a review of bear populations throughout North America, Bunnell and Tait (1985) indicated that male black bears normally have a higher mortality rate than females. Female bears on Camp Lejeune are extremely vulnerable to vehicle collisions reflected by the inflated mortality rate.

Vehicle related deaths are a common occurrence and contribute greatly to mortality rates in many southeastern regions (Wooding and Brady 1987). Although not the focus of this study, road crossings were analyzed indirectly when processing radio-telemetry data (Chapter VII; Home Range, Habitat Utilization, and Distribution). The data illustrated that black bears crossed major thoroughfares up

to 7 times in a 24 hour period, primarily between 1700 and 0800 hrs. This high frequency of road crossings is reason for concern because the traffic volume on Camp Lejeune will continue to grow as the installation expands its training operations. Further study is needed to determine whether vehicle collisions are affecting adult and sub-adult male mortality rates.

Biologists have few reliable techniques to derive accurate, objective, and replicable estimates of size and density for many wildlife species, including bears (Pelton 1970, Sterling et al. 1986). Many of the techniques employed to estimate bear populations have been subjective and lack statistical variance and replicability (Harris 1986). Attaining reliable data concerning black bear population densities often is hindered by such factors as: 1) low population density, 2) habitat often characterized by rough, almost impenetrable terrain, 3) inaccessibility by the researcher to large areas, 4) large spatial distribution and movement patterns, 5) difficulty of capture-observation or recapture-observation techniques (Pelton et al. 1978), and 6) subjective methods for estimating effective study area size.

Black bear densities have been estimated by a variety of techniques including Lincoln Petersen estimates, Schnabel and Jolly-Seber estimates, direct counts, sign counts, and modifications thereof. Many of these estimators result from

inherent biases and violation of assumptions over which the researcher has little control. Even when used with minimal violations and proper research design, a single estimator can give conflicting results.

The Coastal Plain of eastern North Carolina has been estimated to harbor 750 to 1000 black bears (Monschein 1981). Collins (pers. commun. 1989) indicated that population levels of bears in eastern North Carolina may exceed 1000 individuals. Density estimates for Camp Lejeune range from 15 bears/100 km^2 to 30 bears/100 km^2 and are among the lowest reported for the southeastern Coastal Plain (Table 5). Density estimates from the northern portion of the Coastal Plain (Great Dismal Swamp; Hellgren 1988) are much greater than Camp Lejeune and previous studies (Hardy 1974, Hamilton 1978). Hardy (1974) may very well have underestimated density on his study area because of data limitations. Hamilton (1978), in contrast, derived estimates from a much larger data set. Although some of his trapping data may reflect the bias of "trap-happy" bears, the internal and external factors regulating black bear numbers on his study area reflect localized influences, and cannot be perceived as regional in scope. Generalizations about population densities across the southeastern Coastal Plain could lead to mis-management of the species within particular geographic boundaries. Unfortunately, extrapolated data are frequently used for management

purposes.

Black bears in the southeastern Coastal Plain remain in a precarious balance due to the human population growth of the 20th century. The primary responsibility for ensuring the future survival and viability of present black bear populations in the southeastern Coastal Plain should fall on a number of public and private agencies that control the lands containing black bear habitat and potential habitat (Pelton 1989). Cooperation between federal agencies, private organizations, and local conservation groups is mandatory to curb the rapid destruction of important black bear habitat. Camp Lejeune has the benefit of federal ownership, but does not exist in a bubble. The external influences of human population growth are expressed in other forms. Increased military training ultimately affects normal regulatory mechanisms of Camp Lejeune bears by increasing the local human population. Direct confrontations are generally avoided, but increases in vehicle traffic exert added pressure on the population, evident in the high mortality rate.

The black bear population on Camp Lejeune is reproductively viable, but external influences and unknown natural mechanisms maintain bear numbers at a low threshold. The transient nature of the male cohort, a high female mortality rate, and a lack of solid information about dispersal and immigration patterns creates a need to

continue a policy of prohibiting black bear harvests until further research on these topics can be completed. Although the primary purpose of black bear sanctuaries has neither been refuted nor identified as functional for Camp Lejeune, it appears that the Base is providing refuge for adult females. The re-establishment of Camp Lejeune as a black bear sanctuary should be considered as an option for future management plans (Chapter VIII; Management Overview).

CHAPTER VI

DENNING ECOLOGY

Introduction

Adaptation by black bears to a diversity of habitats throughout the United States is due partly to their ability to become dormant during winter. Johnson and Pelton (1980b) suggested that bears have evolved a flexible, endogenous circannual rhythm linked to annual plant cycles as the ultimate denning mechanism. Proximate causes for denning include photoperiod, bear nutritional condition, climatic factors, and food availability.

Denning habits of black bears on the Coastal Plain of North Carolina have been researched in Dare County (Hardy 1974), Bladen County (Hamilton 1978, Hamilton and Marchington 1980), and in Great Dismal Swamp of Virginia-North Carolina (Hellgren and Vaughan 1989, Hellgren 1988). Periodic flooding (Hamilton and Marchington 1980, Hellgren and Vaughan 1987, Hellgren 1988) and availability of areas which provide proper cover requirements (Hamilton and Marchington 1980) may be limiting factors to den site security. Den sites should remain dry throughout winter to prevent den abandonment (Smith 1985).

The direct impact of forestry and habitat improvement actions on denning behavior in coastal environs is poorly understood and has received only anecdotal mention (Hamilton 1981, Hellgren 1988). Disturbance of denned bears from research activities are well documented (Hamilton and Marchinton 1980, Smith 1985, Seibert 1989).

Den Site Selection and Characterization

Fourteen bears (12 females, 2 males) were radio-monitored four to seven times weekly until they entered winter dens. Nine bears (7 females, 2 males) were used for analysis because of data limitations. Two bears (one adult male and a subadult female) appeared to remain active during the winter of 1989-90. Fourteen den sites were characterized, 10 dens were located and measured.

Dens were found in several habitats. The most common was the pocosin community (n=11). Pocosins are characterized as ombrotrophic bogs dominated by dense stands of ericaceous shrubs such as ti ti (*Cyrilla racemiflora*), fetterbush (*Lyonia lucida*), *Ilex spp.*, and discontinuous mats of greenbriar (*Smilax laurifolia*) with a sparse overstory of pond pine (*Pinus serotina*), loblolly bay (*Gordonia lasianthus*), sweet bay (*Magnolia virginiana*), and red bay (*Persea borbonia*). Pocosins and carolina bays were used almost exclusively by bears in Bladen County, North

Carolina for forage, cover, and denning habitat (Hamilton and Marchinton 1980). Black bears in Great Dismal Swamp (GDS), Virginia-North Carolina, utilized pocosins in greater proportion than their availability (Hellgren and Vaughan 1987). Hardy (1974) stressed the importance of the pocosin community to bears in Dare County, North Carolina.

The second habitat used (n=2) was a lowland pine-hardwood type dominated by pond pine, red maple (*Acer rubrum*), tupelo gum (*Nyssa sylvatica* var. *biflora*), and other mesic hardwoods. The understory was comprised of fetterbush, gallberry (*Ilex spp.*), and dense pockets of laurel-greenbriar. Bears (n=9) in Great Dismal Swamp denned in a similar pine-maple habitat (Hellgren and Vaughan 1987).

The third habitat used (n=1) was an area of forest regenerating after a disease episode (pine beetle infestation), characterized by a sparse canopy and a dense shrub layer. Dominant understory species included fetterbush, *Ilex* spp., switch cane (*Arundinaria gigantea*), a number of bay species, and wax myrtle (*Myrica crifera*). Overstory species included pond pine, loblolly pine, red maple , sweet bay, and black gum (*Nyssa s. sylvatica*).

Ten dens were located and measured (Table 6), two dens were observed from a distance ($\bar{x}$=8.0m), and 2 dens were characterized by the vegetational composition of the associated habitat type (pocosin). Dens observed from a distance were not flagged and only one was located after the

Table 6. Site characteristics of black bear ground nests on Camp Lejeune, North Carolina.

Bear	Den Dimensions (cm) Length	Width	Height	Bedding Material Under bear	On sides	Reproductive Status	Habitat Type
01	100	70	60	12	15	2 cubs	Pocosin
01	120	116	112	3	7	solo	Pocosin
03	80	80	90	10	16	solo	Pocosin
04	n/a	n/a	n/a	n/a	n/a	1 cub	Pocosin
04	112	110	90	10	12	2 cubs	Lowland Pine-Hardwood
06	110	90	75	10	16	3 cubs	Disease Area
06	108	75	--	10	12	1 yearling	Lowland Pine Hardwood
08	100	80	80	4	12	3 cubs	Pocosin
08	107	77	85	6	8	2 yearlings	Pocosin
09	71	62	65	8	10	1 yearling	Pocosin
09	147	117	68	12	16	2 cubs	Pocosin

-- No over-hanging vegetation present. Overstory canopy 15 m vertical.

bears emerged. All observed dens were classified as groundnests (Fig. 8).

The term open ground nest as related to observed dens on Camp Lejeune is a misnomer. Dense, impenetrable vegetation is an important habitat requirement for black bears throughout their range (Pelton 1980). The cover requirement for ground nesting black bears on the Coastal Plain has been described (Hardy 1974, Hamilton 1978, Hellgren 1988), but never quantified. A unique characteristic of all den locations found during this study was the percentage of vegetation cover at the hibernacula was at or near 100% ($\bar{x}$=94%). Vegetation cover at den locations was significantly greater ($F=1121.73$, $P<0.0001$) than random locations, suggesting that bears selected areas with denser vegetation at a greater frequency than by chance alone.

The bedding material present at each site was derived from the surrounding vegetation. The most common material used for all dens was fetterbush leaves and stems. Hellgren and Vaughan (1989) reported fourteen bears utilizing ground nests that were constructed of debris raked from around the site. Bed dimensions seem to be related to occupant size, concurring with other reports of bed dimensions and occupant size (Johnson and Pelton 1983). Bear 01, estimated by size to be the largest bear, had the largest ground nest.

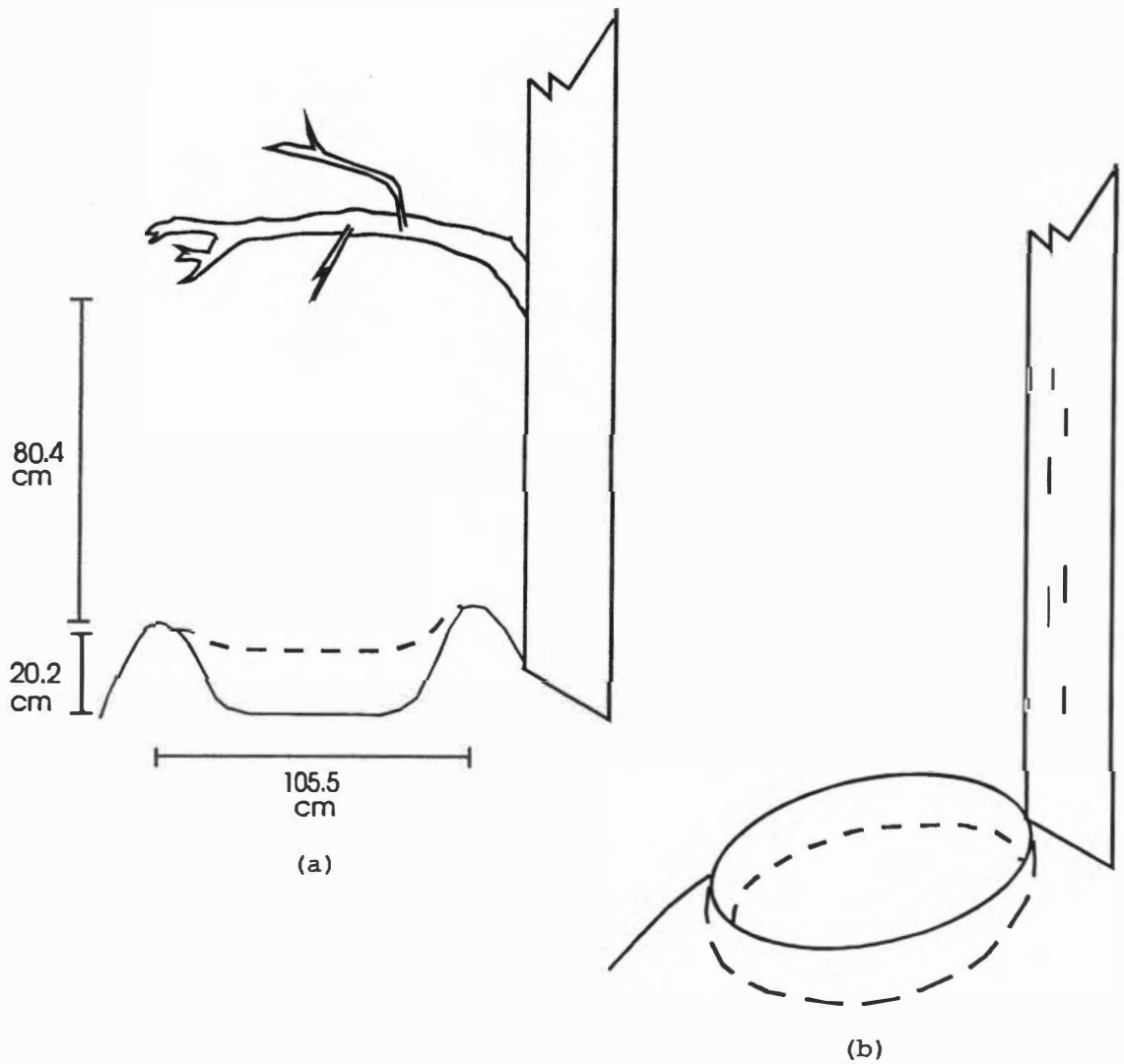


Figure 7. Structural representation of ground nests used by black bears on Camp Lejeune, North Carolina, 1988-1989; a, in cross section; b, generalized.

There were no differences (P>0.05) between female cohort nest dimensions except depth of bedding under the bear. Females with cubs had significantly (P=0.0088) deeper bedding materials. Smith (1985) reported three ground nests that varied in height at the north aspect. Black bears in GDS denning in cavities had den entrances with an affinity to north (Hellgren and Vaughan 1987). The association of vertical structures and reduced light intensity may be an important aspect of den site suitability (Mysterud 1980, Johnson and Pelton 1983). All observed dens, except the den of bear 06 in 1989-90, were located in areas with a closed understory and less than 1.0 m from vertical objects.

Winter active black bears have been reported from many geographical areas (Lecount 1980, Smith 1985, Hellgren and Vaughn 1987). Winter activity on Camp Lejeune was recorded for 5 of 7 bears in 1988-89 and for 3 of 7 bears in 1989-90 (Table 7). Activity unrelated to human disturbance was recorded for 2 bears. One adult male (bear 11) and a sub-adult female (bear 16) never denned at permanent sites, but maintained multiple den locations. Adult males and subadults of both sexes have been reported to remain active during winter in mild climates (Hellgren 1988). Lecount (1980) described bears in Arizona utilizing multiple den locations during a single denning period. Winter activity was recorded for five bears in Great Dismal Swamp (Hellgren and Vaughan 1989).

Table 7. Winter movements of black bears on Camp Lejeune, North Carolina, 1988-1990.

Bear	Date of Movement	Distance in meters	Proximal Cause of Movement
01	02 Feb. 1989	300	Prescribed Burn
03	02 Feb. 1989	600	Prescribed Burn
04	20 Jan. 1989	1000	Prescribed Burn
04	25 Jan. 1989	1400	Prescribed Burn
04	17 Feb. 1990	80	Human Disturbance
06	19 Jan. 1989	800	Human Disturbance
06	20 Dec. 1989	1000	Undetermined
08	12 Feb. 1989	50	Human Disturbance
08	17 Feb. 1990	1200	Human Disturbance
11	Multiple den locations evident		
16	Multiple den locations evident		

Three female bears (01, 03, and 04) were displaced by prescription burns. In all three cases, primary den sites were abandoned and not reoccupied. Bears 01 and 03 were displaced on single occasions, 600 m and 800 m, respectively, and bear 04 on two occasions, 1000 m and 1400 m. Changes in wind direction caused smoke from burning vegetation to waft over the bears' den sites. Presumably, bears circumvented the possible negative effects of smoke inhalation by moving away from the immediate area.

Human disturbances, i.e., military training and research activities, were responsible for four bear movements. In 1988-89 bear 06 was displaced (800 m) by a reconnaissance battalion that was training near her den location. Radio telemetry indicated that she had been denned for <3 weeks. Although the den location was relatively secure, the nearby disruption was sufficient to cause her to move. Bear 06 also abandoned her primary den site in 1989-90 for unknown reasons.

Research activities were responsible for three bear movements. Bear 08 abandoned her primary den site in successive years when researchers approached her location. Cubs were present in 1988-89, but were not abandoned for more than one hour. The cubs were moved approximately 50m to a new location. Yearlings were present in 1989-90 and neither offspring nor bear 08 returned to the den site after displacement. Bear 01 moved from her den site after a dart

was fired at her. Although the dart missed, the disruption was enough to prompt her to move. She travelled a distance of 800 m and settled in a habitat similar to her first den site.

Females with cubs had a higher degree of fidelity to the den site when disturbed. After a dart was fired at her, Bear 04, climbed a tree and "whoofed" and "popped" her jaws for five minutes before departing. Audible contact was maintained throughout the cub handling process. Bear 09 was successfully darted, but moved only 10 m away from her ground nest. She would have had ample time to travel a greater distance before complete immobilization.

Den Entry

There were no differences ($P>0.05$) in mean den entry dates among sex/age cohorts. Den entry dates were 23 Dec. ± 10.4d for females with cubs (n=6), 20 Dec. ± 1.2d for females with yearlings (n=4), 25 Dec. ± 10.6 for solo females (n=2), and 25 Dec. ± 4.5d for males (n=2). No data were available for den emergence.

Generally, pregnant females and non-pregnant females with yearlings entered dens first. In many studies (Lindsey and Meslow 1976, Johnson and Pelton 1980, Schwartz et al. 1986) pregnant females and females with cubs were reported to be the first cohort to enter dens.

Discussion

The exclusive use of ground nests by black bears on Camp Lejeune was not unexpected. The prominent use of ground dens by bears in GDS (Virginia-North Carolina, Hellgren and Vaughn 1989) and Osceola and Ocala National Forests (Florida, Wooding and Hardisky 1992) lend support to these findings. Other studies in eastern North Carolina also reported the use of ground nests for hibernacula (Hardy 1974, Hamilton 1978, Hamilton and Marchinton 1980). Smith (1985) reported ground nests being used for hibernacula by male bears only on the White River, NWR, Arkansas. Even in northern latitudes, bears construct ground nests with regular frequency (Maine; C. McLaughlin, pers. commun.).

Information on the direct effect of fire and smoke on bear behavior is not well documented and little exists, other than anecdotal mention, about the effect of fire and smoke on the denning behavior of black bears in the Southeast (Hamilton 1978, Hellgren 1988). The displacement of bears from winter dens due to prescribed burns on Camp Lejeune is the first substantiated occurrance in the Southeast. Displaced bears were not negatively impacted, as evidenced by their successful redenning. One female successfully gave birth to 2 cubs approximately 10-14 days after settling at a new den site. Prescribed burns have the potential to be a limiting factor on the denning success of

black bears in the Southeast.

