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DEMOGRAPHY, MOVEMENTS, ACTIVITY, HABITAT UTILIZATION AND MARKING BEHAVIOR OF A BOBCAT (*LYNX RUFUS*) POPULATION IN SOUTH-CENTRAL FLORIDA

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's Thesis of

Douglas A. Wassmer

with a major in Zoology has been approved by the Examining Committee on 15 October 1982 as satisfactory for the thesis requirement for the Master of Arts degree.

Thesis Committee:

Major Professor: Dr. James N. Layne

Member: Dr. Roy W. McDiarmid

Member: Dr. Henry R. Mushinsky

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DEMOGRAPHY, MOVEMENTS, ACTIVITY, HABITAT UTILIZATION AND MARKING BEHAVIOR OF A BOBCAT (LYNX RUFUS) POPULATION IN SOUTH-CENTRAL FLORIDA

by

Douglas A. Wassmer

An Abstract

A thesis submitted in partial fulfillment of the requirements for
the degree of Master of Arts in the
Department of Biology in the
University of South Florida

December, 1982

Major Professor: Dr. James N. Layne

ABSTRACT

Eighteen (6 male and 7 female adults, 5 juveniles) radio-collared bobcats (Lynx rufus) were monitored on the Archbold Biological Station and vicinity during 1979-1982. Mean density was 0.06 males, 0.11 females, and 0.19 juveniles per 100 ha. Mean sex and age ratios were 0.6 adult males per adult female and 1.22 juveniles per adult. Breeding occurred from September to March. Mean size of 13 mobile litters was 2.5 (range 1-4). Nine (50%) of 18 collared cats died. Nine additional individuals were found dead or reported killed. Known causes of 16 deaths were: road-killed 8, feline panleukopenia or notoedric mange 5, shot 2, dog predation 1. Mean and extreme lifetime ranges of male and female adults were 2553 ha (1482-3108) and 1444 ha (935-2160), respectively. Corresponding home range values during 12, 3- to 16-week intervals were 1453 ha (1187-2007) and 931 ha (779-1301). High mortality in this essentially unexploited population resulted in individually unstable ranges. There were no differences in overall range variability between adult males and adult females. One female and one male adult abandoned their ranges, the female's range being acquired by her offspring. Adult males and females formed consort relationships, which involved sharing a home range area and occasionally travelling or resting together in all seasons. Marking behavior involving urine, feces, and hindfoot scrapes varied seasonally and appeared to play a significant role in maintenance of home range boundaries of adult males and adult females. Older juveniles also marked natal range boundaries.

Females used their entire range in all seasons, but activity and movement patterns varied with the age of their offspring. Natural habitats were preferred to man-modified areas. Comparisons with data from other bobcat populations are made. Implications of the findings of this study to the management of bobcat populations are discussed.

Abstract approved: ______________________

Major Professor

Adjunct Professor, Biology

15 October 1982

Date of Approval

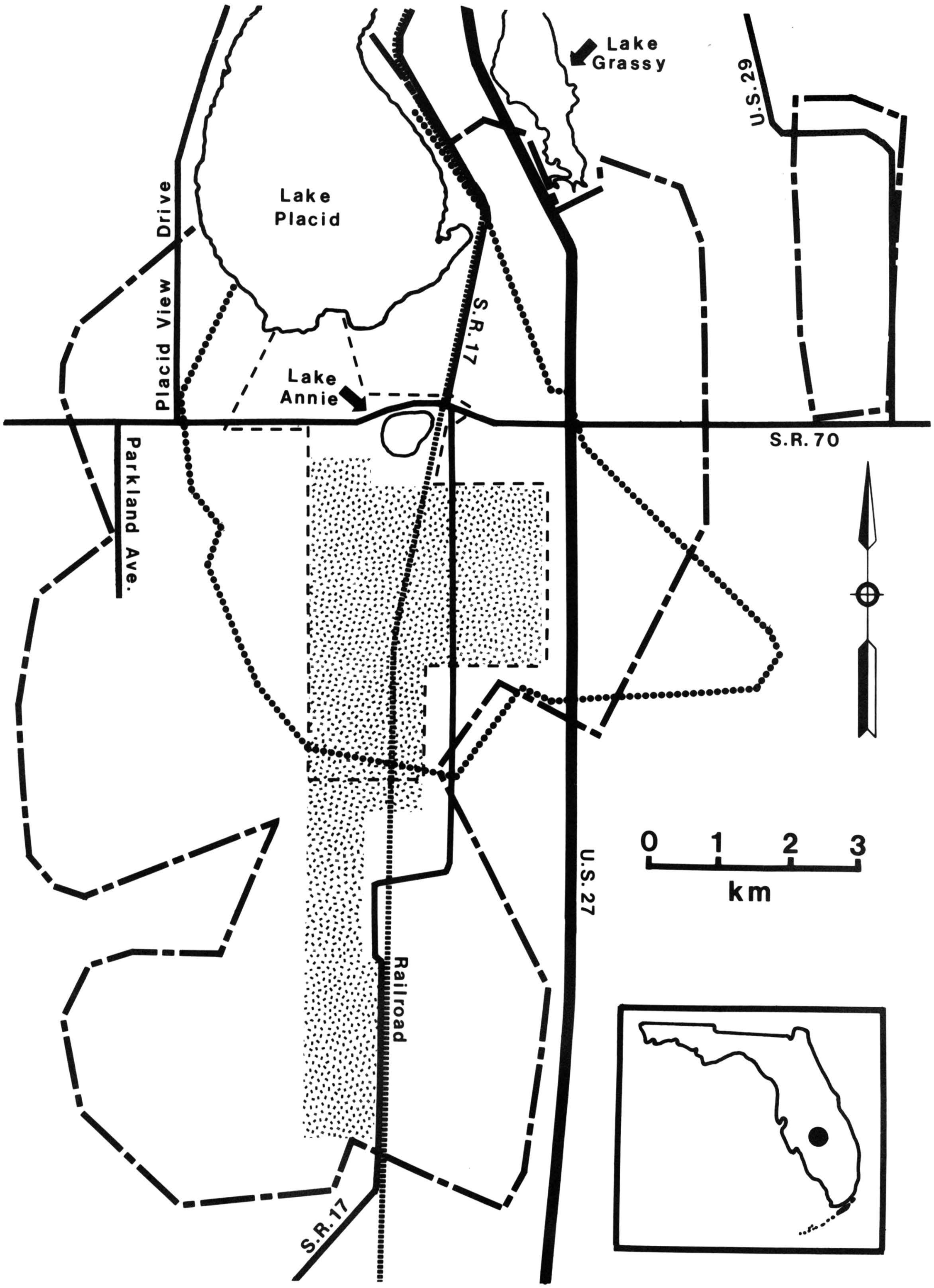
INTRODUCTION

Previous studies of the bobcat (*Lynx rufus*) in the southeastern United States (e.g. Buie, Fendley and McNab 1979, Hall 1973, Marshall 1969, Miller 1980) and in other parts of its extensive geographic range (e.g. Bailey 1972, Kitchings and Story 1979, Lawhead 1978, Zezulak and Schwab 1979) have revealed considerable variation in habitat preferences, movement patterns, population levels, and other aspects of the species' ecology and behavior. Such variability emphasizes the need for basic ecological and life history data from many populations throughout its range in order to gain a more complete understanding of the basic biology of the species and its functional role in natural and man-modified ecosystems of North America. The bobcat is currently classified as an Appendix II species of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) which requires a scientific determination that levels of harvest are not detrimental to the species' survival before allowing export of hides. This status, coupled with increasing pressure on the bobcat by the fur trade (National Wildlife Federation 1977), has also created an urgent need for more detailed information on population dynamics, habitat requirements, and other ecological parameters of regional populations as a basis for intelligent management.

Although numerous references to distribution, habits, foods, and other features of bobcat life history appear in the published literature on Florida mammals, most of this information is of a general or anecdotal nature. Guenther (1980) conducted the first intensive investigation of a bobcat population in Florida from January through September 1979 at the Archbold Biological Station, 10 kilometers (km) south (S) of the town of Lake Placid, Highlands County, Florida (Figure 1). His study site consisted of the 16 square-kilometer (km^2) Station property (referred to in the present study as the "core area") and approximately 40 km^2 of adjacent lands. The present investigation was also conducted on the core area and on approximately 92 km^2 of neighboring lands from October 1979 through March 1982.

The principal objective of this study was to assess seasonal and year-to-year variations in demographic characteristics, activity patterns, habitat use, and social organization with emphasis on marking behavior. A feline panleukopenia virus (FPLV) outbreak during the winter of 1979-1980 offered a unique opportunity to observe the effects of an epizootic on the ecology and social organization of a wild carnivore population. Guenther's data have been incorporated in the present analyses to give a more complete picture of the ecology and social organization of the population over the 39-month period of the combined studies.

Figure 1. Location of study area showing Archbold Biological Station (stippled) and areas occupied by radio-collared bobcats during Guenther's (1980) study (dotted line) and the present study (heavy dashed line). The isolated area in the upper-right corner is the home range of a juvenile (M-9) in April and May 1981. Light dashed line encloses the principal scat and scrape census area.


Lake Grassy
U.S. 29
Lake Placid
Placid View Drive
S.R. 17
Lake Annie
S.R. 70
Parkland Ave.
0 1 2 3
km
U.S. 27
Railroad
S.R. 17

DESCRIPTION OF STUDY AREA

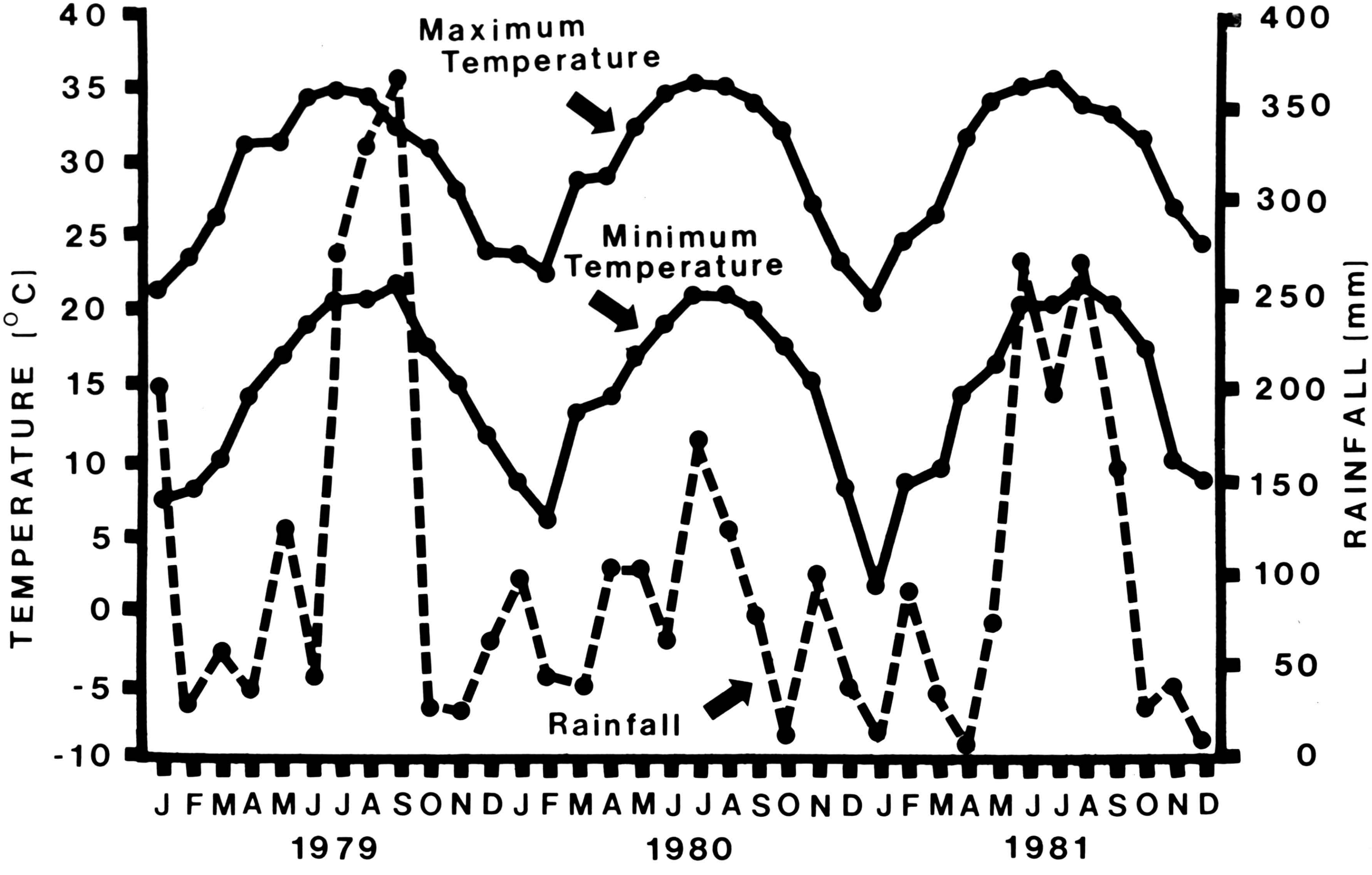
Topography

The study area is located near the southern edge of the Lake Wales Ridge, a 161 km southward extension of the state's Central Highlands region and the most prominent topographical feature of peninsular Florida. The Ridge contains relict sand dunes, scarps, and other shoreline characteristics and materials which indicate a former marine influence (White 1970). At the study site the Ridge ranges from about 6 to 12 km in width and from 30 to 68 meters (m) in elevation. The eastern and western edges of the study area lie just off the Ridge and include, respectively, portions of the Istokpoga-Indian Prairie Basin and the Western Flatlands (Davis 1943).

Climate

The area is characterized by hot, wet summers and cooler, dry winters. Mean annual rainfall and temperature are, respectively, 1370 millimeters (mm) and 22.2 degrees Celsius (C). Relative humidity usually ranges from about 75-85 percent (%) at dawn to about 20-45% at midday throughout the year (Douglass and Layne 1978). Figure 2 shows monthly rainfall and mean daily maximum and minimum temperatures recorded at the Archbold main weather station during the period 1979-1981. During this interval, mean annual temperature was 21.9 C

Figure 2. Rainfall and mean daily high and low temperatures each month at the Archbold Biological Station from 1979 through 1981.

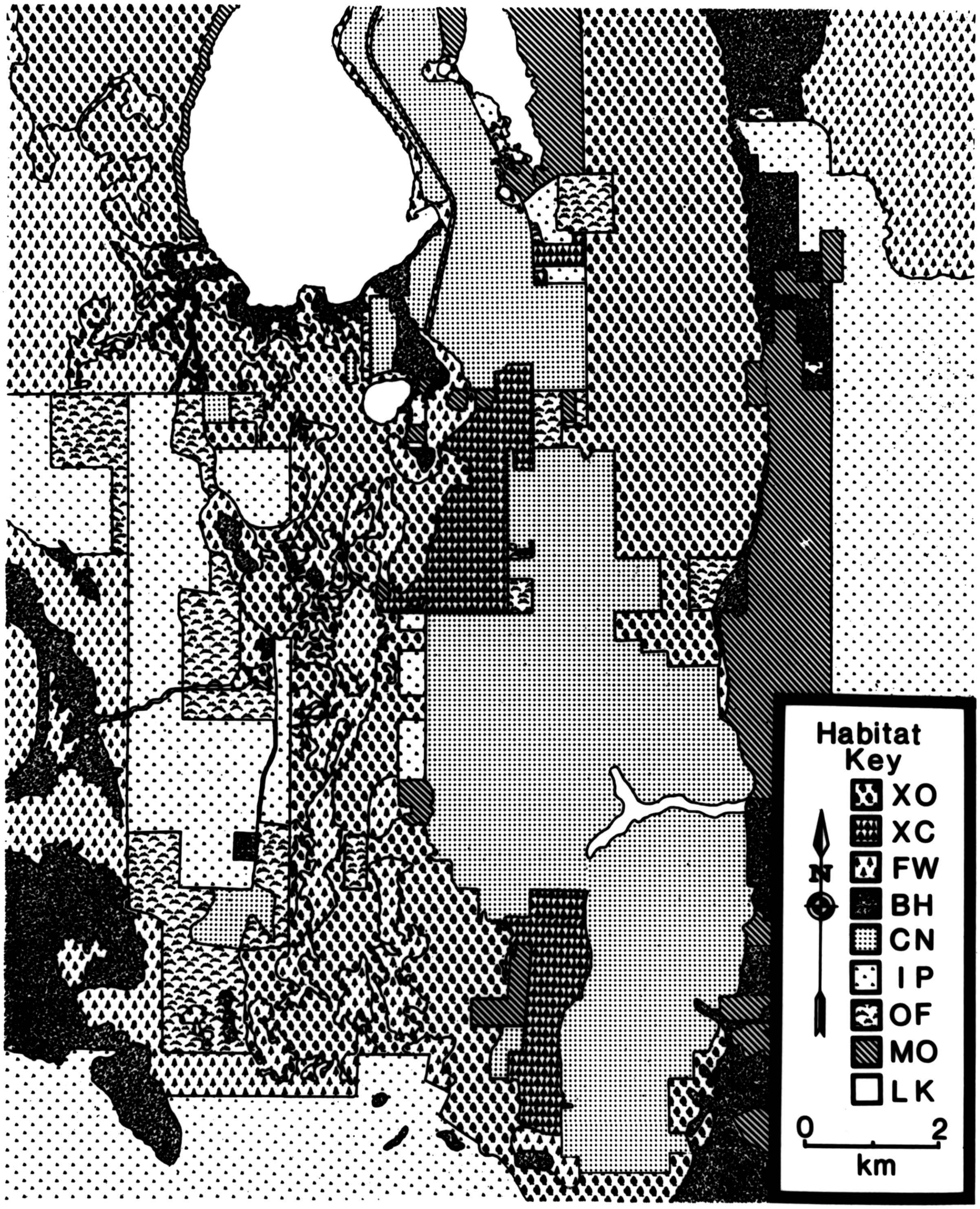

Maximum Temperature
Minimum Temperature
Rainfall
TEMPERATURE [°C]
40
35
30
25
20
15
10
5
0
-5
-10
RAINFALL [mm]
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1979
1980
1981

and extreme high and low temperatures were 37.2 C and -7.2 C, respectively. Daily high and low temperatures for the warmer months (May-October) averaged 33.2 C and 25.9 C, respectively, while corresponding averages for the cooler months (November-April) were 19.0 C and 9.9 C. Mean annual rainfall was 1201 mm, with 879 mm (73%) occurring from May to October and 322 mm (27%) occurring from November to April. Standing water was present in drainage canals, creeks, and seasonal ponds throughout 1979 and early 1980. During summer 1980, most of these dried up and open water sources were limited to two large and three small permanent lakes or ponds, scattered livestock watering troughs, and an irrigaion ditch system in a 113 ha tree nursery. Dry conditions prevailed during the rest of the study despite normal rainfall in 1981.

Habitats

Seven major habitats (southern ridge sandhill, sand pine scrub, scrubby flatwoods, swale, bayhead, seasonal ponds) are found in the core area (Abrahamson, Johnson, and Layne 1981). Similar associations and variously man-modified habitats constitute the balance of the study site. For purposes of this investigation, habitats were grouped into eight general categories as follows (percentage of each type within the total 107 km^2 area occupied by all bobcats studied from 1979 through 1982 given in parentheses): closed canopy xeric pine-oak (4), open canopy xeric pine-oak (26), flatwoods (20), bayhead (9), citrus grove and tree nursery (15), old field (10), improved pasture (13), and man-occupied (3). Figure 3 shows the distribution of these habitat types in the study area.

Figure 3. Habitats of the study area. (XO = xeric pine-oak, open canopy; XC = xeric pine-oak, closed canopy; FW = flatwoods; BH = bayhead; CN = citrus grove and tree nursery; IP = improved pasture; OF = old field; MO = man-occupied; LK = lake)


Habitat Key
XO
XC
FW
BH
CN
I P
OF
MO
LK
N
0
2
km

Xeric pine-oak communities, which share many plant species, include southern ridge sandhill, sand pine scrub, and scrubby flatwoods associations. These communities are characteristic of the deep, sandy soils of the Lake Wales Ridge. South Florida slash pine (Pinus elliotti var. densa) and sand pine (P. clausa) are the dominant overstory species. Common understory and shrub layer species are turkey oak (Quercus laevis), scrub oak (Q. inopina), Chapman's oak (Q. chapmani), sand live oak (Q. geminata), myrtle oak (Q. myrtifolia), scrub hickory (Carya floridana), rusty lyona (Lyonia ferruginia), scrub palmetto (Sabal etonia), saw palmetto (Serenoa repens) and rosemary (Ceratiola ericoides). Ground cover is generally sparse and consists of grasses, forbs, lichens, or shrub and tree sprouts. Xeric pine-oak habitats with canopy coverage ranging from 0 to 25% were classed as "open canopy" and those with coverage from about 50 to 100% as "closed canopy". The most extensive blocks of closed canopy habitat were in a portion of the core area that had not been burned for approximately 54 years.

Flatwoods communities are found on generally level, sandy soils with a relatively high water table. South Florida slash pine is the dominant overstory species. Typical shrub and ground cover components are gallberry (Ilex glabra), fetterbush (Lyonia lucida), wiregrass (Aristida stricta), cutthroat grass (Panicum abscissum) and saw palmetto. Grassy seasonal ponds and swales are included in this category. Flatwoods tend to be fire maintained and are generally open habitats with scattered pines. Small blocks of flatwoods habitat with dense pines and saw palmetto shrub layer often occur at the fringes of ponds, lakes, and bayheads and in the core area where fire has been excluded.

Bayheads, dominated by broad-leaved evergreen trees that form a dense, closed canopy, are found along creeks, at lake edges, and in shallow depressions with muck soils in flatwoods. The typical overstory species include loblolly bay (*Gordonia lasianthus*), red bay (*Persea borbonia*), sweet bay (*Magnolia virginiana*) and slash pine. Characteristic shrub layer components are young bay trees, wax myrtle (*Myrica cerifera*), gallberry and saw palmetto. Mosses and ferns are often abundant on the ground, and muscadine grape (*Vitis rotundifolia*) is common along edges.

Citrus groves and tree nurseries are found principally on land that formerly supported xeric pine-oak communities. Mature, evergreen citrus trees range about 4 to 8 m in height and diameter. Grasses and forbs are generally allowed to grow between tree rows from June to January, but are disced under during late winter and spring. Most groves and nurseries within the study area are irrigated. For purposes of this study, the old field category includes abandoned lots, fallow agricultural fields, abandoned citrus groves, abandoned pastures, and railroad and road right-of-ways. Improved pastures are open areas of dense, short-cropped natural or exotic grasses and occasional widely-scattered shrubs. An 18-hole golf course is also included in this category. Man-occupied areas include three light industrial complexes of about 3 ha each, an extensive housing development with scattered houses and much open land, a mobile home park, a recreational vehicle park, several areas containing clumped rural residences, and a few gardens or agricultural fields.

The study area was bisected by a railroad and contained several paved and improved roads and numerous sandy woods roads and trails.

MATERIALS AND METHODS

Capture and Handling

Bobcats were captured with National live traps (104 by 50 by 40 centimeters (cm)) usually set and checked once a day before noon. From one to ten traps were used at any given time. Traps were placed at the edge of a road or trail in an area with evidence (scats, scrapes, sightings, telemetry locations, tracks) of current bobcat activity. The entire trap except for the entrance was concealed by dense vegetation. When a special effort was made to catch an individual with a failing radio collar or a mother-kitten family group, the daytime rest site was located and the surrounding area was saturated with traps placed along all likely travel routes. A total of 109 trap sites was used. Of these, 107 were distributed throughout the core area, one was located adjacent to the boundary of the core area and another was 0.5 km from the edge of the core area. Five of the 26 sites used by Guenther (1980) were also included in this study. The number of trapnights (TN) per site ranged from 1 to 61, with a total of 2013 for all sites. Traps were baited with live cotton rats (*Sigmodon hispidus*), adult domestic rabbits, young and adult chickens, and pieces of chicken, cottontail rabbit (*Sylvilagus floridanus*), or gray squirrel (*Sciurus carolinensis*). Live baits and meat were used singly and in various combinations. Meat baits were suspended by a string just behind the trap treadle and live baits were housed with food and water in separate screened enclosures attached either to the inside, upper rear portion of the trap (cotton rats) or to the outside rear of the trap (larger animals).

Bobcats were transported between the laboratory and capture sites in the traps covered with a heavy tarpaulin. They were sedated with intramuscular injections of ketamine hydrochloride at doses ranging from 5 to 36 milligrams per kilogram (kg) of body weight. Low doses were given when changing collars and higher doses when extended examination was necessary. Drugs administration was facilitated by either transferring bobcats into a small, screened box or by squeezing them into the rear of the trap with a plunger consisting of a metal pipe connected to a sheet of plywood slightly smaller than the inside dimensions of the trap. While sedated, bobcats were eartagged, tattoed, sexed, weighed, measured, and checked for reproductive status, molt, ectoparasites, and signs of injury or disease. Plaster casts were made of right fore and hind feet, and the animals were fitted with color-coded radio collars. Bobcats were allowed to recover before release at the site of capture.

Subjects

Thirteen bobcats captured and radio-collared (Table 1, Figure 4) included 8 adults (3 males, 5 females) and 5 juveniles (3 males, 2 females). Three male and two female adults previously collared by Guenther (1980) were also included in the study. In addition, an emaciated 5.3 kg adult female (F-2) infested with mange mites (Notoedres sp.) was darted with a Cap-chur gun on 27 April 1979 and died shortly thereafter; and a 2.4 kg juvenile female (F-7) captured

Table 1. Data on individual bobcats captured and radio-instrumented.

