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STATUS OF THE BOBCAT IN ILLINOIS

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W-126-R-4

STATUS OF THE BOBCAT IN ILLINOIS

FINAL REPORT

Federal Aid Project W-126-R-4

Submitted by:

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Division of Wildlife Resources
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FINAL REPORT

STATE OF ILLINOIS

W-126-R-4

Project Period: 1 July 1995 through 30 June 1999

Project: Status of the Bobcat in Illinois

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NEED: The bobcat (*Lynx rufus*) has been protected in Illinois since 1 July 1972 when the provisions of the Wildlife Code of 1971 (Public Act 77-1781, Illinois Revised Statute 61, Section 2.30) became effective. The Illinois Endangered Species Protection Board listed the bobcat as Threatened effective 31 December 1977. Distribution of the bobcat in Illinois was documented by Rhea (1982) who helped assemble historic sighting reports and new information during concurrent studies of the bobcat and river otter in Illinois conducted by the Cooperative Wildlife Research Laboratory (CWRL) at Southern Illinois University. Historical records reveal reports of bobcats from 78 Illinois counties (Rhea 1982: Appendix 1, Figs. 1 and 2). Trapper interviews conducted at furbearer clinics in 1980 and 1981 plus a survey of 700 Illinois trappers in March 1981 (Rhea 1982, CWRL unpubl. data) indicated sightings in 50 counties during 1981-82. An Illinois Department of Conservation (now Department of Natural Resources) survey (unpubl. data) of hunters participating in the 1992 Deer Firearms Season yielded reports of bobcats from 33 counties; a similar survey in 1993 documented reports from 38 counties. The current distribution is uncertain because data lack statistical confidence and reliability to allow comparisons over time or by method. More reliable information is needed to assess the status of the bobcat in Illinois and develop a recovery plan that could eventually lead to delisting as a threatened species in Illinois.

OBJECTIVES:

1. Determine the bobcat's relative abundance and distribution in Illinois.

2. Map and estimate the area and relative quality of habitat types that support, or have potential to support, bobcat populations.

3. Develop criteria for assessing the bobcat's status in Illinois.

EXECUTIVE SUMMARY

This report for W-126-R-4 summarizes the accomplishments of the final year and the entire 4-year span of the grant proposal period that began 1 July 1995. When this project began the bobcat was listed as a state threatened species and few data were available to critically assess its status and distribution in Illinois. We suspected that bobcats were becoming more abundant because of more frequent sightings, but conclusive evidence was lacking. Species-habitat relationships that ultimately define the distribution and abundance of a species were unknown for the bobcat in Illinois. The project was designed with 3 jobs to answer important questions that collectively would provide managers criteria to assess the bobcat's status and adaptively manage this important component of Illinois' fauna. We worked concurrently on Jobs 1.1 and 1.2 to obtain data necessary to develop criteria to assess and monitor the species' status (Job 1.3). The results of these efforts are reported as recommendations in Job 1.4. Following is a summary of the accomplishments of W-126-R. The project was completed on schedule and expected results and benefits achieved.

Job 1.1. Status and Distribution

The objective of this job was to determine the bobcat's relative abundance and distribution in Illinois. We used data from a variety of hunter and trapper surveys and compiled sighting records from all available sources (n = 2,997) to provide a current record of bobcat distribution and relative abundance throughout the state. A subset (n = 2,266) of these data were used to analyze regional and annual trends in abundance. Intensive field studies utilizing radiotelemetry were conducted in southern Illinois to determine survival and define home ranges. These data, along with those obtained from Job 1.2 form the basis for assessment of the species' status in Illinois.

We concluded that the bobcat was widely distributed in Illinois and no longer warranted classification as "threatened" as defined by The Illinois Endangered Species Protection Board. Bobcats were sighted in 99 of 102 Illinois counties, and trends from multiple types of surveys suggested that abundance increased throughout the state during the 1990s, especially in the 16 southern Illinois counties. Results from field studies of radiocollared bobcats provide more evidence that bobcats in Illinois are abundant and faring well. Home ranges of both sexes did not vary seasonally and were generally stable over years. Similar to other studies, most juvenile males dispersed long distances from natal ranges. Survival of bobcats was high relative to studies of exploited populations. Most mortalities were attributable to human activities; only 1 was due to natural causes. Further, despite disparities in behavior between males and females, we found no differences in seasonal survival.

Job 1.2. Habitat Mapping

The objective was to map and estimate the area and relative quality of habitat types that support, or have potential to support, bobcat populations. We used sighting location and digital landscape data, 2 multivariate statistical techniques, and a geographic information system (GIS) to model relative population abundance and habitat distribution of bobcats at 2 spatial scales. We modeled presence or absence and relative abundance of bobcats at the county scale using 2- and 3-group canonical discriminant analysis (CDA). The 2-group CDA differentiated presence or absence of bobcats in a county based on proportion of woods, patch density of woods, and proportion of slope $\geq$18%. The 3-group CDA differentiated low, medium, and high abundance of bobcats in a county based on proportion of woods, proportion of slope $\geq$18%, and density of rural roads. Model predictions indicated that bobcats occurred in moderate to high numbers in nearly 40% of the state. Statewide habitat suitability models constructed with logistic regression predicted that 31% of Illinois offered habitat considered good to excellent.

Data that fully report the objective of this job are included in a thesis submitted at the end of Segment 3 (Gibbs 1998) and a draft manuscript appended to this report (Woolf et al. 1999).

Digital files of habitat maps and sighting location overlays created for this job are maintained at the Cooperative Wildlife Research Laboratory.

Job 1.3. Bobcat Status Assessment

The objective for this job was to develop criteria for assessing the bobcat's status in Illinois. Scent station surveys and information from Jobs 1.1 and 1.2 were used to evaluate effectiveness and dependability of various approaches to monitor the status of the bobcat in Illinois. Scent station surveys were ineffective and we do not recommend their use to monitor bobcat status in Illinois. The request for information contained in the Illinois Department of Natural Resources (IDNR) Digest of Hunting and Fishing Regulations each year 1995-98 provided very useful location data that helped to map distribution and validate habitat models, but was not useful for tracking relative abundance. Trapper surveys produced information that was inconsistent compared to deer and spring turkey hunter surveys; thus, we do not recommend that trapper surveys be used to assess bobcat status. Firearm deer and archery surveys provided trend data that agree in direction, although not magnitude of change. The overall trend of spring turkey surveys agreed with the deer hunter surveys, but not in all years. We were more confident in the trends depicted by the surveys of deer hunters and recommended they be used to track bobcat population trends. However, no survey technique we examined was able to reliably measure magnitude of annual population fluctuations.

We also used home range and survival data from field studies to further evaluate bobcat status. We found that despite the differences on our study area relative to others, individual bobcats in Illinois require similar amounts of space in which to live. Survival rates were among the highest reported, and mortality from malnutrition or infectious disease was not detected. All but 1 mortality was attributed to human causes; however, most occurred from vehicle collisions and not incidental or illegal harvest. From these results, we concluded that bobcats appear to be faring well on the Illinois landscape.

Job 1.4. Analysis and Report

The purpose of this job was to synthesize information obtained from Jobs 1.1, 1.2, and 1.3 and (1) provide an evaluation (including maps) of bobcat habitat quality throughout the state, and (2) recommend procedures to monitor the status of the bobcat on a regular basis. Maps and recommendations are provided.

LITERATURE CITED

Gibbs, T. J. 1998. Abundance, distribution, and potential habitat of the bobcat in Illinois. Thesis, Southern Illinois University, Carbondale, Illinois, USA.

Rhea, T. 1982. The bobcat in Illinois: records and habitat. Thesis, Southern Illinois University, Carbondale, Illinois, USA.

Woolf, A., C. K. Nielsen, T. Weber, and T. J. Gibbs-Kieninger. 1999. A multiscale approach to estimating the distribution and quality of bobcat habitat in Illinois (submitted).

STUDY 1. STATUS OF THE BOBCAT IN ILLINOIS

JOB 1.1. STATUS AND DISTRIBUTION

Objective: Determine the bobcat's relative abundance and distribution in Illinois.

INTRODUCTION

When this project began in 1995 the bobcat was listed as a state threatened species and few data were available to critically assess its status and distribution in Illinois. We suspected that bobcats were becoming more abundant because of more frequent sightings, but conclusive evidence was lacking. Also, species-habitat relationships that ultimately define the distribution and abundance of a species were unknown for the bobcat in Illinois.

This job incorporated surveys of people participating in various types of outdoor recreation and compilation of existing records to address the objective at a statewide scale. We compiled and analyzed data to determine if population status differed on a regional basis and if annual trends could be detected.

Intensive field studies were conducted at local levels in southern Illinois to determine bobcat abundance in specific landscapes, to better understand species-habitat relationships, and to obtain ecological data necessary for science-based management. Both the statewide and regional scale data obtained in this job also provided information necessary to achieve objectives of the remaining jobs in this study.

STUDY AREA

We studied bobcat ecology on 3 primary study sites in southern Illinois (Fig. 1). The southern Illinois region includes the Shawnee Hills, Ozark, Lower Missippi River Bottomlands, and Coastal Plain natural divisions (Neely and Heister 1987). The Shawnee Hills and Ozark divisions consist of rolling hills with loess and loam soils (Neely and Heister 1987). The Mississippi River Bottomlands and Coastal Plain divisions comprise the Mississippi and Ohio

INSERT FIG. 1

River floodplains and consist of sandy and silty alluvial soils (Neely and Heister 1987). Land use/land cover in the region consists primarily of crop land (39%) characterized by corn and soybeans, closed-canopy mixed hardwoods forests (25%) dominated by white oak (*Quercus alba*), black oak (*Q. rubra*) and hickory spp. (*Carya* spp), and rural grasslands (24%, Table 1). Streams are abundant on the landscape (Table 2). Elevation ranges from 92-316 m; average slope is 1.4° (Table 2). Climate in southern Illinois is characterized by short, cool winters and hot, humid summers. About 119 cm precipitation falls annually, mostly as rain during the spring and summer months (Neely and Heister 1987). Average monthly temperatures range from 2° C in January to 27° C in July (Neely and Heister 1987).

Southern Illinois also is characterized by a relatively high level of human influence resulting in a patchy landscape with high interspersion of land use/land cover types. Human population density is >21 persons/km^2 (Table 2). Road densities in the region are >1 km/km^2 (Table 2).

Most activities were focused on study area 1, a 1,000-km^2 portion of Jackson, Johnson, Union, and Williamson counties (Fig. 1). Relative to the rest of southern Illinois, study area 1 has a higher proportion of woodlands and lower proportion of cropland (Table 1) and steeper slopes (Table 2); however, human, road, and stream densities are similar. Study area 1 has a considerably higher human density and slightly more road length than the other study areas (Table 2).

METHODS

Sighting Reports

We reviewed the sightings compiled by Rhea (1982) and added to these bobcat sightings collected by the IDNR from successful hunters during firearm deer seasons (1992-98) and spring and fall turkey seasons (1992-98), volunteer deer archery surveys (1992-97), and trapper surveys (pooled during 2 periods, 1990-93 and 1994-97) to assess trends in county-wide sighting reports.

Table 1. Land use/land cover of 3 bobcat study areas and 16 southern Illinois counties from Luman et al. (1995).

	1		2		3		Southern Illinois	
Class	ha	%	ha	%	ha	%	ha	%
Urban Land	408	0.4	163	0.2	127	0.1	17,991	1.1
Transportation	603	0.6	578	0.7	543	0.5	13,196	0.8
Cropland	10,642	10.6	22,471	28.4	11,886	11.7	629,835	39.2
Grassland	26,512	26.4	5,927	7.5	25,473	25.1	378,854	23.6
Woodland	55,473	55.2	36,036	45.5	58,635	57.8	402,839	25.1
Wetland	6,791	6.8	13,986	17.7	4,793	4.7	163,149	10.2
Totals	100,429	100.0	79,161	100.0	101,458	100.0	1,605,863	100.0

Table 2. Selected characteristics of 3 bobcat study areas and 16 southern Illinois counties.