Den abandonment, as a result of research activities, is a common occurrance throughout black bear range. Smith (1985) reported den abandonment by 6 females when inspected ≤ 2 weeks after den entry. Black bears in Alberta (Teitje and Ruff 1980) were most likely to abandon dens when disturbed shortly after den construction. Beecham et al. (1983) found that the rate of den abandonment was inversely related to the length of time the bear had been denned. Smith (1985) related the degree of concealment to den abandonment and believed that open ground nesters would have a higher rate of abandonment. Pelton et al. (1980) suggested that black bears occupying ground nests were more likely to abandon their dens.

Hamilton and Marchinton (1980) reported that all attempts to view bears in ground nests resulted in den abandonment. Their method of approach may have been responsible for their observations. No path clearing tools, i.e., machetes, were used to approach den sites, however, a high rate of abandonment still existed (36%).

Physiological conditioning and environmental stimuli have been postulated as proximal denning mechanisms (Lindsey and Meslow 1976, Johnson and Pelton 1980). The effects of mild climatic conditions on denning chronology have been expressed as a later mean den entry date for all cohorts. In 1988-89 parturient females were the last cohort to enter

dens. Radio telemetry data indicated that these females were extremely active around their den site during the pre-denning period. Scats collected near these den locations had high quantities of gallberries and greenbriar berries, a major food resource during late fall and early winter (Hellgren 1988). Observed soft mast, on a subjective level, was only moderately abundant during that year. Nutritional conditioning appeared to be a regulatory mechanism for later den entrance dates of parturient females in 1988-89.

The use of ground nests on Camp Lejeune may be a synthesis of factors. Ground nests were oval in shape reflecting the energy saving curled position of sleeping, denned bears (Johnson and Pelton 1979). Flat topography and dense vegetation surrounding den sites would likely reduce heat loss due to wind convection (Hellgren 1988). Moen (1968) reported that dense stands of conifers provide protection from wind and temperature extremes in northern latitudes. The nearly impenetrable vegetation around den sites on Camp Lejeune dampens environmental influences and also reduces the effect of human disturbance evidenced by only one non-research related disturbance. Few places on Camp Lejeune remain sacrosanct from military training except extremely dense pocosins.

The availability of tree dens on Camp Lejeune is not a limiting factor to denning success. Trees old enough to attain diameters suitable for cavity formation and bear

occupancy are found in relatively low frequency. In 50 random transects only 2 trees (1 bald cypress, 1 yellow poplar) were located with cavities suitable for bear occupancy.

Microelevational changes within pocosins also may allow bears to utilize ground dens (Hellgren 1988). Four ground nests were located in areas with a seasonally high water table, but were positioned on hummocks of soil and vegetation 20-40cm above mean ground level. Hummocks were manifested as islands or raised platforms on the banks of drainage systems, defining a natural water fluctuation. One ground nest was located below the high water mark of a drain, but no eminent threat of flooding was present because of a relatively dry autumn and winter.

The soils of pocosins are seasonally saturated, with excess precipitation expressed as run-off. During this study, annual precipitation was depressed and water tables reflected high evapotranspiration by remaining below mean ground level, a corollary to mid-summer conditions. This hydro-condition aided the accessibility of den locations and made regularly inundated areas navigable. Normal precipitation regimes would have made access to many den locations a difficult task. All but one den location was above mean ground level, suggesting a recognition by bears of the security associated with constructing nests on elevated surfaces.

CHAPTER VII

HOME RANGE DYNAMICS, HABITAT UTILIZATION AND DISTRIBUTION

Introduction

Black bears in southeastern wetlands have not received much attention from the scientific community until recently. Work by Hardy (1974), Hamilton (1978), Landers et al. (1979), and Hamilton and Marchinton (1980) represented the body of knowledge on coastal black bears prior to the 1980's. Hellgren's (1988) work in Great Dismal Swamp, along with work conducted by Smith (1985) on the White River in Arkansas, is the most comprehensive documentation of wetland black bear populations to date.

Black bears on the Atlantic Coastal Plain require a complex mosaic of habitats which fulfill foraging, denning, and cover needs (Hellgren 1988). The spatial and temporal orientation of food resources affects overall home range dynamics, including seasonal distribution, range overlap, range shape, and range size. Demographic factors such as sex, age, social behavior, and reproductive status also affect spatial use by black bears. In many regions the distribution of human refuse (sanitary landfills and refuse containers) has a direct influence on home range dynamics

(Rogers 1976, Herrero 1983). Camp Lejeune, North Carolina, and surrounding regions such as Croatan National Forest, Hoffman Forest, Holly Shelter Swamp, and Angola Swamp, support the last remaining breeding populations of black bears in eastern and southeastern North Carolina.

Home Range Size

Annual ranges, calculated on a 12 month basis starting with the date of capture, were determined for 6 females and 2 males. Estimates of mean annual home range, 20.4 km^2 (adult females), 11.8 km^2 (subadult females), and 60.5 km^2 (adult males), were comparable to convex polygon home range estimates made in other southeastern wetlands (Hardy 1974, Hamilton 1978, Abler 1985, Smith 1985, Hellgren 1988). Male home ranges were larger than female ranges ($P=0.032$)(Table 8). Home range sizes for female groupings (solitary females, subadult females, females with cubs) were not different ($F=1.18$, $df=2$, $P=0.3392$). Home ranges for female groupings were slightly larger in this study than reported for Great Dismal Swamp (Hellgren 1988). Annual home range size for individual females with and without cubs ($F=1.14$, $df=1$, $P=0.4701$). Home range size did not differ among seasons for solitary or subadult females ($P>0.05$).

Shifts in distribution shifts for females are most likely associated with habitat quality and food

Table 8. Total and seasonal home range size (km^2) of solitary adult females, females with cubs, subadult females, and male black bears[1] on Camp Lejuene, North Carolina, 1988-1989. Bears were monitored for > 50% of a season and with at least 2 locations per week. The 100% convex polygon method was used to calculate seasonal and total home range size.

Sample	N	Median[2]	Mean	SD	Range	Locations per bear
Summer						
Solitary Females	4	8.1	9.4	4.6	5.4-16.0	20-38
Subadult Females[3]	-	-	-	-	-	-
Females with Cubs	3	9.6	11.0	5.7	6.0-17.3	26-31
Late Summer (17 July to 31 August)						
Solitary Females	4	5.9	5.4	3.2	1.7-8.2	14-24
Subadult Females	4	7.7	11.4	9.2	5.3-24.8	12-19
Females with Cubs	2	9.9	9.9	1.2	9.1-10.8	17-22
Early Autumn (1 September to 15 November)						
Solitary Females	7	9.2	8.1	4.6	2.4-13.9	21-29
Subadult Females	2	3.6	3.6	1.0	2.9-4.3	19-25
Females with Cubs	4	5.7	8.4	7.7	2.7-19.5	17-24
Late Autumn (16 November to 1 January)						
Solitary Females	6	6.1	6.0	1.7	3.3-7.9	27-31
Subadult Females	2	14.6	14.6	4.9	11.2-18.1	21-25
Females with Cubs	4	12.7	16.5	14.1	4.0-36.5	18-23
Total Range Size (≥ 8 months)						
Adult Females	7	21.9	20.4	10.0	3.8-33.6	90-264
Subadult Females	2	11.8	11.8	6.9	6.9-16.6	76-115
Adult Males	2	60.5	60.5	3.8	57.8-63.1	32-48

[1] Male data were used only for annual comparisons of home range size.

[2] Medians within the same column and season are not different ($P>0.05$) according to a protected LSD design.

[3] Summer and late summer data pooled.

availability, factors which play an important role in fetal development and offspring nurturing. One female (Bear 06) on Camp Lejeune did exhibit a major shift during early fall. The movement was of limited duration, starting at 2100 and ending at 0700. The trek was a direct route with little deviation and the return also was direct (Fig. 8). A similar movement occurred for Bear 09 (Fig. 22). An examination of telemetry data indicated that this bear was radio-located when swimming in the New River. It is not known whether the bear was traveling east or west, however, a subsequent radio-location placed her on the east bank of the river. This was a real movement and not the result of telemetry error.

Home Range Overlap

Annual home range overlap was extensive for females in both 1988 and 1989 (Fig. 9 and Fig. 10). In 1988, seasonal overlap, measured by the percentage of non-overlapping range did not differ ($P>0.10$) for summer, late summer, or early fall home ranges. Non-overlapping range for late fall was significantly different ($P<0.05$) from summer and late summer, but did not differ ($P>0.10$) from early fall ranges. For 1989, seasonal overlap did not differ ($P>0.05$) between seasons. Home range overlap between males and females was extensive (Fig. 11 and Fig. 12).

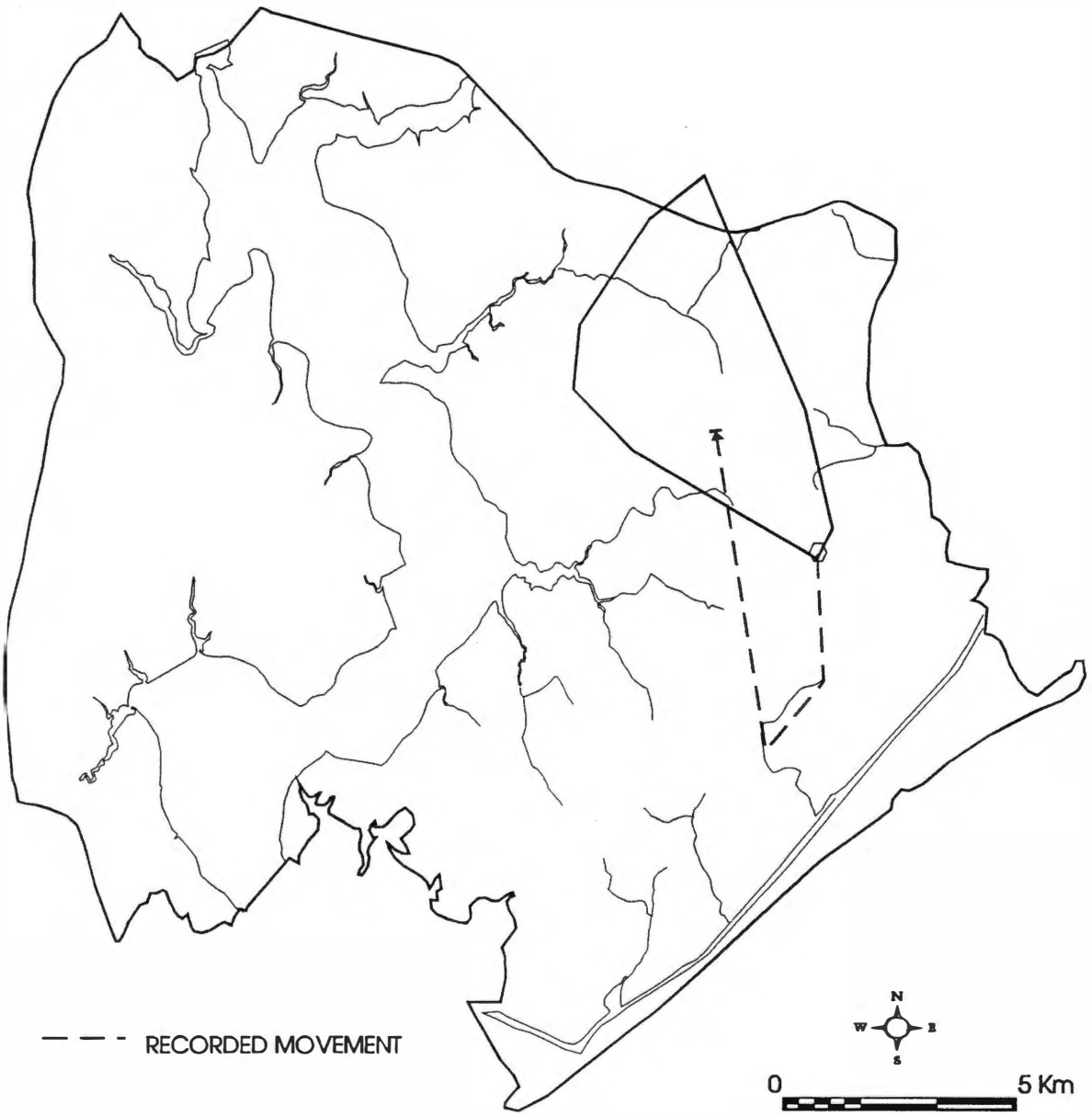


Figure 8. Unexplained movement of bear 06 on Camp Lejeune, North Carolina, early fall 1989.

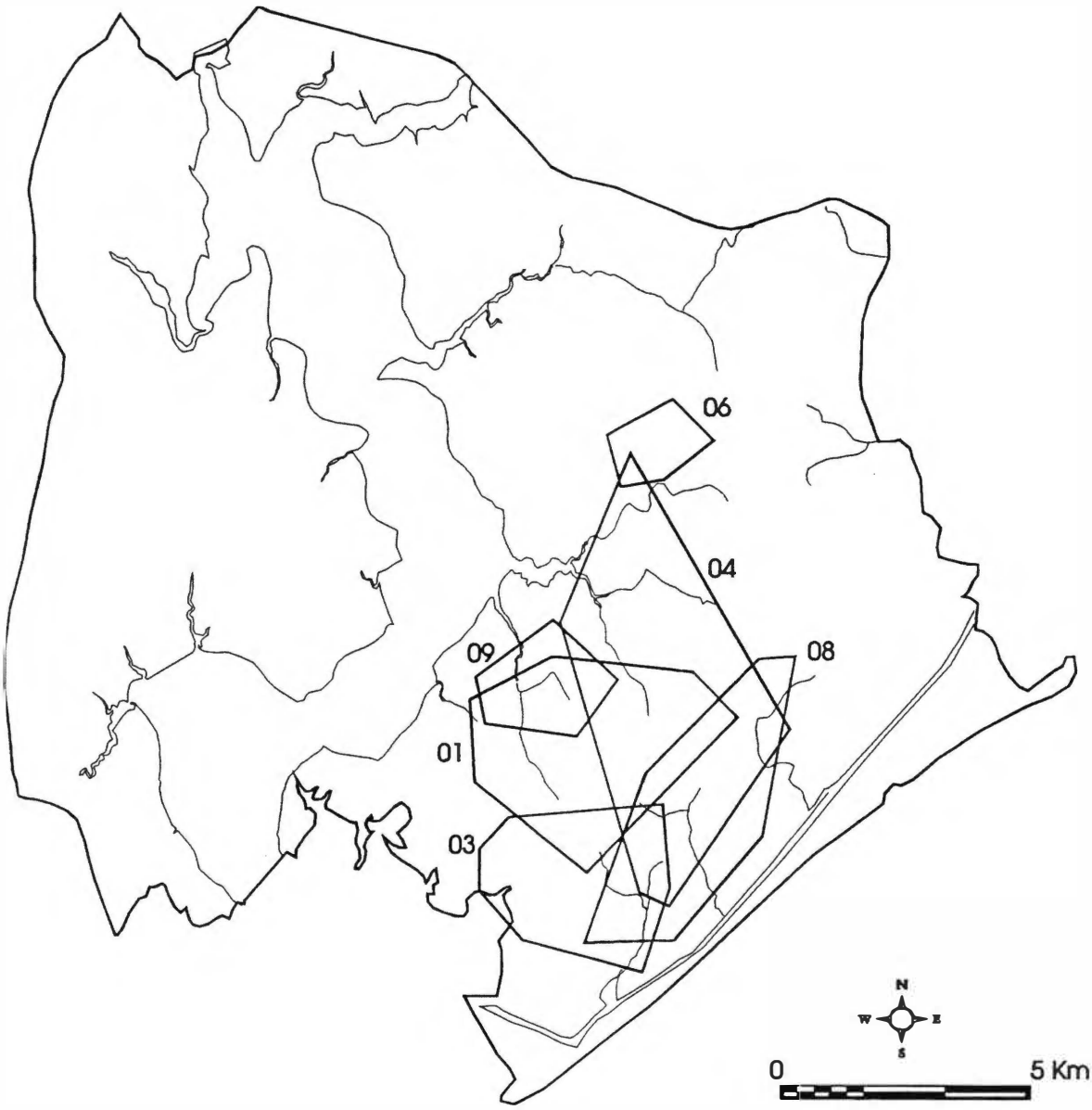


Figure 9. Home range overlap for female bears on Camp Lejeune, North Carolina, 1988.

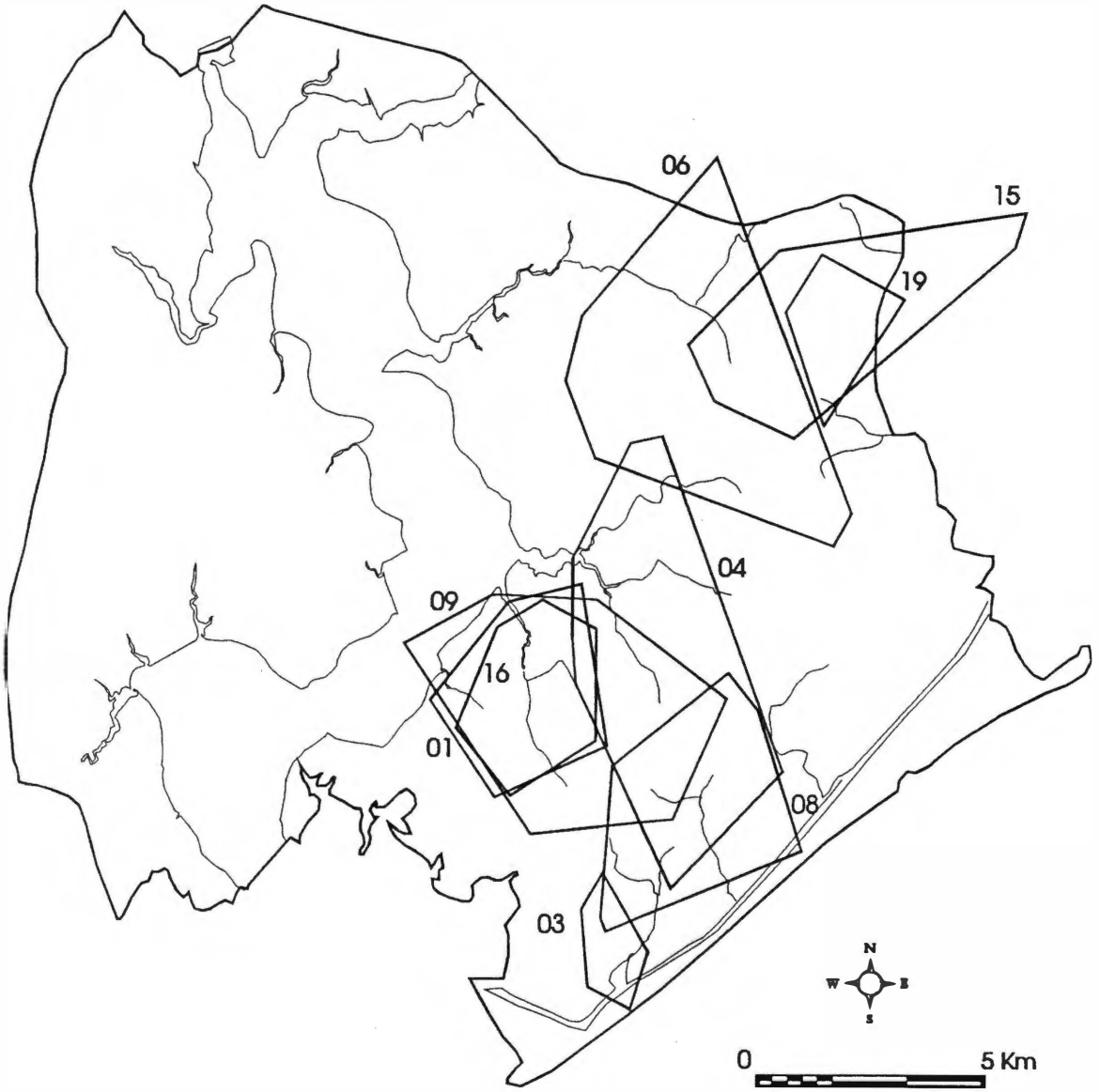


Figure 10. Home range overlap for female bears on Camp Lejeune, North Carolina, 1989.