			Body measurements (mm)					Upper canine (mm)	
Bobcat	Dates of captures or recoveries	Weight (kg)	Total length	Tail	Hind foot	Ear from notch	Ear from crown	Maximum diameter at gum line	Length from gum line to tip
Adult Females									
F-1[a]	2 May 79	-	-	-	-	-	-	-	-
	8 Dec 79	8.8	913	182	170	63	-	6.1	13.4
	11 Jan 80	9.6	-	-	-	-	-	-	-
	20 Jan 80	-	-	-	-	-	-	-	-
	14 Oct 80	10.1	-	-	-	-	-	-	-
	15 Jan 81	-	-	-	-	-	-	-	-
F-3[b]	1 Jun 79	5.8	845	160	160	62	-	6.1	11.9
	2 Aug 82	6.3	846	157	160	67	65	6.4	11.9
F-4	25 Jul 79	7.8	845	138	163	61	-	8.4	12.7
F-8[c]	31 Jan 80	6.5	837	158	160	71	69	5.6	13.3
	12 Feb 80	-	-	-	-	-	-	-	-
F-9	1 Feb 80	7.8	865	150	154	70	-	5.6	15.0
	23 Sep 80	7.0	865	150	155	68	-	6.1	16.3
F-10[d,e]	13 Feb 80	9.9	894	146	163	65	57	6.4	13.9
	4 Mar 80	8.2	-	-	-	-	-	-	-
F-11	9 Mar 80	9.4	910	168	172	65	74	6.6	14.2

Table 1 (cont'd)

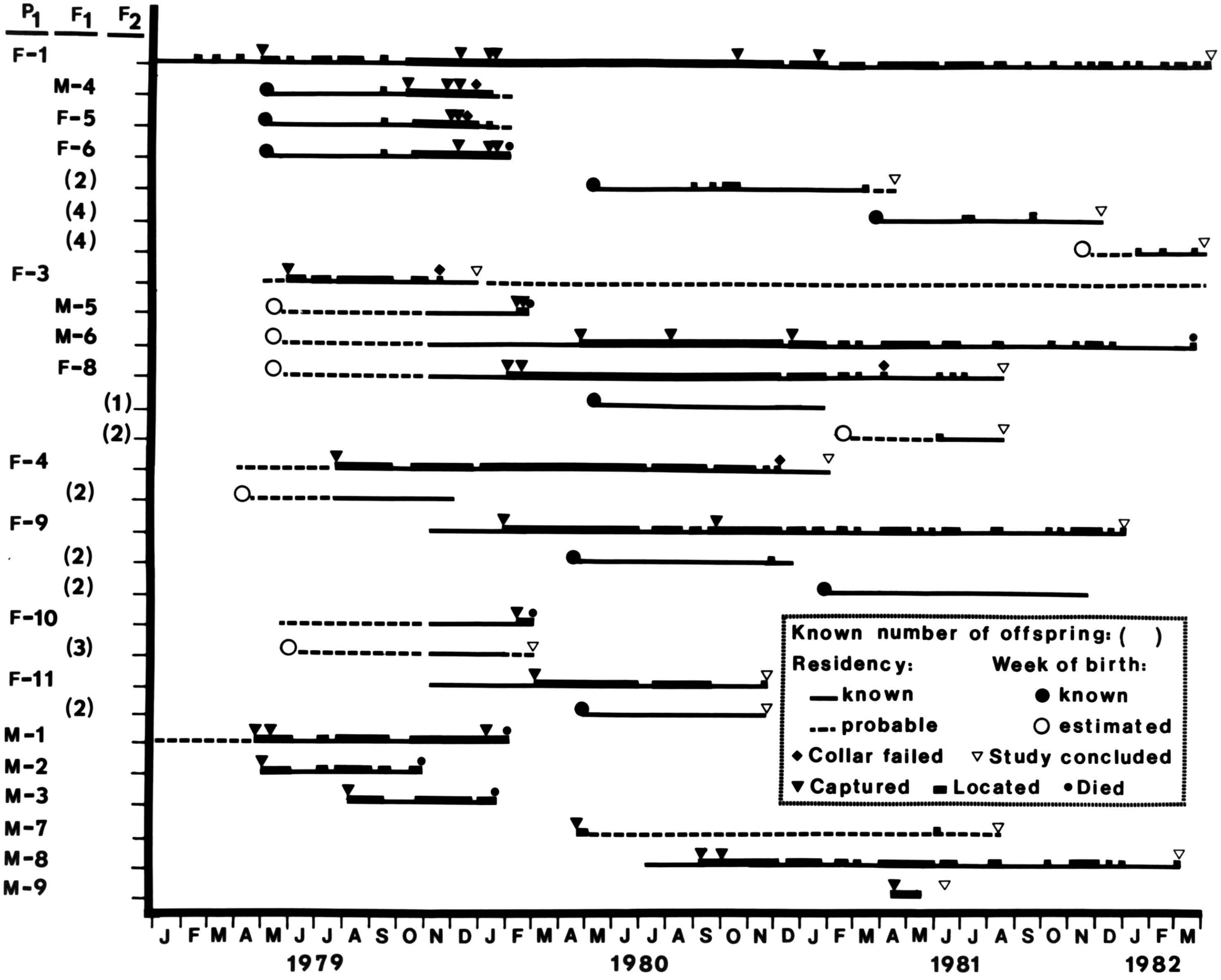
Bobcat	Dates of captures or recoveries	Weight (kg)	Body measurements (mm)					Upper canine (mm)	
			Total length	Tail	Hind foot	Ear from notch	Ear from crown	Maximum diameter at gum line	Length from gum line to tip
Adult Males									
M-1[e]	28 Apr 79	9.4	895	139	163	85	-	8.7	16.9
	13 May 79	-	-	-	-	-	-	-	-
	11 Jan 80	9.5	-	-	-	-	-	-	-
	5 Feb 80	9.4	-	-	-	-	-	-	-
M-2[f]	5 May 79	9.5	931	167	168	71	-	9.2	15.6
	4 Nov 79	-	-	-	-	-	-	-	-
M-3[e]	9 Aug 79	9.0	908	155	173	70	-	7.5	15.8
	16 Jan 80	8.1	-	-	-	-	-	-	-
M-6[b,c]	19 Apr 80	8.5	-	-	-	-	-	-	-
	29 Jul 80	10.3	-	-	-	-	-	-	-
	20 Mar 82	9.1	978	160	183	67	64	7.0	16.5
M-7[b,f]	26 Apr 80	9.5	986	181	191	65	63	6.8	16.2
	12 Jul 82	-	-	-	-	-	-	-	-
M-8	11 Sep 80	10.5	901	148	173	71	74	7.1	16.9
	30 Sep 80	-	-	-	-	-	-	-	-
Juveniles									
F-5[g]	27 Nov 79	5.7	795	170	170	70	72	5.6	12.5
	7 Dec 79	-	-	-	-	-	-	-	-

Table 1 (cont'd)

			Body measurements (mm)					Upper canine (mm)	
Bobcat	Dates of captures or recoveries	Weight (kg)	Total length	Tail	Hind foot	Ear from notch	Ear from crown	Maximum diameter at gum line	Length from gum line to tip
F-6[g]	7 Dec 79	5.4	805	156	159	65	-	-	-
	9 Dec 80	5.4	806	155	161	66	-	5.8	12.1
	20 Jan 80	6.2	-	-	-	-	-	-	-
M-4[g]	11 Oct 79	5.3	770	155	160	71	-	3.8	5.7
	25 Nov 79	6.7	790	175	178	77	-	6.7	14.0
	7 Dec 79	-	-	-	-	-	-	-	-
M-5[c]	11 Feb 80	7.9	954	174	188	61	59	7.2	16.0
	16 Feb 80	-	-	-	-	-	-	-	-
	20 Feb 80	7.3	-	-	-	-	-	-	-
M-9[h]	15 Apr 81	6.4	866	172	172	70	67	6.3	13.8

[a] Captured outside study area in 1974; captive-reared and released on study area in May 1975
[b] Road kill
[c] Probable kitten of F-3 born in spring 1979
[d] Died 28 February but body not recovered until after 4 days of freezing weather
[e] Panleukopenia victim
[f] Body not recovered in sufficient time for measurements
[g] Known offspring of F-1 born early May 1979
[h] Captured outside study area, radio-instrumented and released

Figure 4. Summary of bobcat (M = males, F = females) captures, births, deaths, and periods of residency on the study area as determined by radio-tracking, trailing, and sightings during Guenther's (1980) and the present study. Geneology (P_1 = parent, F_1 = first generation offspring, F_2 = second generation offspring) indicated where known.


P1
F1
F2
F-1
M-4
F-5
F-6
(2)
(4)
(4)
F-3
M-5
M-6
F-8
(1)
(2)
F-4
(2)
F-9
(2)
(2)
F-10
(3)
F-11
(2)
M-1
M-2
M-3
M-7
M-8
M-9
Known number of offspring: ( )
Residency:
known
probable
Week of birth:
known
estimated
Collar failed
Study concluded
Captured
Located
Died
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M
1979
1980
1981
1982

within the core area on 6 and 8 December 1979 was released without radio-tagging due to her small size. Weight; tooth wear, coloration, and stage of replacement (Crowe 1975); and general appearance were used to assign cats to either the adult or juvenile age class. Mean and extreme weights of males and females classed as adults were 9.5 kg (8.1-10.5) and 7.9 kg (5.8-10.1), respectively. Juvenile weights ranged from 5.3 to 7.9 kg (mean 6.2).

One of the females (F-1) included in the study was a semi-tame individual. She was captured in a den outside the study area in spring 1974 at an approximate age of two weeks. The cat was kept in a cottage on the Archbold Biological Station until May 1975 then released at the site. She reappeared at the cottage 16 days later and has continued to return periodically. She is an established member of the study area population and produced litters of 2, 1, and 3 kittens during spring of 1976, 1977, and 1978 (C. E. Winegarner, personal communication). She is regularly fed meat when visiting the cottage. No effort was made to tame the cat during captivity and she has not been handled while free-ranging, except when captured and sedated for a series of treatments for mange in 1978 and for radio-collaring. She is tolerant of but not friendly to humans and except for visitations to the cottage her behavior seems not to differ from wild bobcats. The history of this individual must be considered when interpreting observations made in the present study.

Study Techniques

The principal method of investigation was radio telemetry. Tracking individuals on foot, visual observations, and observations of sign (scats, scrapes, etc.) were also used. The mean number of all locations (including captures, radio fixes, and sightings) obtained for instrumented bobcats during Guenther's (1980) and the present study was 320 with a range of 7 to 1248. The mean interval between the first and last location records of marked cats was 327 days, with a range of 9 to 1143 days.

Radio Telemetry

Radio equipment used was manufactured by AVM Instrument Co., Dav-Tron Inc., and Wildlife Materials Inc. Both a 12-channel AVM Model L12A receiver and a Dav-Tron Model RM receiver were used. Most of the radio-tracking was done with a 4-wheel drive vehicle equipped with a dash-mounted marine compass and a roof-mounted, 8-element AVM, dual-Yagi Null Peak antenna system (pictured in Guenter 1980). An AVM hand-held, collapsible, 4-element Yagi antenna was used occasionally. Radio collars weighed 127-185 grams (g), had a pulse rate of 60-121 beats per minute (bpm), and transmitted in the 150-151 megaHerz (mHz) range. Collar antennas were either whip-type external steel wire cables or steel wires or copper alloy bands incorporated into the collar material. Transmitters were powered by two or three 1/2 to 2/3 ampere lithium batteries. Service life of collars was extremely variable. Several failed after 3 to 10 days of use and three that were placed in service in summer and fall 1980 were functioning well when tracking was terminated in December 1981. Slow-pulsed (60 bpm) transmitters with whip antennas had the longest service life, and their signals could be received at greater distances. Fluctuations in signal strength and tone quality indicated that a bobcat was moving, while steady signals and tone indicated inactivity. Radios with slightly higher pulse rates (70-80 bpm) and collar antennas provided better signals for determining activity. An attempt was made to approach to within 1 km of a radio-collared bobcat to obtain bearing. Guenther estimated that within this distance, bearings were accurate to ± 3 degrees. A minimum of two bearings, usually obtained within 1 to 5 minutes (min) of each other, were used to plot an animal's position by triangulation. Data recorded for each location included date, time, weather, and activity state (moving or inactive).

Radio-tracking was conducted from 20 October 1979 through 31 December 1981. Tracking was conducted at all hours of the day and night. Emphasis was placed on obtaining records of important events such as a male-female interaction or the movements of a female with newborn young rather than on obtaining one location per cat per day. As a result, individuals were monitored for periods ranging from 15 min to 24 hours on 1 to 35 consecutive days separated by intervals of usually less than a week. A total of 4493 radio locations was obtained on the 18 instrumented bobcats. Combined with Guenther's earlier data (851 radio locations on five of the cats), the study provides essentially continuous information on the population over a 32-month period.

Tracking

Trailing bobcats on foot was used as a supplement to radio-tracking to obtain more detailed data on movements and activities of marked individuals, marking behavior, litter size, and adult male-female and female-young interactions. Tracks were also used to detect the presence of unmarked cats and to estimate their sex and age class. The probable presence of unmarked residents was assumed from repeated occurrence of tracks that did not compare with those of known bobcats. When such tracks occurred only at the periphery of an instrumented bobcat's home range, the unknown cat was assumed to be of the same sex. If the unknown tracks were within the interior of the range of a collared cat, the unknown individual was assumed to be of the opposite sex. This interpretation is based on the findings of Lawhead (1978), Guenther (1980), Miller (1980) and other investigators that same-sexed individuals exhibit very little range overlap while opposite-sexed bobcats may exhibit substantial overlap. I used this technique to determine portions of the range boundaries of four individuals (F-9, F-10, F-11, M-8) prior to their capture. Lembeck (1978) estimated the range of an adult female suspected to be present from the known range boundaries of other females and later confirmed his estimate by capturing and radio-tracking the individual.

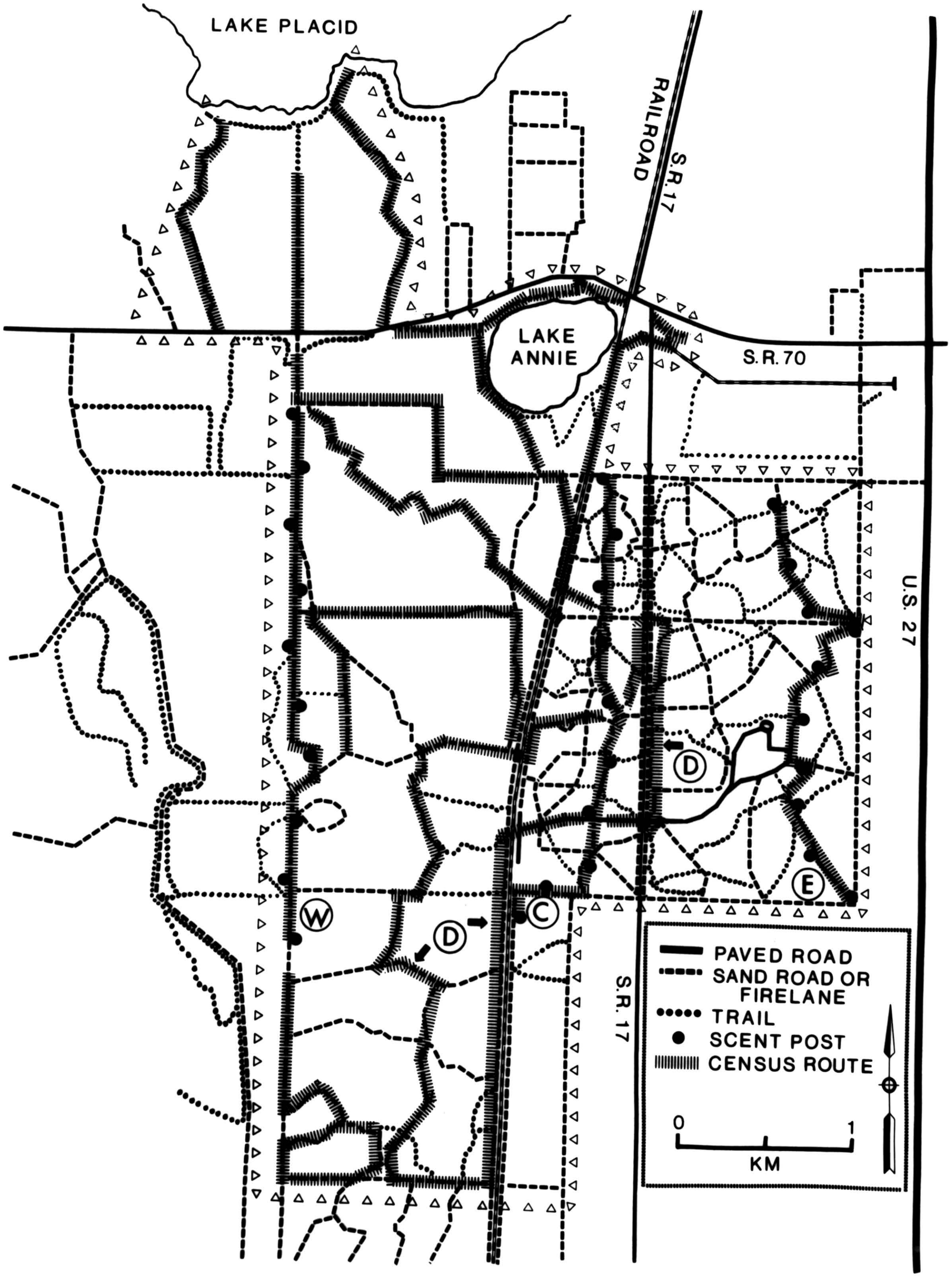
Scat and Scrape Censuses

Periodic censuses of bobcat scrapes and exposed feces were made along primitive roads, firelanes, foot trails, and railroad tracks within the study area from 23 October 1979 through 16 April 1981. Foot trails and railroad tracks were walked and roads or firelanes were surveyed from a vehicle at a speed of 1-5 km per hour. All scats were collected and scrapes were usually marked with a toothpick to prevent their being recounted in a subsequent census. Regular censuses were made along 37 km of routes contained within an approximately 18 km^2 area

(Figures 1 and 5) consisting of the northern half of the core area and the lands between it and the southern shore of Lake Placid. Approximately half of the total distance of these routes was comprised of the three 2.9 km bobcat scent post survey routes (ABS-W, ABS-C, and ABS-E) and the 10 km scat survey route (DDG-T) established by Guenther (1980). Most routes within this area were censused once or twice monthly; a few regularly-driven roads were inspected more frequently; and some trails that were infrequently marked were searched every 1 to 3 months. Other parts of the study area were searched irregularly. Data recorded for all deposit sites within the study area included date of observation, locality, number of scats or scrapes and their relative positions, apparent presence or absence of urine in scrapes, estimated site circumference, substrate, identity of depositor when known, and the apparent age of each deposit.

As it was not possible to census all routes on the first day of each month, I used various types of evidence to determine the apparent age of a deposit so that it could be assigned to a particular month. Time since the route was last searched, whether or not the deposit was made before or after a recent rain, amount of human or other disturbance of the site, and the condition of the scat or scrape were all considered. Totals of 2220 exposed scats and 5291 scrapes (including scrapes containing scats) were recorded within the study area. Of these, 1461 scats (66%) and 3326 scrapes (63%) were discovered along the regular census routes. In addition, a number of urine deposits unaccompanied by other sign and buried scat depositories were observed.

Figure 5. Principal bobcat scat and scrape census area (delimited by triangles) showing regularly searched routes, including three 2.9 km bobcat scent post survey transects (W = ABS-West, C = ABS-Central, E = ABS-East) and the 10 km scat census route (D = DDG-T) established by Guenther (1980).


LAKE PLACID
RAILROAD
S.R. 17
LAKE ANNIE
S.R. 70
U.S. 27
D
W
D
C
E
S.R. 17
PAVED ROAD
SAND ROAD OR FIRELANE
TRAIL
SCENT POST
CENSUS ROUTE
0
1
KM

Visual Observations

A total of 349 sightings of bobcats were made by me or reported by others during the study. Sixteen of the collared cats and 10 unmarked but recognizable (e.g. kittens accompanying a collared female) individuals were observed. In addition, unidentified cats were seen on 30 occasions. Observations at night were made with either vehicle headlights or a hand-held 200,000 candlepower spotlight. If the vehicle was not moving, the cats usually stood and looked at the light before moving off.

Data Analyses

Density

Estimation of absolute density of natural animal populations is often extremely difficult, and the present study was no exception. Simply dividing the number of cats known or suspected to be present during a particular time interval by the total area of the study plot would give a highly questionable estimate, as there was a good chance of cats being present and undetected in the more peripheral parts of the study area. In addition, knowledge of movement patterns of unmarked peripheral cats that were recorded was not sufficient to determine the extent to which their home ranges lay outside the boundaries of the study area. Furthermore, the relatively high turn-over of cats during the epizootic coupled with the lag time in live-trapping new individuals made it difficult to keep track of the animals in even a relatively small area.

Because of these problems, the procedure adopted utilized only data from the cluster of individuals centering on the core area that was most intensively and continously monitored. Separate estimates were calculated for adult males, adult females, and juveniles still associated with the mother. In the case of adults, the number of contiguous individuals of the same sex was divided by the total area of the respective observed home ranges less the area of any overlap. If there was an apparent gap between observed home range boundaries of adjacent individuals as in the case of some females, that area was included in the total area. When marked or subsequently marked individuals were known to be present during a particular interval but the data were not sufficient to determine their home ranges, their home range areas were estimated from data from prior or subsequent periods if there was no reason to assume any significant change in their movement patterns over the time periods involved. Estimates of juvenile density were based on the total number of juveniles known or believed to be present in the combined area of all female ranges. As litter counts were of young approximately three months or older, the present juvenile density estimates apply to mobile young prior to dispersal.

Density estimates were computed for 12 time intervals during the period from April 1979 through August 1981 when the population was most intensively monitored. Five of the intervals were based on known deaths or disappearance of individuals. The break-points for the remaining intervals were more subjective, involving times of collar failures which prevented further detailed monitoring of individuals or prolonged (about 1 month) gaps in radio tracking.

Movements

All bobcat locations obtained by radio-tracking, capture, and visual observations were plotted on a large scale (1:4800) map of the study area gridded at 200 m intervals into 4-hectare (ha) quadrats. To give a more complete picture of the movement patterns of the population, Guenther's (1980) data were also included. Home range areas were estimated by the minimum polygon method (Mohr 1947). Overall or "lifetime" ranges were determined for each individual based on all locations for the animal for the entire period it was studied. Home ranges were also calculated for those individuals with a sufficient number of locations that were present during each of the 12 time periods mentioned under Density above. The extent of day-to-day movements of bobcats within their lifetime home ranges was based on distances between the first radio locations on consecutive days with a minimum interval of 5 hours between observations.

Activity

For the analysis of temporal activity patterns, only the first moving or inactive record obtained for an individual in a given hour was used, and records for all individuals were grouped into 3-hour intervals. The period between midnight and 0600 hours was relatively poorly sampled, with only 325 (7%) of the total of 4966 hourly records included within this interval.

Habitat Utilization

The areas of different habitat types contained within lifetime home ranges of individual bobcats were determined by counting the 4-ha quadrats containing each type. When more than one habitat occurred within a quadrat, each was assigned a fractional value equal to the number of habitat types represented, regardless of the actual coverage of the habitats in the quadrat. For example, if habitats A and B occurred in a given habitat, each was assigned a value of 2 ha. Intensity of use of different habitats within a home range was assumed to be reflected by the number of an individual's locations that fell in quadrats containing a given habitat type. Locations occurring within quadrats containing more than one habitat were assigned fractional values for use of each habitat corresponding to the number of habitats within the quadrat (e.g. if habitats A and B occurred in a quadrat, the bobcat was assumed to be using 1/2A and 1/2B). Habitat preferences were assessed by comparing the frequencies of locations in different habitats with the relative areas of those habitats.

Statistical Analyses

Statistical tests used included Mann-Whitney U (U), Spearman Rank Correlation (Rho), and Chi-square (X^2) as described in Siegel (1956) and the Log-likelihood Ratio (G) given in Zar (1974). A probability (P) level of 0.05 or less was considered significant (*) and a P of 0.01 or less was considered highly significant (**) with the appropriate degrees of freedom (d.f.). Symbols used include (<) for "less than", (>) for "greater than", (=) for "equals", and (±) for "plus-or-minus".

RESULTS

Capture Success

A combined total of 2513 TN in this and Guenther's (1980) study resulted in 18 original captures and 19 recaptures (1.5 total captures per 100 TN) from April 1979 through January 1981. Trap success (captures per 100 TN) in different seasons was as follows: December through February - 3.1, March through May - 1.1, June through August - 0.7, September through November - 1.1. The number of TN in each period ranged from 609 to 660.

Meat baits were more effective than live baits or live and meat baits combined. A total of 755 TN with meat baits, 1535 with live baits, and 223 with mixed baits resulted in 19 (2.5 per 100 TN), 17 (1.1 per 100 TN), and 1 (0.4 per 100 TN) captures, respectively. The difference in capture frequencies between live and meat baits is significant ($X^2 = 6.59^*$, d.f. = 1). Bobcats also tended to be captured sooner with meat baits than with live baits (mean of 1.8 TN from the day a trap was set compared with 7.9 TN). All captures with live animals were with chickens.

A total of 175 individuals of 15 nontarget species captured included: 81 raccoons (Procyon lotor), 42 opossums (Didelphis virginiana), 8 spotted skunks (Spilogale putorius), 7 domestic dogs, 5 striped skunks (Mephitis mephitis), 5 gray foxes (Urocyon cinereoargenteus), 5 armadillos (Dasypus novemcinctus), 5 gopher tortoises (Gopherus polyphemus), 5 blue jays (Cyanocitta cristata), 4 turkey vultures (Cathartes aura), 2 domestic cats, 1 cottontail rabbit, 1 marsh rabbit (Sylvilagus palustris), 1 box turtle (Terrapene carolina), 1 black vulture (Coragyps atratus), 1 great horned owl (Bubo virginianus), and 1 red-tailed hawk (Buteo jamaicensis).

Density

The mean density estimate for combined sex and age classes over the period 28 April 1979 to 12 August 1981 was 0.37 individuals per km^2. Mean densities of adult males, adult females, and juveniles during this period were 0.06, 0.11, and 0.19, respectively.

Total densities in different periods of the study ranged from a maximum of 0.51 in the interval 1 July - 25 October 1979 to a low of 0.28 in the interval 1 December 1980 - 8 March 1981 (Table 2). Values for adult males ranged from a high of 0.09 in summer-fall 1979 to a low of 0.05 from July 1980 to March 1981. Maximum and minimum estimates for adult females were 0.14 in late winter 1980 and 0.09 in the periods 20 July - 7 October 1980 and 9 March - 12 August 1981. Male density estimates for the different time periods ranked significantly lower ($U_{10,12} = 2^{**}$, 1-tailed) than those of females, with males showing a more pronounced decline in late fall and winter 1979. Male density was still below the original level at the end of the study. Highest (0.31) juvenile density was attained in spring-fall 1979, and the lowest (0.12) occurred in the interval 29 February - 30 April 1980. Juvenile densities showed a fairly distinct trend. They were relatively high at

Table 2. Estimated numbers and densities (individuals per km^2) of bobcats on the study area during 12 time periods (see text for methods). If two values for bobcat numbers are shown, the second value (in parentheses) is the number of bobcats in the interval whose home range areas were estimated from data obtained in a prior or subsequent interval. Density calculations for juveniles are based on combined adult female home range areas in a given period. Area is combined home range in km^2.

	1979			1980						1981		
Sex and age class	28 Apr to 30 Jun	1 Jul to 25 Oct	26 Oct to 16 Jan	17 Jan to 5 Feb	6 Feb to 28 Feb	29 Feb to 30 Apr	1 May to 19 Jul	20 Jul to 7 Oct	8 Oct to 30 Nov	1 Dec to 8 Mar	9 Mar to 30 Jun	1 Jul to 12 Aug
Ad. males												
Number	2	3	2	1	?	?	2(1)	2	2	2	2	2
Area	24	32	32	18	-	-	27	37	43	43	33	35
Density	0.08	0.09	0.06	0.06	-	-	0.07	0.05	0.05	0.05	0.06	0.06
Ad. females												
Number	4(4)	4(2)	6(4)	6(4)	6(2)	5(1)	5	5	5(1)	3	3(1)	3(1)
Area	35	35	52	50	43	50	49	54	51	35	33	34
Density	0.11	0.11	0.12	0.12	0.14	0.10	0.10	0.09	0.10	0.09	0.09	0.09
Total adults												
Number	6(4)	7(2)	8(4)	7(4)	-	-	7(1)	7	7(1)	5	5(1)	5(1)
Density	0.19	0.20	0.18	0.18	-	-	0.17	0.14	0.15	0.14	0.15	0.15
Juveniles												
Number	11(11)	11(6)	11(6)	9(6)	6(3)	6	7	7	7(2)	5	8(2)	8(2)
Density	0.31	0.31	0.21	0.18	0.14	0.12	0.14	0.13	0.14	0.14	0.24	0.24
Total bobcats												
Number	17(15)	18(8)	19(10)	16(10)	-	-	14(1)	14	14(3)	10	13(3)	13(3)
Density	0.50	0.51	0.39	0.36	-	-	0.31	0.27	0.29	0.28	0.39	0.39
Ratios												
Male:female	0.73	0.82	0.50	0.50	-	-	0.70	0.56	0.50	0.56	0.67	0.67
Juv:adult	1.63	1.55	1.17	1.00	-	-	0.82	0.93	0.93	1.00	1.60	1.60

the beginning of the study in 1979, declined through 1980, and increased again in 1981. It should be noted that density estimates in the initial periods of the study involve a higher proportion of estimated home ranges than later ones and therefore may be less reliable.

Sex and Age Ratios

Based on density estimates presented above, mean age and adult sex ratios over the entire period of the study were 1.22 juveniles per adult and 0.60 adult males per adult female, respectively. For those time periods for which data are available, age ratios ranged from 0.82 to 1.63 juveniles per adult, and adult sex ratios varied from 0.50 to 0.82 males per female. Juvenile-adult ratios paralleled population trends, with higher values in 1979, reduced values in 1980, and an increase in 1981. The proportion of adult males to adult females was relatively high in 1979, declined through 1980, and increased again in 1981.