Descriptor	1	2	3	Southern Illinois
Human				
Population size	17,840	5,097	4,936	345,024
Density (humans/km^2)	17.8	6.4	4.9	21.5
Road				
Length (km)	1,372	842	977	22,753
Density (km of roads/km^2)	1.4	1.1	1.0	1.4
Stream				
Length (km)	1,037	937	1,027	18,025
Density (km of streams/km^2)	1.0	1.2	1.0	1.1
Railroad Track				
Length (km)	35	43	24	1,125
Density (km of tracks/km^2)	<0.1	<0.1	<0.1	<0.1
Mean slope (degrees)	3.0	3.4	3.4	1.4

We also compiled reports from the IDNR Natural Heritage database (1982-95), a request for sightings contained in the 1995-98 IDNR Digest of Hunting and Fishing Regulations, necropsy records, and from miscellaneous additional sighting information. Survey data are referred to by their source (e.g., firearm deer) and other records combined in an "other" category.

We assessed temporal and regional trends in relative abundance and distribution of bobcat reports from firearm deer seasons, spring turkey seasons, and volunteer archery deer surveys, combined (n = 2,266). Fall turkey and trapper surveys were not evaluated due to extremely low annual sample sizes. Natural heritage database reports, sightings solicited in the IDNR Digest of Hunting and Fishing Regulations, and "other" reports were not statistically analyzed because of small samples sizes and the biases associated with variation in effort to obtain sighting reports. We analyzed annual sighting data separately for 2 regions [southern Illinois (the 16 counties south of Interstate 64) vs. northern Illinois (the remaining 82 counties of the state excluding Cook, DuPage, Kane, and Lake counties] because preliminary data assessment revealed marked differences in reports between these regions. This regional division was also logical due to potential differences in quantity of suitable habitat between northern and southern Illinois. For each survey, we used 1-way analysis of variance (ANOVA) to test for effects of survey year by region on the number of bobcat reports per county (PROC GLM, SAS Institute 1990). We performed post-hoc pairwise tests with the Tukey-Kramer method (SAS Institute 1990:944) to compare differences in means between all combinations of years when ANOVA results were significant. Alpha was set at 0.05 for all statistical tests.

Field Studies

Trapping and Handling.—We used cage-type and foot-hold traps to capture bobcats during trapping periods that began late November and ended no later than 30 March each year. Cage-type traps constructed of galvanized wire mesh were 38 x 38 cm x 90 cm long; various brand manufactured and homemade traps were used. Foot-hold traps were unmodified coilspring Number 3 Soft-catch® (Woodstream Co., Lititz, Pennsylvania, USA) with short (35 cm) chains; double swivels were placed between the stakes and trap and a shock absorbing coil spring was placed between chain links. These traps were placed in baited dirt-hole or cubby sets; commercial bobcat lures and visual attractants were frequently used in combination. We baited cage traps with whole or partial carcasses and chunks of meat from a variety of animals; visual attractants were placed nearby. Traps were systematically placed either where people reported sighting bobcats, or at locations where we thought bobcats would encounter our traps. Traps were checked daily and trap nights of operation recorded for all operable traps.

We released non-target animals without further handling; except they were manually restrained with a body-gripping device or a snare-pole to facilitate release from foot-hold traps. Captured bobcats were chemically immobilized for handling using a combination of ketamine hydrochloride (HCl) and xylazine HCl (both in 100 mg/mL concentration solution). The drugs were premixed in a solution of 90 mg ketamine and 10 mg xylazine/ml and administered intramuscularly at a target dose of about 13 mg/kg estimated body mass. We used a pole-syringe to inject the drug mixture into the hip or thigh muscle of bobcats in foot-hold traps. Most bobcats in cage traps were restrained in 1 end with a device constructed of reinforcing rods. The drug mixture was injected with a hand-syringe; however, a pole was used on occasion when bobcats could not be sufficiently confined to reach with a hand-syringe. If drug effects were not noted within 10-15 min, additional drug mixture was administered and the time to the nearest sec recorded.

Drug induction period was measured with a stop watch to the nearest sec and defined as the time from injection to when the bobcat no longer responded to tactile stimuli. We then removed the bobcat from the trap, determined sex, and weighed it to the nearest 0.1 kg with a spring balance. Bobcats were aged as juvenile or adult based on size, mass, and condition of dentition. After attaching a radiocollar, bobcats were examined for injuries and ectoparasites, anatomical measurements taken (nearest mm) with a cloth tape or plastic ruler, and pelage and overall physical condition noted. We monitored body temperature, respiration, and pulse during the handling period. Bobcats were then placed in a shaded place near the trap site to recover without further disturbance. Time from injection to when the animal first lifted its head (initial recovery) and time when it regained sufficient mobility to leave the area were recorded to the nearest sec. Capture and handling procedures were conducted in accordance with a protocol approved by the Southern Illinois University at Carbondale Institutional Animal Care and Use Committee (SIUC Animal Assurance #A-3078-01). Bobcats were captured under provisions of Illinois Endangered Species Permit #95-14S issued to the principal investigator.

Radiotelemetry.—-We fitted adult and selected juvenile (generally >5 kg) bobcats with Telonics (Mesa, Arizona, USA) model 315-S6A and Wildlife Materials (Carbondale, Illinois, USA) model HLPM-2140M radiocollars equipped with mortality sensors. Collar weights were 120-130 g; expected collar life was 17 and 20 months for Telonics and Wildlife Materials collars, respectively. We used standard ground and aerial radio-telemetry techniques to track bobcats (White and Garrott 1990). One vehicle, a TS-1 scanner (Telonics, Mesa, Arizona, USA), hand-held 2- or 3-element yagi antennas, and a compass were used for ground tracking. Two-element yagi antennas mounted on the wing struts of a Cessna 172 aircraft or on the skid of a Bell Long Ranger II helicopter were used for aerial telemetry.

We determined point locations (Universe Transverse Mercator coordinate system) for bobcats from radio-telemetry, capture, and visual locations. Most (89%) locations were obtained by taking $\geq$2 bearings approximating right angles at established bearing stations <2 km from bobcats. Less than 20 min elapsed between first and last bearings for 94% of all locations. We used the program LOCATEII (Nams 1990) to estimate locations according to the maximum likelihood estimator (Lenth 1981) and to calculate bearing error (n = 200, $\bar{x}$ = 4.16°, SD = 3.00) and error polygons (n = 200, $\bar{x}$ = 1.59 ha, SD = 1.82; Springer 1979). Homing (5%), capture (3%), visual (2%), and aerial (1%) locations were plotted on 7.5 minute series (1:24,000) United States Geological Survey topographic maps.

We radiotracked bobcats throughout the year; 20, 30, 25, and 25% of locations were obtained during winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov), respectively. Most (94%) locations were taken during 0600-1800 hrs. To minimize the potential influence of autocorrelation (Swihart and Slade 1985), 97% of locations were collected $\geq$20 hrs apart for individuals. To evaluate whether results would be biased by primarily diurnal sampling, we analyzed data from 14 bobcats captured during 1995-96 that had both day and night locations. Of 183 total night locations, only 22 (12%) were outside diurnal home ranges; these locations came from 6 of the14 bobcats. The average distance between outside locations and diurnal home range boundaries was 407.7 m (SD = 334.3). Thus, we concluded that the paucity of nocturnal locations would not bias home range results.

Home Ranges.—-We calculated total and seasonal minimum convex polygon (MCP, Mohr 1947) home ranges in RANGESV (Kenward and Hodder 1996:31-33) for bobcats with $\geq$30 and $\geq$15 locations, respectively. Total home ranges included all locations and were calculated at 100, 95 and 50% intervals to display the following areas occupied by individuals: the entire area, the entire area excluding outlier locations, and core areas. To gain some preliminary insight on differences in intensity of home range use between males and females, we calculated ratios of home range area (100% MCP, km^2):core area (km^2). We also calculated 100% MCP seasonal home ranges; for bobcats with same-season location data for $\geq$2 years (e.g., a bobcat with data for spring 1997 and spring 1998), seasons were pooled to increase sample sizes. We used 1-way analysis of variance to test for differences ($\alpha = 0.05$) in seasonal home range size (PROC GLM, SAS Institute 1990).

We classified residential status of bobcats depending on movement behavior and home range persistence (Litvaitis et al. 1987). Residents were defined as adults that maintained stable home ranges and juveniles that remained in natal ranges. Juvenile home ranges were considered natal from capture until dispersal was documented or until adulthood (~2 yrs) was reached. Juveniles that moved from natal ranges and established new ranges entirely outside the boundaries of the former were considered dispersers (Lidicker 1975). Similarly, we quantified pronounced spatial shifts in home ranges of adults when an individual moved from a stable home range and established a new home range completely outside the boundaries of the former.

Survival.—We estimated survival rates using numbers of transmitter-days (Trent and Rongstad 1974, Heisey and Fuller 1985*a*) in the program MICROMORT (Heisey and Fuller 1985*b*). We estimated the following maximum survival rates derived from the minimum number of known mortalities (i.e., confirmed mortalities): (1) annual survival (1 Jan of year t to 1 Jan of year $t+1$) for males and females combined (sexes were pooled due to small annual sample sizes), and (2) seasonal survival pooled over all study years for males and females separately. For analysis 2, pooled male and female survival rates were determined when survival rates between the sexes were similar. Minimum annual survival rates for males and females combined were derived from the maximum possible number of deaths (i.e., the number of confirmed mortalities plus individuals whose loss of radio contact was suspicious). We did not estimate seasonal minimum rates because of the minor influence these few additional mortalities would have on survival calculations and tests of significance. Generalized chi-square tests in the program CONTRAST (Hines and Sauer 1989, Sauer and Williams 1989) were used to test for differences in survival rates. We maintained experimentwise error rate ($\alpha = 0.05$) during multiple comparisons by adjusting α with the Bonferroni method (α /number of multiple comparisons, Neter and Wasserman 1974).

Bobcats were entered into survival estimations the day following capture. We censored bobcats from survival estimation upon death, radiocollar failure or loss, or if individual fates were unknown. Date of mortality was recorded as halfway between the dates of last live location and mortality location.

RESULTS

Sighting Reports

We compiled 2,997 bobcat sighting reports during 1982-98 (Appendix A). Firearm deer surveys provided the most (48%) sightings; spring turkey, and archery surveys yielded 13 and 8% of reports, respectively. The remaining sightings came from "other" (12%), IDNR digest solicitation (10%), trapper (4%) surveys, and fall turkey (3%) surveys. Bobcats were reported from 99 of 102 Illinois counties; 91 counties had $\geq$3 sightings which we defined indicative of a potential resident population and 17 counties reported >30 sightings which we defined as indicative of a high resident population. Counties with the most overall sightings were Union (12%), Jackson (9%), and Johnson (8%). Only DeKalb, Piatt, and Stark counties had no bobcat sightings during the study period.

Regional Differences.— More bobcats were reported from southern than northern Illinois when years were pooled and in 87% (26 of 30) of individual years for firearm deer, spring turkey, archery deer surveys, the IDNR digest, and other sightings (Table 3). Trapper surveys revealed the opposite pattern; 73 (39 and 34 during 1990-93 and 1994-97, respectively) and 39 (15 and 24 during 1990-93 and 1994-97, respectively) bobcats were reported from northern and southern Illinois, respectively. The magnitude of cumulative regional differences (Table 3) ranged from 1.5 (archery deer) to 13.6 times ("other") more bobcats observed in the 16 southern Illinois counties compared to the remainder of the state.

Regional Annual Sighting Trends.— Sightings/survey year did not differ for either spring turkey or trapper surveys in northern Illinois ($0.09 < F < 0.92$; $1 < df_{model} < 6$, $162 < df_{error} < 567$; $0.480 < P < 0.966$). Differences did exist in mean number of sightings/county over years for both the firearm ($F_{6, 567} = 12.06$, $P < 0.001$) and archery deer surveys ($F_{4, 405} = 4.63$, $P < 0.001$) in the northern region, but the 2 surveys produced different patterns. The archery deer survey pattern was constant to slightly declining in the northern region with fewer bobcats reported successive years after a peak in 1993 (Fig. 2). Survey years 1993 and 1994 had the most bobcat

Table 3. Regional bobcat sightings by survey type in Illinois, 1992-98.