Figure 11. Home range overlap between male and female bears on Camp Lejeune, North Carolina, 1988.

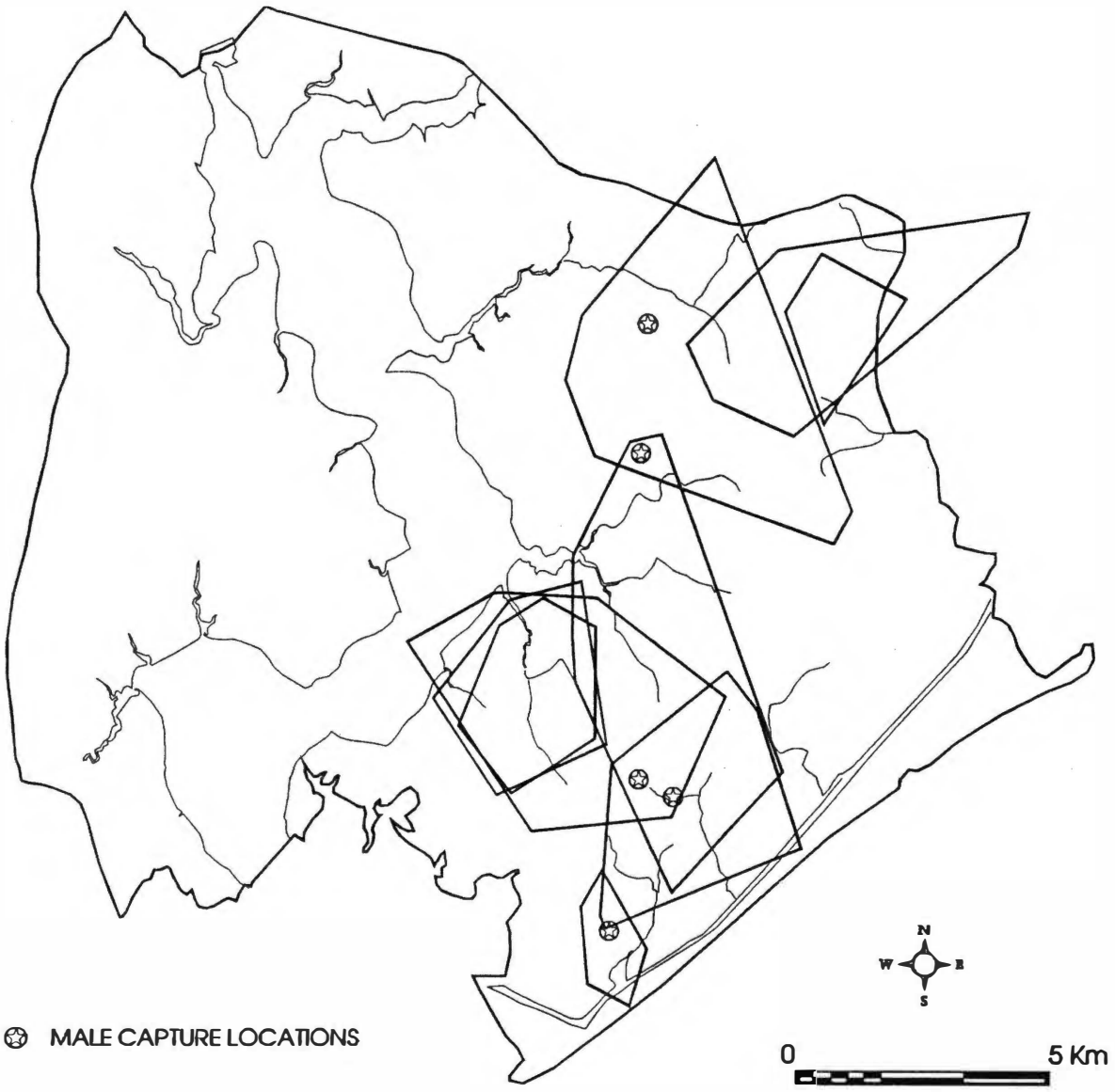


Figure 12. Distribution of male capture locations in relation to female bear home ranges on Camp Lejeune, North Carolina, 1989.

Habitat Utilization

Of the 1680 radio locations obtained during the study, only 1210 met habitat use criteria. Males were not included in habitat analysis due to small sample sizes and limited radiolocations on a seasonal basis.

For collared females, proportions of major cover type groupings at the study area level were different (χ^2 = 11.71, df=9, P=0.08) from proportions within an inclusive composite home range of long-term monitored bears (Table 15). The area within the composite home range contained proportionately more (P<0.05) pocosin habitat, pine-hardwood, and xeric hardwood habitats and proportionately less (P<0.10) mixed pine and pine-hardwood habitats. At the individual stand level proportions of stand types also were different (χ^2 = 41.98, df=55, P=0.42). The composite range contained proportionately more (P<0.05) miscellaneous filler-pond pine and longleaf stands and proportionately less (P<0.10) longleaf-loblolly, loblolly-longleaf, and loblolly-pond pine stands. Salt marsh, as a major cover type grouping and stand type, was proportionately less (P<0.10) available for the composite home range. These differences led to conflicting results in habitat use vs. availability analyses. Using the entire study area as available habitat, use significantly different (P<0.10) from availability could occur simply because the home ranges of

collared females do not encompass the entire area (Hellgren 1988). For this reason, the composite range best represents available habitats, therefore these data will be presented and discussed. This same scenario holds true for habitat utilization at the stand level.

Habitat Utilization for Composite Range

During summer, pine-hardwood and pocosin habitats were used in greater ($P<0.10$) proportion than their availability, whereas pure-pine, mixed pine, xeric-hardwoods, hardwood-pine, salt marsh, the landfill and openings (tactical landing zones and wildlife openings) were used proportionately less ($P<0.10$) than their availability (Table 9). Mesic-hardwood and hardwood-pine habitats were used in proportion to their availability.

Use of habitat types by female bears was not proportional to availability during late summer ($\chi^2=25.61$, $df=9$, $P=0.004$). Pocosin, mesic-hardwood, and xeric-hardwood habitats were used more ($P<0.10$) than expected, whereas pure-pine, salt marsh, landfill, and openings were used proportionately less ($P<0.05$) than their availability. Hardwood-pine, pine-hardwood, and mixed pine habitats were used in proportion to their availability.

During early fall, habitat use by female bears was not proportional to availability ($\chi^2=73.44$, $df=9$, $P=0.008$).

Table 9. Seasonal habitat use vs. availability for black bears on Camp Lejeune, North Carolina, 1988-1989.

Habitat	%	All Year		Summer[1]		L. Summer		Early Fall		Late Fall	
	%	%		%		%		%		%	
	Available	Used	Pref.[2]	Used	Pref.	Used	Pref.	Used	Pref.	Used	Pref.
Pure Pine	34.1	26.6	-	19.1	-	16.7	-	24.0	-	26.9	-
Mixed Pine	11.5	7.7	0	7.3	-	13.3	0	12.8	0	7.3	-
Pine-Hardwood	24.5	26.2	0	31.8	+	25.6	0	27.0	+	21.2	-
Pocosin	13.5	17.9	+	25.5	+	24.4	0	16.8	+	23.7	+
Mesic Hardwood	8.2	12.6	+	8.2	0	10.0	+	13.3	+	8.3	0
Xeric Hardwood	2.6	6.4	+	0.0	-	6.3	+	4.2	+	9.1	+
Hardwood-Pine	1.4	1.6	0	0.9	0	1.1	0	1.9	0	1.6	0
Salt Marsh	.3	1.0	+	0.0	-	0.0	-	1.0	+	0.4	0
Landfill	.9	1.2	0	0.0	-	0.0	-	1.6	+	0.4	0
Openings	3.0	0.0	-	0.0	-	0.0	-	0.2	-	0.0	-
N Locations		1210		180		120		525		385	

[1] Spring and Summer data pooled because of small sample size.

[2] + = used more than available, - = used less than available, 0 = used in proportion to availability ($P<0.10$).

Pine-hardwood, pocosin, mesic-hardwood, xeric-hardwood, salt marsh, and the landfill were used more (P<0.10) than expected, whereas pure-pine and openings were used proportionately less P<0.05) than their availability. Pine mixtures and hardwood-pine habitats were used in proportion to their availability.

Use of habitat types by females was not proportional to availability during late fall (χ^2=57.07, df=9, P=0.001). Only pocosin and xeric-hardwood habitats were used more (P<0.10) than expected. Mesic-hardwood, hardwood-pine, and salt marsh habitats were used in proportion to their availability. All other habitat categories were used proportionately less (P<0.10) than their availability.

On a year round basis, pocosin, mesic-hardwood, xeric-hardwood habitats, and salt marsh habitats were used more (P<0.05) than expected. Pure-pine and openings were used less (P<0.10) than expected. Mixed pine, pine-hardwood, hardwood-pine, and the landfill were used in proportion to their availability.

Habitat Use by Individual Bears

Habitat use for individual bears followed the same general patterns of use at the composite range level (Table 10). Bears whose home range had major proportions of pocosin habitat (n=2) had a strong preference for that

Table 10. Yearly habitat use vs. availability within individual convex polygons for 6 female black bears with > 100 radiolocations, Camp Lejeune, North Carolina, 1988-1989.

Habitat	Bear 01		Bear 03		Bear 04		Bear 06		Bear 08		Bear 09	
	% Avail.	% Used	% Avail.	% Used	% Avail.	% Used	% Avail.	% Used	% Avail.	% Used	% Avail.	% Used
Pure Pine	31.9	27.2(-)[1]	29.9	11.5(-)	38.2	31.3(-)	12.3	18.1(+)	35.3	24.7(-)	33.1	28.1
Pine Mixture	8.1	9.8	5.2	5.8	12.2	6.2(-)	35.8	18.1(-)	9.6	5.8(-)	10.3	9.5
Pine-Hardwood	22.0	18.1(-)	29.9	44.2(+)	25.4	37.5(+)	20.7	18.1(-)	30.2	32.5	19.3	19.2
Pocosin	28.8	35.1(+)	18.4	13.5(-)	9.0	9.1	7.4	15.9(+)	4.0	5.2	23.7	26.9
Mesic-Hardwood	1.0	9.1(+)	9.4	17.3(+)	9.1	13.5(+)	11.9	13.8	11.4	13.6	9.5	11.4
Xeric-Hardwood	5.0	10.2(-)	7.7	5.9	0.7	2.4(+)	2.9	3.6	4.0	11.0(+)	4.0	4.8
Hardwood-Pine	0.0	0.0	0.2	0.0(-)	1.8	5.7(+)	0.0	0.0	0.6	0.6	0.0	0.0
Salt Marsh	0.0	0.0	0.0	1.0(-)	0.0	0.0	0.0	0.0	0.4	5.8(+)	0.0	0.0
Landfill	0.0	0.0	0.0	0.0	0.4	0.1(-)	6.0	12.3(+)	0.0	0.0	0.0	0.0
Openings	3.2	0.0(-)	0.0	0.0	3.2	0.0(-)	2.4	0.7(-)	7.0	0.6(-)	0.1	0.1
N Locations	264		104		209		138		168		116	
χ^2	56.83		68.01		51.11		42.12		63.59		3.04[2]	
d.f.	6		5		7		6		7		4	

[1] + = used more than available, - = used less than available ($P<0.05$).

[2] Use for all habitat categories not significantly different ($P>0.25$) than available.

habitat ($P<0.05$). One bear having only a small percentage (7.4%) of its home range in pocosin habitat still showed a strong preference for that habitat. Mesic hardwood habitats were either used more ($P<0.05$) than expected or used in proportion to their availability. Xeric hardwood habitats, those dominated by various oak species, sweetgum, and miscellaneous hardwoods were used in greater porportion than their availability by two bears and proportionately less by one bear.

One habitat category, pure-pine, was a preferred habitat for one bear. Habitat analysis at the overall study area level and the composite home range level did not reflect the affinity this bear had for this stand type. Pure-pine, particularly pure stockings of either loblolly or longleaf pine have various species of *Vaccinium* as a major understory component. Although seasonal analyses were not conducted for individual bears, it is known that longleaf pine stands were frequented by the above mentioned bear during late summer and early fall.

Salt marsh, which was used more than exepected during early fall at the composite level, also was used more than expected by one bear. The influence of this habitat type was seasonal in effect. During late summer to early fall along the Atlantic seaboard, blue crabs (*Callinectes sapidus*) invade the shallow waters of estuarine marshes. Numerous bear tracks, partially eaten crab carapaces, and a

small number (n=2) of bear scats with crab remains were found along the edges of Gillets Creek, a tributary off the Intracoastal Waterway.

Habitat Utilization for Individual Stand Types

Individual stand types were determined for the composite home range and habitat use vs. availability analyses were then conducted. In discussion, values following listed stand types represent percentages that were available vs. used, respectively. Major cover groupings are adequate for broad analysis of habitat utilization, however, individual stand types provide a finer level of detail. Generalities regarding habitat use can be avoided if black bear habitat relationships can be explained at a micro-level rather than at a major cover type level. Examination of individual stands can give a clearer picture of habitat use as it relates to the habitat requirements of food and cover. Although this study was not designed to assess food habits, a discussion of habitat utilization cannot be thoroughly made without reference to food availability. At the level of individual stands, understory composition can be more readily determined from observation and does not necessarily need a detailed vegetation analysis.

During summer, female bears used miscellaneous filler (0.1,20), loblolly-scrub oak (1.9,4.5), pond pine-

miscellaneous hardwood (7.3,13.6), and gum-miscellaneous hardwood (3.2,8.2) more than their availability (Table 11). Pure miscellaneous filler habitats are dense stands of ericaceous shrubs with little to no overstory component and limited light penetration. Pond pine-miscellaneous hardwood and gum-miscellaneous hardwood habitats are generally associated with riparian areas and are densely vegetated. The above habitat types partially fulfill cover requirements. Loblolly-scrub oak habitats, in contrast, are not densely vegetated, but have a relatively contiguous *Vaccinium spp.* understory. Phenological development of *Vaccinium* provides an abundant food source during summer. The use of these soft mast species as a major summer food item is well documented (Hardy 1974, Hamilton 1978, Landers et al. 1979, Hellgren 1988).

Miscellaneous filler was a preferred habitat (0.1,12.2) during late summer. Other habitats used more than their availability included loblolly-pond pine (2.6,6.7), loblolly-miscellaneous hardwood (6.6,11.1), gum-miscellaneous hardwood (3.2,6.7), and miscellaneous hardwood-sweet gum (0.6,5,2). Along with the aforementioned secure cover provided by the filler stand type, soft mast such as *Ilex spp.* is a primary understory component. Hellgren (1988) reported that *Ilex coriacea* comprised 20% by volume of late summer bear scats in Great Dismal Swamp. This same shrub is abundant on Camp Lejeune and is

Table 11. Seasonal habitat use vs. availability at the individual stand level for black bears on Camp Lejeune, North Carolina, 1988-1989.

Stand Type[2]	% Available	All Year % Used	All Year Pref.[3]	Summer[1] % Used	Summer Pref.	Late Summer % Used	Late Summer Pref.	Early Fall % Used	Early Fall Pref.	Late Fall % Used	Late Fall Pref.
0000	0.1	7.8	+	20.0	+	12.2	+	5.1	+	5.7	+
0004	8.0	5.5	-	2.7	-	6.7	0	3.4	-	6.9	0
0007	0.3	0.0	-	0.0	-	0.0	-	1.5	+	0.0	-
0008	0.9	1.6	+	0.0	+	0.0	-	3.2	+	0.0	-
0009	3.6	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-
0100	19.8	13.6	-	12.6	-	11.1	-	11.8	-	12.2	-
0103	2.0	0.7	-	0.0	-	0.0	-	0.8	-	0.8	-
0104	1.2	0.9	0	1.8	0	0.0	-	0.8	0	0.4	-
0115	1.5	1.7	0	2.7	0	0.0	-	1.3	0	1.2	0
0200	0.8	1.7	+	0.0	-	0.0	-	1.0	0	3.7	+
0203	0.4	0.3	0	0.0	-	0.0	-	0.0	-	0.8	0
0300	13.0	9.0	-	6.4	-	5.6	-	11.2	0	11.0	0
0301	1.6	2.2	+	0.9	0	0.0	-	1.5	0	0.8	-
0304	2.6	6.1	+	2.7	0	6.7	+	6.7	+	2.0	0
0312	1.2	1.7	0	0.9	0	0.0	-	1.9	0	2.0	0
0314	3.7	2.8	-	3.6	0	0.0	-	3.8	0	0.8	-
0315	1.9	2.6	+	4.5	+	0.0	-	2.1	0	3.7	+
0317	0.5	1.4	+	0.0	-	0.0	-	1.3	+	0.0	-
0318	1.2	1.6	0	0.0	-	0.0	-	0.8	0	0.4	-
0319	6.6	6.4	0	0.0	-	11.1	+	7.4	0	2.9	-
0400	5.2	6.8	+	2.7	-	5.6	0	6.5	+	9.8	+
0401	3.0	0.1	-	0.0	-	0.0	-	0.4	-	1.6	-
0403	0.4	2.5	+	1.8	0	0.0	-	2.7	+	0.8	0
0417	0.2	0.1	0	0.0	-	0.0	-	0.0	-	0.4	0
0419	7.3	8.6	+	13.6	+	6.7	0	8.4	+	9.4	+
1213	0.5	1.0	+	0.0	-	0.0	-	0.8	0	2.4	+
1217	0.5	0.4	0	0.0	-	0.0	-	0.6	0	0.0	-
1219	0.5	0.6	0	0.0	-	0.0	-	0.6	0	0.8	0
1319	0.1	0.1	0	0.0	-	0.0	-	0.0	-	0.2	0
1403	0.1	0.1	0	0.0	-	0.0	-	0.0	-	0.1	0

Table 11. Continued.

Stand Type	% Available	All Year % Used	All Year Pref.[2]	Summer[1] % Used	Summer Pref.	Late Summer % Used	Late Summer Pref.	Early Fall % Used	Early Fall Pref.	Late Fall % Used	Late Fall Pref.
1419	0.4	0.5	0	0.0	-	0.0	-	0.2	0	1.6	+
1718	0.3	0.7	+	0.0	0	1.1	0	0.2	0	0.4	0
1719	1.3	1.5	0	0.0	-	0.0	-	1.9	0	0.6	0
1812	0.3	0.2	0	0.0	-	0.0	-	0.2	0	0.0	-
1819	3.2	6.6	+	8.2	+	6.7	+	7.2	+	5.7	+
1900	0.4	0.1	-	0.0	-	1.1	0	0.0	-	0.0	-
1912	0.6	3.5	+	0.0	-	5.2	+	1.0	0	3.7	+
1914	0.1	0.6	+	0.0	-	0.0	-	1.0	+	0.4	0
1917	1.2	1.2	0	0.0	-	0.0	-	1.1	0	1.2	0
1918	1.4	2.0	+	0.0	-	2.2	+	2.1	+	0.4	-
N Locations		1210		180		120		525		385	

[1] Spring and summer data pooled due to small sample size.