Natality

Mean size of 13 litters observed during this and Guenther's study was 2.5 (range 1-4). Twelve of the litters were produced by instrumented bobcats (Figure 4) and one (3 young) by an uncollared female. As all litters observed were over three months of age and may have experienced some mortality, mean litter size at birth in this population is probably higher.

One female gave birth to a litter when about one year old, indicating that some females in south-central Florida breed in their first year. Another female had inconspicuous teats and showed no signs of previous lactation when captured in February 1980, suggesting that her litter born in April 1980 was also produced during her first season.

F-1 was the only adult female whose reproductive history was monitored long enough to obtain some indication of the frequency of litter production. She was known to have had four litters (May 1979, May 1980, April 1981, estimated November 1981) over a 30-month period. She also had produced a litter during each year from 1976 to 1978. Thus, she typically bore only one litter per year, although the situation in 1981 demonstrates that two litters per year are possible. The second 1981 litter was obviously not the result of recycling following the loss of a recently-born litter, as young of the first litter were seen with her until September; and there was circumstantial evidence that at least one juvenile survived until December.

Breeding Season

Seven litters whose birth date was known to the nearest week were born in April (3), May (3), and January (1). Births of five other litters of radio-collared cats were estimated to have occurred in February (1), April (1), May (2), and November (1). An unmarked female on the periphery of the study area apparently produced a litter in April. Back-dating to time of mating, assuming a gestation period of about two months (McCord and Cardoza 1982), indicates that the breeding season extended from September through March. Ten (77%) of the estimated mating dates were in February and March, whereas only one each occurred in the remaining months (September, November, December).

Mortality

Of the 18 instrumented bobcats monitored over the 34-month period from October 1979 to August 1982, 9 (50%) were known to have died. These included five (83%) of six adult males, two (29%) of seven adult females, and two (40%) of five juveniles. Two of three marked juveniles of the same litter disappeared at the same time the third died, and it is suspected that all three perished. Including these two individuals, the mortality rate for all marked cats was 56 percent and for adults and juveniles, 54 and 80 percent, respectively. In addition to the above, nine unmarked bobcats (4 adult males, 2 adult females, 1 juvenile male, 1 juvenile female, 1 unsexed juvenile) were found dead, reported killed, or captured in a moribund condition and died within or at the edge of the study area between January 1979 and August 1982.

Eight (47%) of 17 marked and unmarked cats that died from known causes were killed on roads. These included three marked individuals (2 adult males, 1 adult female) and five unmarked animals (2 adult males, 1 adult female, 1 juvenile male, 1 juvenile female). The marked adult female was lactating, and three days later a 1.6 kg juvenile, possibly her young, was run over 0.4 km from the site where she was killed. Two (12%) unmarked adult males were shot, and one (6%) unmarked juvenile was killed by dogs. Five (29%) of the 17 cats for which cause of death was known, died from parasites (1) or disease (4). In April 1979, an unmarked adult female with a severe infestation of mange mites (*Notoedres cati*) was darted with a Cap-Chur gun and died within a few minutes. She was extremely emaciated (5.3 kg compared to the mean adult female weight of 7.9 kg) and very weak and undoubtedly would have soon died if she had not been captured. Three females among the animals live-trapped and radio-collared from July 1979 to March 1980 had scabby areas with sparse hair or bare patches about the head, neck, and shoulders suggesting a current or former mild mange infestation. The partially decomposed carcass of a marked adult male found in November 1979 also had similar bare patches on the inside of the forelegs. In 1978, prior to the beginning of this study, the semi-tame female (F-1) had been badly infested with mange mites and probably would have died if she had not been captured and treated by C. E. Winegarner (personal communication). It is believed that her three kittens born that year died from mange. These data suggest that there may have been a relatively high incidence of mange in the bobcat population of the study area during 1978 and 1979.

The deaths of four marked individuals (2 adult males, 1 adult female, 1 juvenile male) whose fresh carcasses were recovered in January and February 1980 were attributed to feline panleukopenia (feline distemper), based on necropsies performed at the Kissimmee Diagnostic Laboratory of the Florida Department of Agriculture and Consumer Services. In addition, three other individuals, including a marked juvenile female and her two siblings were suspected to have died from FPLV. The female died in February 1980, but her carcass was not recovered in time for necropsy. Her siblings disappeared about the same time. Another marked adult female may have been infected but recovered. On three occasions (twice during the day, once at night) in February and March, she allowed observers to approach within 5 m and acted dazed. Her movements were also greatly restricted during this period. By April, her movement patterns were normal. The foregoing observations indicate that a FPLV epizootic occurred among the bobcats of the study area during the winter of 1980 and was responsible for the loss of three adults and as many as four juveniles, a substantial segment of the population. An increased incidence of FPLV in domestic cats in the general region of the study area also occurred during this period, according to a local veterinarian (J. Causey, personal communication).

Data on the course of the disease and its effect on behavior was obtained for several of the radio-collared bobcats. A juvenile male was glassy-eyed and lethargic when recaptured four days prior to his death and was slow to move away from the observer when released. Disturbance of the ground under the body, which was found soon after death, indicated that the animal had struggled to stand up. A large amount of greenish, apparently bile-tinted, fluid exuded from the mouth while the carcass was being transported to the laboratory. Another adult male was observed shortly before death on 16 January. It was lying down near a pond unable to get on its feet or hold its uncontrollably bobbing head erect. Fluid was dripping from its mouth. When the animal was checked two hours later, it had managed to get into the pond and had apparently drowned in water about 10 cm deep after a struggle. Four other bobcats known or believed to have died from FPLV also were found near water. On one occasion, the apparently sick female mentioned above spent about an hour in the vicinity of a water-filled ditch. All known or suspected FPLV victims exhibited a progressive reduction in movements from two to four days prior to death.

Movements

Lifetime Home Range

Lifetime home ranges of 12 adult bobcats monitored in this and Guenther's study averaged 1913 ha (Table 3). Mean and extreme range sizes of five male and seven female adults were 2553 ha (1482-3108) and 1455 ha (935-2160), respectively. Adult male ranges were significantly larger ($U_{5,7} = 3^{**}$, 1-tailed) than those of adult females. The individuals were monitored from 16 to 1143 days (mean 465) and located on 26 to 94 percent (mean 44) of the days during the total period they were tracked. The mean number of locations obtained per cat was 333 (range 21-1248).

The shape of home ranges tended to be elliptical. Mean lengths of major axes (maximum range length) and minor axes (maximum length across home range perpendicular to major axis) of adult male home ranges were 7.3 km (range 5.3-9.0) and 5.1 km (range 4.3-5.8), respectively. Corresponding means and extremes for adult female home ranges were 5.2 km (4.2-7.0) and 4.0 km (2.6-6.6). The major axes of adult male ranges were significantly longer ($U_{5,7} = 4^{*}$, 1-tailed) than those of adult females, but their minor axes were not ($U_{5,7} = 7$, 1-tailed). The mean of ratios of major axis to minor axis was 1.5 (range 1.0-2.1) for adult males and 1.4 (range 1.1-1.8) for adult females. The axis ratios of males were not significantly larger than those of females ($U_{5,7} = 15.5$, 1-tailed).

The data suggest that adult female ranges tended to increase more in apparent size with increased period of monitoring than did the ranges of adult males. Rank correlations between range areas and length of

Table 3. Lifetime home ranges of adult bobcats on the Archbold Biological Station and vicinity.

Individual	Days between first and last observation	Days located		Number of locations	Home range area (ha)	Home range axes (km)		
		Number	Percent			Major	Minor	Major:minor ratio
Males								
M-1	284	145	51.1	490	2491	6.0	5.8	1.0
M-2	184	64	34.8	196	1482	5.3	4.6	1.2
M-3	161	59	36.6	196	2585	9.0	4.3	2.1
M-6	690	231	33.5	517	3101	8.4	5.0	1.7
M-8	606	156	25.7	510	3108	7.8	5.7	1.4
Females								
F-1	1143	426	37.3	1248	1822	5.2	4.5	1.2
F-3	168	56	33.3	199	891	4.6	2.6	1.8
F-4	497	257	51.7	600	1943	7.0	6.6	1.1
F-8	519	232	44.7	531	1271	4.6	3.4	1.4
F-9	699	251	35.9	466	2160	6.8	4.2	1.6
F-10	16	15	93.8	53	935	4.2	3.3	1.3
F-11	258	121	46.9	171	1164	4.2	3.6	1.2

monitoring intervals were significant for the seven adult females (Rho = 0.79*) but not for the five adult males (Rho = 0.60). Observed range areas were not significantly correlated with number of observations for either adult males (Rho = 0.73) or adult females (Rho = 0.64).

There is no basis for considering home ranges of juveniles still with the mother separately from those of adults, since the movements of the young largely reflect those of the parent. For example, although the observed lifetime range of the semi-tame female (F-1) was 1822 ha compared with a mean range of 1067 ha for three of her young (M-4, F-5, F-6) during fall and winter 1979-1980, estimates of F-1's range during the same periods were 1100 ha (fall and early winter) and 1149 ha (mid-winter). The ranges of all three juveniles were contained within that of the mother. Simultaneous radio-monitoring of the adult and tracking of the young of her May 1980 and April 1981 litters indicated that kittens past the nursing age gradually extended their movements beyond rest sites in the interior of the range, so that by late in their fourth month they were using the entire range of the female. Movements along boundaries as well as within interiors of their mothers' ranges was noted also for all other older litters of radio-collared females.

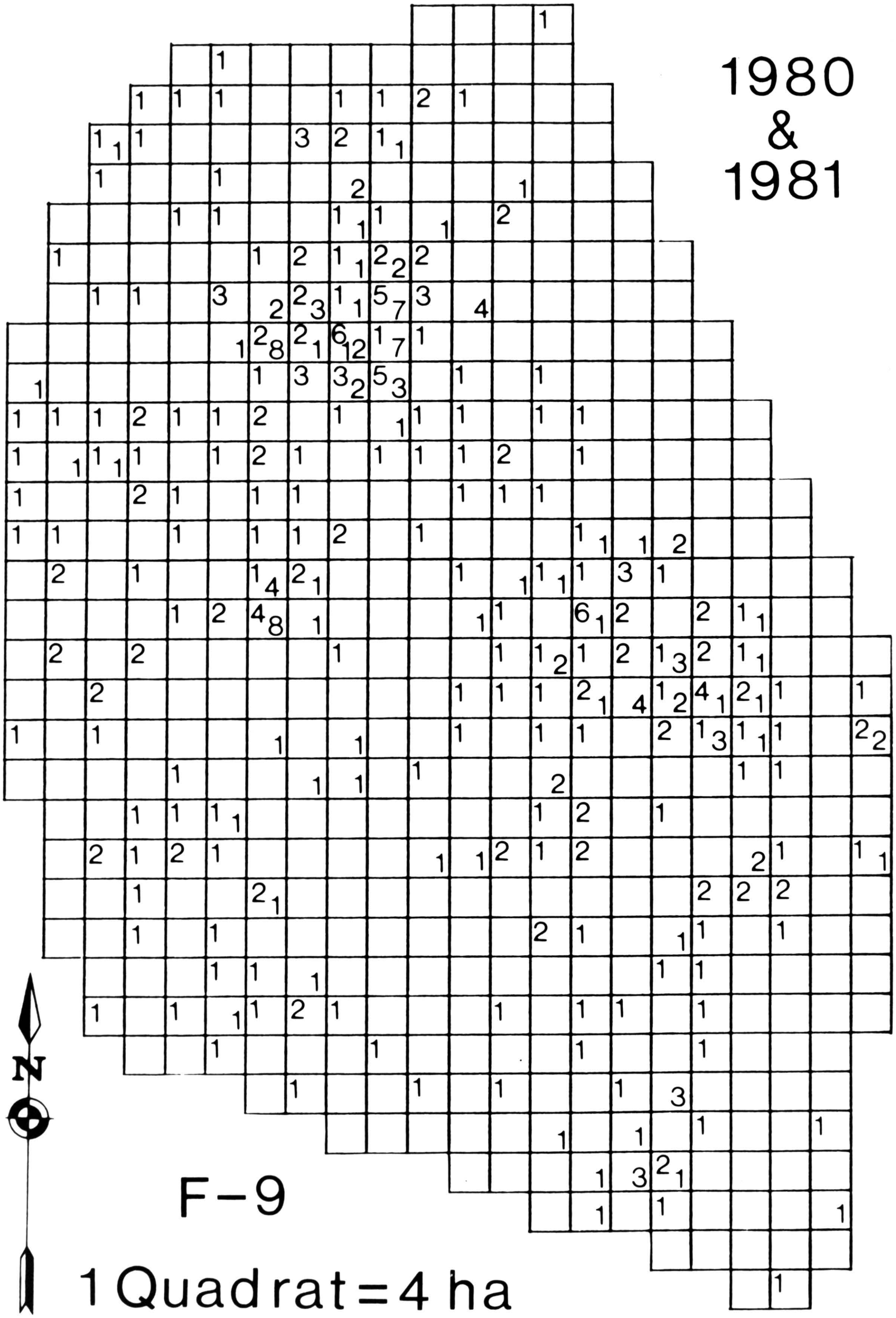
Home range boundaries tended to coincide with environmental features such as railroad tracks, firelanes, roads, footpaths, and well-defined boundaries between natural and man-modified habitats. When portions of the vacated range of a deceased bobcat were occupied by surviving same-sexed neighbors or when a range boundary shift occurred between two same-sexed bobcats, the new boundaries were usually established along such distinctive features.

No "exploratory" movements as often reported in bobcat literature were detected. It is possible that with the relatively intense tracking effort in this study, visits to peripheral areas were more often recorded and thus the areas were recognized as part of the range, whereas with less frequent monitoring movements to such peripheral areas might have been classified as "exploratory".

Roads, trails, railroad tracks, and paths were an important influence on daily movements of bobcats. For example, adult female F-9's lifetime home range contained one or more of these environmental features in 345 (64%) of 540 quadrats comprising her range. Quadrats with such potential travel routes contained 219 (83%) of 265 sample location records obtained at least 1 hour apart when the cat was moving. The frequency of active location records in quadrats with roads, trails, etc. was significantly greater than expected on the basis of the overall proportion of such quadrats ($X^2 = 39.58^{**}$, d.f. = 1). Ninety-six (70%) of 138 records obtained at least 12 hours apart when the cat was resting occurred in quadrats with potential travel routes. This proportion was not significantly different from that for quadrats without routes ($X^2 = 1.69$, d.f. = 1). However, 31 (74%) of the 42 resting locations not found in quadrats with potential travel routes occurred in quadrats adjacent to those with potential routes. Thus 92 percent of all recorded rest sites of this individual were within 400 m of a road, trail, path, or railroad tracks.

The proportion of the 4-ha quadrats contained within its home range boundary in which the resident cat was known to occur provided an index of the extent of home range utilization by adults. An example is shown in Figure 6. Based on this analysis, adults visited from 10 to 62

Figure 6. Typical example of an adult female bobcat lifetime home range gridded at 200 m intervals showing distribution and frequency within 4-ha quadrats of locations obtained while the individual was moving (upper-left corners) or inactive (lower-right corners).



1980
&
1981

F-9

1 Quadrat = 4 ha

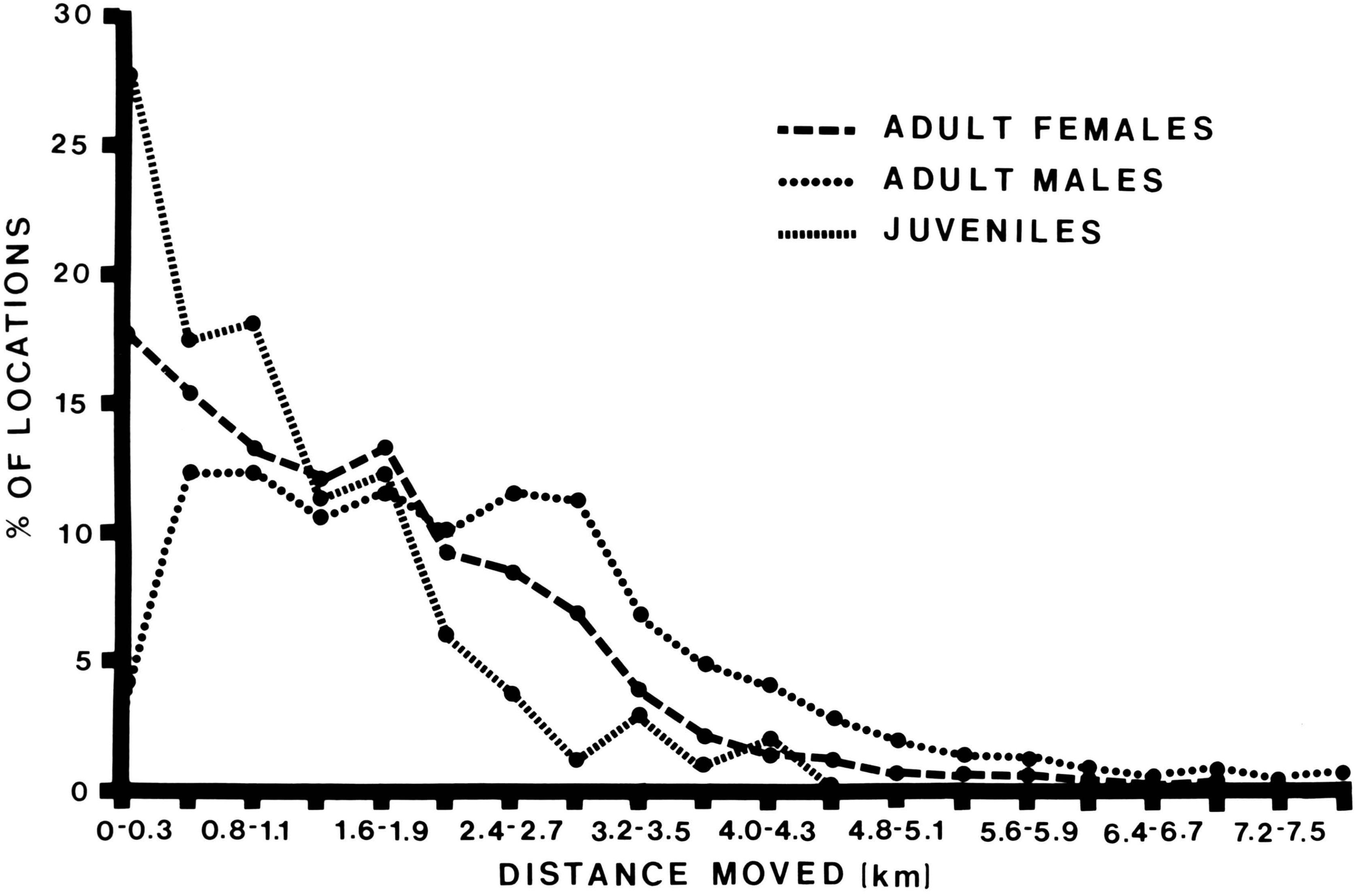
percent of the area in their lifetime home range. Males appeared to use their home range area less thoroughly than females. Five males were recorded in from 14 to 34 percent of their quadrats (mean 27%) compared with a range of 10 to 62 percent (mean 40%) for seven females, the difference in ranking of means of individuals of each sex being significant ($U_{5,7} = 7^*$, 1-tailed). As sample size increased, the number of quadrats containing more than one location also tended to increase. The maximum number of locations in a single quadrant was recorded for the semi-tame female F-1. She had 59 locations in the quadrat including the dwelling at which she was fed. The distribution of her locations outside of this area was not obviously different from other females in the population. About 47 percent of the quadrats visited by females contained more than one location, as compared with only 29 percent for males. As in the case of percentage of quadrats used, this difference points to more intensive utilization of the home range area by females.

Comparison of the distributions of active and inactive (= rest sites) locations, indicates that, although inactive locations occurred throughout the range, there was a tendency for them to be clumped into two to six vaguely-defined areas near the periphery of the home range, as evident in the map of female F-9 (Figure 6). An average of 42 percent (range 32-51) of the home range quadrats used by females contained rest sites, compared with 27 percent (range 27-36) in the case of males, indicating that females used relatively more areas within the home range for resting. An average of 17 percent (range 9-24) of the female quadrats with locations contained only rest sites. Comparable values for males were 17 (range 13-20). Thus there appears to be no sex difference in the relative proportion of the home range area used only for resting.

Figure 7 compares the percentages of day-to-day distances moved by six adult males (464 records), seven adult females (985 records), and five juveniles (145 records). Adult males moved greater distances from day-to-day than adult females, and juvenile movements were more restricted than those of adult females. Four percent of adult male, 17 percent of adult female, and 28 percent of juvenile daily movements were less than 0.4 km while 26 percent of adult male, 10 percent of adult female, and 5 percent of juvenile movements were 3.0 km or greater. The average day-to-day distance moved by all bobcats was 1.6 km. Means and ranges of day-to-day movements of adult males, adult females, and juveniles were 2.1 km (0-7.6), 1.4 km (0-6.6), and 1.0 km (0-4.2), respectively. The mean distances moved by individual males ranked significantly greater than those of adult females ($U_{6,7} = 4.5^{*}$, 1-tailed). Individual juvenile means also ranked significantly lower than those of adult females ($U_{5,7} = 2.5^{**}$, 1-tailed).

The composite means of adult male day-to-day distances moved during the months of December to February, March to May, June to August, and September to November were 2.5, 1.9, 2.1, and 2.1 km, respectively. Corresponding values for adult females were 1.6, 1.4, 1.2, and 1.4 km. Mean juvenile movements in fall, winter, and spring were 0.9, 1.1, and 1.3 km, respectively. Individual means of day-to-day distances moved by males during the months of December to February were significantly larger than those during March to May ($U_{4,5} = 2.5^{*}$, 1-tailed) but were not significantly different from those of other seasons. The only significant seasonal difference between means of daily distances moved

Figure 7. Percentages of different day-to-day distances moved by adult and juvenile bobcats on Archbold Biological Station and vicinity.


ADULT FEMALES
ADULT MALES
JUVENILES
% OF LOCATIONS
30
25
20
15
10
5
0
0-0.3
0.8-1.1
1.6-1.9
2.4-2.7
3.2-3.5
4.0-4.3
4.8-5.1
5.6-5.9
6.4-6.7
7.2-7.5
DISTANCE MOVED (km)

by individual adult females was between the December - February and June - August periods ($U_{5,6} = 5.5^{*}$, 1-tailed). The difference between fall and winter ranks of means of juveniles was not significant, and the data were insufficient for other seasonal comparisons. However, when daily movements of juveniles are compared on the basis of age, distances moved by individuals 8 to 10 months old averaged 22 percent greater than those of juveniles 5 to 7 months old, the difference in ranked means being significant ($U_{3,5} = 6^{*}$, 1-tailed). This difference reflects the greater amount of traveling of older young with the mother.

Temporal Variation in Home Range Size

Observed home range areas of adults in different time periods between April 1979 and August 1981 (Table 4) indicate that most individuals monitored for any period of time exhibited apparent changes in home range size. As in the case of lifetime home ranges, male short-term ranges, eliminating questionable estimates, averaged larger (mean 1453 ha, range 1187-2007) than those of females (mean 931 ha, range 779-1301). The difference is significant ($U_{5,7} = 2^{**}$, 1-tailed). Ranges of males in different time intervals were from 20 to 46 percent (mean 34%) less than their respective lifetime home ranges. Short-term ranges of females varied from 12 to 51 percent (mean 34%) of the lifetime home range. Ratios of maximum to minimum observed home range size for cats with estimates in two or more intervals averaged 0.61 (range 0.29 to 0.85) for five males and 0.67 (range 0.50 to 0.85) for six females. The difference in the ranking of the ratios for males and females is not significant ($U_{5,7} = 11$, 2-tailed), indicating that

Table 4. Home ranges (ha) of adult bobcats on the Archbold Biological Station and vicinity during 12 time intervals between April 1979 and August 1981. Values marked with an asterisk were obtained while the individual was less than a year old and still utilizing the natal range; later values indicate its range as an adult. Estimates in parentheses considered low as a result of too few locations.

	1979			1980						1981		
Individual	28 Apr to 30 Jun	1 Jul to 25 Oct	26 Oct to 16 Jan	17 Jan to 5 Feb	6 Feb to 28 Feb	29 Feb to 30 Apr	1 May to 19 Jul	20 Jul to 7 Oct	8 Oct to 30 Nov	1 Dec to 8 Mar	9 Mar to 30 Jun	1 Jul to 12 Aug
Males												
M-1	1215	1020	1511	1818	-	-	-	-	-	-	-	-
M-2	1242	1131	-	-	-	-	-	-	-	-	-	-
M-3	-	1230	1713	-	-	-	-	-	-	-	-	-
M-6	-	-	-	-	-	475*	583	1600	1820	1983	1924	2027
M-7	-	-	-	-	-	(479)	-	-	-	-	-	-
M-8	-	-	-	-	-	-	-	2134	2525	2334	1481	1560
Females												
F-1	-	(205)	1100	1149	1059	1404	(1026)	1375	1290	1236	1293	1294
F-3	-	586	-	-	-	-	-	-	-	-	-	-
F-4	-	1094	1041	698	683	1167	(881)	1104	859	-	-	-
F-8	-	-	-	(236*)	414*	478*	521	792	983	1043	-	-
F-9	-	-	-	-	1109	1126	(807)	1257	1307	1468	1347	1496
F-10	-	-	-	-	822	-	-	-	-	-	-	-
F-11	-	-	-	-	-	714	(230)	843	-	-	-	-

there is no sex difference in relative variability of the home range over time.

Short-term home range estimates in Table 4 do not exhibit any clear or consistent trends related to sex or season. Observed home range size of an individual frequently changed abruptly from one time period to another. A major cause of such changes was the death or disappearance of a neighbor. An example of such a case is that of an adult male (M-6) who expanded his range about 170 percent within two weeks following the reported death of a presumed adjoining male. Females with recently-born young also usually showed an apparent sharp decrease in home range size (e.g. F-1, F-9, and F-11 in the period 1 May - 9 July 1980). However, detailed monitoring of selected females with small young indicated that, although they did not significantly reduce their home range, they visited the periphery less frequently leading to a lower probability of recording such movements (see following section for a more detailed discussion).

Spatial Organization of Home Ranges

Previous sections on movements have focussed on individual home range size, utilization, and variability. This section examines the arrangement of home ranges in space, and the relationship of this pattern to the social organization of the population. Social factors that may potentially influence home range configuration include intra- and intersexual relationships of adults, interactions between adults and independent juveniles, and the relationships between the mother and her young. The complexity of the factors that may influence home range size, the small numbers of bobcats studied, and the relatively high turn-over of adults leading to considerable instability of the population during a major part of the study, make it difficult to analyze the causes of the type and magnitude of variation in home range size and configuration observed. However, loss of individuals from the population, relationships between adult males and females, and the mother-young relationship appeared to have a significant effect on the spatial organization of the population.

Figures 8, 9, and 10 show the spatial arrangement of entire or partial known home ranges of bobcats in the core area during the 12 time intervals from 28 April 1979 to 12 August 1981 as determined by radio-tracking, trailing, and visual observations. Other bobcats, including individuals whose collars had stopped transmitting or unmarked animals, known or believed to be present during these periods on the basis of tracks or sightings are not included because of the lack of specific data on their ranges. Areas of home ranges mapped are given in Table 4 for all individuals except M-5 and F-2. M-5 was a juvenile that died prior to establishing his own range; and the data for female F-2, who was only observed a few times before her death, did not permit a home range calculation.

Table 4 indicated substantial variation in individual home range size from period to period and Figures 8-10 reveal parallel changes in home range shapes and spatial arrangement. Home range configuration varied continuously throughout the study but tended to be relatively more stable during the initial (April - October 1979) and final (March - August 1981) periods than during the interval from winter 1979-80 to spring 1981. The latter period was marked by increased loss of individuals from the FPLV epizootic and other causes. Comparison of

Figure 8. Bobcat home ranges during four time intervals between 28 April 1979 and 5 February 1980. Boundaries of observed home ranges of adult males and females alive during a given period are shown in heavy and light solid lines, respectively. Heavy and light broken lines represent observed home ranges of adult males and females, respectively, that died or vacated their range in the period preceding a given interval. Boxes around individual numbers indicate the cat was originally captured during that period.