	Year							
Survey	1992	1993	1994	1995	1996	1997	1998	Total
Firearm Deer								
North	38	47	41	85	11	135	180	537
South	45	73	68	135	81	226	282	910
Spring								
North	17	31	30	14	18	17	14	141
South	18	16	25	37	38	48	72	254
Archery Deer								
North	13	42	24	12	8	---[a]	---	99
South	18	16	22	59	30	---[a]	---	145
IDNR Digest								
North	---	---	---	21	20	27	21	89
South	---	---	---	27	43	60	49	179
Other								
North	2	1	2	5	5	2	1	18
South	17	21	39	47	50	48	22	244

[a]Total for both regions = 99. At the time of report preparation regional differences were unknown; hence, these sightings do not appear in the total column.

INSERT FIG 2

sightings; both differed from all other survey years, but not from each other (Table 4). In contrast, firearm deer survey results were constant during the first 3 years then increased except for the marked decline in 1996 (Fig. 2). The last 2 survey years (1997 and 1998) produced the highest numbers; they differed from all other years, but not from each other (Table 4).

Trapper survey sightings ($F_{1, 30}$ = 0.95, $P < 0.337$) did not differ over survey years for the 16 southern Illinois counties. Conversely, annual differences existed for the spring turkey, archery deer, and firearm deer surveys ($3.02 < F < 5.36$; $4 < df_{model} < 6$, $75 < df_{error} < 105$; $0.001 < P < 0.025$). Mean numbers of bobcats sighted/county in the archery deer survey were relatively low (Fig. 3) and did not differ from each other except in 1995, the peak year (Table 5). Data from the spring turkey season survey revealed a steadily increasing trend (Fig. 3); however, only the last year (1998) differed from earlier years (Table 5). The trend revealed by sightings from firearm deer surveys was an increase from 1992 to 1998 except for declines in 1994 and 1996 (Fig. 3). The highest number of sightings in 1998 did not differ from reports in 1995 and 1997, but was significantly larger than all other survey years (Table 5).

Combined data from hunter surveys and other sources (Table 3) reveal similar annual trends in both northern and southern Illinois regions (Fig. 4). In both zones of the state, numbers of sightings were rather stable during 1992-94 and then increased except for an unexplained decrease in sighting reported from both regions in 1996.

Trends in Relative Abundance.—At the beginning of the analysis period in 1992, 40% more bobcats (98 vs. 70) were reported from the 16 southern counties compared to the remainder of the state, whereas at the end of the period 97% more (216 vs. 425) bobcats were reported from the south. Also, there were apparent differences in overall rate of increase within the regions reflected by the composite sighting data (Table 3). In the north, total sightings from 1992 to 1998 increased 209%. Over the same period, total sightings from southern Illinois increased 334%. These data suggest that bobcats increased in abundance throughout Illinois, but the increase was greater in the 16 southern counties compared to the remainder of the state.

Table 4. Mean number of bobcat sighting reports/county in northern Illinois, 1992-98.

Survey	Year	$\bar{x}$ (SD)	Grouping[a]
Firearm Deer	1998	2.2 (3.5)	A
	1997	1.6 (2.9)	A
	1995	1.0 (1.5)	B
	1993	0.6 (1.2)	BC
	1994	0.5 (0.9)	BC
	1992	0.5 (0.9)	BC
	1996	0.1 (0.4)	C
Archery Deer	1993	0.5 (1.1)	A
	1994	0.3 (0.9)	AB
	1992	0.2 (0.6)	B
	1995	0.1 (0.4)	B
	1996	0.1 (0.3)	B

[a]Tukey formula, different letters indicate significance ($P < 0.05$).

Table 5. Mean number of bobcat sighting reports/county in southern Illinois based on various survey methods, 1992-98.

Survey	Year	$\bar{x}$ (SD)	Grouping[a]
Firearm Deer	1998	17.6 (17.0)	A
	1997	14.1 (12.5)	AB
	1995	8.4 (10.1)	ABC
	1996	5.1 (5.8)	BC
	1993	4.6 (7.2)	BC
	1994	4.3 (4.4)	BC
	1992	2.8 (3.8)	C
Spring Turkey	1998	4.5 (5.0)	A
	1997	3.0 (3.6)	AB
	1996	2.4 (3.1)	AB
	1995	2.3 (3.1)	B
	1994	1.6 (2.0)	B
	1992	1.1 (1.8)	B
	1993	1.0 (1.9)	B
Archery Deer	1995	3.7 (4.4)	A
	1996	1.9 (1.7)	B
	1994	1.4 (1.4)	B
	1992	1.1 (2.5)	B

Table 5. Continued.

Survey	Year	$\bar{x}$ (SD)	Grouping[a]
	1993	1.0 (1.2)	B

[a]Tukey formula, different letters indicate significance ($P < 0.05$).

INSERT FIG. 3

INSERT FIG. 4

Field Studies

Trapping and Handling.--Activities resulted in 145 total captures of 96 different bobcats (108 and 37 in live- and foot-hold traps, respectively) during 22 November 1998-27 February 1999 (Table 6). Most captures were in Jackson and Union counties (Fig. 5). Seventy-six different individuals (39 F, 37 M) were radiocollared (Appendix B); between 15 and 22 new individuals were radiocollared per year (Table 6). The additional 69 captures included recaptures of radiocollared individuals (33 during the season of original capture and released without receiving a new radiocollar, 11 from previous years that were fitted with new radiocollars, and 5 from previous years that did not receive new radiocollars), 17 juveniles too small to radiocollar, and 3 individuals that escaped traps.

Project staff compiled 5,249 total trap-nights; annual totals ranged from 956 in 1998-99 to 2,104 in 1997-98. We had higher success with live traps than foot-hold traps during 1995-96 and 1996-97 (Table 6). Overall capture success for live traps was double that of foot-hold traps (Table 6). Captured bobcats were in excellent physical condition except for 2 adult males captured during 1998 and 1 female captured during 1999 that were injured. Both males had superficial lacerations (1 had a puncture wound) only several days old that were attributed to fighting. Wounds were cleaned (the puncture wound was sutured) and the animals released. Radio monitoring revealed normal activity and movements suggesting the wounds healed without complication. The female was thin (she weighed 6.0 kg compared to 7.2 kg when previously captured) and had superficial abrasions, the most serious over a front shoulder; no skeletal injuries were detected by palpation. Cause of the trauma was unknown, but consistent with injuries that occur when struck by a vehicle. The bobcat died 45 days later, but autolysis was too advanced to determine cause of death.

Home Ranges.--We collected 5,028 locations from 76 bobcats during 22 November 1995-31 May 1999. Fifty-six adults (25 M, 31F) were radio-tracked for >4 months. Of these, 45 (23 M, 22 F) provided enough locations ($\bar{x}$ = 89.8 total locations, SD = 39.1) for total home range

Table 6. Total captures of bobcats in southern Illinois, 1995-99. Capture success is listed parenthetically as *n* bobcats/100 trap-nights.

	Total Captures[a]		Radiocollared[b]	
Capture Season	Live Traps	Foot-hold Traps	Males	Females
1995-96	9 (3.1)	9 (0.2)	8	7
1996-97	41 (2.6)	7 (1.2)	14	8
1997-98	21 (0.7)	12 (1.0)	11	8
1998-99	37 (1.4)	9 (1.8)	4	16
Totals	108 (1.6)	37 (0.8)	37	39

[a]Includes all new captures and recaptures.
[b]Individuals receiving first radiocollar.

INSERT FIG 5

calculations (Tables 7 and 8); 11 (2 M, 9 F) yielded seasonal data only. Seasonal home ranges for these 56 adults were calculated from 22.6 - 33.9 (SD = 7.0 - 10.2) locations/season. Ten juveniles (5 M, 5 F) were radiotracked; stable home range data were available from 3 that reached adult status (Tables 7 and 8). Ten individuals (8 adults, 2 juveniles) provided too few locations for home range calculations or dispersal analysis.

Male home ranges were larger than female home ranges for all seasons and in total (Tables 7 and 8). Total 100% MCP home range sizes for males were >3 times larger than females (males: $\bar{x}$ = 57.8 km^2, SD = 45.7; females: $\bar{x}$ = 18.9 km^2, SD = 12.7). For both males and females, total 50 and 95% MCP home ranges varied in size and shape among individuals (Figs. 6 and 7). Total 50 and 95% MCP home ranges for males were 7.1 and 40.0 km^2, respectively (Table 9, Fig. 6). For females, total 50 and 95% MCP home ranges were 3.1 and 13.8 km^2, respectively (Table 10, Fig. 7). Males (8.1:1) had a larger home range:core area ratio than females (6.1:1).

We found no differences in seasonal home range size for males ($F_{3, 70} = 0.50$, $P < 0.686$) or females ($F_{3, 70} = 0.86$, $P < 0.469$). Seasonal home ranges for males ranged from 27.5 km^2 during spring to 21.5 km^2 during summer. Seasonal home ranges for females ranged from 12.1 km^2 during fall to 8.9 km^2 during spring.

Home ranges of the resident bobcats tended to be stable; only 4 of the 56 (7%) adults radiotracked >4 months shifted home range. Three bobcats that shifted home range were males and all shifts occurred <6 months following capture. Male #1 maintained a stable home range during November 1995-January 1996 then made several excursions >5 km to the west during February-May 1996. He then remained in the western area exclusively until the end of the study (Fig. 8). Male bobcat #26 stayed within a stable home range during January-May 1997. In June 1997, he began establishing a new home range 8 km to the east and remained in that home range until radio contact was lost 1 year later (Fig. 8). We were unsure of the age of this bobcat because his body mass and size were less than the average adult. If he was a subadult when

Table 7. Seasonal and total 100% minimum convex polygon home range sizes of adult male bobcats in southern Illinois, November 1995-May 1999. Number of locations per home range calculation is listed parenthetically.

	Home Range Size (km²)				
ID	Winter	Spring	Summer	Fall	Total
1	16.5 (32)[a]	5.6 (59)	14.3 (41)	12.8 (40)	b (188)
2	23.1 (21)	25.6 (22)	24.2 (15)	c (8)	46.3 (66)
3	c (3)	42.0 (18)	20.0 (19)	---	58.2 (40)
9	21.3 (20)	22.6 (27)	30.9 (28)	20.4 (34)	45.2 (109)
12	23.1 (21)	22.7 (48)	25.8 (62)	23.6 (30)	46.4 (173)
14	26.1 (26)	26.2 (27)	16.0 (24)	24.0 (27)	48.8 (104)
15	19.6 (37)	19.9 (50)	13.5 (52)	15.2 (74)	26.3 (213)
16	20.0 (22)	c (14)	19.8 (20)	18.3 (23)	47.7 (79)
17	51.3 (44)	32.5 (31)	47.7 (36)	36.6 (46)	80.3 (157)
21	9.7 (28)	21.4 (21)	5.8 (31)	18.7 (36)	34.7 (116)
22	33.1 (16)	56.1 (20)	c (6)	c (7)	173.7 (49)
23	d (23)	d (22)	29.3 (32)	d (35)	e (112)
25	c (12)	12.8 (17)	43.4 (27)	58.1 (39)	78.1 (95)
26[f]	d (30)	30.1 (21)	6.4 (24)	37.5 (42)	g (117)
27	14.4 (16)	7.8 (17)	12.3 (18)	17.6 (19)	26.4 (70)
29[h]	c (7)	c (9)	14.3 (17)	a (9)	105.8 (42)

Table 7. Continued.