[2] Referenced by specie composition in Table 14.

[3] + = used more than available, - = used less than available, 0 = used in proportion to availability ($P<0.05$).

prominent within the miscellaneous filler stand type. Other preferred habitats, particularly loblolly-pond pine, also contain various *Ilex* species or have a high *Vaccinium* stocking in the understory. Hard mast-producing trees are abundant within the gum-miscellaneous hardwood stands. Individual tree species associated with this stand category include black gum (*Nyssa sylvatica*) and tupelo gum (*Nyssa s. biflora*). Hard mast in the form of gum berries is an important food item during late summer to early fall (Landers et al. 1979, Hellgren 1988).

During early fall the number of preferred stand types increased. Miscellaneous filler stands were used more than their availability (0.1,5.1). Mixed pine stands, loblolly-pond pine (2.6,6.7), pond pine-miscellaneous filler, and pond pine-loblolly (0.4,2.7), which are primarily associated with mesic sites, were preferred stands. Loblolly-maple (0.5,1.3) and gum-miscellaneous hardwood (3.2,7.2) stands were used in greater proportion to their availability. In many studies, oak mast is a prominent feature in the diet of bears during early fall (Hamilton 1978, Landers et al. 1980, Smith 1985, Hellgren 1988, Seibert 1989). On Camp Lejeune only one stand representing oak species, miscellaneous hardwood-red oak (0.1,1.0), was a preferred habitat.

Late fall stand types selected include, miscellaneous filler (0.1,5.7), slash pine-miscellaneous filler (0.8,3.7), pond pine-miscellaneous filler (5.2,9.8), and pond pine-

miscellaneous hardwood (7.3,9.4). These stand types have varying amounts of *Ilex* in the understory with dense vegetation vital to secure cover. Gum-miscellaneous hardwood (3.2,5.7), sweet gum-white oak (0.5,2.4), and red oak-miscellaneous hardwood (0.4,1.6) stands also were used in greater proportion to their availability.

Bear Distribution

Bear Distribution in Relation to Class I Roads

Female bears were located farther ($P<0.05$) from Class I roads during late fall than any other season (Table 12). Early fall locations were significantly farther ($P<0.05$) from Class I roads than summer or late summer locations. Compared to random locations, female bears were located closer ($P<0.01$) to Class I roads during all seasons except early fall (Table 11). Most bear sightings on Class I roads were classified as road crossings. Paved surface roads on the Base have a well defined buffer of manicured grass which extends 3-10 m from the road edge. Attractants to roads such as soft mast producing vegetation are mostly absent from this class of roads.

A χ^2 analysis indicated that areas ≤100 m, 100-200 m, and 400-800 m from Class I roads were used more ($P<0.05$) than expected throughout the year (Table 17). Areas between

Table 12. Mean Distances of female black bears to Class I[1] and Class II[2] roads on Camp Lejeune, North Carolina, 1988- 1989.

Season	Number of Locations	Distance (m) Class I	SE	Distance (m) Class II	SE
Summer	320	489[A]	100	135[A]	33
Late Summer	263	446[B]	124	202[A]	45
Early Fall	706	508[C]	57	205[A]	21
Late Fall	391	536[D]	64	169[A]	21
All Seasons	1680	609[*]	38	196[*]	13
Random Points	400	824[E]	76	438[B]	26

[1] Class I roads are defined as paved surface roads with a maximum speed limit of 55 mph.

[2] Class II roads are defined as unimproved earthen or gravel surfaced roads including, timber harvest roads, access roads, and tank trails.

[A] Values in the same column with different letters are significantly different ($P<0.05$) according to Paired T-tests with protected LSD controlling for comparisonwise error.

[*] Values in the same row with the "*" designation are significantly different ($P<0.01$)

200-400 m were used in proportion to random locations (n=100) within this distance category. Zones ≥800 m from roads were used less ($P<0.05$) than expected. A seasonal analysis revealed that bears frequented zones ≤200 m more ($P<0.05$) than expected during each season except early fall. During this season areas ≤100 m were used less than expected. Only during early fall were areas 400-800 m used more ($P<0.05$) than expected.

Bear Distribution in Relation to Class II Roads

There were no differences ($P>0.05$) in mean distances of female bears to Class II roads throughout the year or between seasons. Random locations were farther ($P<0.01$) from roads than actual bear locations (Table 11). A χ^2 analysis indicated that areas ≤200 m from Class II roads were used more ($P<0.05$) than expected throughout the year (Table 17). Additionally, bears used this distance category more than expected within each season except during early and late summer when use was proportional to availability for areas 100-200 m from roads. Areas 200-400 m from roads were preferred ($P<0.05$) on an annual basis and during early and late fall. Distance categories >400 m (400-800 m and ≥800 m) were used proportionately less than their availability throughout the year and during each season. The latter occurrence may be related to road densities,

juxtaposition to preferred habitats, and human use of Class II of roads.

Bear Distribution In Relation to Artificial Foods

Artificial food sources found on Camp Lejeune include sanitation bins, roll-off dumpsters, and the sanitary landfill. Bivouacs established during military training exercises provide an unreliable source of artificial food. After training exercises are finished, however, refuse from mess tents is normally deposited in sanitation bins and roll-off dumpsters at the convergence of secondary (Class II) and primary roads (Class I). This food remains until the bins or dumpsters are emptied. Other human refuse, such as household garbage, is illegally deposited in sanitation bins on a regular basis.

Female bears on Camp Lejeune, with minor exception, appear to be opportunistic in relation to artificial food resources. Of the four bears included in this analysis, one showed a patterned orientation to artificial foods (See, A Special Case, this chapter). The remaining female bears preferred areas >800 m from artificial foods on an annual basis and during each season (Table 13). During late fall, however, two bears (06 and 09) showed a preference for areas <200 m from artificial foods. The preference or avoidance of areas in close proximity to artificial foods is

Table 13. Distribution of radiolocations of 4 female black bears to distribution of random points for distance to artificial food resources, Camp Lejeune, North Carolina, 1988-1989.

Distance (m)	% Random	Summer % Used	Summer Pref.[1]	Late Summer % Used	Late Summer Pref.	Early Fall % Used	Early Fall Pref.	Late Fall % Used	Late Fall Pref.	All Year % Used	All Year Pref.
Bear 04											
<200	10.0	29.2	+	31.6	+	5.6	-	12.1	0	12.4	0
200-400	8.0	25.0	0	↓[2]	--	↓	--	↓	--	6.7	-
400-800	30.0	20.8	0	42.1	0	45.4	+	41.4	+	37.3	+
>800	52.0	25.0	-	26.3	-	49.1	0	46.6	0	43.5	0
N	200		24		19		108		58		209
Bear 06											
<200	12.0	↓	--	↓	--	↓	--	25.0	+	16.7	0
200-400	31.0	↓	--	↓	--	20.3	-	↓	--	3.6	-
400-800	34.0	72.2	0	28.5	-	18.8	-	21.4	-	22.5	-
>800	23.0	27.8	0	71.4	+	60.9	+	53.6	+	57.2	+
N	150		18		28		64		28		138

[1] Preference: + = used more than expected ($P<0.05$), - = used less than expected, 0 = used proportionately.

[2] ↓ = Data were pooled into the next category whose sample size met χ^2 expected values for cell size.

Table 13. (continued)

Distance (m)	% Random	Summer % Used	Summer Pref.	Late Summer % Used	Late Summer Pref.	Early Fall % Used	Early Fall Pref.	Late Fall % Used	Late Fall Pref.	All Year % Used	All Year Pref.
Bear 08											
<200	8.2	↓	--	↓	--	↓	--	↓	--	2.4	-
200-400	14.1	↓	--	↓	--	19.8	+	↓	--	4.2	-
400-800	15.3	↓	--	↓	--	↓	--	18.4	0	14.3	0
>800	61.8	100.0	+	100.0	+	80.2	+	81.6	+	79.1	+
N	170		14		25		86		49		174
Bear 09											
<200	0.0	↓	--	↓	--	↓	--	15.2	+	5.2	+
200-400	6.9	↓	--	↓	--	↓	--	↓	--	2.6	-
400-800	39.7	↓	--	50.0	-	11.3	+	↓	--	10.3	-
>800	53.4	100.0	+	50.0	+	53.6	0	84.8	+	82.8	+
N	130		15		17		62		35		129

misleading.

Twenty seven observations were made of bears at artificial food sources; 25 at sanitation bins and two at the landfill. The importance of the landfill to female bears on Camp Lejeune could be established for only two bears (04 and 06). However, the number of distinct bear tracks (n=7) observed near this location suggested that the landfill was used more than habitat utilization data indicated. A great deal of effort was expended on trapping around the landfill with only one capture recorded and only one additional collared bear located in close proximity to it. Based upon the observed level of use, possibly 4-5 unknown bears used the landfill at different times during the year. A slight increase in track frequency and track size was noticed during the breeding season; this was most likely due to transient males looking for an easy meal.

Through learned experience, certain bears are cognizant of artificial food locations and visit these areas on an irregular basis. Bears on Camp Lejeune supplemented their diets with artificial foods during all seasons even when natural foods were closely juxtaposed to artificial food sources. Natural foods on Camp Lejeune, at least during the course of this study, were plentiful and therefore bears did not appear to be dependent upon artificial foods.

A Special Case

The availability of artificial foods was responsible for the shape and overall area of bear 04's home range during both 1988 and 1989 (Figs. 10 and 11). The pattern of her home range in 1988 was delineated by the landfill on the north, TLZ (Tactical Landing Zone) Goose on the east, TLZ Albatross on the south, and TLZ Jaybird on the west. In 1989, the shape and overall area of her home range were similar to the previous year (24.3 km^2 in 1988, 26.8 km^2 in 1989).

Discussion

The value of pocosin habitat to black bears on Camp Lejeune has been adequately demonstrated. Female black bears preferred pocosin habitats on an annual basis, as well as during each season except late summer (Table 9). At the stand level, the pattern of use for miscellaneous filler and pond pine-miscellaneous hardwood habitats was the same as the aggregate community type. Pond pine-miscellaneous hardwood stands accounted for 35% of all pocosin community types. An average of 15% (range 4.0 to 28.8%) of the total area within individual female home ranges was pocosin habitat. Pocosins also provide excellent denning habitat evidenced by 8 out of 11 den sites being found within

pocosin communities (see Chapter VI).

Pocosins habitats are poorly drained and have soils with a high organic content (Sharitz and Gibbons 1982, Zeveloff 1983). Carolina bays which are vegetatively and structurally similar to pocosins were used almost exclusively by bears in Bladen County, North Carolina for forage, cover, and denning habitat (Hamilton and Marchington 1980). Hellgren (1988) reported that within a single 600 ha pocosin 8 of 15 (56%) and 7 of 20 (35%) radiocollared females used the area during August and November-December, respectively. Beyond the borders of Camp Lejeune, pocosin communities provide the last expanses of suitable habitat for black bears in the Atlantic Coastal Plain (Monschein 1980). The work of Landers et al. (1979) and Hamilton and Marchinton (1980) suggested that pocosin habitats are important to black bears. Earlier work by Hardy (1974) in Dare County, North Carolina, alluded to the importance of pocosins, but no definable use patterns could be determined. The data presented in this study, combined with the work of Hellgren (1988), indicates that pocosins are a vital habitat type for black bears in the Southeast.

Considerable home range overlap between male and female black bears appears to be a universal pattern and is reported in most studies of bear populations. Males, by having home ranges which overlap many females, increase their chances of reproduction. This pattern of home range

overlap has been adequately demonstrated for this study, other wetland populations (Hamilton 1978, Smith 1985, Hellgren 1988), and populations in mountain regions (Warburton and Powell 1985, Beringer 1986, Seibert 1989).

Barber and Lindzey (1986) reported a dominance hierarchy among adult males and subordinates which determined temporal associations with estrous females. In support of these findings, data from Camp Lejeune indicates that dominant males attend estrous females for varying periods of time (D. Brandenberg, pers. commun.). Maintaining contact with an estrous female reduces access by other males when the female is receptive, but may serve to increase competition between males when their ranges overlap.

Home range overlap among females has been the subject of much discussion. Considerable overlap for females has been reported for Idaho (Amstrup and Beecham 1976, Reynolds and Beecham 1980) and Washington (Lindsley and Meslow 1977). In more recent Southeastern studies (Beringer 1986, Seibert 1989), home range overlap was reported as extensive. Female bears on Camp Lejeune exhibited extensive annual overlap with varying degrees of seasonal overlap. Similar patterns of home range overlap were documented for other wetland populations (Abler 1985, Smith 1985, Hellgren 1988).

Exclusive female home ranges have been reported in Montana (Jonkel and Cowan 1971), Minnesota (Rogers 1977),

and Alberta (Young and Ruff 1982). Lecount (1980) reported limited home range overlap among females in Arizona. In North Carolina (Hamilton 1978), adult female black bears were reported to have the least amount of overlapping range. As in the case of Hamilton (1978), Hellgren (1988) cautioned about making judgements about spatio-temporal relationships from a small percentage of a resident bear population. It is believed that greater than 80% of resident female bears on Camp Lejeune were being monitored during the course of this study.

Intrinsic behavioral mechanisms such as kinship and social intolerance have been offered as explanations of female home range overlap (Jonkel and Cowan 1971, Rogers 1977, Lindzey and Meslow 1977). Other studies have related the spatial and temporal distribution of food (Reynolds and Beecham 1980, Rogers 1987) and temporal separation of areas of common use (Lindzey and Meslow 1977, Garshelis and Pelton 1981) as factors affecting female home range overlap. Abler (1985) and Smith (1985) attributed a considerable amount of overlap to aggregated food sources and kinship. Within any study, all these ideas may be working as individual forces or concomitantly.

In this study, the spatial and temporal distribution of food appeared to be a major influence on home range overlap. Productivity within habitats during summer appeared to be a function of quantity as well as quality. Food resources

were evenly distributed and fairly abundant. Female home range overlap during this season was minimal. In late summer and early fall high quality foods are available, but are patchy in distribution. Important food items are found in localized areas such as oak, gum, and pocosin habitats. A marginal increase in home range overlap between females was observed for these seasons. The degree of home range overlap may be a function of territoriality.

Territoriality may be optimal when resources are plentiful and evenly distributed or accessible and predictable (Reynolds and Beecham 1977). Horn (1968) showed that in areas where food resources are patchy and temporally unpredictable, defense of fixed territories is not advantageous. Resident bears would benefit from territorial behavior, particularly true for females with cubs (Rogers 1987). Intimate knowledge of available resources in a given area would increase territorial behavior as an aid to reproductive fitness and cub survivorship. Females without cubs may still exhibit territorial defense to maintain land tenure when nutritionally stressed (Hellgren 1988). Cubs of the year also are less mobile during early summer and more susceptible to predators (male bears) and nutritional stress (Elowe and Dodge 1989). This would increase the potential for territorial behavior even when food availability is high.

The degree to which a solitary forager will tolerate

another conspecific within its territory will depend upon the costs associated with tolerating the interloper versus ejecting it (MacDonald 1983). This cost may be tempered by the degree of genetic relatedness between the original territory holder and the 'extra' group member. Also, the degree of overlap and concordance in resource utilization among adjacent territory holders may reflect their degree of genetic relatedness (MacDonald 1983). Although familial relationships were unknown for female bears on Camp Lejeune, the size of the female cohort, the degree of seasonal overlap among particular individuals, and observation of bear interactions suggest a measure of genetic relation for several bears.

As noted, annual home range overlap for females was extensive, particularly for bears 01 and 09 during 1988 and for bears 01, 09, and 16 during 1989 (Fig. 10 and 11). This occurrence is not unusual for female bears throughout their range (Amstrup and Beecham 1976, Hellgren 1988, Seibert 1989). Although inferences regarding relationship can be made through behavioral observation, verification of genetic relatedness is made using molecular genetic techniques (Burke 1989, Pemberton and Amos 1990, Gilbert et al. 1991, Packer et al. 1991).

Analyzing static and dynamic interactions among female bears would provide a clearer picture of the degree of overlap and congruence in utilization. Static interaction

is the degree of spatial overlap and concordance in utilization distribution among animals with overlapping home ranges while dynamic interaction is the degree of dependency in the movements of individuals sharing a common area. Multilocus VNTR (DNA fingerprinting) analysis could be used to compare static interaction among females on three levels of genetic relatedness: parent-offspring, siblings, and unrelated individuals. Gilbert et al. (1990) successfully used multilocus VNTR analysis to examine genetic variability both within and among island fox populations on the California Channel Islands. Using multi-response permutation procedures (MRPP) the distribution of locations within the area of overlap could be examined to determine whether bears sharing a common area is statistically distinguishable. A statistical procedure which considers temporal dependency of movements is needed to analyze dynamic interactions.

The distribution shift of female bears to areas 400-800 m from Class I roads during early fall may be a function of habitat position. Productive hard mast stands are located further from primary roads compared to other habitats used on an annual basis. Hellgren (1988) reported a seasonal shift of bears away from major roadways on the border of Great Dismal Swamp due to the location of mast producing trees. At other times of the year important food components are evenly distributed throughout the base.

Traffic volume on Class I roads is relatively heavy as they serve as primary ingress/egress routes for the base. The posted speed limit on most of these roads (Marines Road, Sneads Ferry Road, NC-172, Lyman Road) is 55 mph. Military vehicles have a maximum speed of 45 mph. Weekday traffic (Monday thru Friday) is heaviest, particularly during early morning (0600 to 0800) and early evening (1600 to 1730). Heavy traffic volume would preclude bears from crossing roads during daylight hours, although diurnal crossings did occur. Dependent upon the season, most bear crossings occurred from 1800 to 0700 on the following day. Earlier crossings were noted during early to late fall when daylight hours are reduced.

The distribution of bears to Class I roads is of primary concern due to an abnormally high mortality rate for females and cubs of the year (See Population Dynamics, Chapter VI). Vehicle related deaths accounted for 8 out of 11 mortalities. Most of these mortalities appeared to be dependent upon two conditions: 1) dense habitat converging on the edge of a road, and 2) the time of day. Whether bears cross or avoid roads may depend on the surrounding habitat (Seibert 1989). Hugie (1982) documented bears repeatedly crossing roads at a specific location where understory cover was extremely dense. On his study area in western North Carolina, Seibert (1989) reported that bears were most frequently seen along a road which had a thick

understory of mountain laurel and rhododendron.

Class I roads which bisect important bear habitat, such as pocosins and riparian areas (mesic hardwoods), and roads which cut historic travel corridors were crossed more frequently than roads through marginal habitats. An example of this was observed on Lyman Road (Fig. 7). High frequencies of bear crossings on this road have been reported during the last decade by EMD Camp Lejeune (C. Peterson, pers. commun.). Investigation of the road margin in a number of locations revealed that bears were crossing this road with great frequency. A 24 hr telemetry session on Bear 06 revealed that crossings were made up to 7 times during the course of a day. Crossings occurred primarily in two locations at which heavy cover converged on the road margin. Both locations had reasonably heavy bear traffic which suggested a regularly used travel corridor.