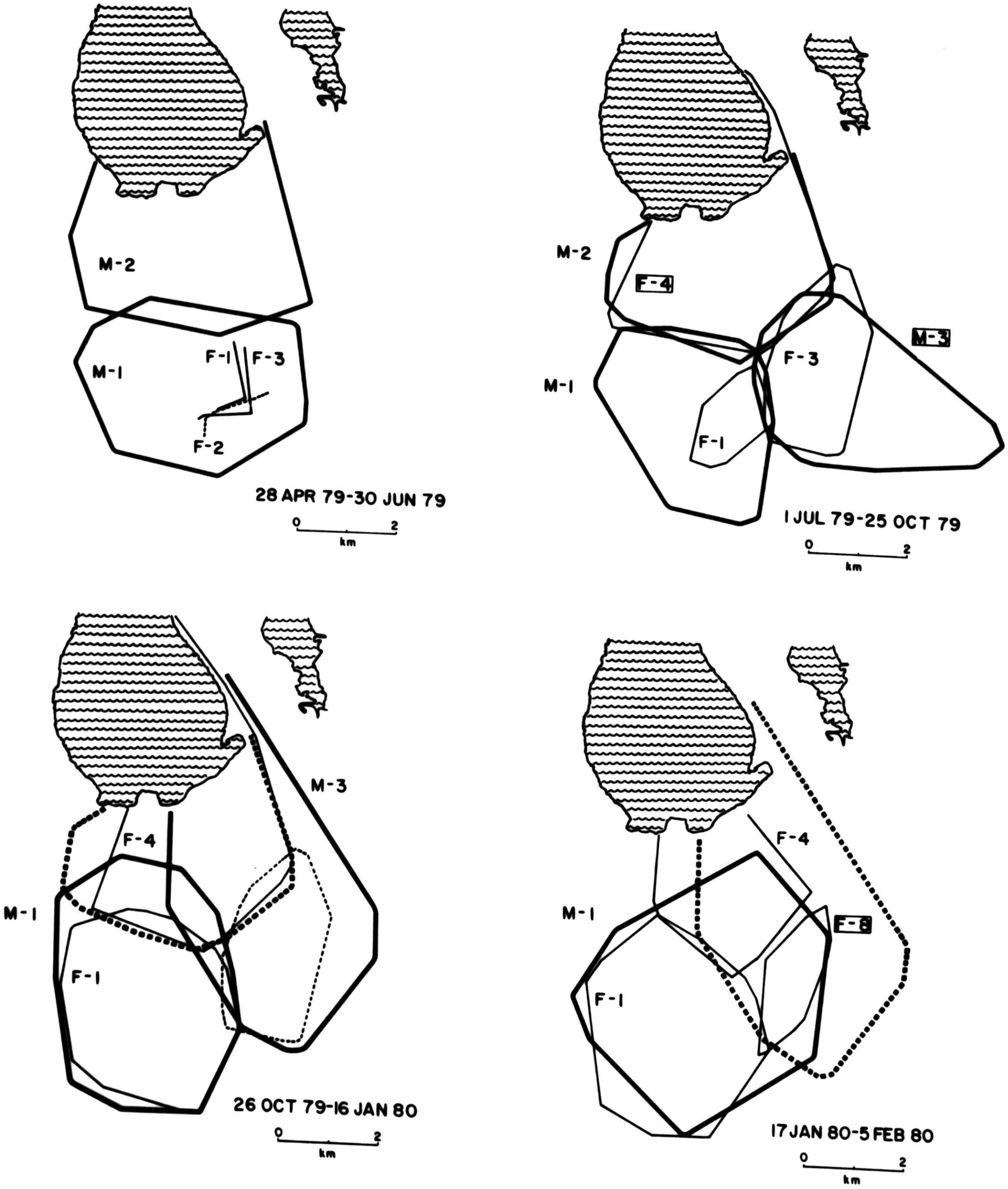
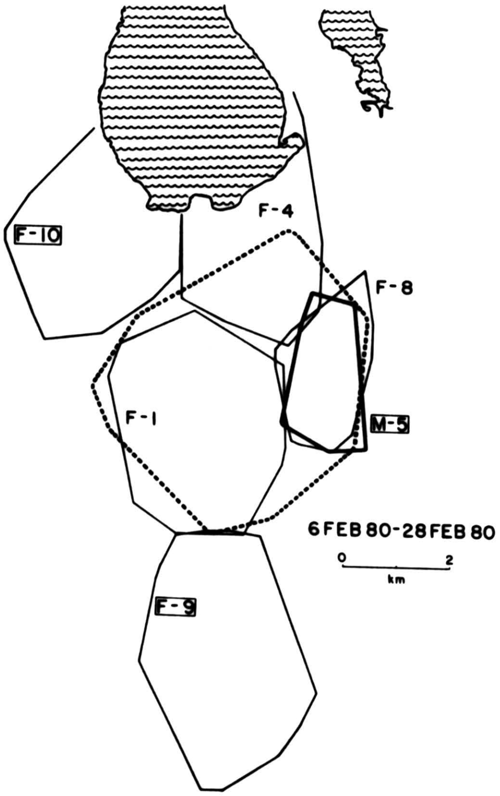
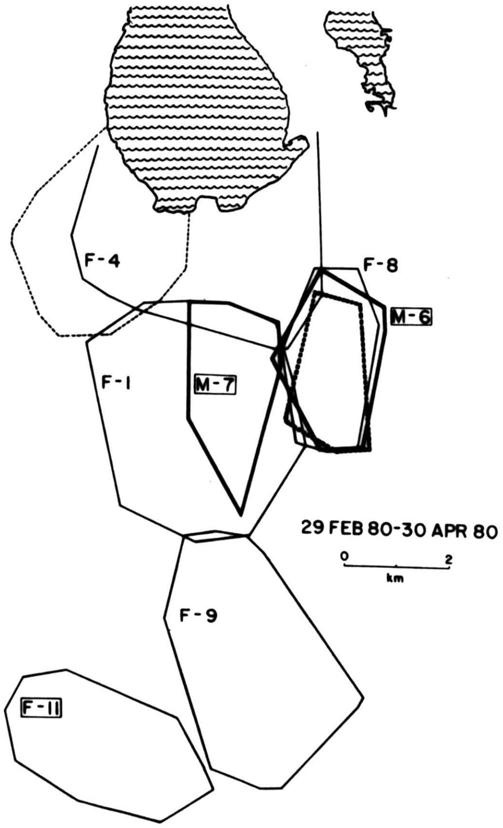

M-2
M-1
F-1
F-3
F-2
28 APR 79-30 JUN 79
0
2
km
M-2
F-4
M-3
M-1
F-3
F-1
1 JUL 79-25 OCT 79
0
2
km
M-3
F-4
M-1
F-1
26 OCT 79-16 JAN 80
0
2
km
F-4
M-1
F-8
F-1
17 JAN 80-5 FEB 80
0
2
km

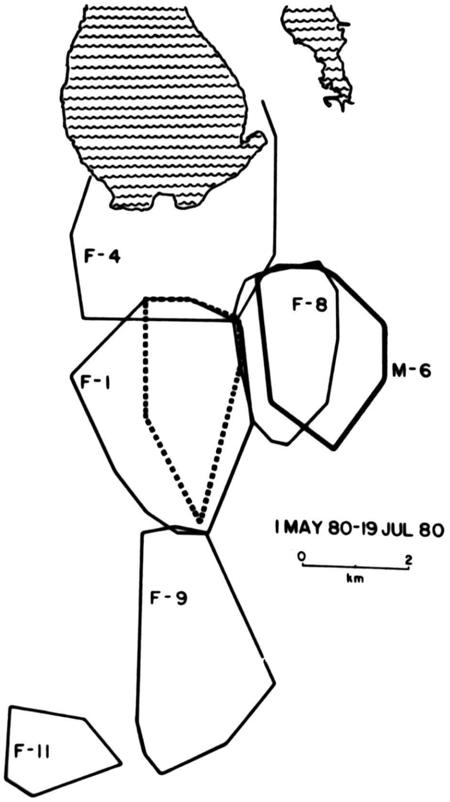
Figure 9. Bobcat home ranges during four time intervals between 6 February 1980 to 7 October 1980. See Figure 8 for description of symbols.



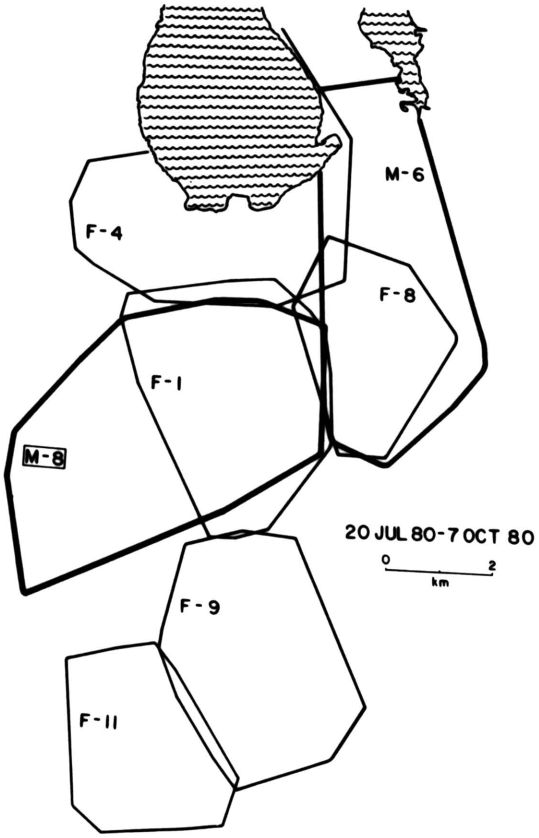
6 FEB 80-28 FEB 80



29 FEB 80-30 APR 80

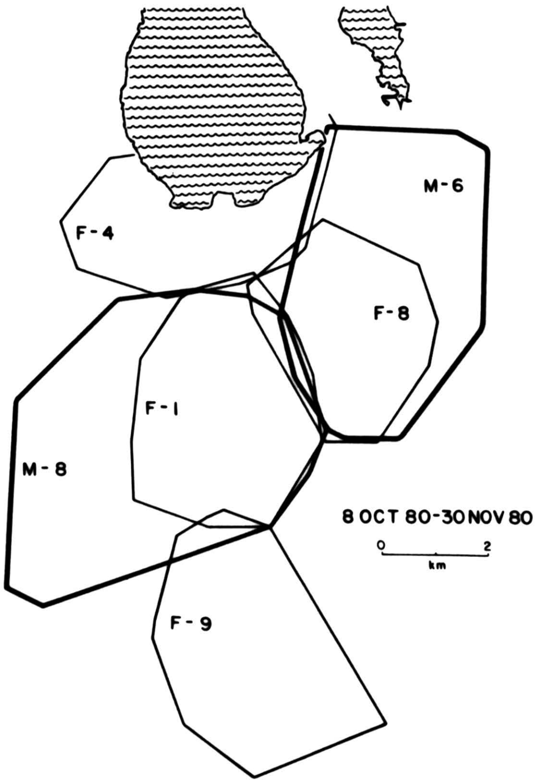


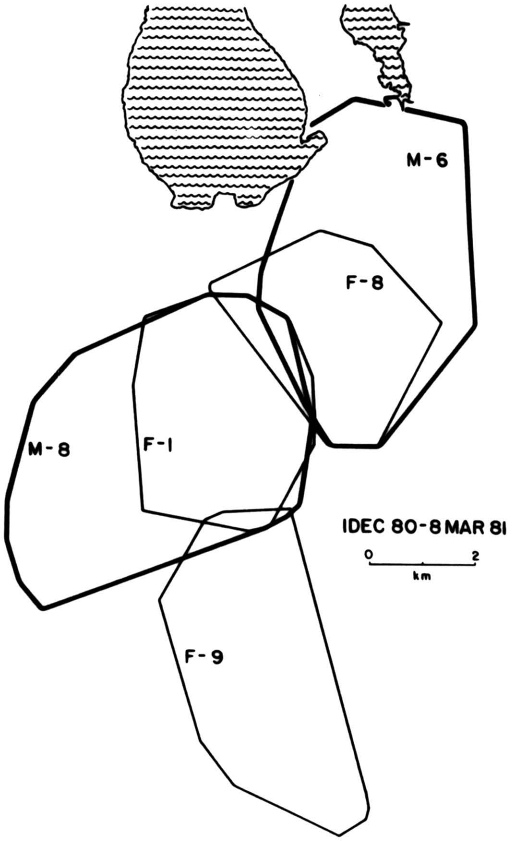
1 MAY 80-19 JUL 80

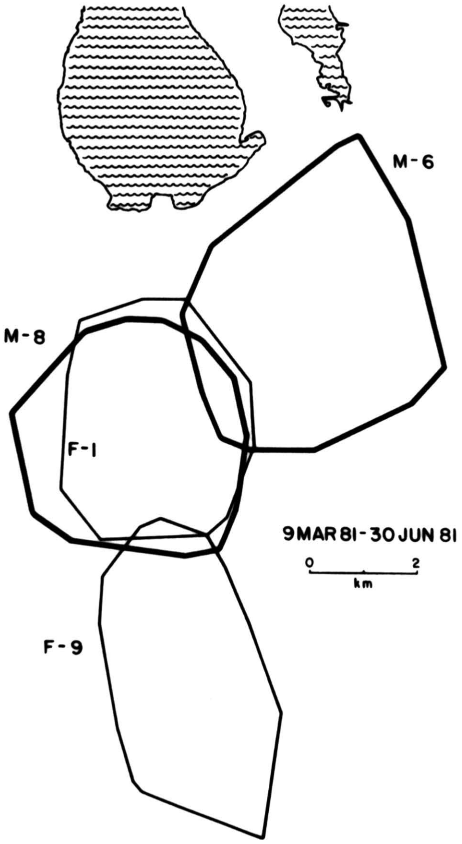


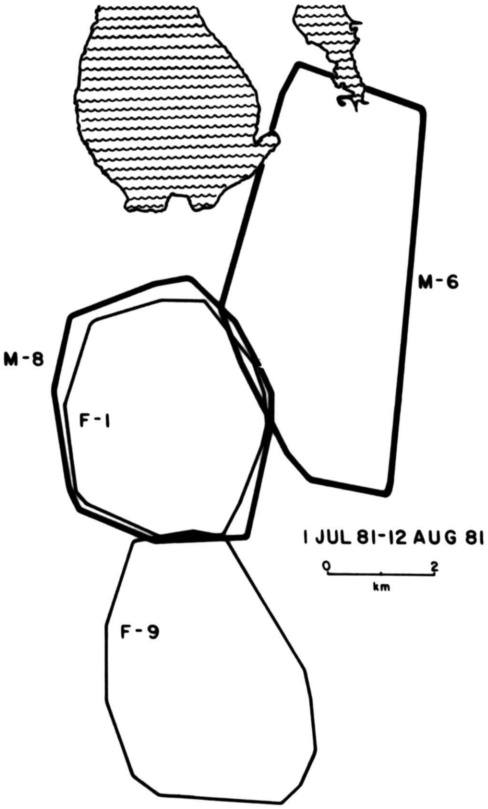
20 JUL 80-7 OCT 80

Figure 10. Bobcat home ranges during four time intervals between 8 October 1980 to 12 August 1981. See Figure 8 for description of symbols.


F-4
M-6
F-8
F-1
M-8
F-9
8 OCT 80-30 NOV 80
0
2
km


M-6
F-8
M-8
F-1
F-9
1 DEC 80-8 MAR 81
0
2
km


M-6
M-8
F-1
F-9
9 MAR 81-30 JUN 81
0
2
km


M-6
M-8
F-1
F-9
1 JUL 81-12 AUG 81
0
2
km

the range maps for the periods 1 July - 25 October 1979 (Figure 8) and 1 July - 12 August 1981 (Figure 10) suggests that, despite the death or disappearance of a number of bobcats and considerable shifting of home ranges of survivors during the middle phase of the study, the configuration of ranges at the end was generally similar to that at the beginning, even though only two (F-1, F-4) of the original group of resident adults were included in the final cohort. The home range configuration of the July - August 1981 cohort would resemble that of July - October 1979 even more closely if the probable ranges of three additional individuals known to be present were added. These include an adult female (F-8, whose collar failed earlier) whose range was probably mostly located in the southern half of M-6's and a male (unmarked) with enclosed female (F-4, whose collar failed earlier) range located between the ranges of M-8 and F-1 and the lake to the north.

Although resident bobcats had variable home range configurations, they exhibited a strong tendency to remain in the same general area. Only one case of a possibly established individual totally abandoning its home range and moving out of the study area was recorded. A 9.5-kg male (M-7) trapped and marked in late April 1980 was radio tracked for three days following release, after which the transmitter failed. The area over which it moved during this period is shown in Figure 9 (29 February - 30 April 1980). It was reported sighted on 20 August 1980 and 3 June 1981 within 2 km of the area it had occupied in April 1980. On 12 July 1982, it was found dead on a highway 70 km ENE of the study area. An adult female (F-3) apparently also shifted her home range within the study area. From June through November 1979 she was regularly monitored in the areas shown in Figure 8 (28 April - June 1979, 1 July - 25 October 1979). Although her collar failed in November, her continued presence in the area through December was confirmed by trailing. An unidentified radio-collared cat, which might have been this individual, was seen at the edge of her earlier established range in late February 1980. She may also have been seen on 20 August 1980 at the periphery of her previously known home range. On 2 August 1982, this female was found dead on a highway about 1.5 km from the nearest edge of her old range. As her former range had been occupied by a breeding female (F-8) in the intervening period between the last possible record of her occurrence in the area and her death in 1982, it seems reasonably certain that she had moved completely away from her old range.

Neither resident adult males nor females showed appreciable home range overlap with adjacent bobcats of like sex. The overlap of adjacent adult male home ranges that were believed to be relatively accurately delimited averaged 5 percent, with a range of 1 to 11 percent. Mean and extremes of home range overlap of adult females were 3 and 0 - 17 percent, respectively. These values indicate that there was little difference in the degree of exclusiveness of home ranges of adult males and females from those of others of the same sex. It is believed that home range boundaries of adjacent individuals of the same sex that were either widely separated (e.g. F-1 and F-10, Figure 9: 6-28 February 1980) or broadly overlapping (e.g. F-1 and F-8, Figure 10: 1 December 1980 - 8 March 1981) are largely artifacts of inadequate sampling or use of the minimum polygon method of calculating home ranges which produces relatively arbitrary boundaries. Tracking of neighbors, radio locations, and sightings suggest that, in general, mutual use of areas by members of the same sex is confined to a narrow zone along the line of contact of the current home range boundaries.

Bobcats of the same sex apparently only rarely came into close contact with neighbors. Only four cases of two adult males or two adult females being in close proximity were recorded during the study. Females F-4 and F-1 were found resting within 200 m of each other during the day on 4 December 1978, and F-4 and F-8 rested near each other during the day on 3 October 1980 and apparently walked within 100 m of each other at night on 30 August 1980. Only one questionable instance of two adult males being close together was recorded. On the night of 8 October 1980, M-6 and M-8 apparently followed one another about 2 minutes apart along a stretch of railroad tracks, then each veered off in a different direction.

Death or disappearance of a resident bobcat resulted in major changes in the size and shape of home ranges of remaining animals of the same sex. In contrast, opposite-sexed survivors did not exhibit such a response to the loss of a neighbor, indicating that different spacing mechanisms may be operating for males and females. Three clear-cut examples and a probable fourth case of this phenomenon were documented. After the death of M-2 in late October, adjoining males M-1 and M-3 expanded their home ranges into the area of M-2's former range, whereas there were no obvious changes in the observed home ranges of the three females whose ranges were adjacent to (F-1, F-3) or included within (F-4) M-2's range (Figure 8: 1 July - 25 October 1979, 26 October 1970 - 16 January 1980). M-2 died in mid-January 1980, and his death was followed by additional expansion of M-1's range but no obvious changes in movements of females (Figure 8: 26 October 1979 - 16 January 1980, 17 January - 5 February 1980). Female ranges also remained stable following the death of M-1 in early February 1980 (Figure 8: 17 January - 5 February 1980, Figure 9: 6-28 February 1980). The most dramatic male range expansion recorded was that of M-6 in late July 1980, following the probable death of an unmarked adult male (not shown on the range map) on the N boundary of his range (Figure 9: 1 May - 19 July 1980, 20 July - 7 October 1980). All female ranges also showed a slight increase between these two periods, which is believed to reflect apparent changes in their movements related to age of their young rather than a response to the expansion of M-6's range. In the one case of a confirmed female death (F-10), which occurred in late February 1980, one of two neighboring females (F-4) exhibited a marked expansion of her range into the vacated area (Figure 9: 6-28 February 1980, 29 February - 30 April 1980). The other female (F-1) also probably extended her movements into the former area of F-10, but data available up to the time of F-10's death were not complete enough to definitely establish the boundary between the home ranges of these two individuals. It is of interest to note that in two cases in which two marked individuals of the same sex expanded their ranges into a vacated range, the individual acquiring the larger amount of new territory had an original range that was either smaller than that of the other (F-4 compared to F-1) or contained a greater amount of man-modified habitat (M-3 compared to M-1).

Adjoining same-sexed bobcats began moving into vacated ranges within a short time after the death of the resident. In six cases, movements of adjacent individuals into vacated ranges were first detected within 5 to 14 days, with a mean of 9 days. There was no significant difference ($U_{2,4} = 4$, 2-tailed) between sexes in the time before the first recorded incursion into the new area. New home range boundaries in the invaded area appeared to be established quickly (within 3 weeks) with no evidence of "jockeying" for position.

In contrast to the exclusiveness of home ranges of same-sex individuals, there was a strong tendency for adult male ranges to be superimposed on those of adult females (Figures 8-10). In the majority of cases, a single, smaller female range was largely or entirely contained within the larger home range of a male, with the association between the individuals persisting until one of them died. Guenther (1980) referred to this spatial association between an adult male and female as a "consort" relationship.

Of nine male/female range overlap combinations recorded in different periods of the study (Figures 8-10), six involved a single female: M-1/F-1, M-2/F-4, M-3/F-3 during the period 1 July - 25 October 1979 (Figure 8), M-7/F-1 from 29 February to 30 April 1980 (Figure 9), M-6/F-8 from 29 February to 8 March 1981 (Figures 9 and 10), and M-8/F-1 from 20 July 1980 to 12 August 1981 (Figures 9 and 10). The remaining combinations involved a male and more than one female: M-1/F-1, F-4 and M-3/F-3, F-4 from 26 October 1979 to 16 January 1980; and M-1/F-1, F-3, F-4 from 17 January to 5 February 1980 (Fiqure 8). Five of six consort relationships involving one female appeared to become established in spring and summer coincidental with the periods of kitten dispersal and the birth and early development of new litters, while those involving more than one female developed during the period of highest mortality. One of the consort associations involving a single female was between probable siblings M-6 and F-8. The history of the single female consort combinations are described below.

Figure 8 (28 April - 30 June 1979, 1 July - 25 October 1979) shows how abandonment of the eastern portions of their ranges by adult males M-1 and M-2 resulted in the realignment of major portions of their range boundaries with those of adult females F-1 and F-4, respectively. Although the figure does not show the entire range of F-1 until after 25 October 1979, she is believed to have used all of the area used by M-1 during the period of 1 July - 25 October 1979. Evidence for this conclusion was the absence of signs, such as accumulation of old scats along a road or trail, in the western portion of her range after 25 October which would have suggested that another adult female had occupied a portion of the range of M-1 during summer and early fall 1979. The abandonment of natural habitats in the eastern portions of ranges of M-1 and M-2 also allowed male M-3 to orient his range with that of F-3, resulting in a total of three consort relationships involving three adult males and three adult females with adjacent ranges. That adult males would give up large tracts of natural habitats in an apparent effort to include an entire female range within their range boundaries suggests that the formation and maintenance of a consort relationship is important in the social organization of the bobcat population. The consort combination of M-7 and F-1 requires special comment as it appears to be the reverse of the usual case of a larger male range with a contained smaller female range. The small range shown for M-7 during the 29 February - 30 April 1980 period is based on only seven radio locations and undoubtedly represents less than the actual range. Because of collar failure, this animal could not be tracked in subsequent periods. Following his collar failure and apparent disappearance of M-7 from the range of F-1 in late spring 1980, adult male M-8 aligned his range boundary with that of F-1 (Figure 9, 20 July - 7 October 1980) resulting in a spatial arrangement of ranges in which about 97 percent of F-1's area was contained within about 49 percent of M-8's range. This arrangement persisted until early March 1981 (Figure 10), after which the male gradually ceased movements in the western portion of his range. As a result, all of F-1's observed range was contained within about 83 percent of the male's range by summer 1981.

Considering consort associations involving more than one female, two were established in the period 26 October 1979 to 16 January 1980 (Figure 8) following the death of M-2 on 25 October. Male M-1, initially associated with only female F-1, extended his range to also overlap a portion of that of female F-2, who had been associated with only M-2 prior to his death. During the same period, M-3 also extended his range to encompass part of F-4's. Although his previous female associate, F-3, could not be radio tracked after 15 November because of collar failure and thus is shown as "missing" in Figure 8, evidence from tracks indicated that she was probably still in the area with her three juveniles. Following the death of M-3, M-1 expanded his range to include that of F-8 (Figure 8: 17 January - 5 February 1980). F-8 was a presumed young of F-3 and was probably still within her natal range at that time, providing further circumstantial evidence that F-3 was still present. Thus, during this period M-1's range contained all or major portions of the ranges of at least two and probably three adult females, two (F-1, F-3) of which had young. It is interesting that while the range of male M-1 contained all or portions of the ranges of more than one female, the female with which he was originally associated occupied the major share of his range. The number of different males with which a given female was known to be associated during the study ranged from one to three.

Although the ranges of given males and females were superimposed and both cats were known to use the same places within the common area, observations indicated that for the most part the residents did not visit the same sites at the same time. Thus, although they were spatially associated, they tended to be temporally isolated. However, males and females were occasionally recorded in apparently close proximity, if not actually together, based on radio-tracking, visual observations, and trailing. Instances of such close association were logged in every month of the year except June and July, during which least radio tracking was done and fewer marked male/female combinations were present in the population. These observations indicate that adult males and females with overlapping ranges do associate, if only infrequently, outside of the breeding season. Observations suggested that mating regularly occurs while young are still in the natal range. The semi-tame female F-1 and female F-9 apparently bred while their young were still present. F-9 was observed on 30 November 1980 with one of her two kittens born about 20 April, and she gave birth to her next litter in early January 1981. F-1 produced a litter about 1 April 1981. She was last known to be accompanied by both the male and female offspring of her 3 May 1980 litter on 22 February 1981. On 5 March, a juvenile believed to be the male kitten was observed at the edge of

F-1's range and was backtracked to an area near where F-1 was resting. F-1 was observed with three juveniles from her April 1981 litter on September 9 and produced her next litter about mid-November 1981. Circumstantial evidence also indicates that on two successive occasions, F-1 not only mated but also bore litters while juveniles of her previous litter were still present. During the first two weeks after the birth of her April 1981 litter, tracks of a juvenile thought to be those of the male mentioned above were observed on five different days along the edge of her range and a short distance within, near one of the rest sites used by the female and the kittens of the previous litter. Two sets of fresh, alternately overlapping tracks observed on 3 December 1981 indicated that she had been in the company of an older juvenile after the estimated mid-November birth of the next litter. Her tracks and those of a juvenile also were found together on 14 December, but on that occasion it could not be determined whether the cats had actually been together or if they had passed the spot at different times.