	Home Range Size (km^2)				
ID	Winter	Spring	Summer	Fall	Total
36	12.1 (21)	32.0 (21)	14.8 (18)	20.7 (47)	38.0 (107)
47[h]	c (13)	13.0 (20)	13.7 (26)	d (24)	23.1 (83)
50	c (11)	123.7 (21)	30.3 (22)	34.1 (24)	196.5 (78)
51	c (8)	25.9 (26)	24.1 (33)	13.4 (28)	46.8 (95)
52	c (7)	4.3 (24)	6.9 (26)	5.9 (30)	10.4 (87)
53	c (5)	15.3 (19)	19.7 (29)	13.9 (32)	30.5 (85)
54	c (4)	18.7 (20)	50.3 (22)	34.5 (29)	57.8 (75)
55	c (4)	19.0 (15)	10.5 (19)	15.4 (25)	24.5 (63)
56[f]	---	c (10)	c (6)	---	9.1 (16)
$\bar{x}$ (SD)[I]	22.5 (11.1)	27.5 (25.1)	21.5 (12.5)	23.9 (12.6)	57.8 (45.7)

[a]Size of the pre-shift winter home range; total winter locations (pre-and post-shift) = 48.

[b]Total pre-shift home range size = 19.3 (*n* = 54); total post-shift home range size = 24.1 (*n* = 134).

[c]Home range size not calculated due to small sample size.

[d]Home range size not calculated due to transient behavior.

[e]Used 3 separate non-stable home ranges; sizes = 24.6 (*n* = 48), 32.3 (*n* = 41), and 38.6 (*n* = 26).

[f]Possibly subadult individuals.

[g]Total pre-shift home range size = 48.1 (*n* = 27); total post-shift home range size = 60.0 (*n* = 90).

[h]Juvenile when captured, these sizes represent seasonal totals following establishment of a stable range.

[i]Summary statistics calculated for seasonal and total home ranges with $\geq$15 and $\geq$30 locations, respectively.

Table 8. Seasonal and total 100% minimum convex polygon home range sizes of adult female bobcats in southern Illinois, November 1995-May 1999. Number of locations per home range calculation is listed parenthetically.

	Home Range Size (km^2)				
ID	Winter	Spring	Summer	Fall	Total
5	6.0 (20)	6.2 (27)	7.7 (35)	11.5 (37)	14.5 (119)
7	a (12)	18.8 (26)	26.5 (43)	13.9 (42)	29.9 (123)
8	a (9)	10.7 (25)	---	---	12.9 (34)
10	11.4 (16)	5.7 (26)	6.6 (44)	6.8 (36)	15.9 (122)
11	3.4 (17)	8.8 (27)	9.5 (42)	7.9 (40)	11.5 (126)
13[b]	8.1 (16)	21.3 (27)	18.7 (38)	19.5 (32)	34.2 (113)
24	6.6 (29)	10.0 (27)	6.4 (34)	5.4 (41)	16.8 (131)
28	21.7 (29)	32.7 (25)	33.9 (34)	38.6 (39)	57.4 (127)
32	9.2 (19)	7.6 (23)	7.6 (26)	16.2 (38)	16.9 (106)
33	a (14)	4.6 (21)	a (13)	14.5 (33)	c (81)
38	6.2 (19)	6.3 (20)	a (10)	13.4 (26)	18.5 (75)
39	17.4 (15)	a (13)	a (13)	11.6 (27)	29.8 (68)
40	12.1 (19)	16.3 (23)	27.7 (26)	14.7 (25)	40.3 (93)
42	6.4 (17)	7.3 (25)	4.1 (23)	4.7 (27)	9.1 (92)
44	5.4 (22)	18.8 (25)	11.7 (32)	8.6 (26)	20.4 (105)
46	5.4 (22)	9.1 (23)	2.7 (22)	5.4 (24)	21.0 (91)

Table 8. Continued.

	Home Range Size (km²)				
ID	Winter	Spring	Summer	Fall	Total
48	a (13)	3.6 (26)	4.9 (24)	a (12)	9.5 (75)
49	a (8)	4.0 (25)	6.7 (34)	---	8.1 (67)
57	a (8)	2.3 (19)	---	---	4.5 (27)
58	a (8)	6.1 (22)	---	---	7.0 (30)
59	a (7)	4.0 (25)	---	---	5.0 (32)
60	a (7)	6.6 (21)	---	---	6.6 (28)
61	a (7)	6.1 (24)	---	---	6.1 (31)
65	a (5)	10.0 (24)	---	---	10.0 (29)
68	a (3)	3.6 (24)	---	---	3.6 (27)
69	a (5)	11.3 (28)	---	---	11.6 (33)
70	a (4)	5.0 (18)	---	---	5.5 (22)
72	a (3)	3.2 (23)	---	---	3.2 (26)
73	a (3)	11.6 (25)	---	---	12.6 (28)
74	a (2)	2.6 (16)	---	---	2.7 (18)
76	a (2)	3.6 (22)	---	---	4.1 (22)
$\bar{x}$ (SD)[d]	9.2 (5.3)	8.9 (6.7)	11.8 (10.1)	12.1 (8.7)	18.9 (12.7)

[a]Home range size not calculated due to small sample size.

[b]Juvenile when captured, remained in natal home range until adulthood.

[c]Total pre-shift home range size = 19.1 (n = 69); total post-shift home range size not calculated due to small sample size.

[d]Summary statistics calculated for seasonal and total home ranges with $\geq$15 and $\geq$30 locations, respectively.

Table 9. Total 50% and 95% minimum convex polygon home range sizes of adult male bobcats in southern Illinois, November 1995-May 1999.

	Home Range Size (km^2)	
ID	50% MCP	95% MCP
1[a]	3.6	16.6
2	12.2	31.9
3	8.5	51.7
9	11.2	31.0
12	8.0	29.1
14	6.3	28.0
15	8.9	22.0
16	8.1	37.5
17	9.5	67.6
21	4.6	27.3
25	13.4	66.9
26[a]	2.6	43.7
27	3.7	24.1
29[b]	3.5	51.7
36	5.9	29.2
47[b]	2.9	12.6
50	11.5	146.7

Table 9. Continued.

ID	Home Range Size (km^2)	
	50% MCP	95% MCP
51	3.4	27.4
52	1.4	8.7
53	11.3	24.4
54	8.5	38.3
55	8.7	19.4
$\bar{x}$ (SD)	7.1 (3.5)	40.0 (29.8)

[a]Represents post-shift home range size.
[b]Captured as a juvenile.

Table 10. Total 50% and 95% minimum convex polygon home range sizes of adult female bobcats in southern Illinois, November 1995-May 1999.

	Home Range Size (km^2)	
ID	50% MCP	95% MCP
5	2.9	10.2
7	3.7	18.3
8	1.8	12.5
10	2.7	11.4
11	2.7	10.3
13[a]	4.4	21.3
24	1.3	7.6
28	16.9	52.3
32	4.2	16.7
33[b]	2.5	15.0
38	2.6	14.6
39	1.2	20.3
40	5.5	26.9
42	2.2	6.8
44	3.2	13.8
46	1.6	12.3
48	1.6	5.8

Table 10. Continued.

	Home Range Size (km^2)	
ID	50% MCP	95% MCP
49	2.0	5.6
58	0.9	5.8
59	0.5	2.5
61	0.9	4.9
69	3.1	7.6
$\bar{x}$ (SD)	3.1 (3.3)	13.8 (10.6)

[a]Captured as a juvenile.
[b]Represents pre-shift home range size.

INSERT FIG 6

INSERT FIG 7

INSERT FIG 8

captured, the movement represents juvenile dispersal and home range establishment rather than home range shift. Bobcat #23 shifted his home range twice after capture in January 1997. He established a temporary range during summer 1997 7 km to the northeast of his capture location, and then shifted again in November 1997 11 km to the south (Fig. 8) where he remained until radio contact was lost in late June 1998. The 1 adult female that shifted her home range maintained a stable home range during February-November 1997, then moved 32 km to the northwest (Fig . 8) and stayed there until her radio failed in June 1998.

We documented 3 examples of rapid occupation of voids created when radiocollared occupants were killed by automobiles. An adult female (#5) captured in January 1996 maintained a stable home range of about 15 km^2 until she died from unknown causes in June 1997. A different adult female (#49) was captured on the same property as bobcat #5 in February 1998. She held a very similar home range to #5 until hit by an automobile in August 1998. Yet another adult female (#58) was captured about 1 km from the capture sites of #5 and #49; she maintained a home range similar to these bobcats.

Of 7 individuals radiotracked for 2-3.5 yr, only 1 (14%) shifted home ranges. Two bobcats (1M, 1F) were tracked for 2-2.5 yr; both of these animals were hit by vehicles. Five males were followed for 3.5 yr and all animals survived until the end of the study.

Four of 5 juvenile males dispersed >20 km from their natal ranges. Bobcat #4 began dispersal in April 1996 and wandered erratically until June 1996 when he established a temporary home range about 23 km southeast of his natal home range (Fig. 9). He remained there until August 1996, when he again began making long-distance movements. By October 1996, he had moved 55 km to the southeast of his temporary summer home range where he stayed until February 1997. We were unable to locate bobcat #4 until April 1997; he had moved about 26 km northeast to an area previously inhabited by bobcat #19 (hit by a vehicle in Feb 1997) and remained there until his radio failed in July 1997. Bobcat #29 vacated his natal home range in April 1997 and dispersed about 27 km to the southeast where he established a home

INSERT FIG 9

range (Fig. 9) and remained there until contact was lost in August 1998. In September 1997, bobcat #37 began to make erratic transient movements within 15 km of his natal range and continued these movements until January 1998. He then established a home range 59 km southeast of his natal range (Fig. 9) where he remained until contact was lost in July 1998. Bobcat #43 left his natal home range in April 1998 and began a series of short-distance movements within 15 km of his natal range. In early August, he began making longer movements, but was hit by a vehicle 26 km from his natal range. Bobcat #47 was the only juvenile male that appeared to reach adult status near his natal home range (Fig. 9). During January-February 1998, he remained near his capture site, making 1 exploratory movement 7 km to the northwest. He then returned to his natal range and remained there until September 1998. During September he stayed in an area 8 km to the west, but returned to his natal home range in October 1998 and remained there until the end of the study.

All 5 juvenile females remained close to their natal home ranges. However, we were unable to track 4 of 5 for >6 months due to collar loss (n = 2) , malfunction (n = 1), or mortality (n = 1). We monitored bobcat #13 for about 21 months; she remained in her natal home range through adulthood.

Survival.--We entered 75 bobcats (39 F, 36 M) with 28,954 radio-days ($\bar{x}$ days/bobcat = 386.1, SD = 307.9, range 21-1,286) collected during 22 November 1995-31 May 1999 into survival analysis. We confirmed 14 mortalities (8 M, 6 F); loss of radio-contact from 3 other bobcats (2 M, 1 F) were considered possible mortalities. We lost radio-contact with 2 individuals (1 M during Mar 1997 and 1 F during Oct 1998) very abruptly and had 1 individual whose collar appeared to have been cut off (1 M during Jul 1998). Seven (50%) of the confirmed mortalities were hit by automobiles, 2 (14%) were hit by trains, 2 (14%) were incidentally trapped, 2 (14%) were unknown, and 1 (7%) was natural (cachexia resulting from stomach obstruction). Most confirmed mortalities (64%) occurred during winter; 7% and 29% happened during spring and summer, respectively; none occurred during fall. Including the 3 bobcats with suspicious loss of radio-contact, 41 were censored from analyses during the study due to radiocollar loss or failure; 20 were assumed to be alive at the end of the study and were censored on the final day.

Maximum annual survival rates ranged from 1.000 during 1996 to 0.792 (95% CI = 0.608 - 1.000) during 1999 (Table 11) and differed (χ^2_3 = 16.635, P = 0.001) among study years. Annual survival was similar (0.001 $\leq \chi^2_1 \leq$ 0.126, 0.770 $\leq P \leq$ 1.000) among 1997, 1998, and 1999. The only difference (χ^2_1 = 7.600, P = 0.006) between pairs of years was 1996 vs. 1997. Minimum rates were not calculated for 1996 and 1999 because no suspicious mortalities occurred. Minimum survival was 0.776 (95% CI = 0.629 - 0.933) and 0.772 (95% CI = 0.638 - 0.935) during 1997 and 1998, respectively.