Class II road density is relatively uniform throughout the base at 1.7 km/km^2 (Fig. 14). At these densities there are few areas containing desirable habitats far from road margins. Seasonally abundant food sources can be found within close proximity to Class II roads. Carr and Pelton (Great Smoky Mountains National Park; 1984) and Smith (White River NWR; 1985) reported fluctuating bear responses to roads dependent upon seasonally abundant food supplies. Hellgren (1988) indicated that roads and road margins were important habitat components for bears in Great Dismal

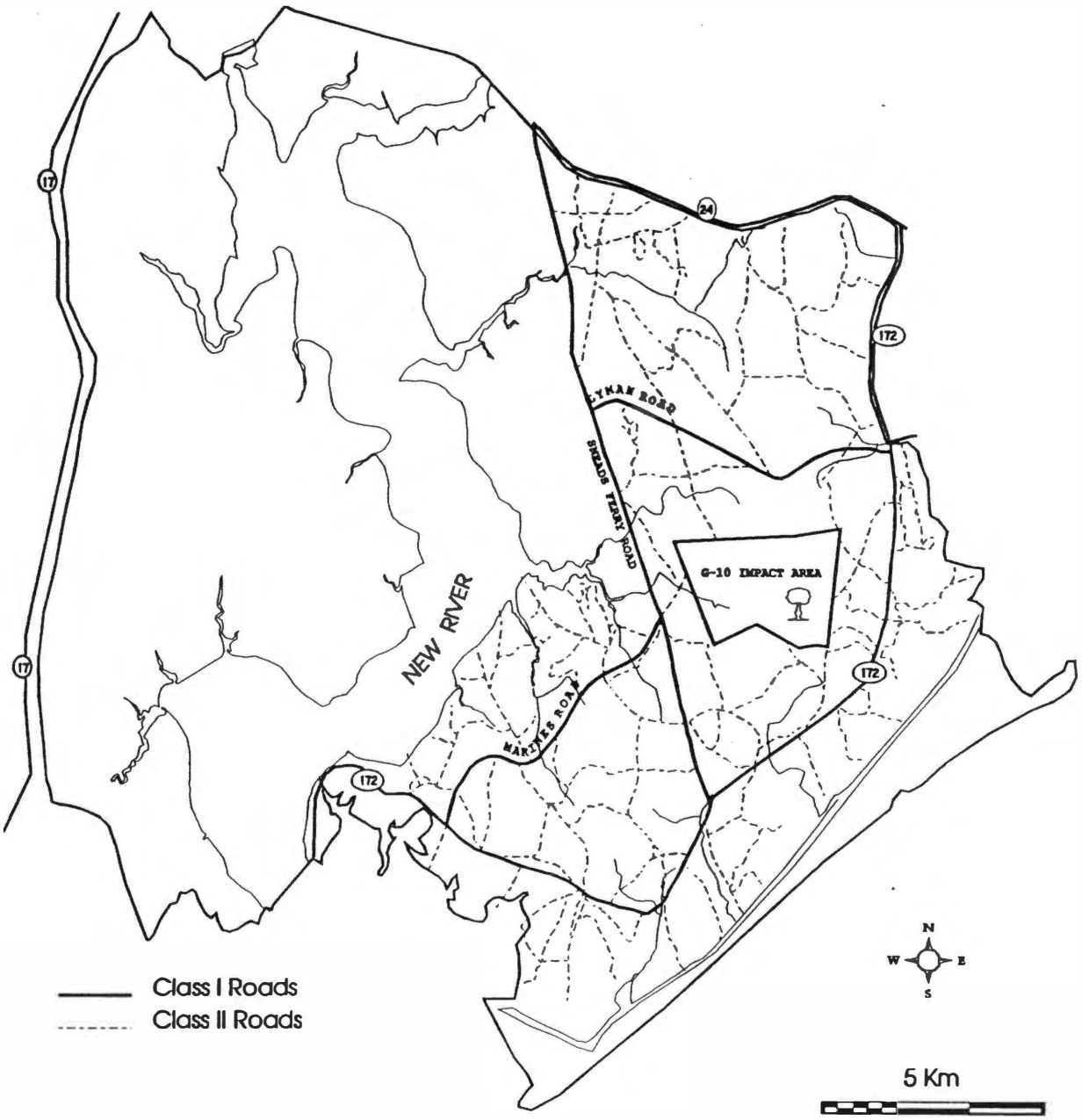


Figure 13. Distribution of Class I and Class II roads for the selected study area on Camp Lejeune, North Carolina.

Swamp.

Along with food availability and juxtaposition to preferred habitats, lowered levels of human activity on Class II roads on Camp Lejeune may be responsible for bear utilization of this road type. Female bears were located closer ($P<0.01$) to Class II roads than to Class I roads. Vehicle access on Class II roads is different from the aforementioned road type. Daily commuter traffic is absent from this class of roads and disturbance levels are related to military training exercises. During a large training operation in 1988, several branches of the armed forces conducted combined operations which increased motor vehicle traffic on Class II roads. Telemetry investigations indicated that bears appeared to remain farther away from roads during these exercises than at other times during the year. Triangulation error may have played a part in these observations, but a survey for bear tracks on Class II roads conducted after the training exercise concluded revealed little use of secondary roads by bears.

Class II roads were used by bears as travel corridors, possibly to facilitate movement through extremely dense vegetation. Evidence to support this hypothesis was available from several individual bears. Bear 04 used secondary roads as daily travel routes. This bear was radio-monitored as she travelled along roads without deviating from the road course, sometimes greater than 6 km.

An abnormal shift in distribution occurred during a 10 hour period for Bear 06 (See Home Range Size, this chapter). This 10 km movement was made almost exclusively on Class II roads.

Hardy (1974) in Dare County reported that bears frequently used secondary roads as travel routes. In protected or unharvested populations, bears are noted to use roads with limited human activity with greater frequency than heavier traveled roads (Garner 1986, Seibert 1989). Avoidance of roads has been documented regarding bear populations that are subject to harvest or have unrestricted access by humans (Hamilton 1978).

Hellgren (1988) reported that a potential bias could occur with distribution data when trapping is conducted within 100 m of roads due to "road happy" bears. In most cases, traps sites on Camp Lejeune were located within 100 m of roads. It is important to note that female bears were located significantly farther from Class I roads than from Class II roads (Table 12). For both of these road classes females used areas closer to roads more than expected during all seasons except during early fall for Class I roads. The frequent use of Class II roads by Camp Lejeune bears is not a limiting factor for the population. For Class I roads, however, behavioral changes associated with the proximity of artificial foods and inflated mortality rates may be influencing natural population regulatory mechanisms.

The opportunistic behavior of bears in relation to artificial foods was observed on numerous occasions. During large scale military training exercises, bears used artificial foods with greater frequency due to availability. This patterned response behavior was observed for 4 bears. Visits to sanitation bins occurred even in the absence of external stimuli as evidenced by 6 of 24 captures made at trap sites juxtaposed to sanitation bins or the landfill.

A qualitative look at the use of sanitation bins showed that only a handful of bears were responsible for most of the observations made. All sanitation bins were located at the juncture between Class II and Class I roads as a convenience for marines in training to dump refuse and for accessibility by sanitation engineers to empty the bins. This situation could have potentially deleterious effects on the bear population by increasing bear-human interactions. Harassment of bears at sanitation bins was observed on four occasions; three occurred after dark and one was observed in the early morning. In all instances, a bear was chased off a sanitation bin and forced to climb a nearby tree. On one of these occasions a spotlight was held on the treed bear while onlookers took pictures. A crowd (12 people) had gathered within a short period of time. The frequency of claw marks on trees in relatively open cover around sanitation bins suggests that this has been a recurring problem.

CHAPTER VIII

MANAGEMENT OVERVIEW

Population Stability

Occupied black bear habitat in southeastern North Carolina is predominantly under ownership of the U.S. Forest Service, U.S. Fish and Wildlife Service, Department of Defense (Camp Lejeune), NCWRC State Game Lands, and private paper company lands (i.e., Weyerhauser, Georgia Pacific). Protection from hunting occurs only on designated paper company lands and currently on Camp Lejeune. Alterations to bottomland hardwood and coastal habitats through agricultural development and forest conversions to pine monocultures results in fragmented habitats compared to what formerly was extensive range (Pelton 1985).

Development around Camp Lejeune poses uncertain threats to the resident black bear population. Relatively secure or permanent dispersal corridors are becoming increasingly narrow, especially along the northern boundary of the Base (NC-24; Fig. 15). The Wallace Creek Drainage provides a secure travel corridor for highly mobile adult male bears during the breeding season and a potential dispersal corridor for sub-adult males. Uncontrolled development

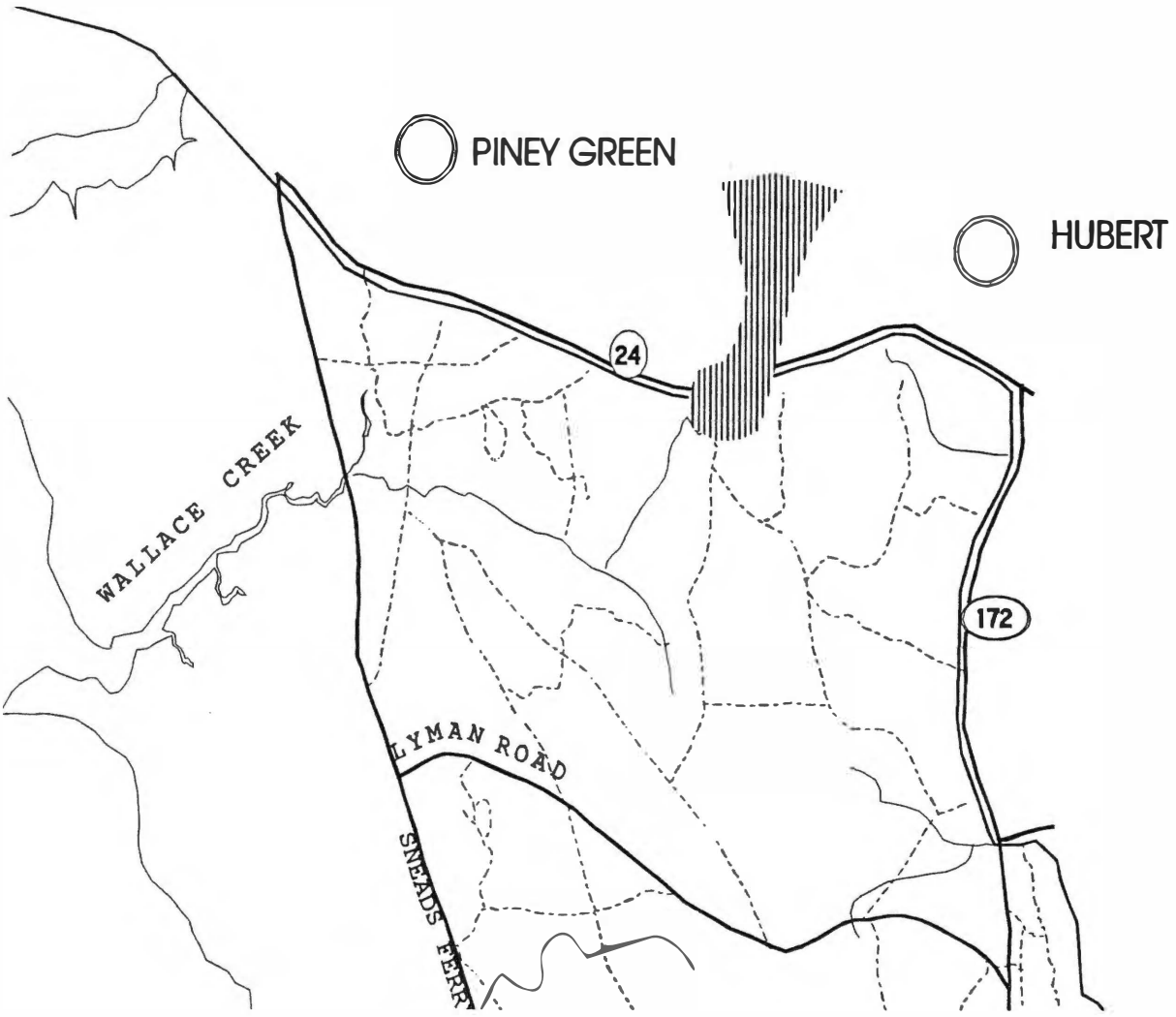


Figure 14. Representative map of the northern boundary of Camp Lejeune with a known dispersal corridor along Wallace Creek.

along the periphery of this drainage will increase contact with humans and may ultimately impede bear movements. Protection of this dispersal corridor is extremely important for the stability of the Mainside bear population.

Heavily-used roads and high-speed highways within and around Camp Lejeune serve as geographic barriers within formerly contiguous habitat. Interstate highways and other multi-lane roads with high-speed, high traffic volumes have been reported to act as mortality sinks (Brody and Pelton 1989, Hellgren and Vaughn 1989). Unverified reports of bear-vehicle collisions on NC-24 warrant further investigation of the impact this roadway has on black bear mortality rates on Camp Lejeune.

Actions to mitigate the impact of high-speed roadways within the borders of Camp Lejuene might consist of reducing allowable speed limits on Class I roads during evening hours. Similar actions have been taken to protect Florida panthers (*Felis concolor coryi*) (U.S. Fish and Wildlife Service 1987).

Changes in hunting methodology, specifically the use of dogs during the last two years of legal harvest, appeared to be selective toward adult males (Fig. 6). The number of adult male bears available for harvest on Camp Lejeune appears to be decreasing. Findings from this study indicate that the majority of males on Camp Lejeune are breeding season transients and may not dwell on the base year-round.

The likelihood also exists that many more male bears are killed by vehicle collisions or legal harvest than is supported by data from this study. In the advent of a legal hunting season on Base, given that the subadult male cohort may exhibit normal dispersal patterns and possess a high vulnerability to vehicle collisions, adult females would most likely dominate the harvest. Hunting mortality under these circumstances would be additive in light of an already high mortality rate for adult females. Exploitation rates of this "K" selected species, having slow reproductive and turnover rates, cannot normally exceed 15 to 25% without causing a population decline (Pelton 1985).

Class II road densities within female home ranges on Camp Lejeune are high enough to caution the use of dogs as a legal means of harvest (Fig. 16). The frequent use of roads by bears and the regularity of bear crossings would most likely work to the hunters advantage.

The response of black bears to being chased by dogs is affected by habitat parameters, home range dynamics, the sex of the bear, and the disposition of the dogs involved in the chase (Allen 1984, Massopust and Anderson 1984). Poelker and Hartwell (1973) reported that dog-hunting was selective for female bears as determined from sex ratios of bears killed during a population control operation in Washington. Habitat type was an important factor affecting the vulnerability of bears to dog hunting in North Carolina

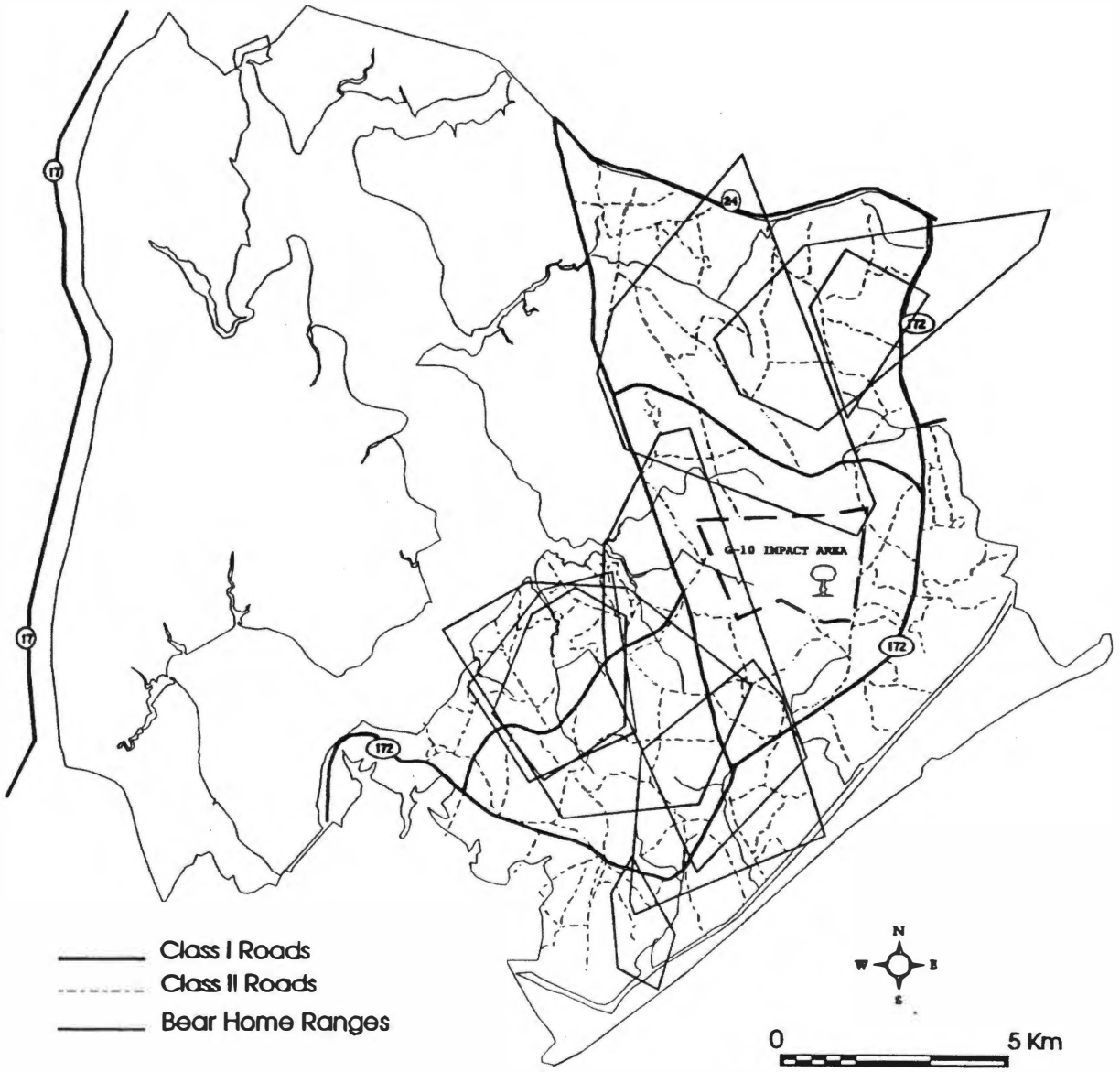


Figure 15. Distribution of Class I and Class II roads within home ranges of female black bears on Camp Lejeune, 1989.

(Hamilton 1978). Bottomland hardwood swamps, similar in vegetation structure to pocosins and wetland areas on Camp Lejeune, were avoided by dog hunters and none of 54 known bears kills recorded from 1974 to 1977 in Bladen County, North Carolina, were made within this habitat type.

Another caution for the use of dogs on Camp Lejeune is the percentage of pocosin habitat within bear home ranges. Escape patterns used by bears are often circuitous and remain within the confines of their home ranges (Allen 1974). An average of 16% (range 4 to 28.8%) of female home ranges are in pocosin habitat. Bears will utilize this densely vegetated area for escape routes and for primary defense measures. Mobility within these habitats is extremely limited and it would be difficult for hunters to retrieve dogs engaged in a bear-dog fight.

Daily changes in areas open to hunting further complicate the use of dogs on the base. Camp Lejeune is divided into alphabetic management units which vary in total acreage. Home ranges of bears are large enough to incorporate portions of two or more individual management units within their boundaries. A block of management units would need to be opened for bear hunters who intend to use dogs as a primary means of take.