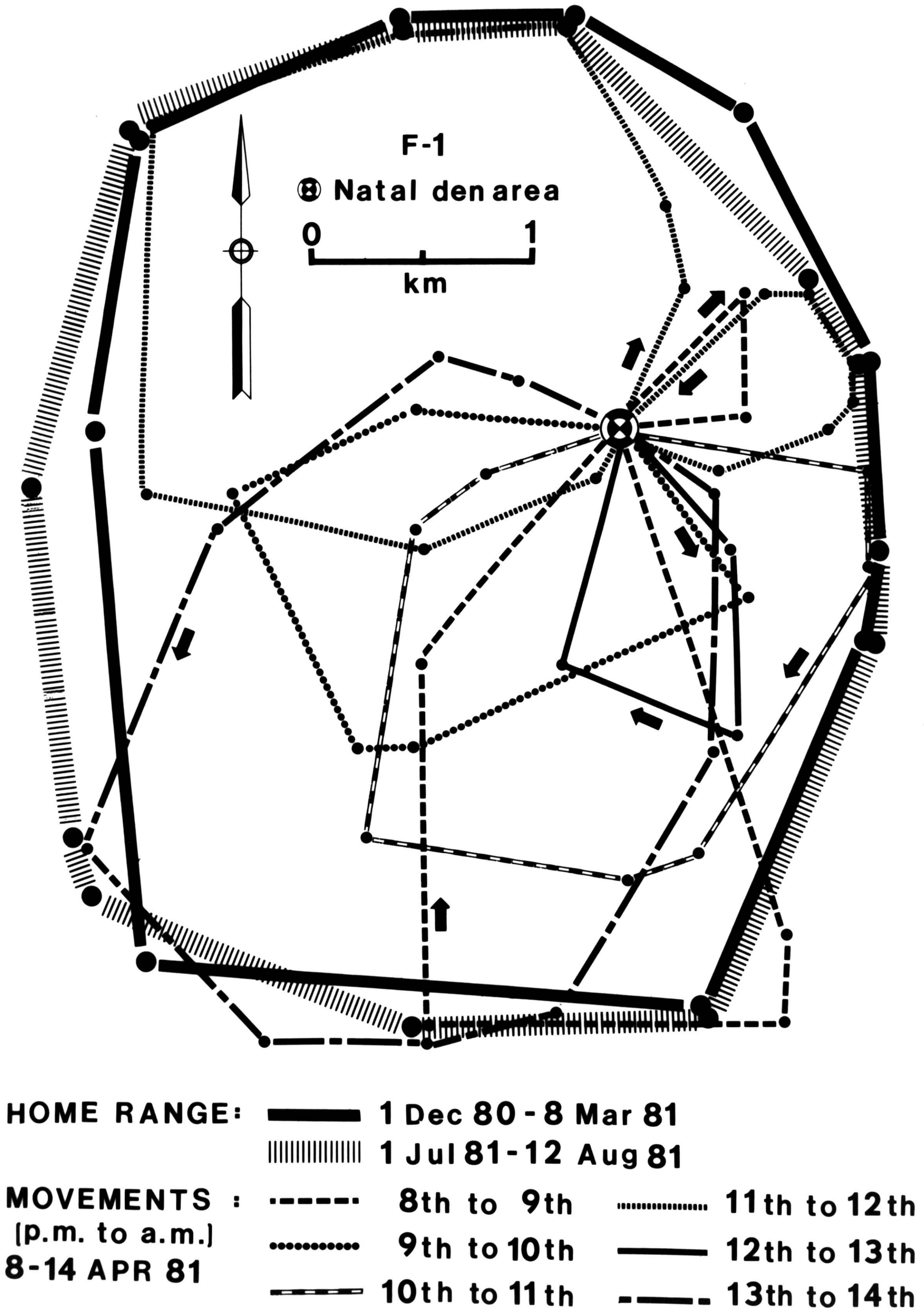
Events involving M-8 (the consort of F-1) during the period of 9 March to 30 June 1981 (Figure 10) suggested that consort males may keep other males from consort females when the females have small young and may influence the dispersal of older juveniles. F-1 gave birth to a litter about 1 April, presumably while a juvenile male of her previous litter (May 1980) was still in her range. On the evening of 5 April 1981, an adjacent adult male (M-6) was located less than 200 m from the den of F-1. After spending about two hours in the area of the den, he moved about 1 km SSE and passed through the area near the cottage where F-1 was occasionally fed and which was her preferred rest area and then moved eastward into the other portions of his home range. On the evening of 8-9 April, he also passed within 0.5 km of the den. Subsequent to M-6's appearance in the area of the den and near the cottage on 5 April, M-8 was found resting during the day less than 200 m from the den on 10, 11, 14, and 24 April and moving about near the den on 11, 13, 26, and 27 April and on 3 May. M-8 also rested near the cottage on the nights of 8 and 12 April and during the day on 16 April and was recorded moving about in the area of the cottage on the evenings of 9, 10, 11, 13, and 14 April. Although no actual contact between the two males was detected, it is possible that M-8's behavior was a response to the presence of M-6 in the vicinity of the den and may have served to discourage further visits by M-6 to the den area. When not in the area of the den or the cottage, M-8 could usually be found moving about along the periphery of other portions of his and F-1's shared range, particularly in that area apparently used by the juvenile kitten. On four of five days during the first two weeks of April that the juvenile was trailed or seen along the edge or a short distance within the range, presence of tracks suggested that it apparently made contact with M-8. No signs of fighting were noted, but on all occasions of probable contact between these individuals there were many, frequently overlapping tracks scattered over a wide area. The tracks of the juvenile were not seen in the area following the last of the apparent contacts with M-8, indicating that it may have dispersed. If this interpretation is correct, its dispersal may have been hastened by the contacts with the adult male.

The presence of their young in ranges of females influences the movements of the adult and also may potentially affect the movements of other bobcats in the population. During this and Guenther's study, five family groups involving three females and five litters were monitored until the young had apparently dispersed (= disappeared). These young associated with their mothers for 8 to 11 (mean 9) months.

During the period of mother-young association, four relatively distinct patterns of movements, correlated with age of the young, were observed in family groups. For the first 1 1/2 to 2 months after birth, while the kittens were immobile, the movements of the mothers were restricted. Following this period and until the young were about 4 1/2 to 5 months old, kittens made limited movements between and around rest sites, which were typically located within the interior of the adult's range, and the mother's movements were less restricted. The young did not accompany her when she visited peripheral portions of the range. When offspring were about 5 to 7 months, they began to accompany the adult to the boundaries of the range. The mother also made independent movements away from rest sites, which were beginning to be used for fewer consecutive days at a time. From this time until the juveniles dispersed, at 8 to 11 months of age, the movements of the young were increasingly independent of the adult, and the family did not use a given rest site more than a day or two. Toward the end of this period, one sibling might be found alone on one side of the range, while the remainder of the family was near the other side.

The best documented example of early post-partum adult female movements was obtained for F-1 (Figure 11) from 8 to 14 April 1981 after the birth of a litter on about 1 April. During this period, she covered the entire area she was known to have used during the December 1980 to March 1981 interval and subsequently used in the July-August

Figure 11. Movement patterns of adult female F-1 over a 6-day period after her litter was born on or about 1 April 1981. Only peripheral locations of travels are shown for comparison with her observed range boundaries during prior and subsequent time intervals.

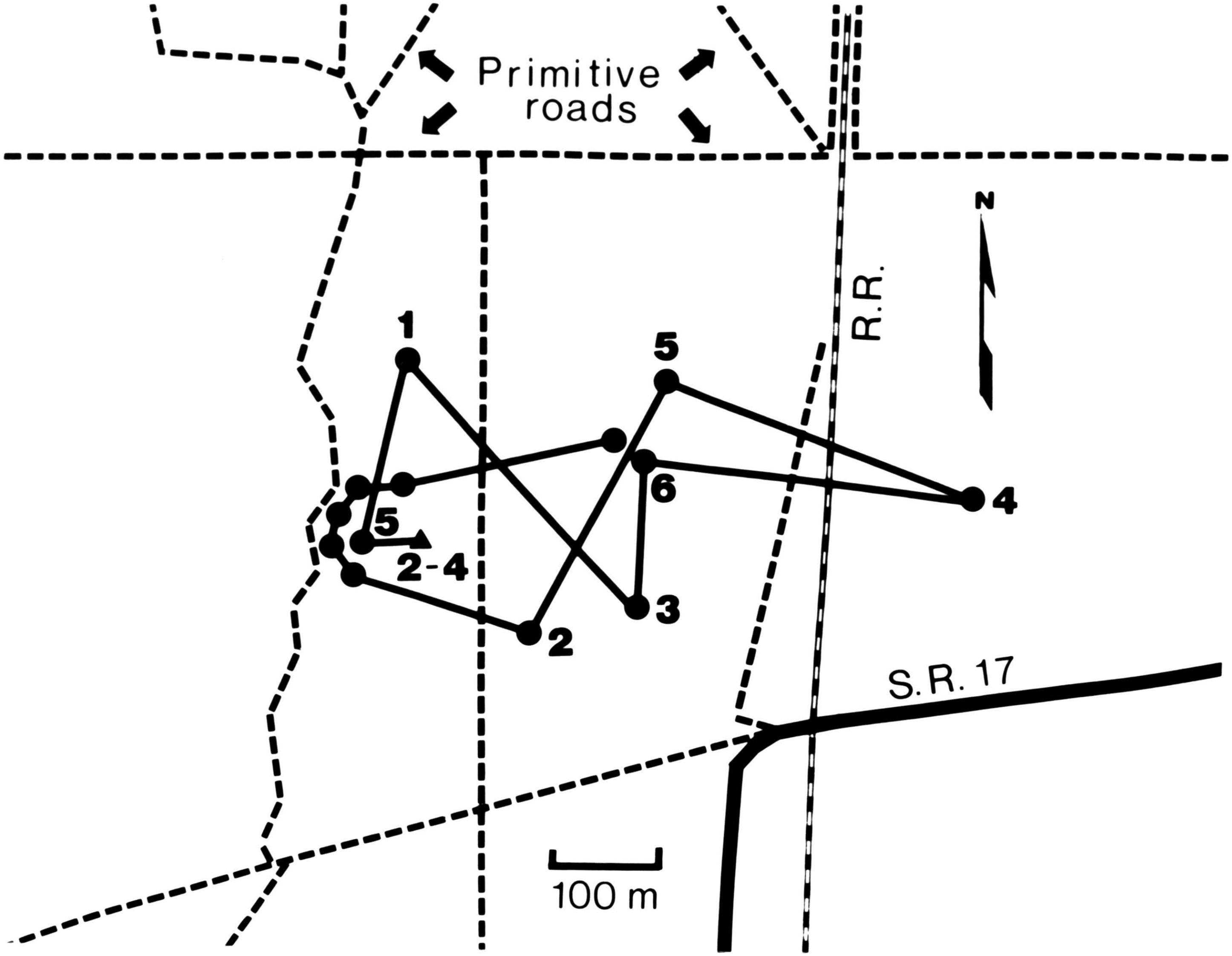

F-1
Natal den area
0
1
km
HOME RANGE:
1 Dec 80 - 8 Mar 81
1 Jul 81 - 12 Aug 81
MOVEMENTS :
(p.m. to a.m.)
8-14 APR 81
8th to 9th
9th to 10th
10th to 11th
11th to 12th
12th to 13th
13th to 14th

1981 period (Figure 10). On two afternoons, she made short circuitous trips to the nearest range boundary, and on four evenings between 1800 and 0100 hours, it appeared that she made deliberate long distance movements that involved travel over most of the other portions of her formerly-established range boundary. On one of these extended excursions, she rested for about 30 min at a site 1 km from the natal den area, probably to consume a prey item, then immediately returned to the den, suggesting that such long movements to range boundary areas may be used both to hunt as well as to patrol the home range boundary.

Maximum distances moved by adult females from natal and secondary den sites during the first two months post partum usually occurred in late afternoon and at night. Because calculations of home ranges of females F-1, F-9, and F-11 with newborn young during the period of 1 May to 19 July 1980 were based largely on radio-locations during morning and afternoon, their observed home ranges during this interval are assumed to be underestimates (Table 4) of the areas actually used.

During the period from birth to 1 1/2 to 2 months, the adult apparently carried the kittens short distances to new rest sites every 1 to 6 days, as no kitten tracks were ever observed where adults crossed sand roads between consecutive known sites. The best example of this pattern of rest-site shifting was obtained for F-9 (Figure 12) during the first 30 days after the birth of her April 1980 litter. Eight sites were used during the first month, each site being used an average of 4 (range 1-6) days. Mean and extreme distances moved between sites were 0.3 km and 0.1 to 0.4 km, respectively. The total area within the polygon defined by the perimeter rest sites was about 0.4 km^2. At least six other sites in the immediate vicinity were used during the second month after the birth of the litter. The semi-tame female (F-1) also

Figure 12. Pattern of den site occupancy by a female (F-9) following birth of her litter in April 1980. Key to symbols: triangle = natal den site, numbered solid dots = secondary den sites used the first month and number of days spent at each site based on daytime resting locations of the adult, unnumbered dots = presumed secondary den sites on 6 days during the second month following the birth of the litter.


Primitive roads
N
R.R.
1
5
6
4
5
2-4
3
2
S.R. 17
100 m

moved her litters about in a similar fashion. For example, at least six sites were used during the first 51 days after the birth of her May 1980 litter. All sites were within an area of about 0.3 km^2. She apparently made her first long distance movement (1.8 km) with the kittens on 22 June in response to disturbance by farm machinery in the immediate area of the rest site used during the preceding few days.

Adults with kittens ranging from about 2 to 4 months old also used rest sites for periods of 1-6 days. However, the rest sites during this period tended to be more generally dispersed throughout the adult's range. During times of the diel period when the adult was active, the kittens accompanied her on short excursions in the vicinity of the rest site. They also apparently explored the area of the rest site on their own. Females with kittens over 2 months of age were occasionally observed carrying food to the rest site area, suggesting that weaning was in progress or had occurred. The family usually traveled between rest sites with the mother in the lead and the kittens following single-file. During this period the adults continued to make independent excursions along the boundary areas of their range. The adult occasionally used a rest site separate from that of the kittens. In some instances, the adult rest site was on the opposite side of the range from that of the young.

During the third phase of movements, the females continued independent movements throughout their ranges but were also frequently accompanied by kittens when traveling their range boundaries. The adults continued to occasionally rest separately from the kittens. When adults were not present, kittens would make independent excursions around the general area of the rest site. On several occasions when she had kittens 5 months of age or older, F-1 was recorded (visual observations, tracking) travelling without her full litter, indicating that litter members of this age may not remain in the same area while the female is away and may rest separately from one another. During the 5 to 7 month age range, kittens traveling with the mother frequently walked abreast or preceded her along the route. Movement of the family group in a line abreast may be indicative of cooperative hunting. Signs of apparent play were most noticeable during this period. Tracks indicated that running, skidding, scraping occasionally with the hind feet was most often involved. Based on tracking, one young would frequently move ahead of others along a travel route and lie in "ambush" to attack the others. Females apparently also participated in such play. D. Guenther (personal communication) actually observed such a play bout at night on 16 September 1979. Female F-1 with her three young about 5 1/2 months old were watched for about 20 minutes in the light of vehicle headlights as they engaged in mock attacks on each other. The juveniles were intent on ambushing one another, one jumping on the back of another from behind a bush as it walked past. The attacks were usually followed by a short chase, with either the animal attacked or the attacker being the pursuer. The mother was occasionally jumped on by a juvenile and would then chase her attacker. The family moved slowly along as they engaged in this play. During this phase of the mother-young association, some kittens came in contact with adult males. Radio telemetry, trailing, and sightings indicated that F-1's litters made occasional contact with resident males from their fifth month until they dispersed.

The fourth phase of family movement patterns was characterized by more frequent and longer movements of the juveniles. Rest areas were used for only up to a few days, and successive sites were often located on opposite sides of the range. All members of the family group frequently traveled throughout all parts of the range. Juveniles also wandered about more on their own, their individual rest sites being up to 0.5 km apart. On several occasions when her older young were resting at scattered sites, F-1 was radio-tracked as she moved through the area near one or more of the sites, beginning alone and ending up with the litter following her. On 6 July 1981, L. Saul (personal communication) heard F-1 giving repeated sheep-like "m-a-a" vocalizations in response to which three of four young appeared and followed her as she left the area. The adult gave 23 calls in about 2 min. The vocalizations were distinctly audible from a distance of about 60 m. These observations suggest that mothers may "round-up" scattered older juveniles by moving from one rest area to another and "calling" the young. On occasion, when a mother was moving about the range with some of her young, others would be located in a distant part of the range. Such instances became increasingly frequent as the young neared the age of dispersal. When young 8 to 11 months old were still in the natal range, contact with the mother appeared to become increasingly infrequent.

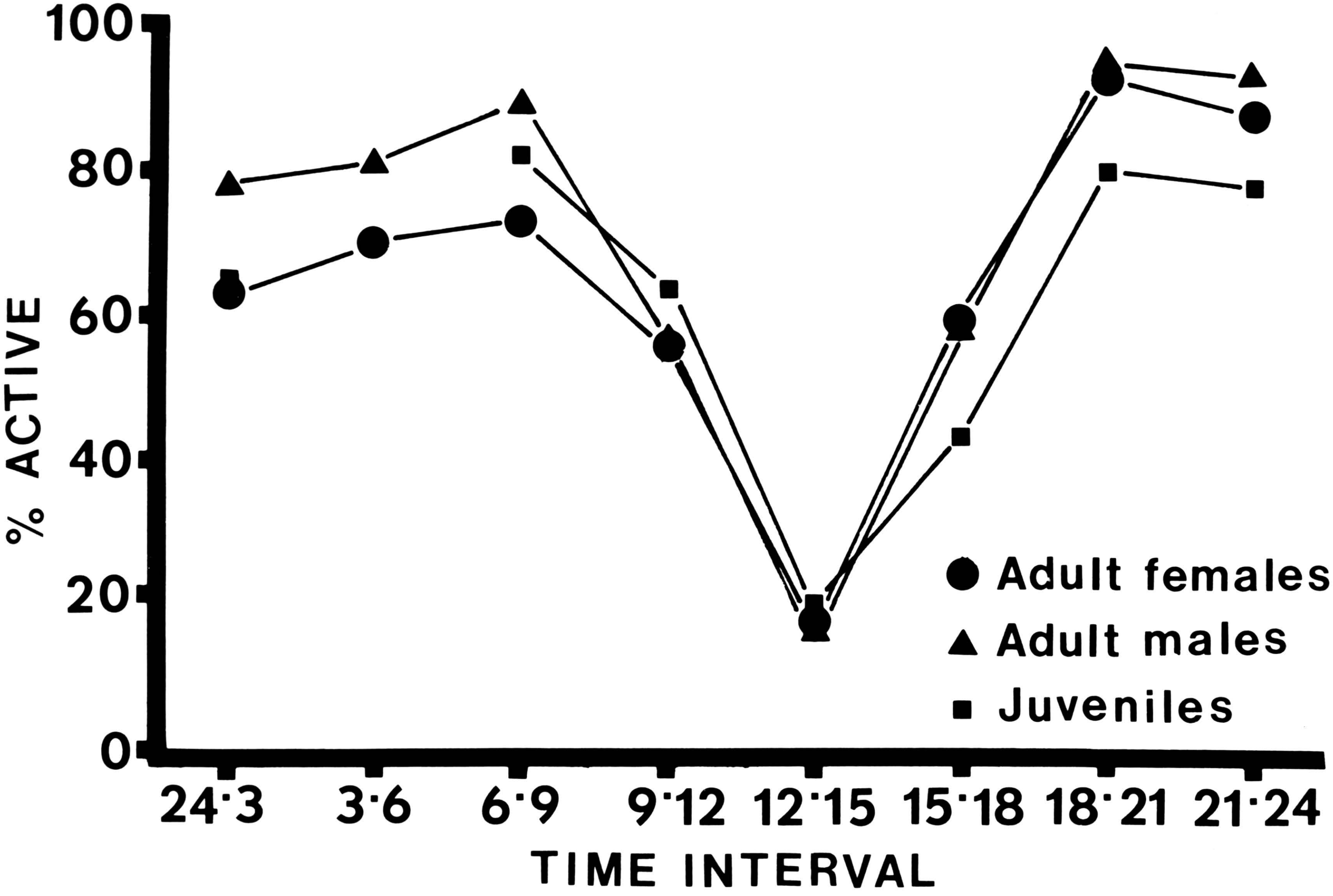
Few data were obtained on dispersal and establishment of home ranges by juveniles of the population but it is believed that most moved out of the study area. However, one probable case of a male (M-6) and female (F-8) of the same litter becoming established as consorts in the natal range was recorded. These presumed young of F-3 apparently remained in the mother's range after the deaths of the overlapping adult males and apparent abandonment of the range by F-3. With time, both individuals greatly extended their movements beyond the presumed natal range. The female had litters in spring 1980 and 1981. Two offspring of the semi-tame female (F-1) may have temporarily restricted their movements such that they used portions of the opposite ends of the natal range for a brief period prior to their dispersal.

Activity

Diel activity patterns of adult and juvenile bobcats based on 4966 locations classified as active (= moving) or inactive (= resting) are shown in Figure 13. Sample sizes for adult males, adult females, and juveniles were 1716, 2859, and 391, respectively. Juvenile records were not obtained during summer months or for the time period 0300-0600 hours in other seasons. However, for the combined data each sex and age group had about the same proportion of observations for each time interval.

The data indicate that the bobcats were primarily crepuscular and nocturnal in their activity but were not infrequently active during the daylight hours. Greatest activity occurred between 1800 and 2400 hours and least activity between 1200 and 1500 hours, with 91 percent of the locations during the first interval representing moving individuals compared with 17 percent during the second. There is some suggestion of a reduction in activity between midnight and 0300 hours (68% of locations active) followed by a slight increase from 0300 to 0900 hours (78% of locations active). There are no marked differences in the activity curves of adult males, adult females, and juveniles in the combined data for all seasons.

Figure 13. Overall diel activity patterns of adult and juvenile bobcats based on data for all seasons combined from April 1979 to December 1981.


100
80
60
40
20
0
% ACTIVE
24·3
3·6
6·9
9·12
12·15
15·18
18·21
21·24
TIME INTERVAL
● Adult females
▲ Adult males
■ Juveniles

Adult male activity in different seasons is shown in Figure 14. The data suggest that in summer males tend to rest more during the daylight hours than in other seasons. The higher frequency of inactive locations between 0900 and 1500 hours during summer (June-August) compared with other seasons is significant ($X^2 = 30.44^{**}$, d.f. = 1).

Seasonal activity curves of females (Figure 15) suggest that females are less active from 0300-0900 during the period March to May and from 0900 to 1500 hours in the interval from June to August than during the corresponding times in other seasons. The differences between frequencies of active locations in these time periods and seasons compared with the respective periods in other seasons are significant (0300-0900:$X^2 = 4.26^{*}$, d.f. = 1; 0900-1500: $X^2 = 25.68^{**}$, d.f. = 1). Most of the adult females monitored from March to August were associated with young, and the differences between their activity patterns and those of adult males during spring and summer may reflect that fact. The differences between the adult female spring and summer curves may be related to differing demands of the young during these periods. Females with young kittens in spring may spend more time nursing during the late night-early morning hours, whereas in summer when the young are older the mother may be forced to spend more time hunting during midday to satisfy the increased energetic demands of the family unit. This explanation of the shifts in the female activity pattern between the March-May and the June-August periods is supported by data for the semi-tame female (Figure 16). During the first month following the birth of a litter in spring, she was clearly less active from 0300 to 0900 hours than she was when the young were 4 to 5 months old and eating solid food. Tracking data indicated that

Figure 14. Composite diel activity patterns of six adult male bobcats during different seasons over the period April 1979 to December 1981. Number of observations each season = December - February, 329; March - May, 355; June - August, 389; September - November, 643.

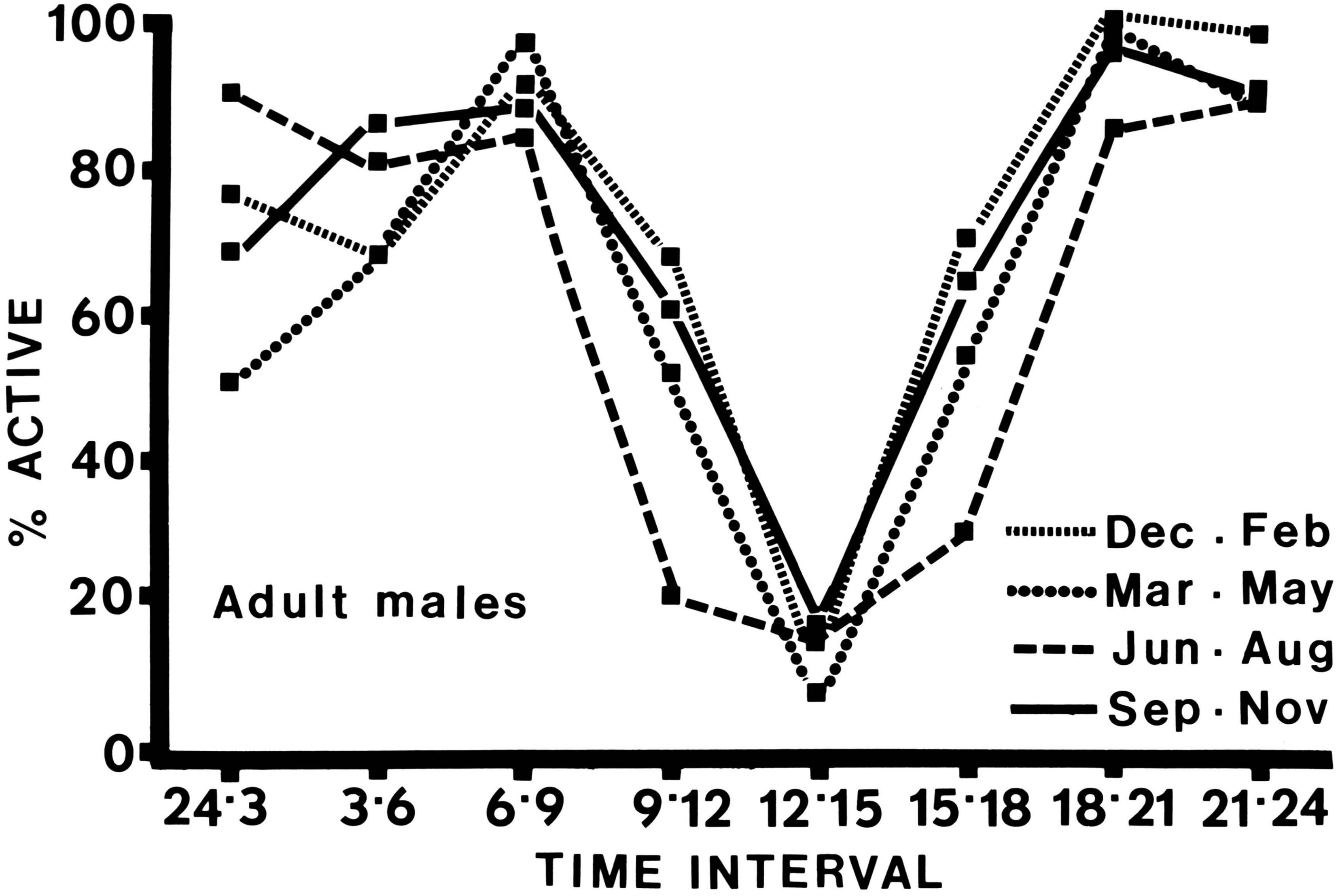

100
80
60
40
20
0
% ACTIVE
Adult males
Dec . Feb
Mar . May
Jun . Aug
Sep . Nov
24·3
3·6
6·9
9·12
12·15
15·18
18·21
21·24
TIME INTERVAL

Figure 15. Composite diel activity patterns of seven adult female bobcats during different seasons over the period April 1979 to December 1981. Number of observations each season = December - February, 647; March - May, 694; June - August, 812; September - November, 706.