Seasonal survival for males was highest during spring and fall (S = 1.000 for both seasons) and lowest during winter (S = 0.860, CI = 0.769 - 0.962; Table 12). Although the test for male seasonal survival over all seasons indicated no difference (χ^2_3 = 7.494, P = 0.058), individual contrasts indicated differences between some seasons. Winter survival was similar (χ^2_1 = 1.733, P = 0.188) to summer survival, but was lower (χ^2_1 = 8.165, P = 0.004) than spring and fall survival (Table 12). Seasonal survival for females ranged from 0.893 (CI = 0.786 - 1.000) during summer to 1.000 during fall and was similar (χ^2_3 = 5.600, P = 0.133) among all seasons (Table 12).

There were no differences in seasonal survival between males and females for any seasons (0 $\leq \chi^2_1 \leq$ 1.297, 0.255 $\leq P \leq$ 1.000); thus, we pooled sexes. Pooled estimates of seasonal survival differed (χ^2_3 = 15.4311, P = 0.002) over all seasons. Winter survival was similar to summer survival (χ^2_1 = 1.506, P = 0.220), but was lower than spring and fall survival (8.120 $\leq \chi^2_1 \leq$ 10.149, 0.001 $\leq P \leq$ 0.004, Table 12). Spring, summer, and fall survival rates were all similar (1.047 $\leq \chi^2_1 \leq$ 4.235, 0.040 $\leq P \leq$ 0.306).

Table 11. Maximum annual survival rates for bobcats in southern Illinois, November 1995-May 1999.

Year[a]	Bobcat Days	Mortalities	S	95% CI
1996 A	4,568	0	1.000	---
1998 AB	9,899	5	0.832	0.708 - 0.977
1999 AB	4,693	3	0.792	0.608 - 1.000
1997 B	9,610	6	0.796	0.663 - 0.955

[a]Years with different letter designations are significantly different (Bonferroni-adjusted $P < 0.008$).

Table 12. Seasonal survival rates for bobcats in southern Illinois, November 1995-May 1999.

Season[a]	Bobcat Days	Mortalities	S	95% CI
Males				
Fall A	3,418	0	1.000	---
Spring A	5,702	0	1.000	---
Summer AB	3,852	1	0.976	0.932 - 1.000
Winter B	4,170	7	0.860	0.769 - 0.962
Females				
Fall A	2,013	0	1.000	---
Spring A	4,667	1	0.981	0.943 - 1.000
Winter A	2,684	2	0.935	0.852 - 1.000
Summer A	2,448	3	0.893	0.786 - 1.000
Pooled				
Fall A	5,431	0	1.000	---
Spring A	10,369	1	0.991	0.974 - 1.000
Summer AB	6,300	4	0.943	0.891 - 0.999
Winter B	6,854	9	0.889	0.882 - 0.960

[a]Seasons with different letter designations are significantly different (Bonferroni-adjusted $P < 0.008$).

DISCUSSION

Distribution and Abundance

Our goal was to update and expand upon a previous study of bobcat sightings (Rhea 1982), and by doing so, assess the animal's status in Illinois. Rhea (1982) compiled bobcat sightings from the late 1800s to 1982 from reports by the Illinois Nature Preserves Commission, credible wildlife observers, trappers, and other individuals. Although our results are not directly comparable with those of Rhea (1982), distribution and abundance of bobcats have clearly increased in Illinois. Rhea (1982) found historic sightings from 73 of 102 (72%) Illinois counties; only 28 counties (27%) had $\geq$3 reports indicative of a potential resident population and only 1 county had >30 reports indicative of a high resident population (Gibbs 1998). Since 1982, the number of counties with bobcat sightings have increased to 99, there were 91 counties with $\geq$3 sightings indicative of a potential resident population, and 17 counties reported >30 sightings which we judged indicative of a high resident population.

Southern Illinois has historically contained the largest area of suitable habitat. Early accounts of the bobcat in Illinois (Wood 1910) commented on their presence in the wooded south. Even when bobcats were thought to be extirpated from settled areas and rare in the north, they still were common in the southern counties of Alexander, Gallatin, Jackson, Pope, and Randolph (Cory 1912). Rhea (1982) concluded that when bobcat populations were at their lowest in Illinois, they likely still existed in southern counties; whereas, they were almost extirpated in the northern counties.

Although the region we defined as southern Illinois encompasses only about 11% of the land area of Illinois, we recorded considerably more bobcat sightings from southern compared to northern Illinois in total, and from all surveys except the trapper survey. This pattern of bobcat distribution and reported abundance is not surprising given the regional differences in habitat. Counties north of Interstate 64 are characterized by a matrix of intensive agricultural land; such habitat is of relative low suitability to bobcats (Rolley 1987). In contrast, the 16 counties south of Interstate 64 are comprised of about 50% forest and grassland (Woolf 1998) which provides more suitable habitat for bobcats than row crop agriculture.

Sighting trends were the same in both southern and northern regions (Fig. 4) suggesting an increase in bobcat abundance throughout the state. Although rates of increase were not measured, they appear different in southern vs. northern regions based on visual examination of the data (Fig. 4). We believe the evidence is clear that bobcats are more abundant now than at the beginning of the study in 1995 and the population trend remains upward. Models constructed by Woolf et al. (1999 submitted; see Job 1.2) predicted that bobcats occurred in moderate to high numbers in nearly 40% of Illinois, and that 31% of the state offered good to excellent habitat. Woolf and Hubert (1998) concluded that bobcat populations were secure throughout the United States, and our data support that conclusion in Illinois.

Field Studies

Our field research contributes toward understanding the status of the bobcat in Illinois and more generally, the ecology of unexploited bobcat populations. Several attributes of this study are unique relative to other bobcat studies. First, only 1 study (Chamberlain et al. 1999) reported data from >65 radiocollared individuals; none represent a spatial scale as large as southern Illinois. Second, only a few studies (Bailey 1974, Lembeck and Gould 1979, Knick 1990) have been conducted on completely unexploited populations. Bobcats in southern Illinois have been protected from harvest for 25 years with no likely exchange between any harvested populations due to geographical barriers (i.e., the Mississippi and Ohio rivers) and distance from the nearest state that allows harvest (Wisconsin). Finally, little is known about bobcat ecology in a landscape consisting of high human densities and agricultural land use. We focused efforts on home range and survival which we considered crucial determinants of bobcat status in Illinois.

Home Ranges.–We determined size of home range (100% MCP) and core areas (50% MCP) to provide insight into areas used by Illinois bobcats and for comparison to other populations. Bobcat home range size is a product of a complex relationship among factors, such as geographic location, habitat quality (including both land cover and prey components), and population density (Anderson 1987, Rolley 1987). Within the same population, home ranges of male bobcats are generally larger than females because of differences in spatial requirements between the sexes.

Generally, the most appropriate comparisons of home range size among bobcat populations are based on regional affiliations because of relative similarities in climate and land use/land cover. Home range sizes of adult bobcats (57.8 and 18.9 km^2 for males and females, respectively) in Illinois were within the range of other regional studies (Kitchings and Story 1979, Hamilton 1982, Rolley 1983, Rucker et al. 1989). Also, consistent with these studies, we found that male home ranges were about 3 times larger than females. It appears that despite our study area having a higher proportion of agricultural land use, restricted harvest, and higher human and road densities, individual bobcats in Illinois used similar-sized areas as bobcats region-wide.

Males had both larger home ranges and core areas than females. Because several researchers have suggested that females use their smaller ranges more intensively than males (Bailey et al. 1974), we calculated home range size:core area ratios. This ratio overcomes the absolute size differences of male and female home ranges, and provides evidence of greater intensity of use as the ratio approaches 1:1. We found that females had a smaller ratio than males which supports the contention they used their home ranges in a more concentrated manner. This phenomenon may be explained by differences in behavior between the sexes. Male home range size is greatly influenced by locations far from the core area that result from wide ranging movements to maximize mating opportunities; however, females do not behave in this way (Anderson 1987, Sandell 1989). Hence, female home ranges are used more intensively and that is reflected in a smaller home range:core area ratio.

Studies of seasonal differences in home range size provide inconsistent results; although direct comparisons among studies is problematic because most define seasons differently.

Anderson (1987) reported that males often have largest home ranges during winter due to breeding activity. McCord and Cardoza (1982) discussed 2 studies that found differences in seasonal home range size; however, Buie et al. (1979) found none. We found no differences in seasonal home range size for either males or females. These results correspond with movement studies of bobcats in Illinois; no seasonal differences in movements were evident for both males and females during spring, summer, and fall seasons (D. Kennedy, Cooperative Wildlife Research Laboratory, Southern Illinois University at Carbondale, unpublished data). However, winter data were not available from this study.

Defining seasons for home range analyses is challenging because of variations in bobcat breeding and parturition seasons. Similar to Hamilton (1982), we defined seasons according to vegetative characteristics (e.g., winter is defined as Dec-Feb). We also presumed these definitions approximated reproductive events (e.g., winter = breeding season); however, newborn litters were found as early as March and as late as August on our study area (A. Woolf, Cooperative Wildlife Research Laboratory, Southern Illinois University at Carbondale, unpublished data). Assuming a 2 month gestation period (McCord and Cardoza 1982:735), the approximate breeding season for bobcats in Illinois was January-June, which was longer than the winter season we defined. A re-evaluation of seasonal data according to different temporal periods may be necessary to provide an alternative assessment of seasonal home range sizes.

Knowledge of home range stability lends insight into bobcat social organization. Although prey declines influence stability in harsh environments (Bailey 1981), adult bobcats generally stay in the same home range until death or until a vacancy is created through the mortality of an adjacent individual (Anderson 1987). Bobcats then may occupy these voids to escape social pressures or utilize higher quality habitat (Lovallo and Anderson 1995). Occupation may result from gradual movements that encompass both the old home range and new area (Bailey 1974, Lovallo and Anderson 1995), or a pronounced spatial shift where the new home range is completely outside the boundaries of the former.

We found that most (93%) adults were residents, indicating high stability of bobcat home ranges in Illinois relative to exploited populations (Hamilton 1982, Rolley 1983, Litvaitis et al. 1987). Similar to bobcats tracked for <2 yr, most (86%) tracked for >2 yr stayed in the same home range, providing evidence that individual home ranges were stable over multiple years. This is not surprising because survival rates on our study area were higher than most harvested populations (see below); hence, fewer vacancies were created for other bobcats to occupy. However, we did document 3 examples of rapid occupation of voids created when radiocollared occupants were killed by automobiles. This indicates that despite the absence of harvest in Illinois, social organization of bobcats appears to be maintained similarly to exploited populations.

We can not explain why 4 radiocollared adults shifted home ranges; no known mortalities occurred leaving spaces re-occupied by these individuals. Although the 1 female shifted home range over only 2 weeks, the 3 males made exploratory movements for 4-9 months prior to complete home range shifts. This suggests that they spent time assessing the advantages (e.g., more suitable habitat) of moving to the new areas or were displaced by other individuals. Habitat composition (and likely, quality in terms of cover and prey) of new home ranges did not appear to differ substantially from the old in any case. However, subtle differences such as minor increases in prey abundance or availability of prime breeding areas may have prompted these individuals to shift home ranges permanently.

Dispersal of juvenile males is common in bobcat populations (Bailey 1979, Hamilton 1982, Kitchings and Story 1984) and influenced by a variety of ecological phenomena (Lidicker 1975, Dobson 1982). Dispersal behavior provides important insight into spatial organization within a population and connectivity of separate populations (Chepko-Sade and Halpin 1987). Behavior of 3 of 4 juveniles during 4-11 months following the onset of dispersal was characterized by wandering movements and establishment of temporary areas of use. After having traveled greater distances, the 2 surviving juveniles settled permanently into new home ranges. This implies that for the months following the onset of dispersal these juveniles searched unsuccessfully for vacant home ranges or tried to occupy areas containing other bobcats. However, they eventually established home ranges either due to distance and direction traveled, increased experience, or creation of voids through mortality of residents. Their relatively long (>70 km) travel distances may indicate differences in population density or spatial organization between our primary study area and the surrounding landscape; however, we had no data to assess this possibility.