Habitat Considerations

Home range dynamics and habitat use by bears on Camp Lejeune was most affected by the spatial and temporal distribution of food resources. Production of important bear foods is directly influenced by natural processes and to some degree by forest management activities. Within pocosin habitats, humans have little control over forage productivity, beyond the occasional fire escape associated with prescription burns. Proposed changes in federal wetland regulations may influence the permitted use of these critical habitat components on Camp Lejeune, but the overall integrity of pocosins and bottomland hardwood will remain intact.

Active forest management on Camp Lejeune, including various timber harvest regimes and prescription burns are well suited to the basic food requirements of black bears. Shelterwood cuts, seed tree cuts, and selective thinning allows for ample soft mast regeneration in the understory. Continuation of current forest management plans will adequately fulfill forage needs of black bears for future generations.

Prescribed Fire and Smoke Management on Camp Lejeune

Prescribed burning is highly recommended for habitat

management in areas where loblolly, longleaf, slash, and pond pine are the primary overstory components (Crow 1973). The positive effects of prescribed fire have been noted for many wildlife species; game and non-game inclusive (Lay 1956, Stoddard 1963, Handley 1969, Dickson 1981, Hamilton 1981, Means 1981, and Ivey 1983). Information on the direct effect of fire and smoke on bear behavior is not well documented and little exists about the effect of fire on the denning behavior of black bears in the Southeast. Hamilton (1981) provides a good summary of the effects of prescribed fire on black bear habitats and populations in Southeastern forests. A major portion of his paper was devoted to the effects of fire on forage production.

The primary benefits of prescribed fire on Camp Lejeune include: 1) wildfire hazard reduction, 2) wildlife habitat improvement, 3) control of undesirable understory species thereby maintaining an open understory, and 4) seedbed preparation. The rotation schedule for prescribed burns on Camp Lejeune is well suited for the general habitat requirements of black bears on the Coastal Plain. Five-year burn rotations in pine and hardwood forestland allow for ample soft mast production while providing enough time for hard mast producing vegetation to attain fire resistant size (Johnson and Landers 1978).

Shorter rotation times are implemented in areas intensively managed for bobwhite quail, turkeys, and red-

cockaded woodpeckers (U.S. Fish and Wildlife Service 1988). The majority of these areas are longleaf pine savannas which are burned on 2 to 3 year rotations in order to maintain a predominantly grass understory. This habitat type, for the most part, has little utliity for black bears on Camp Lejune.

Numerous plow lines are found throughout each forest timber compartment on Camp Lejeune. Plow lines serve to protect sensitive areas from the effects of fire by acting as a fire impediment. In addition to protecting areas, plow lines are utilized by different wildlife species as travel corridors (A. Henry, pers. commun.). Thickly vegetated stream drains, pocosins, carolina bays, and most wetland habitats have been demonstrated as extremely important to black bears on the Coastal Plain (Hardy 1974, Hamilton 1978, Landers et al. 1979, Hellgren 1988, this study). In concordance with current prescribed fire management plans (Wade and Lunsford 1988), the majority of these habitats on Camp Lejeune have plow lines in close juxtaposition. Removal of overhanging debris from plow lines to reduce avenues for fire escape is recommended for all prescription burns. Black bears benefit from the maintenance of plow lines in that key habitat components are protected and potential disturbance during denning is reduced.

Sensitive areas, by standard definitions (USDA 1989), include highly erodible soils, streamside buffer zones,

desirable hardwoods, and special quality wildlife and plant communities which have been subjectively expanded to include pocosins. Areas listed within screening systems for managing smoke include: airports, highways, residential and commercial communities, schools, and recreation areas. The observed effects of smoke on the denning behavior of black bears on Camp Lejeune (Chapter VI; Denning Ecology) require inclusion of critical wildlife habitat within these screening guidelines.

Prescription burns on Camp Lejeune occur concomitant to black bear denning. Measures to lessen the potential deleterious effects of fire and smoke on denned bears should become an integral part of planning for a burn. In addition to prescription parameters already assessed (i.e., humidity, wind direction, fuel moisture), the juxtaposition of a burn to critical denning habitat should be considered. Smoke from prescription burns has been demonstrated to be a disturbance factor for denning black bears on Camp Lejeune. In light of restrictions currently imposed upon burning schedules, it will be difficult for EMD Forestry to further limit their activities. Active cooperation between black bear researchers on the Base and EMD Forestry, communicating the distribution of bears during winter and those habitats which are likely to harbor denning bears will facilitate administration of non-disruptive management actions.

The Military Mission and the Black Bear

Black bears on Camp Lejeune appear adaptable to fluctuating levels of military training. Areas on the base which are subject to heavy military use, such as the G-10 Impact Area and various firing ranges, are avoided by bears during periods of heavy activity. The G-10 Impact Area is generally avoided by all bears. The 400 m buffer zone which lies on the areas perimeter does, however, receive limited use. Concomitant to large training exercises, bears restrict their use of roads as travel corridors, presumably to avoid human contact. Other manifestations of altered behavior resulting from military training have been recorded. Individual bears are known to change their normal feeding patterns when artificial foods become available during training exercises. The potential increase in bear-human conflicts from these incidents, combined with an increase in the frequency with which bears utilize sanitation bins during large scale exercises poses problems for wildlife managers on the Base.

Prior to this study, EMD biologists were relegated to manage the bear population with limited biological data. Bear observations around sanitation bins and reports from field commanders complaining about animals lurking around bivouacs gave false impressions of an increasing bear population. The behavior of a handful of animals is

inadequate to manage a species on a population level.

Factors indirectly associated with the military mission, local human population growth, urban development, and increased traffic volumes negatively impact the black bear population to a greater degree than military training itself. An opportunity to further examine the direct impacts of military training on black bears presents itself with the Great Sandy Run Pocosin Land Acquisition. Researchers working on the land acquisition could assess changes in bear behavior and population characteristics as military training escalates. Additionally, the juxtaposition of the great Sandy Run Pocosin to the Verona side of Camp Lejeune presents an opportunity to fill data gaps which exist in this study regarding black bear population dynamics and habitat use west of the New River.

CHAPTER IX

SUMMARY AND CONCLUSIONS

1. Research was conducted on Marine Corps Base Camp Lejeune, North Carolina during 1988 and 1989.

2. Fifteen individual black bears were captured a total of 24 times in 1896 trap nights. Trapping efficiency averaged 86 trap nights per capture.

3. Fourteen radio collars were deployed, 12 for initial captures and 2 for previously tagged bears. Two bears (1 adult male, 1 adult female) dropped their collars, but were recaptured and one (adult female) refitted. spacer materials were replaced on four occasions.

4. A total of 1680 telemetry locations were collected from radio collared bears using standard ground triangulations. Aerial locations were conducted on two occasions for a single male bear which travelled off base property.

5. The sex ratio of initial captures was 5M:10F (N=15) and differed from 1:1 ($P<0.05$). The disproportionate number of females in the capture sample may be the result of earlier exploitation and disproportionate natural mortality due to roads.

6. Ages of captured bears ranged from 2 to 10 years ($\bar{x}=4.9\pm2.4$). Mean age of males and females were not

different. No subadult males or males greater than 8 years old were captured.

7. Intraspecific and human related factors may be responsible for the absence of a subadult male cohort. Competitive pressures between adult males and subadult males are likely working to influence dispersal mechanisms resulting in antagonistic encounters or hasty departures by subadults. Erratic movement behavior, characteristic of subadult males, also may increase the vulnerability of this cohort to vehicle related mortality.

8. Mean litter size was 2.2 (n=6) and did not vary ($P<0.05$) from other populations in the Southeast. Female bears on Camp Lejeune may breed at age 3, but attain primiparity at age 4.

9. Eleven mortalities were recorded during the study, 9 were either tagged, radio-collared, or both, and two were of unknown bears. All mortality was human caused: vehicle collisions (n=8), research (n=1), and legal kill (n=1, outside the study area). Average annual mortality rates were 0.23, 0.31, and 0.53 for adult males, adult females, and black bears cubs, respectively.

10. Population density for Camp Lejeune was estimated by 4 techniques at 0.16-0.30 bears/km^2, corresponding to 21-40 bears. Twenty three bears were known to inhabit the base as residents or seasonal migrants.

11. Bears denned exclusively on ground nests in three

habitat types; pocosin (N=11), lowland pine-hardwood (N=1), and an area regenerating from a disease episode (N=1). Vegetation density at the hibernacula ($\bar{x}$=94%) was significantly greater than random locations. Microelevational differences within pocosins may allow bears to utilize ground dens in otherwise inundated areas.

12. Winter activity was recorded for 5 of 7 bears in 1988-89 and for 3 of 7 bears in 1989-90. Human disturbances, i.e., military training and research activities, were responsible for four bear movements. Prescription burns were responsible for den abandonment by three bears on four occasions. Overall den abandonment was high (36%).

13. Den entry dates were 23 Dec.±10.4d for females with cubs (n=6), 20 Dec.±1.2d for females with yearlings (n=2), 25 Dec.±10.6d for solo females, and 25 Dec.±4.5d for males (n=2). Parturient females generally denned earlier than all other bear groupings.

14. Forty-two seasonal and 11 annual home ranges were constructed for 15 study animals. Annual male home ranges averaged 60.5 km^2. Poor radio tracking success of males prevented the construction of seasonal home ranges. Female home ranges averaged 10.2, 9.0, 5.7, and 12.3 km^2 during summer, late summer, early fall, and late fall, respectively. No seasonal differences (P=0.085) were detected for female groupings, although females with cubs

generally had larger home ranges. Estimates of mean annual home ranges were 20.4 km^2 for all adult females and 11.8 km^2 for subadult females. Home ranges overlapped extensively within and between sexes of all bears. For females, percentage of non-overlapping range was greatest during summer (94%±0.4) and late summer (95%±7.7) and least during early fall (77%±12) and late fall (66%±2.8).

15. During summer, females used pine-hardwood and pocosin habitats more than expected, whereas pure-pine, mixed pine, xeric-hardwoods, hardwood pine, salt marsh, the landfill, and openings were used less than expected. In late summer, females used pocosin, mesic-hardwood, and xeric-hardwood habitats more than expected. Pure-pine, salt marsh, the landfill, and openings were used proportionately less than their availability.

16. In early fall, females selectively used pine-hardwood, pocosin, mesic-hardwood, xeric-hardwood, salt marsh, and the landfill. Pure-pine habitats and openings were used less than expected. During late fall, pocosin and xeric-hardwood habitats were used more than expected. Mesic-hardwood, hardwood-pine, and the landfill were used in proportion to their availability. All other habitat categories were used less than expected.

17. On a year round basis, females used pocosin, mesic-hardwood, xeric-hardwood, and salt marsh habitats more than expected. Only pure-pine and openings were used

proportionately less than their availability.

18. Habitat use for individual bears followed the same general patterns of use at the composite range level. Bears whose home range contained major proportions of pocosin habitat had a strong preference for that habitat. One bear having only a small percentage (7.4%) of its home range in pocosin habitat used that habitat in greater proportion than its availability. Pure-pine, the landfill, and salt marsh habitats were used more than expected by only one bear each.

19. At the level of individual stand types, only miscellaneous filler stands (ericaceous shrub dominants) were used mor than expected during each season and throughout the year. In summer, loblolly-scrub oak, pond pine-miscellaneous hardwood, and gum-miscellaneous hardwood habitats were used more than expected. During late summer, loblolly-pond pine, loblolly-miscellaneous hardwood, gum-miscellaneous hardwood, and miscellaneous hardwood-sweetgum stands were use din greater proportion than their availability.

20. During early fall, loblolly-pond pine, loblolly-maple, pond pine-loblolly, and miscellaneous hardwood-red oak stands were used more than expected. In late fall, female bears selectively used slash pine-miscellaneous filler, loblolly-scrub oak, sweet gum-white oak, red oak-miscellaneous hardwood, and miscellaneous hardwood-sweet gum stands. During both early and late fall, pond pine-

miscellaneous filler, pond pine-miscellaneous hardwood, and gum-miscellaneous hardwood stands were used more than expected habitats.

21. Female bears were located farther from Class I roads during late fall than any other season. Early fall locations were significantly farther from Class I roads than summer or late summer locations. Plant phenology appears to be responsible for these observations as productive hard mast stands are located farther from Class I roads compared to other habitats used on an annual basis.

22. Traffic volume on Class I roads is relatively heavy (personal observation). Heavy traffic volume would prevent bears from crossing roads during the day. Most road crossings occurred from 1800 to 0800. The distribution of female bears to Class I roads is of primary concern due to abnormally high mortality rates for females and cubs of the year.

23. Mean distances of female bears to Class II roads did not vary throughout the year or between seasons. Random locations were farther ($P<0.01$) from Class II roads than actual bear locations. Female bears were located closer to Class II road than Class I roads during each season and throughout the year. Along with food availability and juxtaposition to preferred habitats, level of human activity on Class II roads may be responsible for bear use of this class of roads. Commuter traffic is absent from Class II

roads and disturbance levels are related to military training exercises. Telemetry investigations indicated that bears appear to remain farther from Class II roads or limit their use Class II roads during large scale training exercises.

24. A total of 27 observations were made of bears at artificial food sources; 25 at sanitation bins and two at the landfill. Only a handful of bears (n=4) were responsible for most of the observations made. The importance of the landfill to female bears could be established for only two bears, however, the number of distinct bear tracks (n=7) observed near this location suggested that this resource was used more than habitat utilization data indicated

25. Development around Camp Lejeune poses uncertain threats to the resident bear population. Relatively secure or permanent dispersal corridors are becoming increasingly narrow, especially along the northern boundary of the base (Wallace Creek Drainage). Protection of this travel corridor is extremely important for the stability of the Mainside bear population.

26. Active forest management on Camp Lejeune including various timber harvest regimes and prescription burns are well suited for the basic food requirements of black bears. Partial clear cuts, shelterwood cuts, seed tree cuts, and selective thinning allows for ample soft mast regeneration

in the understory.

27. Five and three year prescription burn rotations implemented on Camp Lejeune allow for ample soft mast production while providing enough time for hard mast producing species to attain fire resistant size. Prescribed burns on the Base occur concomitantly with black bear denning. Measures to lessen the potential deleterious effects of fire and smoke on denned bears should become an integral part of the prescribed fire management program.

28. Black bears on Camp Lejeune appear adaptable to fluctuating levels of military training. Factors indirectly associated with the military mission, local human population growth, urban development, and increased traffic volumes negatively impact the black bear population to a greater degree than military training itself.

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APPENDICES

APPENDIX A

Table 14. Stand types for the selected study area on Camp Lejeune, North Carolina.

Stand Cover Type (EMD code)	Coverage in ha (% area)	Group Type
Miscellaneous Filler[1] (0000)	36.4 (0.3)	Pocosin
Filler - Pond Pine (0004)	1.6 (0.01)	Pocosin
Salt Marsh (0007)	180.9 (1.3)	Marsh
Longleaf Pine - Filler (0100)	1423.3 (10.5)	Pine
Longleaf-Loblolly Pine (0103)	586.8 (4.3)	Pine Mix
Longleaf-Pond Pine (0104)	67.2 (0.5)	Pine Mix
Longleaf-Scrub Oak (0115)	203.2 (1.5)	Pine-Hardwood
Slash pine-Filler (0200)	76.9 (0.6)	Pine
Slash-Longleaf Pine (0201)	14.1 (0.1)	Pine Mix
Slash-Loblolly Pine (0203)	39.2 (0.3)	Pine Mix
Loblolly Pine-Filler (0300)	3302.7 (24.3)	Pine
Loblolly-Longleaf (0301)	511.9 (3.8)	Pine Mix
Loblolly-Pond Pine (0304)	729.6 (5.4)	Pine Mix
Loblolly-Poplar (0311)	6.4 (0.02)	Pine-Hardwood
Loblolly-Sweetgum (0312)	310.8 (2.3)	Pine-Hardwood
Loblolly-White Oak (0313)	191.4 (1.4)	Pine-Hardwood
Loblolly-Red Oak (0314)	605.4 (4.4)	Pine-Hardwood
Loblolly-Scrub Oak (0315)	346.4 (2.5)	Pine-Hardwood
Loblolly-Maple (0317)	54.6 (0.4)	Pine-Hardwood

Table 14. (Continued)

Stand Cover Type (EMD Code)	Coverage in ha (%area)	Type
Loblolly-Gum[2] (0318)	74.1 (0.5)	Pine-Hardwood
Loblolly-Miscellaneous[3] (0319)	864 (6.3)	Pine-Hardwood
Pond Pine-Filler (0400)	868.2 (6.4)	Pocosin
Pond-Longleaf Pine (0401)	135.1 (1.0)	Pine Mix
Pond-Loblolly Pine (0403)	136.8 (1.0)	Pine Mix
Pond Pine-Maple (0417)	30.3 (0.2)	Pine-Hardwood
Pond Pine-Gum (0418)	7.3 (0.1)	Pine-Hardwood
Pond Pine-Misc. (0419)	590 (4.3)	Pocosin
Poplar-Misc. (1119)	10.9 (0.1)	Hardwood
Sweetgum-White Oak (1213)	48.9 (0.4)	Hardwood
Sweetgum-Red Oak (1214)	5.6 (0.01)	Hardwood
Sweetgum-Maple (1217)	28.3 (0.2)	Hardwood
Sweetgum-Gum (1218)	90.6 (0.7)	Hardwood
Sweetgum-Misc. (1219)	46.1 (0.3)	Hardwood
White Oak-Loblolly (1303)	80.9 (0.6)	Hardwood Pine
White Oak-Misc. (1319)	178.1 (1.3)	Hardwood
Red Oak-Filler (1400)	1.6 (0.01)	Hardwood
Red Oak-Longleaf (1401)	11.7 (0.1)	Hardwood Pine
Red Oak-White Oak (1413)	18.6 (0.1)	Hardwood
Red Oak-Misc. (1419)	125.8 (0.9)	Hardwood

Table 14. (Continued)

Stand Cover Type (EMD Code)	Coverage in ha (%area)	Type
Maple-White Oak (1713)	19.4 (0.1)	Hardwood
Maple-Loblolly (1703)	6.1 (0.01)	Hardwood Pine
Maple-Gum (1718)	25.4 (0.2)	Hardwood
Maple-Misc. (1719)	179.3 (1.3)	Hardwood
Gum-Loblolly (1803)	9.3 (0.1)	Hardwood Pine
Gum-Cypress (1806)	37.2 (0.3)	Hardwood
Gum-Sweetgum (1812)	12.1 (0.1)	Hardwood
Gum-Maple (1817)	96.3 (0.7)	Hardwood
Gum-Misc. (1819)	517.2 (3.8)	Hardwood
Miscellaneous-Filler (1900)	70.8 (0.5)	Hardwood
Misc.-Loblolly (1903)	18.2 (0.1)	Hardwood Pine
Misc.-Pond Pine (1904)	10.1 (0.1)	Hardwood Pine
Misc.-Sweetgum (1912)	167.5 (1.2)	Hardwood
Misc.-Red Oak (1914)	120.6 (0.9)	Hardwood
Misc.-Maple (1917)	107.6 (0.8)	Hardwood
Misc.-Gum (1918)	52.6 (0.4)	Hardwood
Landfill (8888)	33.2 (0.2)	Landfill
Wildlife Openings (9999)	32.8 (0.2)	Openings

[1] Fillers are any number of ericaceous shrub species.
[2] Gum trees are separated by position; Black gum (Nyssa sylvatica on xeric sites and Tupelo gum (Nyssa s. biflora) on more mesic sites.
[3] Miscellaneous items are any number of hardwood species.