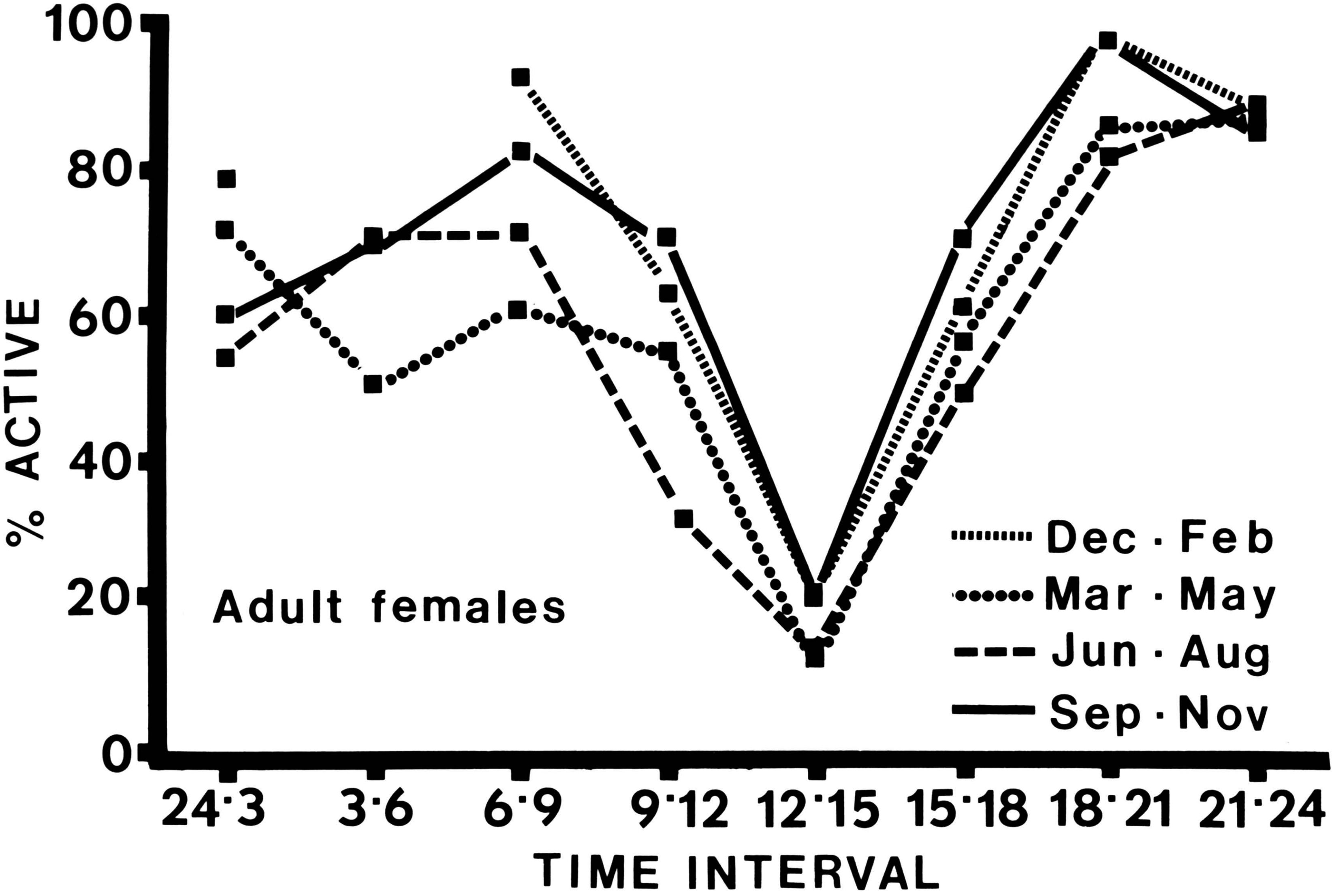
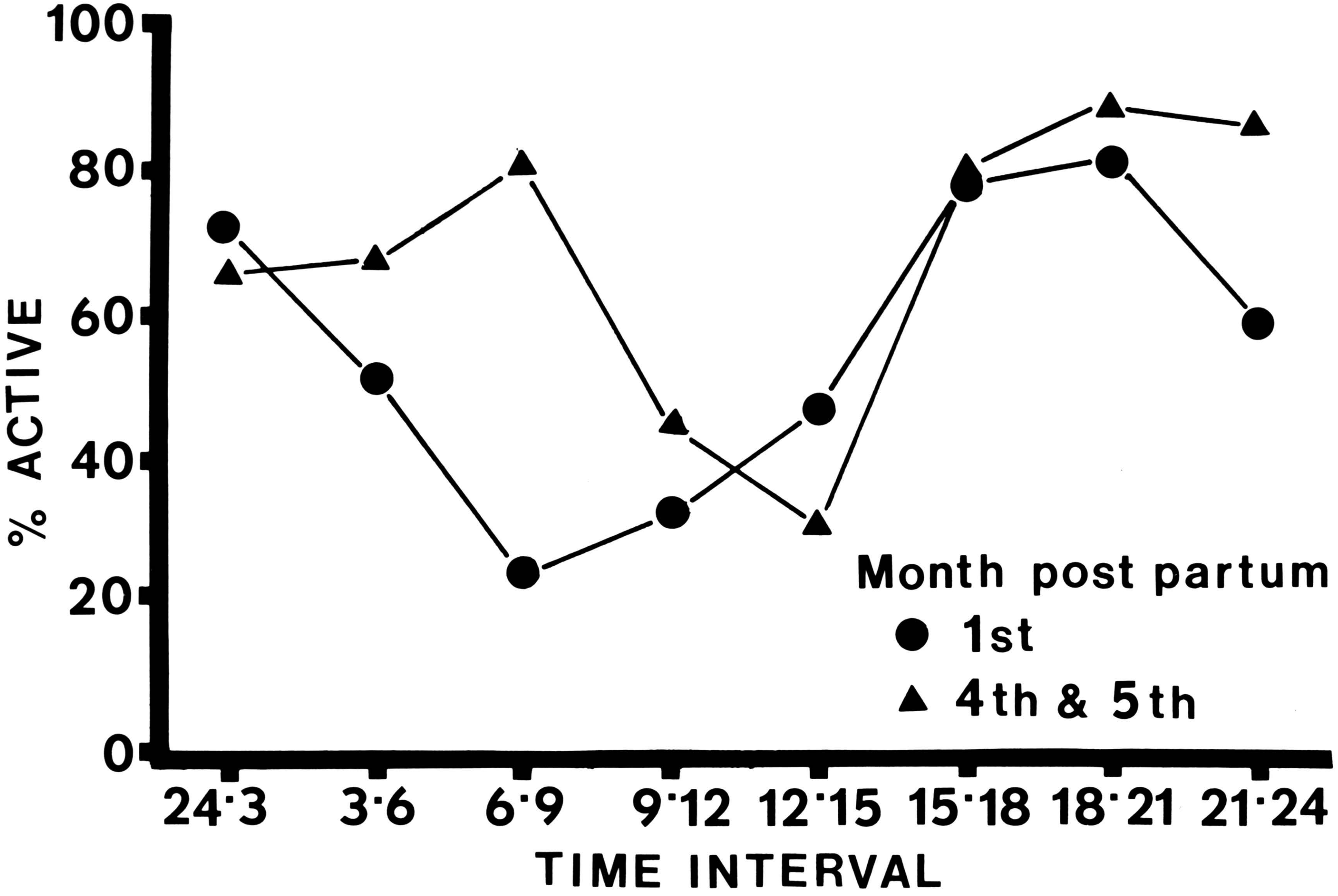

100
80
60
40
20
0
% ACTIVE
Adult females
Dec · Feb
Mar · May
Jun · Aug
Sep · Nov
24·3
3·6
6·9
9·12
12·15
15·18
18·21
21·24
TIME INTERVAL

Figure 16. Composite diel activity patterns of an adult female bobcat (F-1) during the first and fourth and fifth months after birth of a litter. Number of observations = 347.


100
80
60
40
20
0
% ACTIVE
24·3
3·6
6·9
9·12
12·15
15·18
18·21
21·24
TIME INTERVAL
Month post partum
● 1st
▲ 4th & 5th

the female usually rested with or very near young during their first month. Even though this semi-tame female was occasionally artificially provisioned, she often became much thinner when her kittens were 3 to 7 months old, providing support for the supposition that mothers with older young may have to hunt more during the day to provide enough food for the family.

Habitat Utilization

The proportions of habitat types in the area of all lifetime home ranges combined and percentages of habitats in individual home ranges are given in Table 5. The home ranges of all bobcats except two adult females (F-10, F-11) and one juvenile male (M-9) isolated from the main cluster of animals in the core area contained each of the eight habitat types recognized. Closed canopy xeric pine-oak habitat was not present in the ranges of the two females, and one of them (F-11) also had no man-occupied areas within her range. The juvenile range lacked closed canopy xeric pine-oak habitat and citrus groves or tree nurseries.

Xeric pine-oak habitats were the best-represented natural habitats in bobcat home ranges. The average proportion of the closed canopy phase contained within individual ranges was double its relative abundance on the study area as a whole. Although most habitats were found in all ranges, their proportions in different ranges were highly variable. In general, the relative amounts of a given habitat seemed to vary less among adult male ranges than among adult female ranges. Adult male ranges also appeared to contain proportionately more man-modified and less natural habitat than did

Table 5. Percentage distribution of habitat types within lifetime home ranges of five adult males, seven adult females, and five juveniles. Habitat abbreviations as follows: XO = xeric pine-oak, open canopy; XC = xeric pine-oak, closed canopy; FW = flatwoods; BH = bayhead; CN = citrus grove and tree nursery; IP = improved pasture; OF = old field; MO = man-occupied. Percentages of each habitat type in the area containing all bobcat ranges listed below habitat headings in parentheses.

		Natural					Man-modified				
Individual	Number of locations	XO (26.6)	XC (4.0)	FW (19.8)	BH (8.9)	Total (59.3)	CN (14.9)	IP (13.5)	OF (9.6)	MO (2.7)	Total (40.7)
Adult males											
M-1	358	29.1	13.4	22.5	4.4	69.5	8.4	12.2	8.4	1.6	30.5
M-2	150	30.0	4.9	17.5	14.0	66.5	19.1	5.5	5.5	3.4	33.5
M-3	116	24.5	14.1	6.4	5.9	50.9	40.1	0.7	6.6	1.6	49.1
M-6	422	26.5	13.0	6.9	3.3	49.7	37.7	2.6	6.8	3.1	50.3
M-8	367	22.8	1.5	29.2	7.1	60.5	0.7	28.0	10.6	0.2	39.5
Mean		26.6	9.4	16.5	6.9	59.4	21.2	9.8	7.6	2.0	40.6
Adult females											
F-1	581	34.1	3.7	27.3	2.9	68.0	1.7	16.5	13.5	0.3	32.0
F-3	167	14.0	43.5	9.7	0.7	67.9	21.7	1.3	2.2	6.8	32.1
F-4	518	31.8	2.1	22.9	11.9	68.7	17.4	5.7	6.2	2.0	31.3
F-8	430	21.6	28.4	10.0	4.6	64.6	24.8	1.4	5.9	3.2	35.4
F-9	403	44.8	0.9	22.7	0.7	69.0	10.7	11.1	6.0	3.2	31.0
F-10	34	34.3	-	26.9	12.1	73.3	1.8	11.9	11.4	1.6	26.7
F-11	154	13.5	-	35.1	16.7	65.3	5.7	4.4	24.6	-	34.7
Mean		27.2	11.2	22.1	7.1	68.1	12.0	7.5	10.0	2.4	31.9
Juveniles											
M-4	163	37.6	4.6	34.4	4.2	80.7	2.5	12.6	3.7	0.6	19.3
M-5	19	12.3	62.7	6.6	0.9	82.5	10.0	0.2	4.7	2.6	17.5
M-9	19	9.2	-	8.2	39.0	56.4	-	27.9	0.9	14.8	43.6
F-5	51	38.1	3.7	36.3	4.6	82.6	1.0	12.0	3.7	0.6	17.4
F-6	100	37.0	3.4	35.9	4.3	80.6	0.6	13.7	4.5	0.6	19.4
Mean		26.8	14.9	24.3	10.6	76.6	2.8	13.3	3.5	3.7	23.4

the ranges of adult females, the difference approaching the level of significance ($U_{5,7} = 8$, $P = 0.07$, 1-tailed).

The portions of the mothers' home ranges in which juveniles were radio-tracked contained a significantly ($U_{5,7} = 7^*$, 1-tailed) greater proportion of natural habitat than the observed lifetime ranges of the females. This is particularly well demostrated in the ranges of juveniles M-4, F-5, and F-6, who were the young of the semi-tame female (F-1). It should be emphasized that a tendency to avoid man-modified habitats is not necessarily constant for females with young or even the same female with different litters. For example, on a later occasion when F-1 had an unmarked litter her range had changed to include a large area of old field and improved pasture habitats, and it appeared that she regularly visited the old field with her young.

Ratios of the proportion of observed locations in a given habitat to the proportion of that habitat in the home range, an index of relative intensity of use (= "preference") of different habitats, show that most individuals did not utilize habitats in their ranges in direct proportion to their availability (Table 6). There were no consistent trends in intensity of use of particular habitats among the cats, one individual showing disproportionately high use of one habitat and low use of another with another individual showing the reverse. However, there was an overall tendency for relatively more intense use of natural compared to man-modified habitats. Although adult males had proportionately less natural habitat area within their home ranges than did females, they averaged more intensive use of it. Both sexes tended to use open canopy xeric pine-oak habitats less intensively

Table 6. Ratios of proportions of locations in various habitat types to the proportions of the respective habitats in the lifetime home ranges of individual bobcats. Abbreviations of habitat types as in Table 5.

	Natural					Man-modified				
Individual	XO	XC	FW	BH	Total	CN	IP	OF	MO	Total
Adult males										
M-1**	1.18	0.85	1.34	1.28	1.18	0.12	0.84	0.60	1.16	0.60
M-2**	1.07	0.59	1.17	1.06	1.06	0.55	1.21	1.17	1.72	0.88
M-3**	0.73	1.80	1.51	1.99	1.28	0.53	5.46	0.87	2.52	0.73
M-6**	0.58	2.90	1.62	1.42	1.39	0.49	1.56	0.69	1.25	0.62
M-8**	1.38	2.80	1.16	1.03	1.27	0.19	0.47	0.80	5.58	0.59
Mean	0.99	1.79	1.36	1.36	1.23	0.38	1.98	0.83	2.45	0.68
Adult females										
F-1**	0.99	2.76	1.20	1.63	1.22	0.33	0.30	0.50	13.23	0.52
F-3**	0.50	1.66	0.33	0.31	1.22	0.52	0.09	0.67	0.54	0.54
F-4**	0.90	0.76	0.90	1.88	1.06	0.78	0.60	0.85	2.27	0.86
F-8**	0.68	1.81	1.10	1.36	1.29	0.28	2.31	0.39	1.27	0.47
F-9**	1.26	0.98	1.22	1.24	1.24	0.31	0.57	0.67	0.18	0.46
F-10	0.80	-	1.08	0.61	0.88	1.08	0.62	2.23	0.02	1.34
F-11**	0.42	-	0.95	0.71	0.78	0.76	0.55	1.73	-	1.42
Mean	0.79	1.59	0.97	1.11	1.10	0.58	0.71	1.01	2.92	0.80
Juveniles										
M-4*	0.85	3.61	1.05	0.52	1.07	0.12	0.33	0.45	12.65	0.69
M-5	1.24	0.95	0.80	0.01	0.95	0.93	0.01	2.07	1.01	1.25
M-9**	1.15	-	0.64	1.08	1.03	-	0.38	21.67	0.89	0.97
F-5*	0.98	2.47	0.94	0.75	1.02	0.01	0.61	9.44	10.89	0.91
F-6**	0.65	2.86	0.99	3.04	1.01	0.02	0.66	0.85	2.86	0.92
Mean	0.97	2.47	0.88	1.08	1.02	0.27	0.40	5.10	5.67	0.95

* Differences in observed and expected frequencies of locations significant at the 0.05 level on basis of G-statistic

** Differences in observed and expected frequencies of locations significant at the 0.01 level on basis of G-statistic than other natural habitats. Among man-modified habitats, adult males used improved pastures more heavily than did females, the difference being significant ($U_{5,7} = 7^*$, 1-tailed).

Except for the unusually high frequency of the semi-tame female in the vicinity of the dwelling where it was fed, females were associated with man-occupied habitats less than males. It should be noted, however, that the ratios of use of man-occupied habitats probably indicate somewhat higher utilization than was actually the case. This is because man-occupied areas were usually small and thus generally were included in quadrats with other habitat types. As a result of the method of calculating habitat use, man-occupied habitat frequently received partial credit for locations falling in quadrats also containing other habitats. Thus, in calculating the ratios, a few locations in a relatively small area of the range that contained man-modified habitats would result in an exaggerated "importance" value.

The juveniles showed more intensive use of certain habitat types than did adults. For example, only one adult (M-6) had a ratio over 3 for use of any habitat, whereas four out of the five juveniles had one or more ratios of habitat use ranging from 3.04 to 21.67. Two (M-4, F-5) of the five juveniles showed unusually intense association with man-occupied habitats. These were kittens of the semi-tame female, and their high use of the man-occupied category reflects their visitations to the dwelling in company with their mother until about 8 months of age. F-6 was also a member of this litter, and her relatively lower association with man-modified habitats is explained by the fact that most of the data on her movements were obtained when the young were older and less frequently accompanied the mother to the dwelling. The most intensive use ratio (21.67) for a given habitat by any cat was that of juvenile M-9 in old field. The range of this individual, which was probably still with the mother, was isolated from the groups of cats in the core area that was studied most intensively (Figure 1). The extensive association with old field habitat by this individual may have been due to the presence of a poultry yard in the area.

Females used thick patches of saw palmettos or dense shrub thickets as natal den sites and preferred rest sites when accompanied by young. Adult males and females without young also tended to use areas of dense vegetation for resting.

Although radio tracking alone was seldom accurate enough to delineate the exact travel routes of individuals being monitored, a combination of radio tracking plus tracking on foot, the placement of scats and scrapes, and occasional visual observations indicated that bobcats generally moved about their home ranges along roads, footpaths, animal trails, or railroad tracks or followed natural openings through the vegetation rather than bushwacking through dense cover. They also hunted along these routes, but usually carried prey into dense cover to consume it.

Marking Behavior

Classification of Marking Behavior

Bobcats, and other felids as well, perform several actions involving odor and/or visual cues that serve to advertise their presence and thus potentially function as a form of communication among conspecifics. These actions are here termed "marking behavior," although admittedly their function is not well understood. One of the objectives of this study was to obtain further insight into the role of such behavior in the social organization of bobcat populations.

The three major types of marking behavior recognized were as follows:

1) Scrapes - distinctive elongate ruts or "ploughed" areas with "spoil" piled at the rear made in the soil or litter by alternate rearward thrusts of the hind feet with the body in a semi-squatting position. Usually either feces or urine, but apparently not both, are deposited in the scrape. Depending upon whether they contained feces, urine, or neither, scrapes were designated as fecal scrapes, urine scrapes, or empty scrapes. Of 863 fresh (less than 2 days old) scrapes examined, 42.1 percent (363) contained feces, 56.5 percent (488) contained urine, and 1.4 percent (12) were empty. Scrapes are made by both adult males and females. Older juveniles still associated with the mother scrape mark in conjunction with scrape-marking by the mother and also independently. A male and female of a litter of the semi-tame female began fecal scraping when about five months old, at which age the young began to accompany the mother to the periphery of her range. Observations indicated that when the young were smaller the mother and young tended to bury their feces in a common site when they were in the vicinity of a rest area. Deposits of buried feces were also found in the vicinity of a rest site of another female with small kittens.

2) Urine marking - deposition of urine onto the substrate or

objects on the ground from a squatting position (squat-urination) or spraying it on above-ground objects from an upright posture (spray-urination) without construction of a scrape. Among adults, only female bobcats were observed squat-urinating without first scraping. A juvenile of unknown sex about 5-6 months old was also recorded squat-urinating without scraping. Observations of individuals and examination of tracks and sign showed that squat-urinating individuals could direct the urine to a given spot by swiveling their hips and without breaking their stride. In spray-urinating, the cats directed their rear end toward the object, occasionally slightly lifting the hind leg on that side.

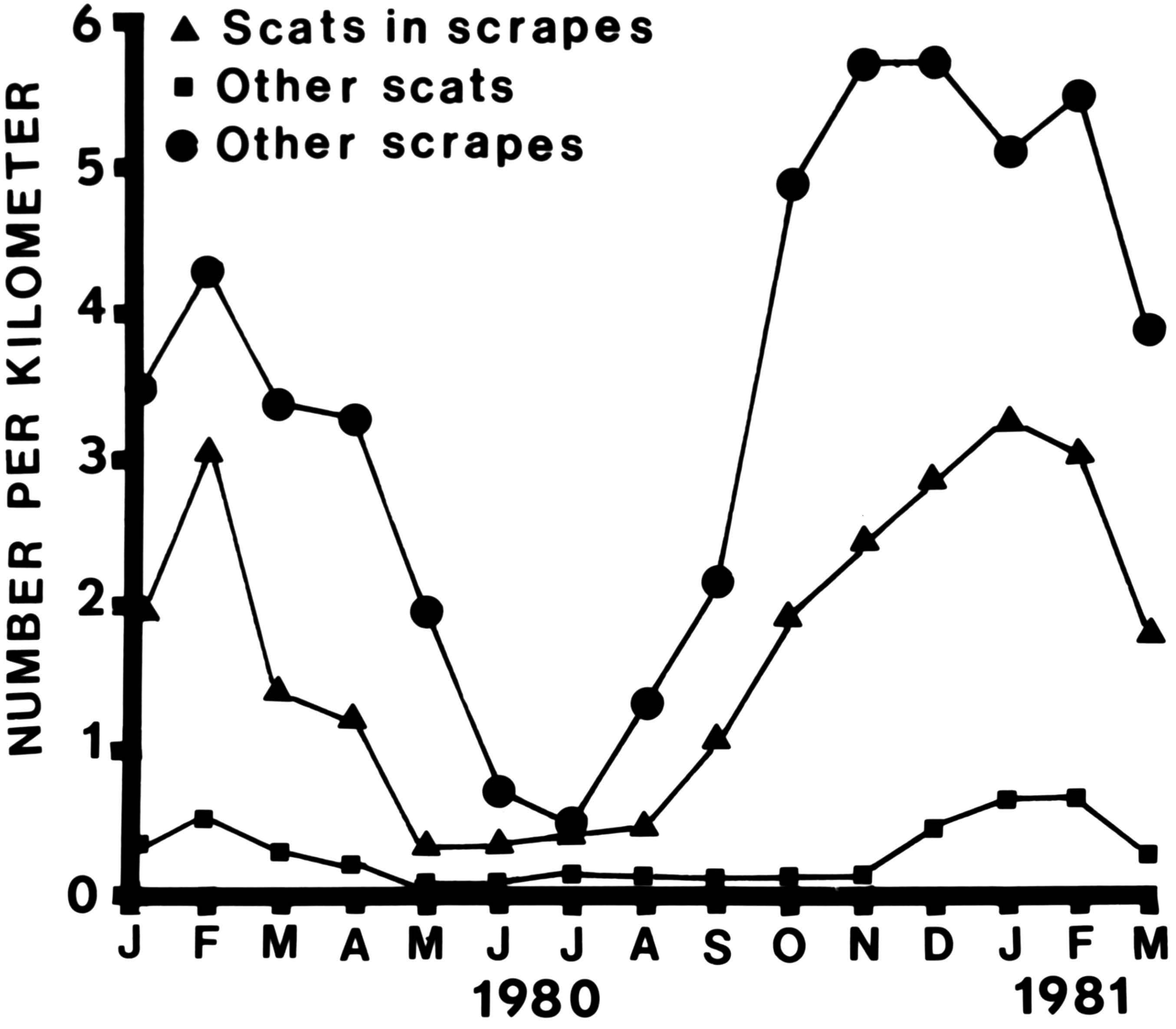
3) Scat marking - deposition of scats, without scraping, which are left exposed. Deposition sites are usually in places such as paths, bare patches of ground, or mounds where they are conspicuous. Sometimes large numbers of scats accumulate at a particular site. This type of mark is less frequent than fecal scrapes.

Scratches made on trees by bobcats scratching their claws may also have a communicatory as well as a maintenance function. Only two such "scratching posts" were encountered in the study area. One of these, a dead stub, was regularly used by the semi-tame female when loafing in the yard of the cottage at which she was fed.

Seasonal Variation in Marking Behavior

Monthly censuses of exposed scats and scrapes along prescribed routes from January 1980 through April 1981 revealed pronounced seasonal variation in marking behavior (Figure 17). Although the three

Figure 17. Seasonal and yearly variation in frequency of bobcat marking behavior from January 1980 to March 1981.


▲ Scats in scrapes
■ Other scats
● Other scrapes
NUMBER PER KILOMETER
0
1
2
3
4
5
6
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
1980
1981

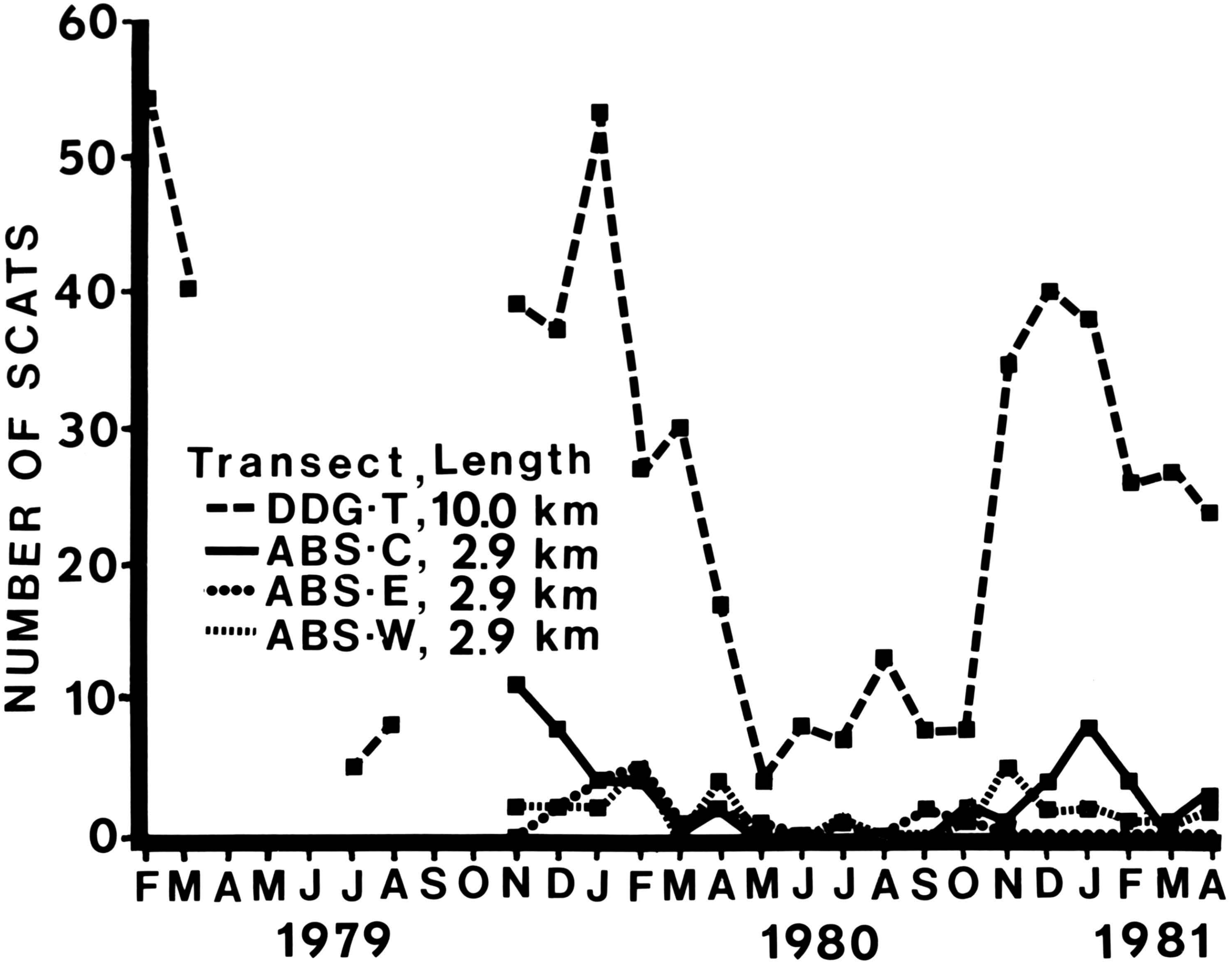
categories of marks - fecal scrapes, other scrapes (presumably mostly urine scrapes), and exposed scats without scrapes - exhibited parallel trends, "other scrapes" showed the most dramatic seasonal fluctuations, with a peak from November through February and lowest level in June and July. The data, particularly counts of scrapes without scats, for the two years suggest a higher incidence of marking activity in winter of 1981 than the previous year.