Survival.–We determined natural and human-influenced mortality factors for bobcats and quantified similarities or differences in sex- and season-specific survival because of the importance of these characteristics to bobcat population ecology. Many studies have shown that these attributes can vary considerably according to region and harvest levels (McCord and Cardoza 1982:750, Anderson 1987:20). Such differences in sex- or season-specific survival then have very important implications regarding bobcat management.

Annual survival rates (range = 0.792-1.000) for unexploited bobcats in Illinois were higher than in most exploited populations [e.g., 19 and 61% on 2 separate Minnesota study areas (Fuller et al. 1985), 56-66% in Oklahoma (Rolley 1985)] and higher than the unexploited population (67%) on Knick's (1990) study area. Survival rates for other unharvested populations (Bailey 1974, Lembeck and Gould 1979) were not available; however, our estimates appear comparable or higher. Aside from differences in latitude and climate, our study area differs from those of Bailey (1974) and Knick (1990) and Lembeck and Gould (1979) in 2 primary ways. First, although not reported in these studies, human and road density is likely much higher in southern Illinois than restricted-access sites in southeast Idaho (Bailey 1974, Knick 1990:6), or the chaparral hills of southern California (Lembeck and Gould 1979:53). Second, although harvest was prohibited on these study areas, it was legal statewide, and harvest on adjacent lands may have influenced the populations studied. Indeed, Bailey (1974) reported that 7 of 20 (35%) mortalities occurred by harvest of tagged individuals that had moved outside of his study area.

Several studies have shown that natural mortality can have an important influence on bobcat populations. In areas with fluctuating or extreme environmental conditions, prey abundance and availability can be severely limiting (Lembeck and Gould 1979, Knick 1990). Infectious diseases (e.g., feline panleukopenia) are rarely major concerns, but occasionally cause mortalities (Lembeck and Gould 1979, Chamberlain et al. 1999). We diagnosed only 1 natural mortality; cachexia due to stomach obstruction from a large hair ball. Further, a separate data set of southern Illinois bobcat necropsies (A. Woolf, Cooperative Wildlife Research Laboratory, Southern Illinois University at Carbondale, unpublished data) confirmed that debility due to either infectious disease or malnutrition was uncommon. Ninety-one of 93 (98%) bobcats >1 yr old collected primarily as road-kills were in good or excellent physical condition. Infectious disease was not evident in the 2 exceptions; 1 was cachectic from a prior injury, and the cause of poor condition of the other was unknown.

Generally, human activities cause the most mortalities in bobcat populations (Bailey 1974, Berg 1979, Hamilton 1982). Legal harvest is responsible for a high proportion of deaths in exploited populations (Fuller et al. 1985, Rolley 1985, Lovallo 1993); incidental or illegal harvest can occasionally be limiting in unexploited populations (Knick 1990). Mortalities from vehicle collisions also have been reported from a few studies, but these generally comprise <20% of total deaths (Knick 1990, Chamberlain et al. 1999).

Human activities were the major mortality factor for Illinois bobcats, causing 11 of 14 (79%) diagnosed deaths. In addition, we documented the highest reported proportion (64%) of vehicle-related (7 and 2 by automobiles and trains, respectively) mortalities for bobcats. We attribute this to the relatively high road density (1.4 km/km^2) and use in southern Illinois. Although not usually reported, other study areas appear to contain much lower road densities [e.g., Lovallo and Anderson (1996:73) report road densities of 0.144-0.562 km/km^2]. Compared to other unharvested populations (Lembeck and Gould 1979, Knick 1990), we found a lower proportion (14%) of mortality from incidental or illegal harvest. This may simply be attributable to fewer licensed trappers (that make incidental captures while trapping for other species) operating in Illinois (Woolf and Hubert 1998) relative to other studies.

Several studies have quantified sex- and season-specific differences in bobcat survival; however, direct comparisons are difficult given that seasonal definitions are rarely the same. Annual survival is often lower for males than females in exploited populations. This is commonly attributed to males being more vulnerable to harvest because of their increased movements (Anderson 1987:20), although this explanation may not be entirely correct in all situations (McCord and Cardoza 1982:751-752, Chamberlain et al. 1999:618). However, as in other unexploited populations (Knick 1990), we detected no differences in annual survival between males and females.

Studies of both harvested and unharvested populations have provided mixed results regarding differences in sex-specific seasonal survival rates. Fall-winter survival rates of males are generally lower than females due to hunting and trapping (Fuller et al. 1985). However, unharvested bobcats studied by Knick (1990) exhibited no differences in sex-specific seasonal survival.

We found both similar and different results from sex-specific seasonal analyses compared to other studies. Similar to Knick (1990) but contrary to Chamberlain et al. (1999), we found no differences in seasonal survival between males and females. Chamberlain et al. (1999:618) suggested that low summer survival of females versus males may have been due to increased energetic demands of parturition and young-rearing. Specifically, they indicated that kitten-rearing females may exhibit greater movement rates and diel activity during these periods than others; however, empirical data from their study area seem to contradict this interpretation (Leopold et al. 1995:63-67; Edwards 1996:34-35, 54-60).

Similar to most harvested populations, we found that sex-pooled seasonal survival was highest (64%) during winter, although winter and summer were not statistically different. These results contradict those of Knick (1990) who detected no seasonal differences in sex-pooled seasonal survival on his unharvested study area. Our significant findings were likely due to the increased risk of mortality from incidental harvests during winter. Incidental harvests on our study area were restricted to the winter months and consisted of bobcats trapped by individuals who were likely targeting other species; 1 instance occurred during the legal trapping season in southern Illinois (10 Nov-15 Jan) and the other soon following (18 Feb).

We plan to develop a spatially explicit population model for the southern Illinois region. These survival data will provide input specific to this region as a necessary component of the model.

LITERATURE CITED

Anderson, E. M. 1987. A critical review and annotated bibliography of literature on the bobcat. Colorado Division of Wildlife, Special Report number 62.

Bailey, T. N. 1974. Social organization in a bobcat population. Journal of Wildlife Management 38:435-446.

_____. 1979. Den ecology, population parameters, and diet of eastern Idaho bobcats. Pages 62-69 *in* L. G. Blum and P. C. Escherich, technical coordinators. Bobcat research conference proceedings. National Wildlife Federation Scientific and Technical Series 6.

_____. 1981. Factors of bobcat social organization and some management implications. Pages 984-1000 *in* J. A. Chapman and D. Pursely, eds. Proceedings of the Worldwide Furbearer Conference, Frostburg, Maryland, USA.

Berg, W. E. 1979. Ecology of bobcats in northern Minnesota. Pages 55-61 *in* L. G. Blum and P. C. Escherich, technical coordinators. Bobcat research conference proceedings. National Wildlife Federation Scientific and Technical Series 6.

Buie, D. E., T. T. Fendley, and H. McNab. 1979. Fall and winter home ranges of adult bobcats on the Savannah River Plant, South Carolina. Pages 42-46 *in* L. G. Blum and P. C. Escherich, technical coordinators. Bobcat research conference proceedings. National Wildlife Federation Scientific and Technical Series 6.

Chamberlain, M. J., B. D. Leopold, L. W. Burger, Jr., B. W. Plowman, and L. M. Conner. 1999. Survival and cause-specific mortality of adult bobcats in central Mississippi. Journal of Wildlife Management 63:613-620.

Chepko-Sade, B. D., and Z. T. Halpin. 1987. Mammalian dispersal patterns: the effects of social structure on population genetics. University of Chicago Press, Chicago, USA.

Cory, C. B. 1912. The mammals of Illinois and Wisconsin. Field Museum Natural History Publication 153, Zoological Series II, Chicago, Illinois, USA.

Dobson, F. S. 1982. Competition for mates and predominant juvenile male dispersal in mammals. Animal Behavior 30:1183-92.

Edwards, D. A. 1996. Ecological relationships among bobcats, coyotes, and gray foxes in central Mississippi. Thesis, Mississippi State University, Mississippi State, Mississippi, USA.

Fuller, T. K., W. E. Berg, and D. W. Kuehn. 1985. Survival rates and mortality factors of adult bobcats in north-central Minnesota. Journal of Wildlife Management 49:292-296.

Gibbs, T. J. 1998. Abundance, distribution, and potential habitat of the bobcat in Illinois. Master of Science Thesis, Southern Illinois University, Carbondale, Illinois, USA.

Hamilton, D. A. 1982. Ecology of the bobcat in Missouri. Thesis, University of Missouri, Columbia, Missouri, USA.

Heisey, D. M., and T. K. Fuller. 1985*a*. Evaluation of survival and cause-specific mortality rates using telemetry data. Journal of Wildlife Management 49:668-674.

_____, and _____. 1985*b*. MICROMORT user's guide. Forest and Wildlife Population and Research Group, Grand Rapids, Minnesota, USA.

Hines, J. E., and J. R. Sauer. 1989. Program CONTRAST: a general program for the analysis of general survival or recovery rate estimates. U.S. Fish and Wildlife Technical Report 24.

Kenward, R. E, and N. A. Hodder. 1996. Software for analyzing animal location data (RANGES V). Institute of Terrestrial Ecology, Wareham, UK.

Kitchings, J. T., and J. D. Story. 1979. Home range and diet of bobcats in eastern Tennessee. Pages 47-52 *in* L.G. Blum and P.C. Escherich, eds. Bobcat research conference proceedings. National Wildlife Federation Scientific Technical Service 6.

_____, and _____. 1984. Movement and dispersal of bobcats in east Tennessee. Journal of Wildlife Management 48:957-961.

Knick, S. T. 1990. Ecology of bobcats relative to exploitation and prey decline in southeastern Idaho. Wildlife Monographs 108.

Lembeck, M., and G. I. Gould, Jr. 1979. Dynamics of harvested and unharvested bobcat populations in California. Pages 53-54 *in* L. G. Blum and P. C. Escherich, technical coordinators. Bobcat research conference proceedings. National Wildlife Federation Scientific and Technical Series 6.

Lenth, R. V. 1981. On finding the source of a signal. Technometrics 23:149-154.

Leopold, B. D., L. M. Conner, and K. S. Sullivan. 1995. Ecology of the bobcat (*Felis rufus*) within a forest management system. Completion report for Federal Aid in Wildlife Restoration Project W-48, Study 29.

Lidicker, W. Z., Jr. 1975. The role of dispersal in the demography of small mammals. Pages 103-128 *in* Golley, F. B., K. Putrsewicz, and L. Ryszkowski, editors. Small mammals:

their productivity and population dynamics. Cambridge University Press, New York, USA.

Litvaitis, J. A., J. T. Major, and J. A. Sherburne. 1987. Influence of season and human-induced mortality on spatial organization of bobcats (*Felis rufus*) in Maine. Journal of Mammalogy 68:100-106.

Lovallo, M. J. 1993. Bobcat behavior and home range use in northwestern Wisconsin: in reference to censusing populations. Thesis. University of Wisconsin-Stevens Point, Stevens Point, Wisconsin, USA.

_____, and E. M. Anderson. 1995. Range shift by a female bobcat (*Lynx rufus*) after removal of neighboring female. American Midland Naturalist 134:409-412.

_____, and _____. 1996. Bobcat movements and home ranges relative to roads in Wisconsin. Wildlife Society Bulletin 24:71-76.

Luman, D., M. Joselyn, and L. Suloway. 1995. Critical trends assessment project: landcover database. Illinois Natural History Survey, Champaign, Illinois, USA.

McCord, C. M., and J. E. Cardoza. 1982. Bobcat and Lynx (*Felis rufus* and *Felis lynx*). Pages 728-766 *in* J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins University Press, Baltimore, USA.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37:233-249.