Table 15. Summary of data on captured bears on Camp Lejeune, North Carolina, 1988-1989.

Date of Capture	ID No.	Sex	Age in Months	Weight lbs (kg)	Comments
01 July 88	01	F	48[1]	125 (48)	Narrow chest blaze Captured by toes
06 July 88	03[2]	F	60	90 (40.9)	Right forearm badly damaged from unknown causes
20 July 88	04	F	36	85 (38.6)	Routine handling
22 July 88	05	M	48	165 (75)	Open wound left rear leg unrelated to capture
06 Sept 88	06	F	120	275 (125)	Fat density prohibited collection, Landfill bear, Caught in culvert trap
8 Sept 88	07[2]	F	48	105 (47.5)	Right front No. 2 & 5 digit injured during capture
25 Sept 88	08	F	48	160 (72.5)	Prominent "V" chest Blaze
10 Oct 88	09	F	108	165 (75)	Broken UR canine, Caught in culvert trap
20 June 89	09[3*a]	F	120	160 (72.5)	Broken UR & LL canine, Caught in cage trap
22 June 89	04*	F	48	150 (68)	Routine handling
01 July 89	04[**a]	F	48	145 (65.8)	Routine handling
02 July 89	11[a]	M	60	200 (97.8)	Capture related injury to front right wrist, heavy fighting wounds
02 July 89	12[2]	M	48	225 (102.1)	Heavy fighting wounds

Table 15. (Continued)

Date of Capture	ID No.	Sex	Age in Months	Weight lbs (kg)	Comments
03 July 89	13	M	72	262 (118.8)	Caught in culvert trap
03 July 89	08*	F	60	100 (45.4)	Spacer changed, 2 cubs present
11 July 89	15	F	48	105 (47.6)	Routine handling, Large male bear near trap site
14 July 89	16[3]	F	24	80 (36.3)	Routine handling
16 July 89	15[2,3]	F	48	105 (47.6)	Routine handling
17 July 89	05*	M	60	225 (102.1)	Collar dropped 3 weeks prior to capture
18 July 89	01*	F	60	120 (54.4)	2 cubs present
02 Aug 89	17[2]	M	96	280 (127)	Extremely large male, good growth potential
08 Aug 89	06*	F	132	160 (72.7)	3 cubs present
13 Aug 89	19[2]	F	24	50 (22.7)	Right front paw injured during capture
28 Sept 89	16**	F	24	75 (34)	Routine handling

[1] As determined by cementum annuli analysis (Willey 1974).

[2] See Table 2., Summary of Black Bear Mortalities.

[3] Collar changed.

* Recapture from the 1988 trapping season.

** Intra-season recapture.

Table 16. Habitat use vs. availability for female black bears on Camp Lejeune, North Carolina, 1988-1989.

Habitat Type	Composite Home Range[1] Proportion Used	95% CI	Proportion Available	Preference	Overall Study Area[2] Proportion Used	95% CI	Proportion Available	Preference
ANNUAL HABITAT USE (N = 1210, 1264)[3]								
Pure Pine	0.266	0.248-0.284	0.341	-	0.252	0.239-0.269	0.353	-
Pine Mix	0.077	0.066-0.088	0.115	0	0.111	0.100-0.122	0.163	-
Pine-Hardwood	0.262	0.244-0.280	0.246	0	0.262	0.252-0.282	0.241	0
Pocosin	0.179	0.163-0.195	0.135	+	0.190	0.180-0.208	0.067	+
Mesic-Hardwood	0.126	0.114-0.138	0.082	+	0.128	0.117-0.139	0.077	+
Xeric-Hardwood	0.064	0.055-0.073	0.026	+	0.034	0.028-0.040	0.056	-
Hardwood-Pine	0.016	0.005-0.021	0.014	0	0.001	0.000-0.002	0.025	-
Salt Marsh	0.010	0.006-0.014	0.003	+	0.011	0.007-0.015	0.013	0
Landfill	0.012	0.007-0.017	0.009	0	0.011	0.007-0.015	0.002	+
Openings	0.008	0.004-0.012	0.030	-	0.001	0.000-0.002	0.024	-
SUMMER (N = 180, 180)								
Pure Pine	0.191	0.145-0.237	0.341	-	0.194	0.158-0.230	0.353	-
Pine Mix	0.073	0.000-0.060	0.115	-	0.074	0.050-0.098	0.163	-
Pine-Hardwood	0.318	0.264-0.372	0.246	+	0.324	0.282-0.366	0.241	+
Pocosin	0.255	0.215-0.295	0.135	+	0.259	0.219-0.299	0.067	+
Mesic-Hardwood	0.082	0.072-0.092	0.082	0	0.139	0.108-0.170	0.077	+
Xeric-Hardwood	0.000	0.000-0.000	0.026	-	0.009	0.000-0.018	0.056	-
Hardwood-Pine	0.009	0.000-0.020	0.014	0	0.000	0.000-0.020	0.025	-
Salt Marsh	0.000	0.000-0.000	0.003	-	0.000	0.000-0.000	0.013	-
Landfill	0.000	0.000-0.000	0.009	-	0.000	0.000-0.000	0.002	-
Openings	0.000	0.000-0.000	0.030	-	0.000	0.000-0.000	0.024	-

Table 16. (continued)

Habitat Type	Composite Home Range: Proportion Used	95% CI	Proportion Available	Preference	Overall Study Area: Proportion Used	95% CI	Proportion Available	Preference
LATE SUMMER (N = 120, 135)								
Pure Pine	0.167	0.128-0.206	0.341	-	0.176	0.136-0.216	0.353	-
Pine Mix	0.133	0.089-0.177	0.115	0	0.141	0.105-0.177	0.163	0
Pine-Hardwood	0.256	0.200-0.312	0.246	0	0.271	0.224-0.318	0.241	0
Pocosin	0.244	0.189-0.299	0.135	+	0.259	0.213-0.305	0.067	+
Mesic Hardwood	0.100	0.089-0.111	0.082	+	0.106	0.074-0.138	0.077	0
Xeric Hardwood	0.063	0.054-0.072	0.026	+	0.035	0.000-0.074	0.056	0
Hardwood-Pine	0.011	0.007-0.015	0.014	0	0.012	0.001-0.023	0.025	-
Salt Marsh	0.000	0.000-0.000	0.003	-	0.000	0.000-0.000	0.013	-
Landfill	0.000	0.000-0.000	0.009	-	0.000	0.000-0.000	0.002	-
Openings	0.000	0.000-0.000	0.036	-	0.000	0.000-0.000	0.024	-
EARLY FALL (N = 525, 545)								
Pure Pine	0.240	0.217-0.263	0.341	-	0.252	0.229-0.275	0.353	-
Pine Mix	0.128	0.100-0.146	0.115	0	0.129	0.112-0.146	0.163	-
Pine-Hardwood	0.270	0.246-0.294	0.246	+	0.276	0.253-0.299	0.221	+
Pocosin	0.160	0.141-0.179	0.135	+	0.152	0.133-0.171	0.067	+
Mesic Hardwood	0.133	0.121-0.145	0.082	+	0.143	0.125-0.161	0.077	+
Xeric Hardwood	0.036	0.029-0.042	0.026	+	0.031	0.022-0.040	0.056	-
Hardwood-Pine	0.016	0.010-0.022	0.014	0	0.000	0.000-0.000	0.025	-
Salt Marsh	0.010	0.005-0.015	0.003	+	0.015	0.009-0.021	0.013	0
Landfill	0.016	0.009-0.023	0.009	+	0.000	0.000-0.000	0.002	-
Openings	0.000	0.000-0.000	0.036	-	0.002	0.000-0.004	0.024	-

Table 16. (continued)

Habitat Type	Composite Home Range: Proportion Used	95% CI	Proportion Available	Preference	Overall Study Area: Proportion Used	95% CI	Proportion Available	Preference
LATE FALL (N = 385, 404)								
Pure Pine	0.269	0.234-0.304	0.341	-	0.314	0.286-0.342	0.353	-
Pine Mix	0.073	0.053-0.093	0.115	-	0.076	0.060-0.092	0.163	-
Pine-Hardwood	0.212	0.180-0.244	0.246	-	0.220	0.195-0.245	0.221	0
Pocosin	0.237	0.204-0.270	0.135	+	0.228	0.203-0.253	0.067	+
Mesic Hardwood	0.083	0.073-0.093	0.082	0	0.097	0.079-0.115	0.077	+
Xeric Hardwood	0.091	0.081-0.101	0.026	+	0.051	0.038-0.064	0.056	0
Hardwood-Pine	0.016	0.006-0.026	0.014	0	0.000	0.000-0.000	0.025	-
Salt Marsh	0.004	0.000-0.009	0.003	0	0.008	0.003-0.013	0.013	-
Landfill	0.000	0.000-0.000	0.009	-	0.005	0.001-0.009	0.002	0
Openings	0.000	0.000-0.000	0.036	-	0.000	0.000-0.000	0.024	-

[1] Available habitat represented by inclusive habitats for a composite home range determined by annual home ranges of 8 females radio-monitored $\geq$ 8 months.

[2] Available habitat represented by habitats within the entire study area.

[3] Represents number of locations used in each analysis.

Table 17. Distribution of female black bear radiolocations to distribution of random points for distance to Class I[1] and Class II[2] roads, Camp Lejeune, North Carolina, 1988-1989.

		Summer		Late Summer		Early Fall		Late Fall		All Year	
Distance (m)	% Random	% Used	Pref.[3]	% Used	Pref.	% Used	Pref.	% Used	Pref.	% Used	Pref.
TO NEAREST CLASS I ROAD											
≤ 100	10.6	18.2	+	27.8	+	5.1	-	18.3	+	13.5	+
100-200	9.2	13.6	+	22.2	+	14.1	+	15.0	+	15.2	+
200-400	18.0	31.3	+	16.7	0	14.1	-	23.3	+	16.2	0
400-800	23.5	23.3	0	22.2	0	30.8	+	20.0	-	42.6	+
>800	38.7	13.6	-	11.1	-	35.9	-	23.3	-	34.6	-
TO NEAREST CLASS II ROAD											
≤ 100	12.1	54.5	+	38.9	+	35.9	+	38.3	+	39.3	+
100-200	14.5	22.7	+	27.8	+	21.8	+	16.7	0	20.8	+
200-400	19.8	18.2	0	22.2	0	32.1	+	36.7	+	9.0	+
400-800	29.4	4.5	-	11.1	-	10.3	-	8.3	-	22.1	-
>800	24.2	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-
N	400	320		263		706		391		1680	

[1] Class I roads are defined as primary paved surface roads.

[2] Class II roads are defined as secondary access roads and tank trails.

[3] Preference: + = used more than available ($P<0.05$), - = used less than available ($P<0.05$), 0 = used in proportion to availability. Analysis conducted comparing actual distances to random distances.

APPENDIX B

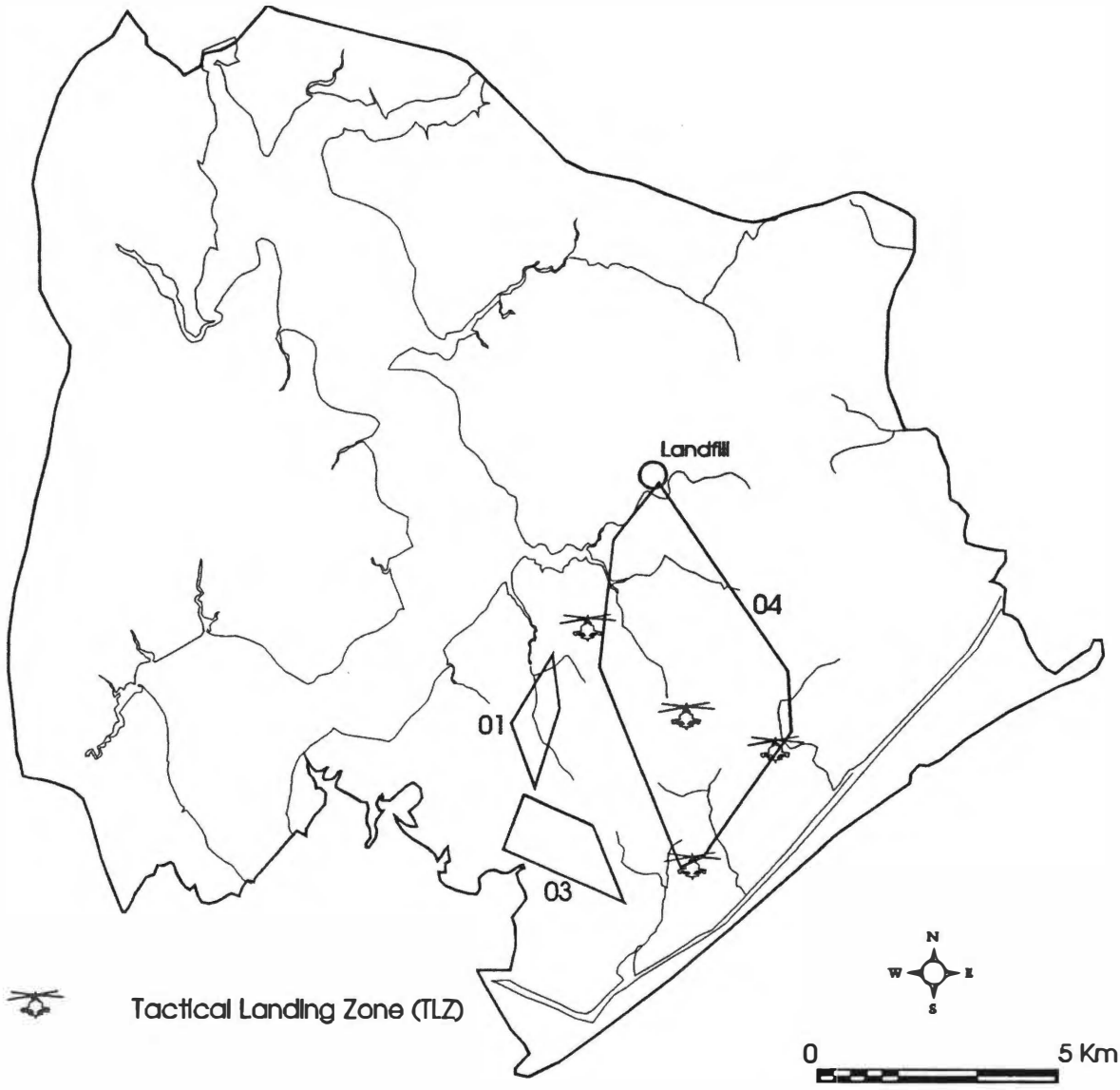


Figure 16. Home range for female bears on Camp Lejeune, North Carolina, late summer 1988.

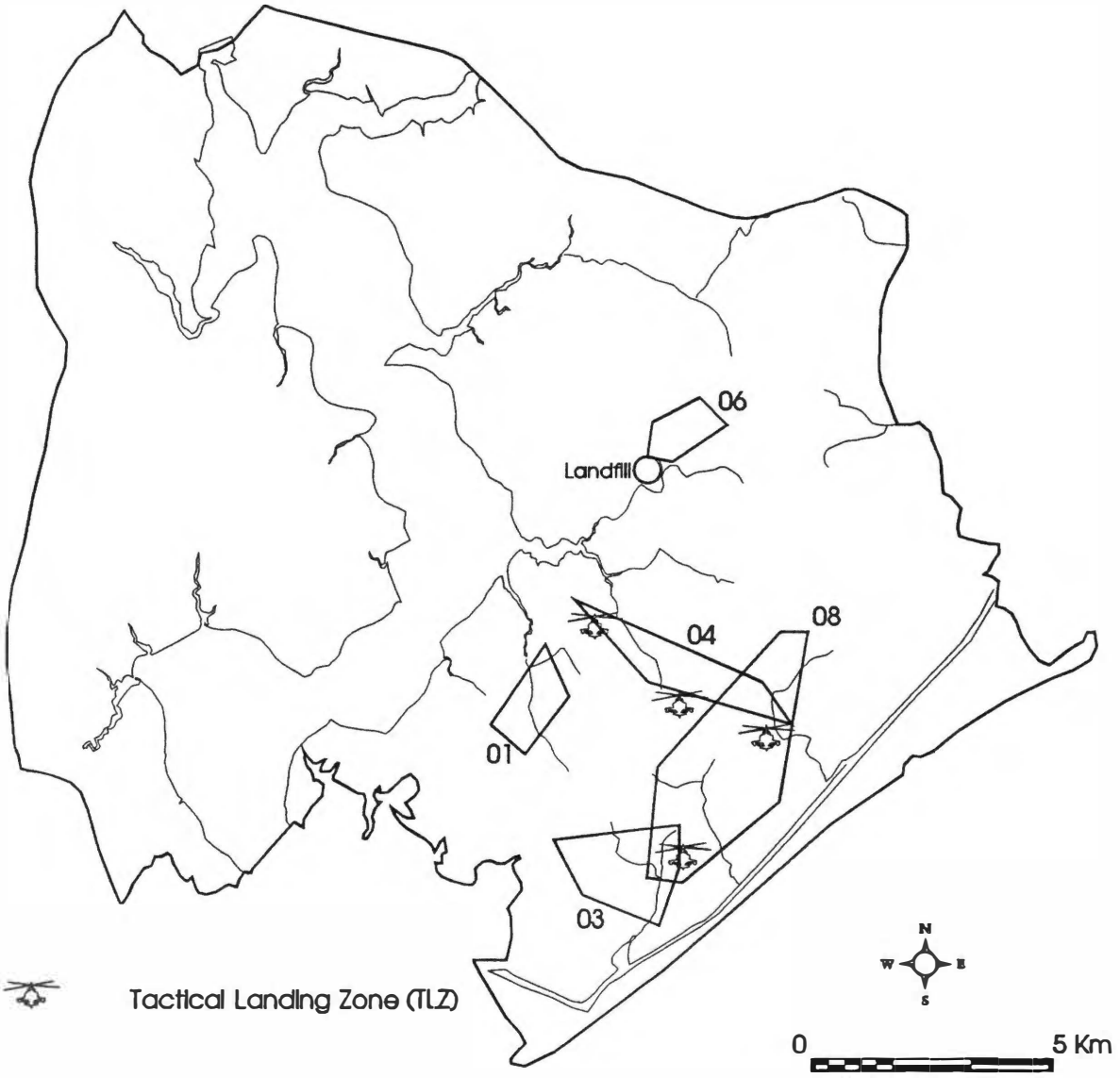


Figure 17. Home range overlap for female bears on Camp Lejeune, North Carolina, early fall 1988.