Numbers of exposed scats along the 10 km census route and the individual scent-post transects established by Guenther (Figure 18) showed trends reasonably similar to those of the combined census routes. However, in contrast to the combined data in Figure 17, counts on the 10 km census line and two of the three scent post transects indicated a higher incidence of marking in winter 1979-80 than in 1980-81.

Spatial Patterns of Marking Behavior

The relationship of marking behavior to the spatial organization of the population was intensively studied from 23 October to 19 December 1979 in the northern portion of the core area (Figure 1) which contained the ranges of two adult males (M-1, M-3) and three adult females (F-1, F-3, F-4). These individuals were closely monitored by radio-tracking and trailing; and the exact locations of scats, scrapes, and urine marking sites recorded during censuses were plotted on maps of home ranges. The death in late October of an adjoining male (M-2) resulted in some readjustment of the home range boundaries of the males but by mid-November their ranges had stabilized.

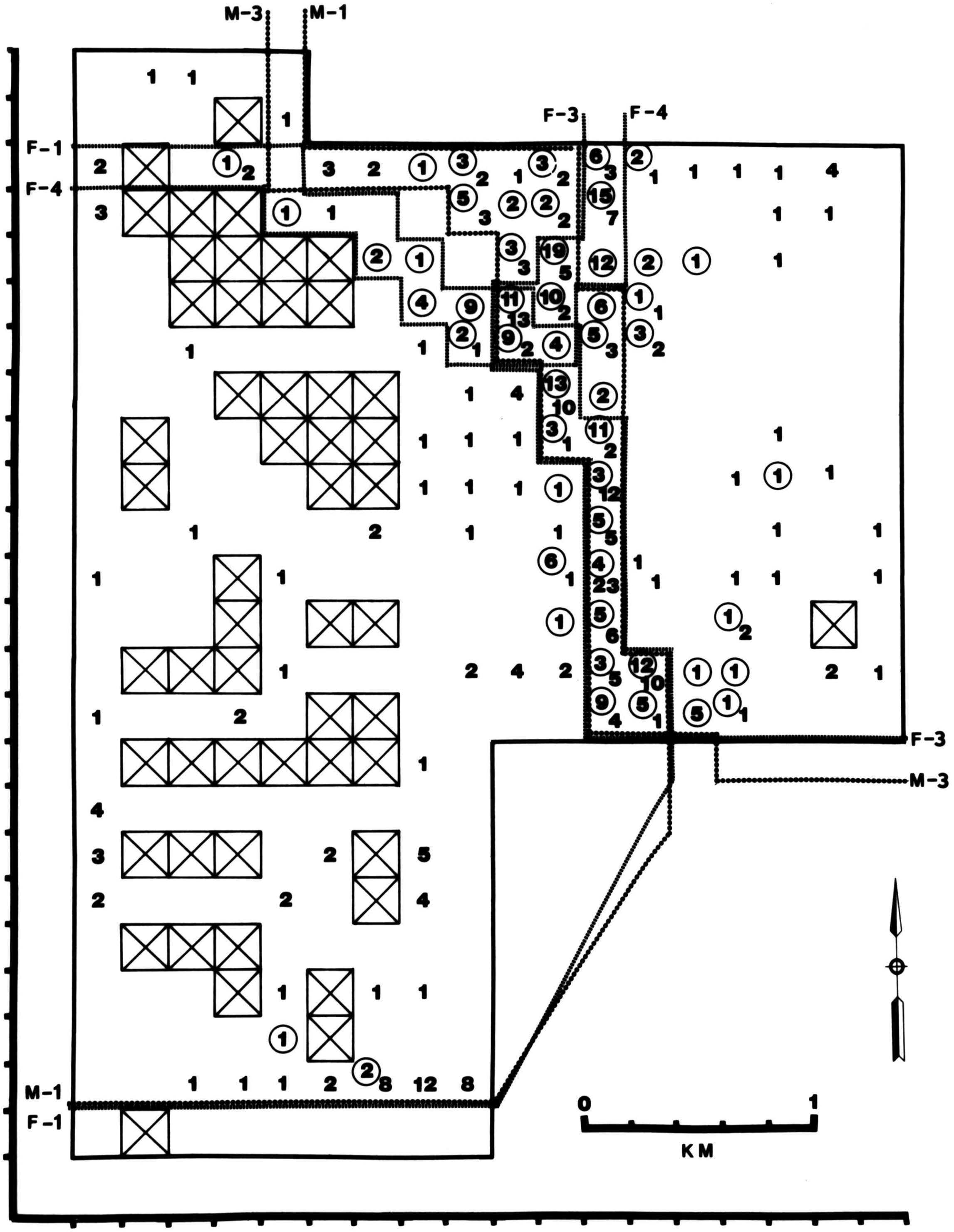
Figure 18. Number of bobcat scats per km on four standard census transects from February 1979 through April 1981.


NUMBER OF SCATS
0
10
20
30
40
50
60
Transect, Length
DDG·T, 10.0 km
ABS·C, 2.9 km
ABS·E, 2.9 km
ABS·W, 2.9 km
F M A M J J A S O N D J F M A M J J A S O N D J F M A
1979
1980
1981

The home range boundaries of the five bobcats and distribution of scats, fecal scrapes, urine scrapes, and presumed urine scrapes in 4-ha quadrats are shown somewhat diagrammatically in Figure 19. It is readily apparent that marking was concentrated along home range boundaries, this relationship being particularly obvious in the case of known and presumed urine scrapes. Segments of scat and scrape census routes were contained in 273 of the 325 4-ha quadrats within the represented area. Sixty of the quadrats with census routes contained segments of home range boundaries and 213 were located in the interior of home ranges. Eighty-five percent (51) of the quadrats with home range boundary segments contained scats or scrapes as opposed to only 31 percent (67) of those in the interiors of ranges, a significant difference ($X^2 = 54.38^{**}$, d.f. = 1). Home range boundary quadrats contained 88 percent (219) of the 248 urine or presumed urine scrapes and 65 percent (173) of the 265 fecal scrapes or isolated scats recorded.

Similar relationships between home range boundaries and marking sites were found in other seasons. For example, the same area was thoroughly searched for scats and scrapes in July 1980, and 22 scats and 55 non-fecal scrapes estimated to be not over two months old were recorded. Fourteen (64%) of the scats and 50 (91%) of the known and presumed urine scrapes were in quadrats that also contained home range boundaries. Four of the five remaining urine scrapes were located near two rest sites used by two females with non-mobile kittens. In fall and winter 1980-81, there was a shift in the focus of marking activity which correlated with a change in the location of boundaries of home ranges.

Figure 19. Semi-diagrammatic map of the north end of the core study area showing locations of home range boundaries of two adult males (M-1, M-3) and three adult females (F-1, F-3, F-4) and frequency of scats and presumed urine scrapes (circled) per 4-ha quadrat during the period 23 October to 19 December 1979.


M-3
M-1
F-3
F-4
F-1
F-4
F-3
M-3
M-1
F-1
0
1
KM

DISCUSSION

Comparisons With Other Studies

Trapping Success

The overall success rate (1.5 captures per 100 TN) for the combined live-trapping of Guenther's (1980) and the present study is generally comparable to values, based on various types of trapping, reported by other investigators in southeastern United States. Lueth (1962) summarized the results of six years of steel jaw trapping on 19 management areas in Alabama. On the 12 areas where bobcats were captured, success rates based on combined yearly trapping data ranged from 0.02 to 0.16 captures per 100 TN with an overall average of 0.10. Miller (1980) caught 1.03 bobcats per 100 TN with mixed box and jaw traps on two nearby hunting preserves in Alabama. Kight (1962) reported on eight years of steel jaw trapping on the Savannah River Plant (SRP) in South Carolina. The mean success rate was 0.74 captures per 100 TN, yearly results ranging from 0.29 to 2.0. Kitchings and Story (1979) box-trapped 0.97 bobcats per 100 TN in Tennessee. The highest mixed steel and box trap success rate (4.8 per 100 TN) reported for the southeast is that of Hall (1973) who studied bobcats at three sites in Louisiana. Trapping success rates in the southeast are generally comparable to those reported in other areas of the bobcat's range. Jones' (1977) and Lawhead's (1978) steel trap success rates at two sites in Arizona were 0.72 and 1.33 captures per 100 TN, respectively. Lembeck (1978) and Gould (1980) reported mixed leg-hold and box trap success rates of 1.02 and 1.04 captures per 100 TN for two areas in California.

Trapping efficiency comparisons must be made with caution because of the great variety of types of bait, traps, and techniques utilized by different workers that can produce differences in trap success unrelated to actual population levels. One of the factors that may potentially influence capture success in mark-and-release studies is the possible change in susceptibility to capture of a given individual related to its previous experience with traps. In the present study, trap success generally was high when new, unmarked bobcats were targeted for capture. However, previously captured bobcats often exhibited an apparent avoidance of traps. On numerous occasions marked individuals being radio-tracked or trailed walked past open traps. An exception to the generalization that new individuals were readily captured was that of the two kittens of F-1's 1980 litter who could not be trapped although, using the same traps, baits, techniques, and approximately the same level of effort, her three offspring in 1979 were captured at least twice each. In several instances, the adult appeared to be instrumental in preventing the two kittens from being captured during the period when they were from 5 to 8 months old by urinating on traps or making fecal or urine scrapes in front of traps, these marks apparently having a "warning" function. She did this most frequently after she had been captured several times. Berrie (1973) reported what seems to be similar behavior for an adult male lynx (_Lynx canadensis_) which deposited very small amounts of feces (= "tokens", Schaller 1967) in front of six traps on one night without being captured.

Population Characteristics

The estimated mean density of adults and juveniles combined (0.37 per km^2) in this study is lower than estimates derived from radio-tracking data for bobcat populations in other areas of the southeast. Miller and Speake (1978) reported from 0.77 to 1.16 bobcats per km^2 for study areas in Alabama. Provost et al. (1973) estimated the density of bobcats on the SRP, South Carolina, as 0.58 per km^2, compared to earlier estimates of 0.13 to 0.19 per km^2 (Kight 1962). Density in Virginia ranged from 0.09 to 0.18 per km^2 (Progulske 1952). Reported densities of bobcats in the southeastern United States tend to be higher than most values available for northern populations and are broadly comparable to those estimates from southwestern United States (McCord and Cardoza 1982). However, critical comparisons between published population data are not possible because of the variety of techniques and assumptions involved in density estimates by different workers.

At least two of the seven females known to have born litters during the study were less than two years of age. Breeding between the first and second years of life has been recorded in other bobcat populations (e.g. Crowe, 1975; Brittell et al. 1979; Fritts and Sealander 1978) but available data are insufficient to provide an adequate basis for geographic comparisons.

Published mean litter sizes of bobcats in different parts of the range based on observations of kittens include 2.8 (California:

Zezulak and Schwab 1979), 2.8 (Idaho: Bailey 1972), and 3.5 (Utah: Gashwiller et al. 1961). Based on these few data, mean litter size (2.5) of bobcats in south-central Florida is relatively low. Fritts (1973) reported mean litter size, based on placental scar and embryo counts, of 2.5 for bobcats in Arkansas. As litter sizes estimated from corpora lutea, placental scars, or embryos are consistently higher than those based on kitten counts, this suggests that litter size may generally be lower in southeastern than in western United States. However, the data base will have to be considerably expanded before such a trend can be confirmed or denied.

An obviously important factor besides a genetic difference that can influence estimates of litter size in a population, whether based on counts of corpora lutea, placental scars, embryos, or kittens, is the age distribution of females, assuming that females breeding for the first time may have smaller litters than older animals. In this study, litter size was lower the year following winter 1979-1980 panleukopenia epidemic than it was in the previous year (11 known young in 4 litters the first year compared with 7 known young in 4 litters the second year). In the first period all four of the females were known to be or appeared to be older animals, whereas in the second interval two of the four were first-time breeders.

One adult female in this study had four litters over a 30-month period (from approximate dates of first to last parturition), with two apparently normal litters being produced in one year (April and estimated mid-November). This appears to confirm the speculation that bobcats in the southern region of the range may occasionally have two litters per year, although one litter annually is the norm. However, since the cat in question was the semi-tame individual (F-1), who was in part artifically provisioned, the occurrence of two litters a year in wild females in the south is still in question.

Variously derived breeding season estimates in different parts of the range include February to April in 11 western states (Duke 1954), January to July or later in Utah (Gashwiler et al. 1961), January to July or later in Wyoming (Crowe 1975), December to March in Arkansas (Fritts and Sealander 1978), February to July with peaks in March and April in Alabama (Miller 1980), and November to July in Texas (Blankenship and Swank 1979). Estimated breeding dates in this study extended from September to March, with most occurring in February and March. The available data suggest that the bobcat has a highly variable breeding season over its range, with no obvious geographic trends based on extreme breeding dates.

A relatively high mortality rate was observed in the essentially unexploited population studied. Over an 1190-day period from the date of the first capture to the date of the last observed death, known loss of 9 (50%) and a probable loss of 11 (61%) of the 18 instrumented bobcats was recorded. In the marked cohort of bobcats, mortality was due to natural causes more frequently (73%) than from man-related causes (27%). Including both known and probable deaths and causes, feline panleukopenia infections killed 7 (39%) of the instrumented bobcats and notoedric mange resulted in the death of another individual. The remaining three collared individuals were killed by autos.

Lembeck (1978) and Gould (1980) reported a high natural mortality rate (18 of 40 radio-collared cats over about 1370 days) in an essentially unexploited bobcat population in San Diego County, California. Eleven (28%) of the collared cats died of natural causes (felid predation - 5, feline panleukopenia - 3, starvation - 3), four (10%) died of human-related causes, and three (7%) died of undetermined but probable natural causes. Including known and probable causes, natural factors accounted for 83 percent of the mortality of the collared individuals. Gould (1980) also reported on a second, exploited bobcat population in San Diego County in which three (21%) of 14 collared cats were harvested and one (7%) died of old age (12 1/2 years). Thus, 75 percent of mortality in this population was human-related. Miller (1980) reported that 8 (40%) of 20 radio-collared Alabama bobcats in two exploited populations died, 63 percent (5 cats) of the mortality resulting from trapping or shooting and 37 percent (3 cats) from unknown causes.

Other investigators (e.g. Bailey 1972, Berg 1979) have recorded deaths of bobcats by various natural and human related mortality agents but did not distinguish between radio-collared and non radio-collared cats in reporting their data. It is difficult to critically assess the relative importance of various mortality factors for other than radio-collared bobcats because of the biases involved in collecting observations for comparisons. In the case of unmarked bobcats, the probability of recovering animals dying from man-related causes is much higher than that of finding animals that have died from natural mortality agents. In the present study, five uncollared bobcats were known to have died from man-related causes (killed on roads, shooting, predation by dogs). Inclusion of these individuals in the sample of collared individuals would result in a considerably altered estimate of natural and man-related mortality, 45 and 55 percent, respectively.

It is important to note that no uncollared bobcats were found dead or reported killed in any area more than a short distance from well-traveled roads.

McCord and Cardoza (1982) noted that documentation of diseases in wild populations of bobcats is sparse and stated that "...bobcat populations have not succumbed to epizootics or die-offs due to heavy parasitic infections...", citing the commonly reported solitary nature and habits of the species as the explanation for the apparent lack of infectious diseases in bobcats. Russell (1978) also rejected the possibility of an infectious disease outbreak as being a significant mortality agent in mountain lions (Felis concolor) due to the solitary nature of the species. In sharp contrast to this conclusion, the findings of this study indicate that parasites and disease were important mortality agents in the population.

The high incidence of current or apparent former mange infestations in cats that were handled, plus one adult (F-1) that undoubtedly would have died from mange if she had not been treated and the fact that five additional animals (3 juveniles in 1978, M-2, F-2) probably died from this cause, indicates that heavy parasitic infections can be a significant cause of bobcat mortality. Death of bocats by mange mites also has been reported in other geographic regions (Pence et al. 1982, Penner and Parke 1954, Pollack 1949).

In addition, the present study apparently provides the first detailed documentation of the course of an epizootic in a wild felid population and indicates that the presumed solitary nature of bobcats does not prevent the spread of disease. In view of the potential significance of the present finding that infectious diseases may be important agents in regulating bobcat population numbers, a relatively detailed account of the spread of FPLV through the Florida population seems warranted. Available evidence suggests that adult female F-4 was the principal FPLV vector. The death of M-2 on 25 October 1979 is thought to have resulted from a mange mite infestation, but it could have been caused by panleukopenia, or both. His carcass was too decomposed to determine the actual cause of death. However, there was no evidence such as broken bones, bullet holes, or lead pellets in or under the carcass which would have indicated death as a result of injury. M-2 also was found dead near water, had rested at the edge of a lake three days prior to his death, and had apparently moved progressively shorter distances on successive days just prior to death as did other confirmed and suspected panleukopenia victims. M-2 and F-4 shared a range in a consort relationship (Guenther 1980) and probably made occasional contact, as noted for other consorts during the combined studies.

Therefore, if M-2 was a FPLV victim, F-4 may have transmitted the disease to him or received it from him. After his death, F-4's movements were more restricted (Figure 8) such that her observed home range was reduced by about 38% between 26 October 1979 and 28 February 1980. Between 26 October 1979 and 16 January, a portion of the west side of her range was given up to adult female F-10. The apparent reduction in F-4's range may have been a consequence of a mild FPLV infection, a loss of "status" when her consort died, or a combination of both.

On 14 January 1980 from 2000 to 2100, F-4 and adult male M-3 were radio-located in close proximity. A check on their tracks at the site on the following day confirmed that they had been together. M-3, found dead on 16 January, was the first confirmed FPLV victim. Between midnight 31 January and 0200 hours on 1 February, F-4 and adult male M-1 were also radio-located together and their close association was confirmed the following day by observations of their alternately overlapping tracks at the site. M-1 was located the evening of 1 February near juvenile F-6. Two consecutive radio locations on M-1 indicated that he had passed through the area that she was using. The site was in a relatively inaccessible part of the shared range of M-1 and his consort F-1. The area was comprised of a dense bayhead bisected by a drainage canal with a high berm. Areas along the berm were frequently used as rest sites by F-1 and her three juveniles (M-4, F-5, F-6), and all five bobcats commonly traversed the bayhead by walking along the berm of the canal. On that particular evening, F-6 (and probably her two siblings whose radio-collars had failed earlier in the study) was located very near the canal, along whose banks M-1 had most likely walked when passing through the area. Thus, although close contact between M-1 and F-6 was not confirmed in this case, it probably occurred. Both M-1 and F-6 died on 5 February, and the presence of the other two juveniles (M-4, F-5), was not recorded by their tracks or sightings after this date.

It is important to note that during the period of probable contact between her offspring (M-4, F-5, F-6) and M-1, F-1 was in another part of her range and did not return to the bayhead site until after the male had left the area. Over the next two weeks, she spent an unusual amount of time in that area and in another remote portion of her range with canals and a pond containing water. C. Winegarner (personal communication) stated that F-1 stayed away from the cottage where she was routinely fed for 18 days from late-January to mid-February, her longest period of absence on record. F-6's carcass was recovered along a canal bank but was too decomposed for necropsy. A search for the bodies of the other two juveniles was unsuccessful. The location of F-6 along a canal bank, the tendency for F-1 to stay near water sources at the time of the disappearance of her other two kittens, and the fact that three (M-1, M-3, F-10) of four confirmed panleukopenia victims were found very near water sources, strongly suggests that all members of the F-1 family group had been infected.

Bittle (1970) stated that FPLV infections range from mild to peracute, with prognoses ranging from high morbidity to high mortality, respectively. The general ability of an individual to survive an infection depends on its susceptibility and the degree to which resistance is developed before the virus produces its destructive effects. Susceptibility to infection is related to absence of antibody. Active immunity is conferred by surviving an infection, and maternal passive antibody will protect young animals for a short period after birth. F-4 was observed on three occasions (once near water for about 1 hour) in February and March 1980 walking slowly or lying about in the open and was obviously sick, as she was easily approached to within a few meters. It is probable that she had a mild form of the infection that resulted in the observed behavior. F-1 also may have contracted a mild form of the disease which would account for her behavior in early February.

Although F-4 was probably the principal FPLV carrier of the disease to other members of the population via direct contact, FPLV also may have been transmitted through contaminated feces. Peak bobcat marking with exposed scats occurred during winter, and bobcats were known to visit each other's marking sites. Bouillant and Hanson (1965) found that healthy minks who received stomach innoculations of 20 percent suspended feces passed by animals experimentally infected with mink enteritis virus (MEV) developed clinical symptoms of MEV, even when carrier feces were half-buried for several months during cold, damp weather, which favored survival of the virus. The winter of 1979-1980 in south-central Florida was relatively cool and wet. These facts suggest that investigation of feces by bobcats could result in transmission of the disease, and that the threat of a succession of outbreaks is present when climatic conditions are favorable. In this regard, all known or suspected FPLV victims had ranges that adjoined or overlapped that of F-4.

The higher incidence of FPLV mortality in males than females may reflect their larger home range size with consequently higher probability of contacting infected animals or feces. Further, FPLV infections occurred during the peak period of marking and the time when breeding usually began (although breeding was apparently delayed that year as a result of the epizootic), which presumably also increased chances of virus transmission.

In addition to causing direct mortality of infected bobcats, FPLV may also cause mortality of embryos or fetuses of pregnant females with a sublethal infection (Povey and Davis 1977). It may be significant in this connection, that female F-1, who possibly had a mild infection during winter 1979-80, produced only two young in her first litter following this period, whereas her two previous successive litters and subsequent two litters numbered 3, 3, and 4, 4, respectively. F-4, who was also suspected to have had a sublethal infection, was also the only collared female in the population who did not rear a litter following the epizootic. Radio-tracking suggested that she had a litter in spring but had lost it by September. This suggests the possibility that the kittens may have contracted the disease from the mother, after losing antibodies obtained from the colostrum (Povey and Davis 1977). Bittle (1970) stated that an animal recovering from an infection could remain a carrier for a long period.

Although infected bobcats were directly (by contact) or indirectly (through feces) probably instrumental in the deaths of other bobcats, other potential vectors including domestic cats and raccoons were present in the study area. Domestic cats were regularly seen prior to the epizootic but not for several months afterwards. Panleukopenia is commonly reported in domestic cats throughout the United States, and J. Causey (personal communication) informed me that a relatively high number of cats with feline distemper were brought to his animal clinic in Lake Placid during the bobcat epizootic. Young (1958) indicated that bobcats are known to kill domestic cats. Nine raccoons were observed sick or found dead from undetermined causes from March to May 1980. Goss (1948) reported that raccoons are susceptible to feline enteritis (FPLV). Evidence of raccoon-bobcat contacts was obtained in this study. Guenther (1980) found traces of raccoon in bobcat scats taken on the study area, and Ryden (1981) observed F-1 killing a juvenile raccoon and carrying it to her young.

The only other data on panleukopenia mortality in wild bobcats is that of Lembeck (1978) and Gould (1980) in California. They reported three confirmed panleukopenia victims at El Capitan Reservoir. However, these deaths were recorded over a three-year period. From January through June 1977, one of 13 radio-collared cats (an adult female) died of FPLV and three others (one female and two male adults) died of undetermined causes. From September through December 1977, an adult male that survived through the earlier "epizootic" died of FPLV. This individual lost about 53 percent of its body weight before death. An adult male trapped in September was recaptured in October and was observed to be sick of undetermined causes. This individual had lost 27 percent of its body weight between captures. In addition, an adult male and an adult female were diagnosed as having died of starvation. Bittle (1970) indicated that anorexia is a sympton of FPLV. In the present study, infected bobcats did not show the dramatic weight loss that was seen in the California population. This may have resulted from a more virulent strain of the virus in south Florida with more peracute cases than in California. An additional FPLV victim (unspecified adult) died in the California study during 1979. These data indicate that FPLV outbreaks may reoccur from year to year. It is important to note that the California outbreaks occurred in winter as did the Florida outbreak, which was correlated with peak marking behavior activity and most frequent social contact between consorts and consort offspring. As in the present study, reproductive rates in the California population were very low in spring following the die-offs.

Movements

The mean adult male (2553 ha) and adult female (1455 ha) observed lifetime home range sizes of bobcats in south-central Florida are higher than values reported for radio-collared bobcats in other populations in southeastern United States, However, the mean and extreme adult male (1453 ha, 1187-2007) and adult female (931 ha, 779-1301) range estimates for twelve 3-week to 4-month time intervals more closely approximate those of most other workers whose observation times for individuals generally were not more than a few months.

Hall (1973) reported mean home range sizes based on the modified minimum area method of 490 ha and 100 ha for adult male and adult female Louisiana bobcats, respectively. Conversions of his bobcat location data to minimum polygon home ranges as used in this study result in mean and extreme adult male and female lifetime ranges of 763 ha (430-960) and 147 ha (127-160), respectively. In Alabama, Miller (1980) found mean adult male and female range sizes to be 263 ha and 112 ha, respectively. Tentative calculations based on spring movements of three adult (2 females, 1 male) North Carolina bobcats gave seasonal ranges from 518 to 1036 ha (Hair et al. 1979). Kitchings and Story (1979) reported a mean range size of 1150 ha for two adult females and a range size of 4290 ha for an adult male bobcat in eastern Tennessee. Buie et al. (1979) estimated that the average sizes of adult male and female bobcat home ranges on the SRP, South Carolina, were 2078 and 1035 ha, respectively. In an earlier SRP study, Marshall (1969) estimated range sizes for one adult female (464 ha), two juveniles (mean 300 ha), and an adult male injected with a lethal dose of radio isotope (357 ha). Erickson and Hamilton (1980) found that the ranges of adult males in Missouri varied in size from 4662 to 7252 ha and that the mean female range size was 2849 ha.

Considerable variation in bobcat home range size is also evident in studies in northern and western states. In Arizona, Lawhead (1978), reported mean and extreme adult male and female ranges of 1017 ha (979-1163) and 517 ha (445-639), respectively. Populations in four areas of California have been studied, including Lava Beds and Joshua Tree Monuments (Zezulak and Schwab 1979), Laguna Mountains (Gould 1980) and El Capitan Reservoir (Lembeck 1978 and Gould 1980). Mean and extreme range sizes of adult bobcats at Lava Beds and Joshua Tree were 5600 ha (2600-9500) and 2630 ha (500-5400), respectively. Extreme range sizes of adult males and females at El Capitan Reservoir were 88 to 640 ha and 60 to 440 ha, respectively. At the Laguna Mountains site, a seasonal range estimate for one female was 49 ha, while seasonal ranges of males varied from 65 to 124 ha. Bailey (1972) reported male bobcat ranges in Idaho varying from 3350 to 10790 ha, with female ranges varying from 910 to 3510 ha. Mean and extreme adult male and female range sizes in Minnesota (Berg 1979) were 6200 ha (1300-20100) and 3800 ha (500-9200), respectively. Brittell et al. (1979) gave home range estimates for populations in eastern and western Washington state. In eastern Washington, an adult male range was 4330 ha and the mean female range was 1160 ha. In western Washington, range sizes varied from 650 to 1550 ha for adult males and from 390 to 840 ha for adult females. In Massachusetts, McCord (1974) reported a mean range size of 2850 ha for two adult females, while an adult male's range was estimated to be 3108 ha.

With the exception of the present and west coast studies, available data suggest a general trend toward larger range size in more northern latitudes. Male bobcat home ranges appear to be consistently larger than those of females throughout the range.