Nams, V. O. 1990. LOCATEII user's guide. Pacer, Truro, Nova Scotia, Canada.

Neely, R. D., and C. G. Heister. 1987. The natural resources of Illinois: introduction and guide. Illinois Natural History Survey, Special Publication 6, Champaign, Illinois, USA.

Neter, J., and W. Wasserman. 1974. Applied linear statistical models. Richard D. Irwin, Homewood, Illinois, USA.

Rhea, T. 1982. The bobcat in Illinois: records and habitat. Thesis, Southern Illinois University, Carbondale, Illinois, USA.

Rolley, R. E. 1983. Behavior and population dynamics of bobcats in Oklahoma. Dissertation, Oklahoma State University, Stillwater, Oklahoma, USA.

_____. 1985. Dynamics of a harvested bobcat population in Oklahoma. Journal of Wildlife Management 49:283-292.

_____. 1987. Bobcat. Pages 672-681 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer conservation and management in North America. Ontario Ministry of Natural Resources, Toronto, Canada.

Rucker, R. A., M. L. Kennedy, G. A. Heidt, and M. J. Harvey. 1989. Population density, movements, and habitat use of bobcats in Arkansas. Southwestern Naturalist 34:101-108.

Sandell, M. 1989. The mating tactics and spacing patterns of solitary carnivores. Pages164-182 *in* J. L. Gittleman, editor. Carnivore behavior, ecology, and evolution. Volume 1. Cornell University Press, Cornell, New York, USA.

SAS Institute. 1990. SAS/STAT user's guide. Version 6. Fourth edition. SAS Institute, Cary, North Carolina, USA.

Sauer, J. R., and B. K. Williams. 1989. Generalized procedures for testing hypotheses about survival or recovery rates. Journal of Wildlife Management 53:137-142.

Springer, J. T. 1979. Some sources of bias and sampling error in radio triangulation. Journal of Wildlife Management 43:926-935.

Swihart, R. K., and N. A. Slade. 1985. Testing for independence of observations in animal movements. Ecology 66:1176-1184.

Trent, T. T., and O. J. Rongstad. 1974. Home range and survival of cottontail rabbits in southwestern Wisconsin. Journal of Wildlife Management 38:459-472.

White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, California, USA.

Wood, F. R. 1910. A study of mammals of Champaign County, Illinois. Illinois State Laboratory Natural History Bulletin 8:501-613.

Woolf, A. 1998. Status of the bobcat in Illinois. Illinois Department of Natural Resources, Annual Performance Report, Federal Aid Project W-126-R-3.

_____, and G. F. Hubert, Jr. 1998. Status and management of bobcats in the United states over three decades: 1970s-1990s. Wildlife Society Bulletin 26:287-293.

_____, C. K. Nielsen, T. Weber, and T. J. Gibbs-Kieninger. 1999. A multiscale approach to estimating the distribution and quality of bobcat habitat in Illinois (submitted).

Appendix A. Bobcat sighting reports for Illinois counties during 1982-98.

County	1982-95 Nat. Heritage Database	1992-98 Firearm Deer	1992-98 Spring Turkey	1992-98 Fall Turkey	1992-96 Volunteer Archery Deer	1995-99 IDNR Digest	1990-97 Trapper Survey	Other[1]	Total
Adams	1	18	8	1	0	0	0	2	30
Alexander	11	55	32	11	4	10	2	11	136
Bond	0	7	1	0	1	1	3	1	14
Boone	0	1	0	0	0	0	0	1	2
Brown	0	17	4	2	0	0	0	0	23
Bureau	1	8	0	0	1	2	5	1	18
Calhoun	0	21	14	1	2	1	0	0	39
Carrol	1	5	6	1	2	2	2	0	19
Cass	0	3	3	1	1	0	0	0	8
Champaign	0	6	0	0	0	0	0	0	6
Christian	0	0	0	0	7	0	1	0	8
Clark	0	8	0	0	1	0	0	0	9
Clay	0	15	9	0	0	2	0	0	26
Clinton	0	3	0	0	0	0	0	0	3
Cook	0	0	0	0	1	2	0	0	3
Coles	0	7	0	0	4	0	0	0	11
Crawford	0	7	0	0	2	1	1	0	11
Cumberland	0	5	0	0	1	0	0	0	6
DeKalb	0	0	0	0	0	0	0	0	0
Dewitt	0	3	0	0	1	1	0	0	5
Douglass	0	4	0	0	0	0	0	0	4
DuPage	0	0	0	0	0	1	1	0	2
Edgar	0	3	0	0	0	0	0	0	3
Edwards	0	2	0	0	0	2	0	0	4

Appendix A. Continued.

County	1982-95 Nat. Heritage Database	1992-98 Firearm Deer	1992-98 Spring Turkey	1992-98 Fall Turkey	1992-96 Volunteer Archery Deer	1995-98 IDNR Digest	1990-97 Trapper Survey	Other[1]	Total
Effingham	0	7	0	0	0	1	2	0	10
Fayette	2	18	0	0	0	1	0	2	21
Ford	0	0	0	0	0	0	1	0	1
Franklin	1	1	0	0	1	3	2	4	12
Fulton	0	18	1	0	2	4	3	0	28
Gallatin	1	25	31	23	3	6	0	3	92
Greene	0	11	3	1	1	1	0	0	17
Grundy	0	2	0	0	1	0	1	0	4
Hamilton	0	10	0	0	1	2	0	0	13
Hancock	1	21	5	0	0	0	0	0	27
Hardin	3	43	2	2	8	5	1	6	70
Henderson	0	4	1	0	0	3	2	0	10
Henry	0	1	2	0	0	1	0	0	4
Iroquois	0	3	0	0	0	0	0	0	3
Jackson	2	91	32	5	11	39	11	70	261
Jasper	0	3	0	0	5	0	0	0	8
Jefferson	0	13	0	0	4	1	0	0	18
Jersey	1	7	6	0	0	6	1	0	21
JoDaviess	6	16	30	6	5	2	7	1	73
Johnson	12	158	18	0	23	17	2	11	241
Kane	0	0	0	0	0	1	0	0	1
Kankakee	0	1	0	0	0	1	0	0	2
Kendall	0	0	1	0	0	1	0	0	2
Knox	0	10	3	0	0	1	3	2	19

Appendix A. Continued.

County	1982-95 Nat. Heritage Database	1992-98 Firearm Deer	1992-98 Spring Turkey	1992-98 Fall Turkey	1992-96 Volunteer Archery Deer	1995-98 IDNR Digest	1990-97 Trapper Survey	Other[1]	Total
LaSalle	1	6	0	0	5	1	2	2	17
Lake	0	0	0	0	1	2	0	0	3
Lawrence	0	6	2	0	1	1	0	0	10
Lee	0	3	0	0	0	2	2	0	7
Livingston	0	1	0	0	0	2	2	0	5
Logan	0	4	0	0	0	1	0	0	5
Macon	0	4	0	0	4	1	0	0	9
Macoupin	0	16	2	1	5	1	3	0	28
Madison	0	10	1	0	1	3	0	0	15
Marion	0	1	1	0	0	1	1	0	4
Marshall	0	4	0	0	1	2	2	0	9
Mason	1	2	2	0	0	0	0	1	6
Massac	2	24	0	0	5	10	1	14	56
McDonough	0	5	1	0	0	1	0	0	7
McHenry	0	3	0	0	2	1	0	0	6
McLean	0	0	0	0	0	1	1	1	3
Menard	0	3	1	0	0	0	0	1	5
Mercer	0	3	0	0	0	1	0	0	4
Monroe	0	4	5	0	1	1	2	1	14
Montgomery	0	9	0	0	7	3	2	0	21
Morgan	0	7	0	0	1	0	1	1	10
Moultrie	1	6	0	0	1	0	2	0	10
Ogle	0	5	1	0	4	4	2	1	17
Peoria	1	14	0	0	1	4	0	1	21

Appendix A. Continued.

County	1982-95 Nat. Heritage Database	1992-98 Firearm Deer	1992-98 Spring Turkey	1992-98 Fall Turkey	1992-96 Volunteer Archery Deer	1995-98 IDNR Digest	1990-97 Trapper Surveys	Other[1]	Total
Perry	0	29	9	0	4	8	0	2	52
Piatt	0	0	0	0	0	0	0	0	0
Pike	5	50	7	2	3	4	4	1	76
Pope	4	84	36	1	22	30	6	51	234
Pulaski	1	93	3	0	8	4	4	31	144
Putnam	0	0	0	0	1	1	1	0	3
Randolph	1	82	23	0	19	8	3	22	158
Richland	0	1	0	0	0	0	0	0	1
Rock Island	0	6	1	0	0	1	2	1	11
Saline	1	26	9	0	6	7	4	9	62
Sangamon	0	8	0	0	0	3	0	0	11
Schuyler	0	27	5	4	1	1	1	0	39
Scott	0	1	2	1	1	0	0	0	5
Shelby	0	9	0	0	5	1	1	0	16
Stark	0	0	0	0	0	0	0	0	0
St. Clair	0	10	1	0	1	6	0	1	19
Stephenson	1	7	8	0	1	0	1	0	18
Tazewell	0	1	0	0	2	2	0	1	6
Union	8	162	56	5	27	30	3	67	358
Vermillion	0	4	2	0	2	1	1	1	11
Wabash	1	2	0	0	0	1	2	0	6
Warren	0	6	0	0	1	0	0	0	7
Washington	0	3	0	0	0	0	0	0	3
Wayne	0	1	0	0	3	1	1	0	6

Appendix A. Continued.

County	1982-95 Nat. Heritage Database	1992-98 Firearm Deer	1992-98 Spring Turkey	1992-98 Fall Turkey	1992-96 Volunteer Archery Deer	1995-98 IDNR Digest	1990-97 Trapper Surveys	Other[1]	Total
White	1	2	0	0	1	1	0	0	5
Whiteside	1	3	1	0	2	1	5	0	13
Will	0	2	0	0	5	1	0	0	8
Williamson	0	25	3	0	2	18	2	11	61
Winnebago	0	1	1	0	0	3	0	0	5
Woodford	0	1	0	0	0	1	0	0	2
Total	73	1,447	395	68	244	297	112	361	2,997

[1]Includes necropsy reports and all miscellaneous sightings reported to the Cooperative Wildlife Research Laboratory.

Appendix B. Radiocollared bobcats in southern Illinois, November 1995-May 1999.

ID Number	Original Capture Date	Sex/Age[a]	Residency Status	Season(s) Recollared	Censor Date	Mortality Date	Total Locations
1	22 Nov 1995	M/A	Shifter	1998	31 May 1999	- - -	188
2	4 Dec 1996	M/A	Resident	1999	31 May 1999	- - -	66
3	22 Jan 1996	M/A	Resident	- - -	- - -	29 Jul 1996	40
4	24 Jan 1996	M/J	Disperser	- - -	1 Jul 1997	- - -	72
5	26 Jan 1996	F/A	Resident	- - -	- - -	21 Jun 1997	119
6	29 Jan 1996	F/J	Resident	- - -	29 Jun 1996	- - -	29
7	29 Jan 1996	F/A	Resident	- - -	13 Nov 1997	- - -	123
8	6 Feb 1996	F/A	Resident	- - -	13 Mar 1997	- - -	34
9	7 Feb 1996	M/A	Resident	- - -	9 Aug 1997	- - -	109
10	10 Feb 1996	F/A	Resident	- - -	11 Dec 1997	- - -	122
11	11 Feb 1996	F/A	Resident	- - -	24 Nov 1997	- - -	126
12	11 Feb 1996	M/A	Resident	1998	31 May 1999	- - -	173
13	15 Feb 1996	F/J	Resident	- - -	6 Nov 1997	- - -	113
14	15 Feb 1996	M/A	Resident	1999	- - -	- - -	104
15	2 Mar 1996	M/A	Resident	1997, 1998	31 May 1999	- - -	213
16	18 Oct 1996	M/A	Resident	- - -	22 Dec 1997	- - -	79
17	12 Dec 1996	M/A	Resident	1998	- - -	13 Dec 1998	157
18	2 Jan 1997	F/A	Unknown[b]	- - -	- - -	8 Feb 1997	13
19	3 Jan 1997	M/A	Unknown[b]	- - -	- - -	1 Feb 1997	6
20	7 Jan 1997	M/A	Unknown[b]	- - -	- - -	9 Feb 1997	7
21	15 Jan 1997	M/A	Resident	- - -	17 Jun 1998	- - -	116
22	15 Jan 1997	M/A	Resident	- - -	15 Jul 1998	- - -	49
23	16 Jan 1997	M/A	Shifter	- - -	24 Jun 1998	- - -	112
24	20 Jan 1997	F/A	Resident	- - -	6 Aug 1998	- - -	131

Appendix B. Continued.