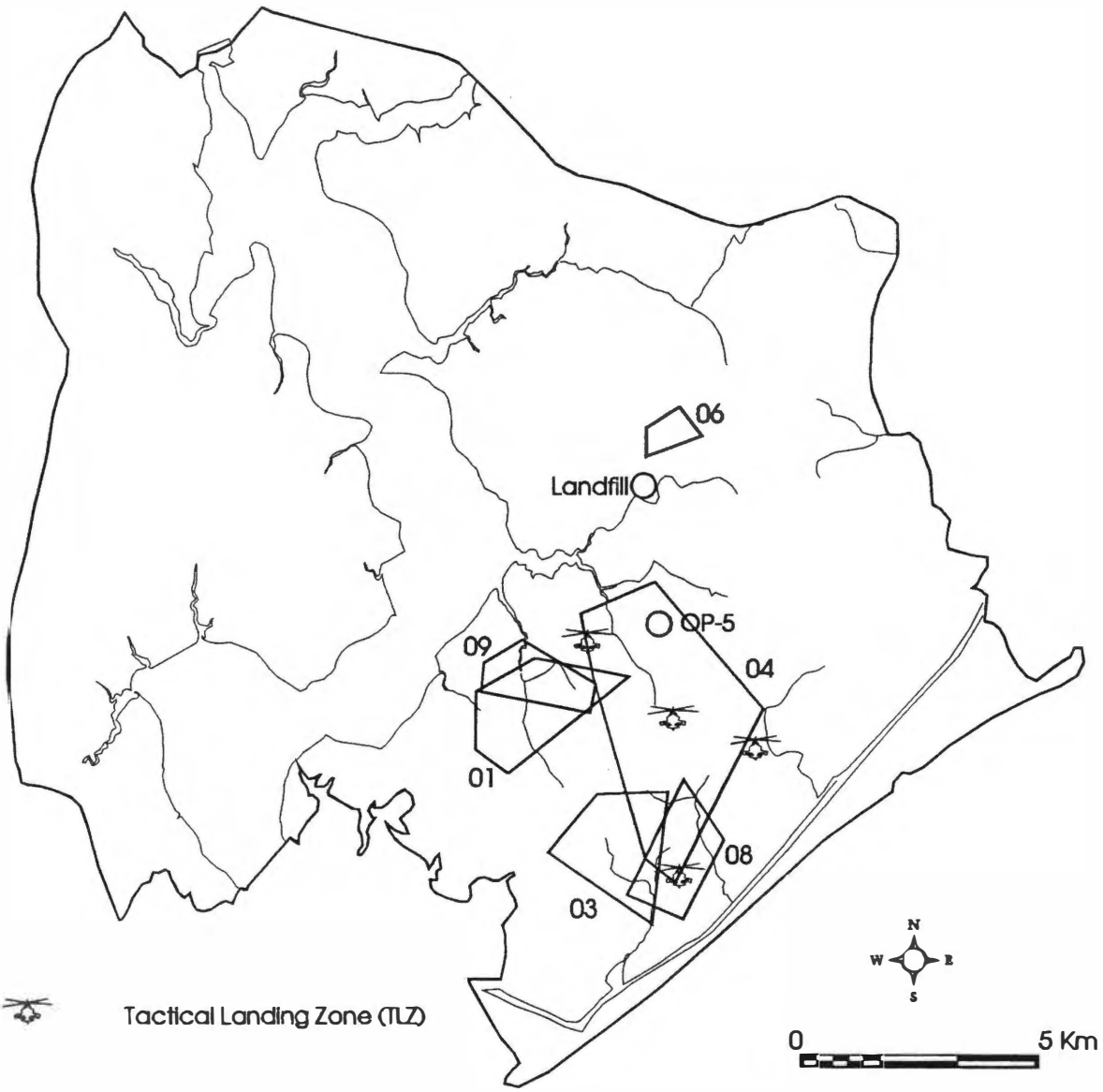


Figure 18. Home range overlap for female bears on Camp Lejeune, North Carolina, late fall 1988.

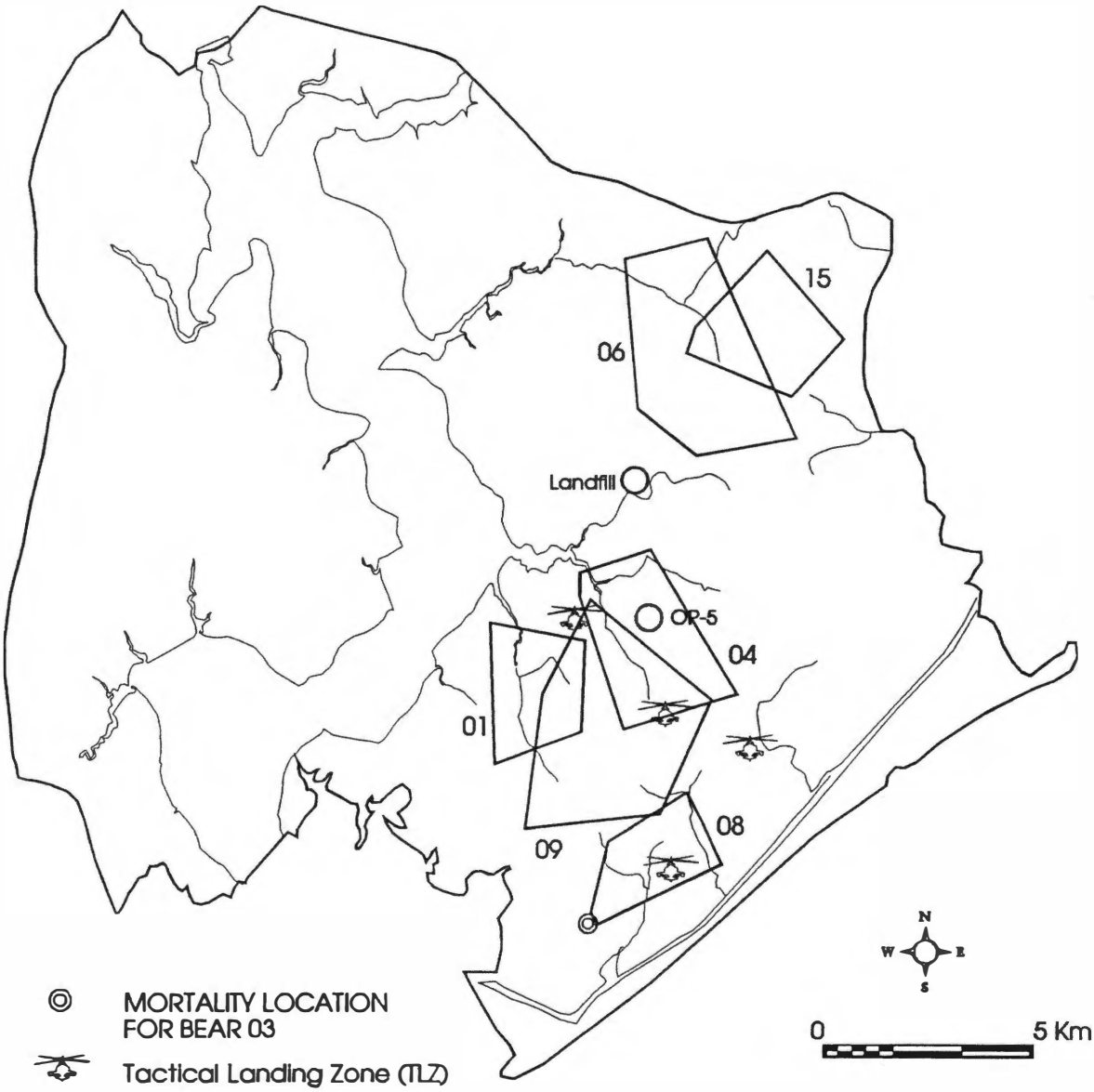


Figure 19. Home range overlap for female bears on Camp Lejeune, North Carolina, summer 1989.

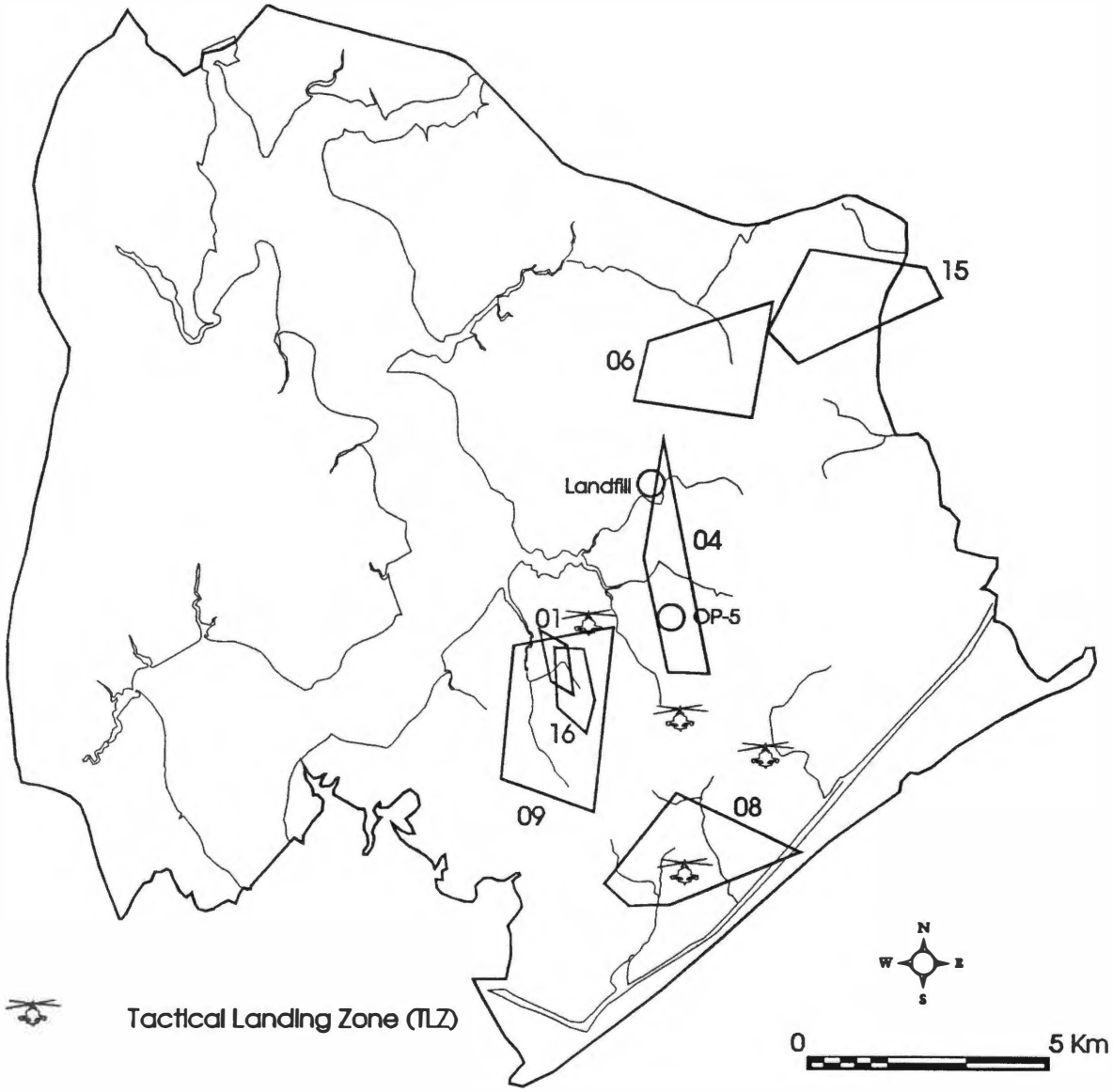


Figure 20. Home range overlap for female bears on Camp Lejeune, North Carolina, late summer 1989.

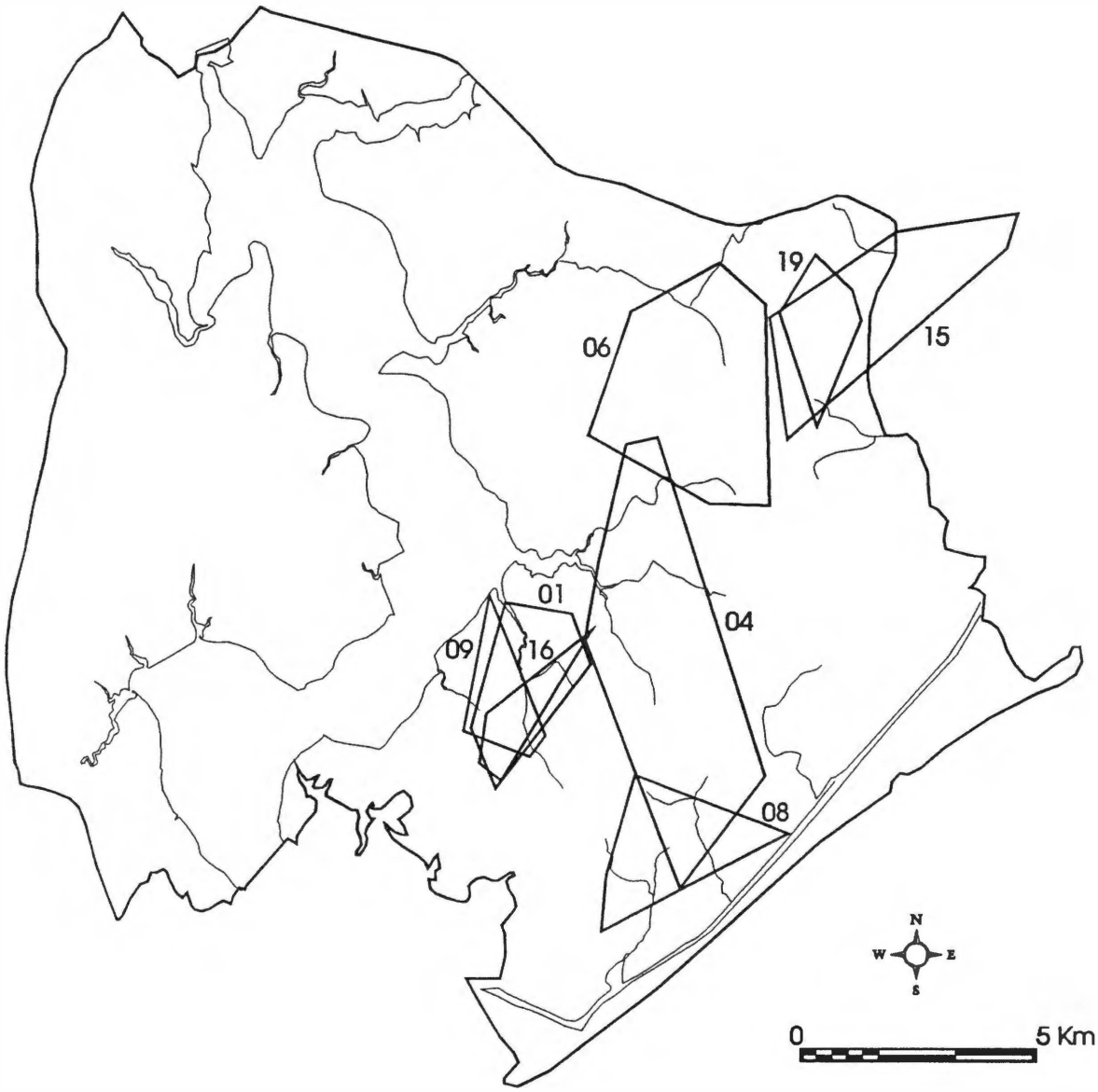


Figure 21. Home range overlap for female bears on Camp Lejeune, North Carolina, early fall 1989.

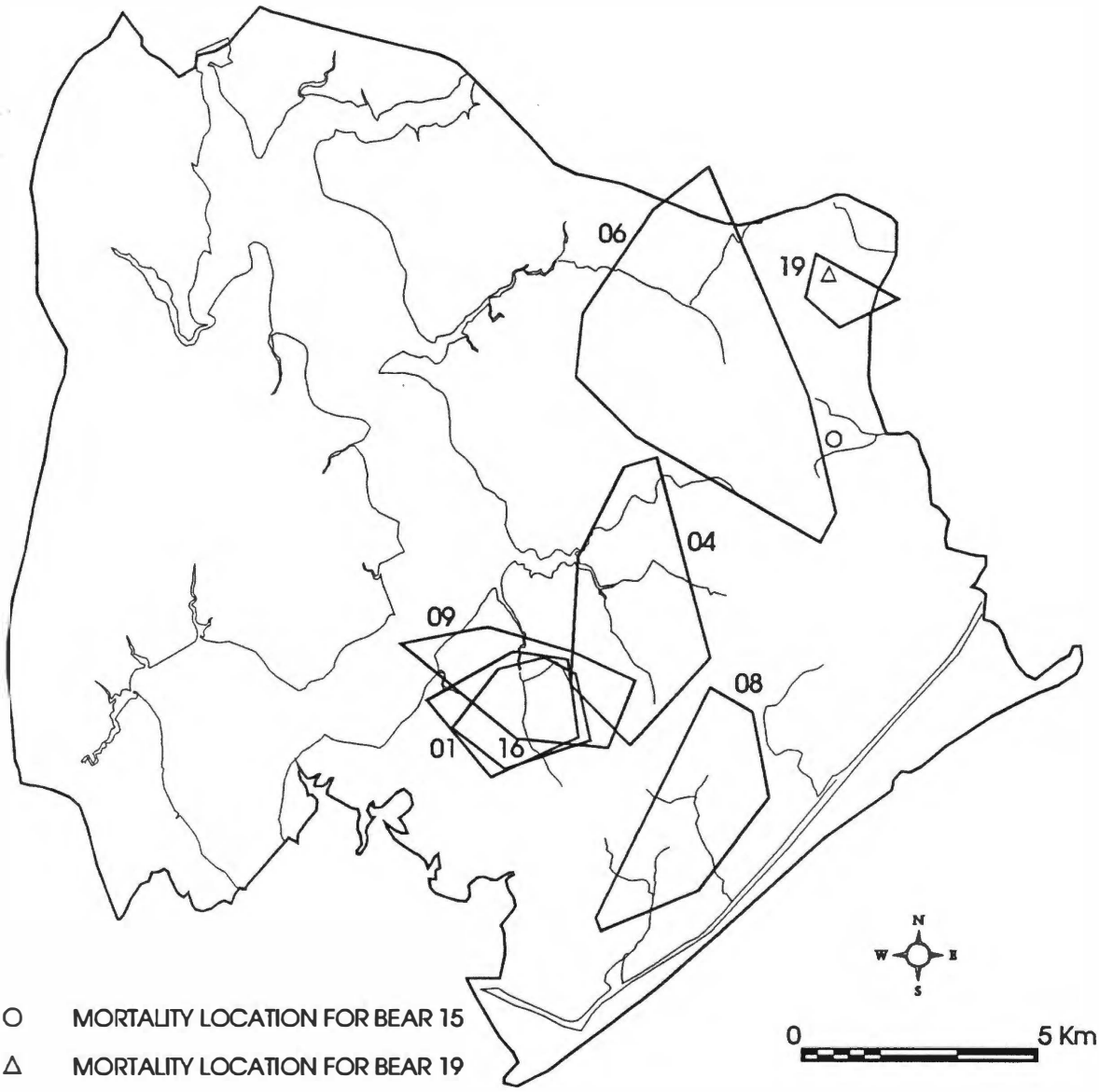


Figure 23. Home range overlap for female bears on Camp Lejeune, North Carolina, late fall 1989.

VITA

Carmen Anthony Lombardo, son of Anthony Charles and Vincenza Mary Lombardo, was born in Paterson, New Jersey, on 31 May 1964. He graduated from Passaic Valley Regional High School in Little Falls, New Jersey in 1982, attended William Paterson College, New Jersey from 1982 to 1984, and transferred to Unity College, Maine where he graduated with a Bachelor of Science in Environmental Studies with a Wildlife Emphasis in 1988. He entered the graduate program in the Department of Forestry, Wildlife, and Fisheries at the University of Tennessee, Knoxville in June 1988, and received a Master of Science degree in Wildlife and Fisheries Science in May 1993.