The observation in the present study that environmental features influence the movements of bobcats and hence home range estimates has been observed by other workers (e.g. Buie et al. 1979, who indicated that individual home ranges generally interfaced along roads, railroads, and waterways). Hall (1973) presented a series of range maps with individual locations. As in the present study, most radio-locations were within a few hundred meters of a road or trail. Miller (1980) indicated that bobcats rapidly accepted and utilized logging roads, firelanes, and farm roads as avenues of travel. High levels of use of these features may be related to a possibly higher abundance of prey along their edges coupled with a bobcat's opportunity for a stealthier approach to prey as compared to stalking in more dense areas. In the Florida study tract, rabbits and cotton rats, the principal prey species in this area (Guenther 1980), were more often seen grazing early successional vegetation along trails and roads than in the sparsely-grassed areas where canopy cover was denser.

In south-central Florida, Alabama (Miller 1980), and presumably elsewhere in the southeast, the abundance of suitable rest sites due to the presence of dense thickets, vine-covered areas, etc. apparently allows for less restricted movement than in other areas. McCord (1974) stated that rocky ledges were important to bobcats and that their location was a factor influencing bobcat movements. Bailey (1972) and Zezulak and Schwab (1979) also indicated that bobcats in their relatively sparsely vegetated study sites tended to be found more often in areas where rock falls, caves, and other such cover occurred. In more severe weather, movements were even more restricted to these areas, which were in high demand and were frequently shared among several cats.

Mean day-to-day distances moved (based on combined seasonal data) by adult males (2.1 km) were greater than those of adult females (1.4 km) or juveniles (1.0 km). The ratio of mean adult male to mean adult female day-to-day movements (1.5 to 1) was roughly proportional to the ratio of their respective mean lifetime home range sizes (1.8 to 1). Longer male than female movements also have been reported by workers in other southeastern studies. Sex differences based on summed distances between successive radio fixes obtained during a 24-hour period were 8.7 km for males versus 6.3 km for females (ratio 1.4 to 1) in South Carolina (Buie et al. 1979), 4.5 versus 1.2 km (ratio 3.8 to 1) in Tennessee (Kitchings and Story 1979), and 4.4 versus 2.9 km (ratio 1.5 to 1) in Louisiana (Hall and Newsom 1976). For comparison, ratios of mean male to mean female range sizes in these studies were 2.0 to 1, 3.7 to 1., and 4.9 to 1, respectively. Hall (1973) also reported the straight-line day-to-day distances of males (2.2 km) and females (.4 km), which gave a 1.6 to 1 ratio. The straight-line distances were about half the summed distances based on movements between 12 locations during diel tracking periods.

Similar results were obtained in Minnesota (Berg 1979), Idaho (Bailey 1972), and Arizona (Lawhead 1978). Berg (1979) determined week-to-week distances moved for adult males (4.3 km) and adult females (2.6 km). The ratio of mean male to female movements (1.6 to 1) was proportional to their respective mean range size ratio of 1.6 to 1. Bailey (1972) found that mean day-to-day distances moved by male and female adults were 1.8 km and 1.2 km, respectively, and the ratio of movements (1.5 to 1) approximated that of their respective mean home range sizes (2.2 to 1). Lawhead (1978) reported mean day-to-day movements of 1.2 km for adult males and 0.9 km for adult females (1.3 to 1) while the male to female mean range size ratio was 2.1 to 1.

The combined data for this and the six studies cited above and using Hall's (1973) day-to-day distances gives a mean ratio of male to female movements of 1.8 to 1 and a mean ratio of male to female home range size of 2.2 to 1. These ratios indicate that, as suggested by the authors, although males tend to have larger ranges than females, they do not move proportionately as much within their ranges as do females.

Seasonal differences in movement patterns of bobcats have been often reported. In the present study, day-to-day distances moved by adult females were least during the summer months (June to August) when the females had young kittens. Late spring to early summer reduction in female movements and/or home range size has been reported by other workers (Bailey 1972, Bailey 1979, Berg 1979, Kitchings and Story 1979, Lembeck 1978). It should be emphasized that reduction in female daily movements during the "denning season" does not necessarily reflect a decrease in home range size as some workers have indicated.

Detailed monitoring of females with small young in this study showed that they continued to utilize their home range but in such a way as to reduce the chances of their being detected in peripheral areas. When with small kittens, females tended to move from den sites to the home range boundaries during the first half of the night. They typically moved to boundaries in a relatively direct manner, travelled along the boundary for some distance, then returned on a rather direct course to the den site. Visits to boundaries on the opposite side of the range would entail long trips. In contrast, females with older young or females without young frequently spent considerable time in peripheral areas of their ranges or moved from one daytime rest site to another along range boundaries. These latter types of behavior were observed for adult males in all seasons.

In the present study, both male and female adults moved significantly greater day-to-day distances during December through February, the main period of juvenile dispersal (8-11 months of age). It is likely that both breeding season activities and the mobility of older offspring influenced the rate of movements of the females. Kitchings and Story (1979) reported that adult male bobcats moved longer distances in winter with no apparent changes in home range sizes. They also found that two older, apparently dispersing, juveniles moved at about the same rate as did two adult females, one of which was presumably their mother. In contrast, Bailey (1972) found that Idaho adult bobcats of both sexes moved least in fall and winter. The difference between observed rates of movement in winter in southeastern and northwestern bobcat populations is probably related to more severe winter weather in the latter region.

Numerous factors, including climatic conditions, population density, food resources, and reproductive behavior, may influence home range size. In this study, home ranges of individual bobcats showed considerable variation over time. Because of small sample size at any given time and a relatively high turnover of individuals, it was not possible to assess the relative importance of various environmental factors in influencing home range size. However, death of a resident individual had a clear-cut influence on home range size of adjacent individuals of the same sex. Bailey (1972) and Miller (1980) also reported marked adjustment of home ranges of neighboring same-sexed bobcats upon the death or disappearance of a resident. Seasonal changes in range size of individual bobcats have also been reported by Buie et al. 1979, Kitchings and Story 1979, Lembeck 1978, and Zelulak and Schwab 1979.

In the present study, 11 of 13 radio-collared adults remained in the same general locality, despite changes in the size and configuration of the range from one period to the next. Two apparently established adults (F-3, M-7) abandoned their ranges. Adult female F-3 probably moved into the area just north of her old range during the panleukopenia epizootic. It is not known if this individual was infected as her radio-collar had failed earlier in the study, making it difficult to follow her movements. In his study in California, Lembeck (1978) found that a number of resident bobcats, especially sick or dying (probably from panleukopenia) individuals, had periods when they became transients in other areas. M-7 was an older individual who appears to fit the description of a nomadic adult (McCord and Cardoza 1982) in that he moved 70 km from the study area after a period of probable residency. Berg (1979) reported that two Minnesota bobcats older than 1 year moved distances of 32 km and 136 km and established new ranges, and Lawhead (1978) also radio-tracked a transient adult on his Arizona study site.

The low degree of male-male (mean 5%) and female-female (mean 3%) home range overlap observed in the present study indicates that same-sexed resident individuals tended to occupy mutually exclusive ranges. A similarly low percentage of range overlap between adjacent same-sexed individuals also has been reported in other populations in the southeast and elsewhere in the range (Bailey 1972 in Idaho, Brittell et al. 1979 in Washington, Buie et al. 1979 in South Carolina). Erickson and Hamilton (1980) in Missouri, Lawhead (1978) in Arizona, and Lembeck (1978) in California reported that males showed substantial range overlap while females did not; whereas in another California study both males and females showed substantial range overlap (Zezulak and Schwab 1979). In the last study area, resources were believed to be limiting. These relatively few data suggest that spacing mechanisms may operate separately in each sex and that the amount of same-sex range overlap may be indicative of the population status relative to available resources.

The high degree of exclusiveness of same-sexed individual ranges was not observed for adult males and females, whose home range overlap varied from 0 to 100 percent during any given interval. The explanation for this wide range of variability in male-female overlap is the tendency of a particular male to superimpose his range over that of a given female, a pattern referred to by Guenther (1980) as a consort relationship. In some cases, a single male range may overlap the ranges of more than one female, but even in such instances more of the range of one female than of the others is included. Consorts share a common territory and use the same rest sites, hunting areas, and routes of travel, but usually not simultaneously. Thus, in a paired male-female situation where same-sexed bobcats are mutually exclusive, the home ranges of adjacent pairs also tend to be mutually exclusive, resulting in the wide variation in overlap for opposite-sexed bobcats.

Although other workers have not articulated this model of the social organization of resident adult males and females in bobcat populations, their observations suggest that the consort relationship, as here defined, may occur commonly throughout the species' range. Berg (1979) found that Minnesota male and female bobcat ranges overlapped from 3 to 100 percent, suggesting a situation similar to that observed in Florida. Brittel et al. (1979) found substantial overlap in male-female ranges while intrasexual overlap was more limited. Buie et al. (1979) observed no intrasexual range overlap in South Carolina bobcats, but found distinct intersexual overlap ranging from small percentages along range peripheries to complete male-female overlap. Erickson and Hamilton (1980) observed that the ranges of female Missouri bobcats overlapped those of males completely but excluded all other females. Karpowitz and Flinders (1979), reporting preliminary results of a Utah study, indicated that a male and female bobcat found in the same general area were located near one another on two occasions, which suggests a consort pair. Kitchings and Story (1979) reported that an adult male range overlapped 90 percent of the ranges of two adult females who had exclusive ranges. In the present study, adult male M-6 shared about half of his range with his presumed sister, and another female was suspected to occupy the other half of his range. Marshall (1969) found negligible overlap between three adjacent South Carolina female bobcats. One male occupied the general area of one of the females. In Alabama, Miller (1980) found a low degree of female-female range overlap and a tendency for males to share portions of their range boundaries with those of females, suggesting consorting pairs. A similar consort pattern may also occur in the Canadian lynx. Saunders (1961) determined by tracking in snow that the range of an adult male nearly completely overlapped that of a female.

One potential adaptive advantage of the consort relationship is increased opportunity of a male to defend his genetic investment in young by protecting them from predation, including cannibalism by other males. Although the latter has not actually been observed for bobcats, there is circumstantial evidence of its occurrence. Crowe (1974) suggested that predation by adult males on newborn young may constitute a significant mortality factor. A kitten found dead during his study had the claw of a conspecific buried in its skull. Erickson (1955) reported bobcat flesh and bones in two bobcat stomachs examined, suggesting cannibalism. Hornocker (1970) reported that an adult male mountain lion killed and ate two of three juvenile mountain lions of the same litter. In the present study, adult male M-8 spent considerable time in the areas of F-1's den and favorite rest site after a male (M-6) from the adjacent territory was detected at or near these two sites. The behavior of M-8 may have been an attempt to prevent M-6 from disturbing the young litter of F-1.

Another potential function of the male in consort relationships might be to provide food for the adult female when she is nursing kittens. There was no evidence for this in the present study, except for the activity of M-8 near the den of a female with young kittens described above. Although recent workers generally assume that male bobcats play no role in care of offspring, Young (1958) stated that both parents may bring food to the young before and after the den is abandoned when kittens are about two months old.

The male consort may also influence the dispersal of older juveniles from their natal range. In the present study, the disappearance of an older male kitten presumed to be the offspring of the female (F-1) in whose range it was located followed a series of apparent contacts with the consort male (M-8). Marshall's (1969) observation of an adult and a juvenile male bobcat growling and spitting at each other (possibly over food), with the larger male pursuing the smaller one may have been a similar case of a resident consort interacting with a juvenile near dispersal age.

There are few comparative data concerning the movement patterns of offspring within the female bobcat's range. The best description is that of Bailey (1979) for Idaho bobcats. General patterns of movements of Idaho kittens were similar to those found in Florida in that movements were generally restricted to den areas until the kittens were past 3 months of age. After this age, vast areas between dens were used by females and older or dispersing offspring. In South Carolina, Marshall (1969), found that an older juvenile used the entire range of its mother, and Kitchings and Story (1979) reported the same behavior for a juvenile in eastern Tennessee.

Little is known about the dispersal of young bobcats from the natal range and the process of establishing a new range. In the present study, one male and female juvenile (M-6, F-8) took over their mother's range during the panleukopenia epizootic. Resident adult males that used the area also had succumbed to the disease. It is likely that this was a special case. Most consort pairs probably do not have such a close genetic relationship.

Activity

The activity pattern found in this study is generally similar to those reported for other southeastern United States bobcat populations. Hall (1973) reported peak summer movements from 1500 to 2300 hours and from 0300 to 0700 hours. Buie et al. (1979) found peaks in activity in fall, winter, and spring to occur from 0400 to 1000 hours and from 1800 to 2400 hours. Miller (1980) reported least year-round activity from 0700 to 1500 hours with a second, less pronounced, rest period from 2200 to 0200 hours.

On a seasonal basis, Florida adult males used more daylight hours for resting and more hours after dark for movements during June through August than they did in other months. The male summer activity pattern is thought to reflect their response to high summer temperatures. Day-time rest sites were usually in dense closed canopy habitats, which were about 3 to 5 degrees C cooler in summer than open canopy areas. Influence of temperature on activity also has been indicated in other parts of the range. Buie et al. (1979) noted that in South Carolina activity showed less of a bimodal pattern during winter than in early spring and in fall, suggesting greater activity during winter daylight hours when it was warmer. Bailey (1972) indicated that bobcats were inactive under conditions of extreme winter weather and that the use of caves was important in water conservation during hot-dry summer months. These data indicate that bobcat activity and site use can reflect a behavioral response to climatic conditions.

Seasonal differences in activity patterns of adult females in this study appeared to be linked more to the needs of their offspring than to climatic conditions. Females tended to spend most of the diel period with newborn young, which resulted in an obvious relative decrease in activity in late-night and early-morning hours during the first month following birth of litters in late spring. In summer, when young were past the nursing age, females tended to be more active during daylight hours than were males. This difference in activity levels probably reflected more intense hunting effort required by the increased nutritional needs of the family unit. Hall (1973) also reported higher levels of activity for females than for males during daylight hours of summer months.

Habitat Utilization

No consistent overall trends in preference for a particular habitat were observed, but in general bobcats selected natural habitats over man-modified habitats for both resting and activity. Although males had proportionately less natural habitat in their ranges (mean 58%) than did adult females (mean 63%), they made relatively more intensive use of it. Males averaged 20 percent greater than expected use of natural habitats when resting and 11 percent greater than expected use when active, while corresponding values for adult females were 12 percent and 8 percent. The relatively larger amount of man-modified habitat in male compared with female ranges is correlated with the observed higher mortality of males from man-related causes. The higher utilization of disturbed habitats by males may also indicate that they are more exploratory than females. No quantitative data on habitat utilization for other southeastern populations are available for comparison.

Natural, undisturbed habitats were particularly important for very young individuals. All den sites and secondary dens were in natural areas, usually thick patches of saw palmetto and dense shrub thickets. These areas also were preferred rest sites for adult males and adult females unaccompanied by young. In Louisiana, Hall (1973) also found a preference for heavy cover as rest sites, areas of dense undergrowth with saplings, vines and briars and cut-over timber areas with many windfalls predominating. In the present study, offspring apparently were not exposed to man-modified habitats until about 2 months of age when they began following the mother to different rest areas within her range.

Roads, footpaths, animal trails, or railroad tracks were important features in all ranges and were used consistently by bobcats when moving about. Early successional vegetation along edges of many roads, firelanes, trails, and the railroad right-of-way were preferred by rabbits and cotton rats, the bobcat's principal prey on the study site (Guenther 1980). Hall (1973) indicated that the average Louisiana bobcat home range contained a mean 4.4 km of shell road and a mean 1.3 km of pipeline. Most individual ranges were covered as bobcats moved along these and other features such as tramlines. Rabbits and cotton rats also were most common in these areas, and Hall suggested use of routes was related to hunting. In Alabama, Miller (1980) also found that bobcats made extensive use of roads and trails within their ranges and preferred early successional areas, probably because of higher densities of rabbits and cotton rats in those areas. Thus, there appears to be a general trend for bobcats in southeastern states to make extensive use of roads, paths, and other open routes when travelling through habitats, and this may be related to hunting activities when low herbaceous cover is associated with these features.

Marking Behavior

Seton (1925) stated that "every field naturalist and hunter knows that, next after the animal itself, the scats and tracks together afford the most information on the habits...of the creature". In the present study, much of the insight gained on various aspects of bobcat marking behavior resulted from an integrated approach of trailing individuals between successive radio locations over the sands and sandy soils that comprise most of the study site.

Peak numbers of exposed scats, fecal-scrapes, and urine-scrapes were made from November through February while fewest such marks were made from May through August. The lowest frequency of marking activity coincided with the last month of adult female gestation and the first three months after the birth of a new litter when young kittens were either immobile or made short movements within the interior of the female's home range. Peak activity coincided with the breeding season and the period of high juvenile mobility. Assuming that most scrapes not containing feces were made in conjunction with urination, it appeared that urine-scrape marking, fecal-scrape marking, and fecal marking without scrapes followed the same seasonal trends. The only noted variation was the decreased urine-scrape marking activity following the panleukopenia epizootic in winter 1979-1980. This may have been related to a lack of resident breeders in the population. It is of interest to note that during this period the birth of new litters commenced about 3 months after the loss (death or disappearance) of juveniles from the population, a phenomenon not observed in other years.

The present study suggests the following patterns of marking behavior tied to the reproductive cycle of the adult female:
1) Resident adult females with nursing kittens tend to bury their feces in the vicinity of the den site or elsewhere in their range but continue spray and squat-urinating within the interior of their ranges and along range boundaries. 2) Immobile kittens probably also bury feces near their dens. 3) Females and mobile juveniles 4 to 7 months old continue to bury feces at common, frequently-used sites near rest areas within the female's range and squat and spray urinate along their travel routes. 4) At about 5 to 6 months of age, juveniles also begin leaving feces exposed in scrapes and probably begin to urine-scrape as well as squat and spray-urinate. 5) As juveniles continue to move about the mother's range and along its boundaries, they increasingly leave more feces exposed and make more urine and fecal scrapes. 6) About the time juveniles are ready to disperse (which coincides with the breeding season of the mother) they are marking at their highest rate as are other adults. 7) After breeding and the dispersal of their juveniles, resident adult females gradually decrease their rate of leaving feces exposed and increase their rate of burying scats such that by the time new litters are born fecal marking is minimal. 8) Adult male marking behavior parallels that of adult females in all seasons and may be a response to the marking activities of the family unit.

Additional support for some of these patterns in bobcats and other

Lynx species is provided by observations of other workers. Bailey (1972) indicated that bobcat kittens old enough to explore outside natal dens began to conceal their feces and that this behavior continued until juveniles were nearly self sufficient, at which time they occasionally left feces exposed. Cats would frequently re-use depositories when burying scats near dens (= rest sites in this study). Both adult males and females fecal-scraped, urine-scraped, spray-urinated, and squat-urinated. Lindemann (1955) reported that European lynxes (_Lynx lynx_) began to return to depositories to bury urine or feces at 100 to 120 days of age and initiated marking of ranges with exposed excrement at ages of 210 to 220 days. Saunders (1961) indicated that juvenile Canadian lynx (_Lynx canadensis_) switched from burying feces to leaving them exposed as they grew older and thus began marking like adults.

Few comparative data are available on seasonality of marking behavior in other bobcat populations, and quantitative information is limited to frequency of scat deposits. Progulske (1952) searched Virginia mountain trails at fairly regular intervals over a 1-year period and found 124 scats, 71 (57%) from mid-September through mid-March and 53 (43%) during the balance of the year. Hall (1973) collected a total of 390 scats on Louisiana study sites over a 19-month period. Mean monthly frequencies of scats found by season were: summer - 15, fall - 12, winter - 37, spring - 23. Miller (1980) stated that scat deposition by bobcats in Alabama was more frequent in winter and early spring and less obvious in other parts of the year. In contrast to the present and other southeastern studies mentioned above, which showed a seasonal trend in scat deposits, no seasonal pattern was evident in monthly scat collections (total of 317 from an approximately 2.4 km^2 area) made by Kight (1962) in South Carolina.

Information on scat deposition has also been reported from two localities in Arizona. Jones (1977) conducted monthly scat censuses along three 1.5 to 3.0 km transects on Arizona mountain and ridge tops from October through March. A total of 42 scats was collected, 16 (38%) in October and November, 3 (7%) in December and January, and 23 (55%) in February and March. Monthly frequencies of total counts per km beginning with the October census were 1.7, 0.8, 0.5, 0, 2.0, and 1.7. There were significant differences between the frequency of scat counts for each transect. Jones suggested these differences apparently were due to weather (which might account for the overall lower trend in early winter), changing activity patterns of bobcats, and possible seasonal differences in bobcat behavior. As in the present study, the peak frequency of scat deposition in late-winter was attributed to the period of mating. Small (1971) searched 60 km of roads and trails in Arizona chapparal and grassland habitats each week from March through July. Monthly frequencies of scats per km were: March - 0.04, April - 0.04, May - 0.58, June - 0.18, and July - 0.12. The dramatic increase in the May count and the subsequent decline was not explained.

The distribution of various types of marks within bobcat home ranges supports the common idea that bobcats are territorial. Krebs and Davies (1978) recognize any occupied area as a "territory" whenever individuals or groups are spaced out more than would be expected from a random occupation of suitable habitats and when this spacing is due to interactions between these individuals or groups. By this definition, bobcat home ranges can be thought of as territories. Gorman (1980) recently reviewed marking behavior data for various mammalian carnivores. He stated that individuals of non-territorial species mark throughout their home range. Territorial species also mark this way, but in addition they mark more intensively at the borders of their ranges. It is argued that species mark their range in order to orient themselves, and that boundary marking is a specialized form of range marking that serves as a warning to conspecifics that they are about to enter "enemy" territory. Data also suggest that marking may have other functions such as relaying information concerning an individual's age, sex, reproductive status, and mood. The potential communicative aspects of urine, feces, and scrapes for felids have been well reviewed by MacDonald 1980, Wemmer and Scow 1977, Leyhausen 1979, and others. The idea that bobcats maintain home range boundaries with excretory products is not new. It was initially advanced by Marshall (1969) who reported that an adult female appeared to maintain her boundary by depositing feces at sites along the range periphery. Bailey (1972) and McCord (in McCord and Cardoza 1982) further developed these ideas. Observations obtained for Florida bobcats support the hypothesis that one of the functions of marking is to inhibit other bobcats from trespassing on an individual's home range. The tendency observed in this study for bobcats to deposit exposed feces and make hindfoot fecal and urine scrapes more frequently on home range boundaries than in the interior suggests that this type of marking behavior is related to the maintenance of home range boundaries. Other observations provided additional evidence for this function of marking behavior. As home range boundaries shifted, there was a corresponding shift in the locus of marking. Bobcats regularly visited sites on their range boundaries and "refreshed" older marks with new ones. Type of deposit at a site was not necessarily consistent, as bobcats would often alternate between fecal-scraping and urine-scraping at these sites. Adjacent pairs regularly visited these sites and added their own deposits to them. Generally, feces tended to begin deteriorating after about a week, especially when rain and scarab beetles were present. Urine odors were strongest the first few days after the deposit. These observations suggest a need for bobcats to regularly renew levels of whatever substances might be used in advertising their status, and that neighboring individuals periodically inspected sites for information concerning other depositors.

In this regard, it is important to note that bobcats were not known to invade the vacated ranges of same-sexed bobcats immediately after their death. Rather, 5 to 14 days passed before invaders were detected within the vacated ranges. It is of interest that the observed lag-time required before invasion was about the same as the time taken for feces to deteriorate and for urine odors to diminish. In the one case of an adult female (F-3) vacating her range, which was taken over by her daughter (F-8) who had been marking home range boundary sites prior to the adult's disappearance, there were no apparent attempts by neighboring adult females to invade the range. This suggests that continued marking along the boundary, even by different individuals, served to maintain the integrity of the range.

In addition to their significance in maintenance of the claws, scratching posts (stretching trees) could potentially have a communication function as suggested by observations of other workers. Rollings (1942) noted that Minnesota bobcats occasionally used stretching trees, usually dry-hardened snags without bark. On one occasion, two cats used the same tree. J. Paul (in Seton 1929) observed a Canadian lynx approach a tree blazed with an ax on four sides at about 1 m up the trunk. After inspecting the marks for several minutes while sitting 3 m from the tree, the lynx cautiously approached the tree and walked completely around it several times before being caught in an unbaited/unscented jaw trap. J. Paul had successfully used this technique to capture other individuals. Only two scratching posts were observed in the course of the present study and no evidence was obtained that they served a marking function. A relatively low incidence of scratching posts was also suggested in Erickson's (1955) study in Michigan, in which only two trees used for scratching were encountered during 394 km of winter tracking.

Synopsis of Principal Findings

The general demographic parameters of the Florida population studied were similar to those of other populations in the southeastern United States with the apparent exception of larger mean home range sizes. Documentation of a feline panleukopenia epizootic provides the first available information on the course of an infectious disease through a population of free-ranging wild carnivores. The death of individuals during the outbreak had a dramatic effect on the movements of neighboring individuals of the same sex. The study further confirms the existence of a "consort" relationship between resident adult males and resident adult females. Bobcats are not strictly solitary, and males may play a significant role in the reproductive cycle of the female for other than breeding purposes. The basic social structure in a stable population would appear to be a series of adult male home ranges superimposed over those of adult females. Each consort pair range would be exclusive of other consort ranges except for minimal overlap along the range periphery. This ideal situation is probably seldom achieved because of mortality and possibly limiting resources, and thus the social organization of a population is probably in a continuous state of flux. The study also provides further insight into the mechanisms involved in maintenance of home range boundaries. Boundaries were regularly patrolled in all seasons and urine and fecal marking was concentrated along boundaries. As no evidence of aggressive interactions between neighbors was obtained, it appears that bobcats "recognize" the land tenure of neighbors and use chemical communication via substances in excretory products, as well as visits to range boundaries, to inform other members of the population of their presence.

Management Implications

A number of the findings of this study appear to be relevant in the context of management of bobcat populations, which is of increasing importance as a result of escalating pressure by the fur trade coupled with continuing loss and degradation of habitats.

The results of this study indicate that even though bobcat populations are not subject to high direct exploitation by trapping or hunting, mortality from natural and human-related causes may be appreciable. If, as found for Canada lynx (Brand and Keith 1979), hunting and trapping mortality in bobcat populations is additive rather than compensatory, the mortality rate may be very high in even relatively lightly harvested populations.

The present study also suggests that large blocks of protected natural habitat may contribute significantly to the maintenance of regional bobcat populations in semi-developed areas. Such natural "core areas" provide safe den sites and habitat for females with young kittens and reduce the hazards of man-related mortality from causes such as vehicles, casual shooting, dog predation, etc. Thus, such areas may serve as a continual source of animals for surrounding, more-developed areas, with the latter constituting a population sink.

Death of resident individuals was shown to have a marked effect on the spatial relationships of the surviving bobcats of the same sex. This is a factor that deserves consideration in assessing the potential impact of harvesting on a population. Increased removal of individuals may lead to further instability in social organization of the population, with possible reduction in productivity and increase in mortality.

Disease and parasites were revealed to be a significant source of natural mortality in the Florida bobcat population and may play a more important role in population regulation of this species than has been previously thought. The role of domestic cats and other wildlife species as reservoirs and vectors of parasites and diseases of bobcats is an additional factor that should be considered in bobcat management. The significance of feral cats in panleukopenia epizootics may increase as more and more development occurs in bobcat habitats. The occurrence of feline panleukopenia in Florida bobcat populations may also have a potential bearing on the status of the endangered Florida panther, *Felis concolor coryi*. As bobcats are common in areas with the best known remaining panther populations, the possibility exists of a feline panleukopenia outbreak spreading from bobcats to panthers.

The study showed marked seasonal trends in marking behavior as well as a tendency to mark more frequently at range boundaries. These findings have important implications in connection with census techniques that use counts of feces as an index of abundance. They indicate that, at a minimum, censuses should be conducted at the same time of year, probably during late fall-early winter when marking is at its peak. Further, the tendency toward concentration of marking along range boundaries could lead to erroneous interpretations of abundance if some census routes happen to be located along range boundaries whereas others are not. This possibility should be considered in designing census studies and determining number of samples needed. These considerations may also apply to scent post census techniques, as the responsiveness of an individual to a scent post may vary seasonally and in relation to where in its range the scent station(s) are located.

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