ID Number	Original Capture Date	Sex/Age[a]	Residency Status	Season(s) Recollared	Censor Date	Mortality Date	Total Locations
25	20 Jan 1997	M/A	Resident	- - -	- - -	1 Dec 1997	95
26	20 Jan 1997	M/A	Shifter	- - -	17 Jun 1998	- - -	117
27	24 Jan 1997	M/A	Resident	1998	- - -	6 Feb 1999	70
28	25 Jan 1997	F/A	Resident	1999	- - -	14 Apr 1999	127
29	26 Jan 1997	M/J	Disperser	- - -	6 Aug 1998	- - -	69
30	30 Jan 1997	M/A	Unknown[b]	- - -	11 Mar 1997	- - -	7
31	30 Jan 1997	F/J	Resident	- - -	21 Dec 1997	- - -	34
32	7 Feb 1997	F/A	Resident	- - -	17 Jun 1998	- - -	106
33	11 Feb 1997	F/A	Shifter	- - -	25 Jun 1998	- - -	81
34	13 Feb 1997	F/J	Resident	- - -	29 Jun 1997	- - -	35
35	17 Feb 1997	F/J	Resident	- - -	- - -	2 Aug 1997	51
36	18 Feb 1997	M/A	Resident	- - -	17 Jun 1998	- - -	107
37	27 Feb 1997	M/J	Disperser	- - -	15 July 1998	- - -	116
38	21 Dec 1997	F/A	Resident	- - -	16 Jan 1999	- - -	75
39	22 Dec 1997	F/A	Resident	- - -	31 May 1999	- - -	68
40	8 Jan 1998	F/A	Resident	- - -	28 Oct 1998	- - -	93
41	13 Jan 1998	M/A	Unknown[b]	- - -	- - -	25 Feb 1998	20
42	18 Jan 1998	F/A	Resident	- - -	9 Mar 1999	- - -	92
43	20 Jan 1998	M/J	Disperser	- - -	- - -	13 Aug 1998	49
44	21 Jan 1998	F/A	Resident	- - -	31 May 1999	- - -	105
45	23 Jan 1998	M/A	Unknown[b]	- - -	- - -	13 Feb 1998	5
46	25 Jan 1998	F/A	Resident	1999	- - -	29 Jan 1999	91
47	29 Jan 1998	M/J	Resident	- - -	31 May 1999	- - -	83

Appendix B. Continued.

ID Number	Original Capture Date	Sex/Age[a]	Residency Status	Season(s) Recollared	Censor Date	Mortality Date	Total Locations
48	1 Feb 1998	F/A	Resident	- - -	31 May 1999	- - -	75
49	5 Feb 1998	F/A	Resident	- - -	- - -	20 Aug 1998	67
50	6 Feb 1998	M/A	Resident	- - -	9 Mar 1999	- - -	78
51	19 Feb 1998	M/A	Resident	1999	31 May 1999	- - -	95
52	21 Feb 1998	M/A	Resident	1999	31 May 1999	- - -	87
53	23 Feb 1998	M/A	Resident	1999	31 May 1999	- - -	85
54	24 Feb 1998	M/A	Resident	- - -	9 Mar 1999	- - -	75
55	4 Mar 1998	M/A	Resident	- - -	31 May 1999	- - -	63
56	25 Mar 1998	M/A	Resident	- - -	11 Jul 1998	- - -	16
57	8 Jan 1999	F/A	Resident	- - -	31 May 1999	- - -	27
58	16 Jan 1999	F/A	Resident	- - -	31 May 1999	- - -	30
59	19 Jan 1999	F/A	Resident	- - -	31 May 1999	- - -	32
60	21 Jan 1999	F/A	Resident	- - -	31 May 1999	- - -	28
61	23 Jan 1999	F/A	Resident	- - -	31 May 1999	- - -	31
62	26 Jan 1999	F/A	Resident	- - -	31 May 1999	- - -	1
63	26 Jan 1999	F/J	Resident	- - -	31 May 1999	- - -	1
64	28 Jan 1999	M/J	Unknown[b]	- - -	31 May 1999	- - -	17
65	1 Feb 1999	F/A	Resident	- - -	31 May 1999	- - -	29
66	4 Feb 1999	M/J	Resident	- - -	31 May 1999	- - -	1
67	4 Feb 1999	F/A	Resident	- - -	31 May 1999	- - -	1
68	5 Feb 1999	F/A	Resident	- - -	31 May 1999	- - -	27
69	5 Feb 1999	F/A	Resident	- - -	31 May 1999	- - -	33
70	6 Feb 1999	F/A	Resident	- - -	31 May 1999	- - -	22
71	9 Feb 1999	M/A	Resident	- - -	31 May 1999	- - -	10

Appendix B. Continued.

ID Number	Original Capture Date	Sex/Age[a]	Residency Status	Season(s) Recollared	Censor Date	Mortality Date	Total Locations
72	13 Feb 1999	F/A	Resident	- - -	31 May 1999	- - -	26
73	13 Feb 1999	F/A	Resident	- - -	31 May 1999	- - -	28
74	17 Feb 1999	F/A	Resident	- - -	31 May 1999	- - -	18
75	22 Feb 1999	M/A	Resident	- - -	31 May 1999	- - -	6
76	22 Feb 1999	F/A	Resident	- - -	31 May 1999	- - -	24

[a]M = male, F = female, A = adult, J = juvenile.
[b]Not enough locations collected to determine residency status.

JOB 1.2. HABITAT MAPPING

<u>Objective</u>: Map and estimate the area and relative quality of habitat types that support, or have potential to support, bobcat populations.

Digital files of habitat maps and sighting location overlays were created and are maintained at the Cooperative Wildlife Research Laboratory. These data and supporting files will be stored on a server during the next project segment so they are readily available to agency staff and collaborating scientists.

Gibbs (1998) reported portions of this job in a thesis that was previously submitted to Illinois Department of Natural Resources, Division of Wildlife Resources staff in lieu of a final report for this job (Woolf 1998). Data presented by Gibbs were reviewed, re-analyzed, and combined with additional data to prepare a manuscript that fully addresses the objective of this job. The attached manuscript (Woolf et al. 1999) has been submitted for publication and is pending review. Following is an abstract of the manuscript.

Abstract: Wildlife-habitat relationship models provide managers with estimates of population abundance and habitat distribution that can ultimately be used to assess species' status and develop management guidelines. We used sighting location and digital landscape data, 2 multivariate statistical techniques, and a geographic information system (GIS) to model relative population abundance and habitat distribution of bobcats (*Lynx rufus*) in Illinois at 2 spatial scales. Our goal was to provide state wildlife managers with information that would contribute to an evaluation of the listing of bobcats in Illinois as a state-threatened species. We modeled presence or absence and relative abundance of bobcats at the county scale using 2- and 3-group canonical discriminant analysis (CDA). The 2-group CDA differentiated (Wilks $\lambda = 0.674$, $P = 0.0001$) presence or absence of bobcats in a county based on proportion of woods, patch density of woods, and proportion of slope $\geq$18%. The 3-group CDA differentiated (Wilks $\lambda = 0.501$, $P = 0.0001$) low, medium, and high abundance of bobcats in a county based on proportion of woods, proportion of slope $\geq$18%, and density of rural roads. Model predictions indicated that bobcats

occurred in moderate to high numbers in nearly 40% of the state. Statewide habitat suitability models constructed with logistic regression predicted that 31% of Illinois offered habitat classified as good to excellent. Statewide habitat suitability models revealed a pattern of probable bobcat distribution similar to that depicted by the county-scale models. However, the habitat suitability model was more useful because it spatially depicted habitat along a probability gradient which provided managers a more explicit assessment of likely bobcat habitat throughout the state. The county-scale models identified important variables that predicted relative abundance of bobcats, but lacked resolution to map the distribution of potential habitats. In conclusion, our models produced useful rapid assessment tools, and the logistic model provided means to identify regions that can be managed in an ecosystem context. In Illinois, they provided data that contributed to a science-based assessment of status that resulted in delisting the species.

LITERATURE CITED

Gibbs, T. J. 1998. Abundance, distribution, and potential habitat of the bobcat in Illinois. Thesis, Southern Illinois University, Carbondale, Illinois, USA.

Woolf, A. 1998. Status of the bobcat in Illinois. Annual Federal Aid Performance Report, Project W-126-R-3, Illinois Department of Natural Resources, Springfield, Illinois, USA.

Woolf, A., C. K. Nielsen, T. Weber, and T. J. Gibbs-Kieninger. 1999. A multiscale approach to estimating the distribution and quality of bobcat habitat in Illinois (submitted).

JOB 1.3. BOBCAT STATUS ASSESSMENT

Objective: Develop criteria for assessing the bobcat's status in Illinois.

INTRODUCTION

When the study began, the status of the bobcat was uncertain, but it was classified as "threatened" in the state. Because of its protected status and relative scarcity, the repertoire of tools available to survey the population, or to estimate population numbers or growth (see Rolley 1987:676-677) were limited. The intensive field studies (see Job 1.1) of population ecology and modeling (see Job 1.2) to determine species-habitat relationships provided data crucial to overall project goals and objectives and contributed important information to accomplish the objective of this job, but by themselves were not suited to assess the species' status statewide. Analyses of the survey results and habitat mapping disclosed that bobcats were far more widely distributed and more abundant than previously thought. Therefore, in addition to a further assessment of results from field studies, we evaluated use of hunter and trapper surveys studied in Job 1.1 and scent station surveys to monitor the relative abundance and population trends of bobcats in Illinois.

METHODS

Scent Stations

Scent stations were set out in mid and late October 1995 and maintained for 2-5 nights each period depending on prevailing weather conditions. Stations were constructed by raking a 1-m diameter circle and then sprinkling a thin layer of hydrated calcium carbonate (lime), calcium carbonate (rock dust), or amorphous silica over the raked area. These substrates were the finest grades available and had a talcum powder consistency. Commercially available bobcat lures and urine were added to a cotton ball and placed in the center of the station as an olfactory attractant. Mourning dove *(Zenaidura macroura*) or northern bobwhite (*Colinus virginianus*) wings were suspended on fishing line over the station, whenever feasible, to visually attract bobcats. Stations were defined as visited if animals disturbed the station substrate or cotton ball.

Scent station transect sites were chosen from a pre-determined route south-southeast of Carbondale, Illinois that encompassed favorable habitat and areas of recent bobcat sightings. Our generalized design was not intended to be a survey, rather the purpose was to determine if we could detect bobcats visiting stations. Scent stations were constructed along secondary roads, railroad beds, and hiking or mowed trails that passed through thickets; old fields; and mixed, hardwood, and coniferous woodlands. Stations were systematically spaced to insure coverage of habitat types and natural travelways. A field data form was used to record station location, condition of station substrate, and species attracted.

Sightings and Surveys

Hunter and trapper survey data compiled and analyzed for Job 1.1 were used in this evaluation. In addition, we quantified differences in statewide sighting trends among all surveys by calculating annual proportional fluctuations and evaluating the direction and magnitude of changes.

Field Studies

We also used home range and survival information from field studies (see Job 1.1) to further evaluate bobcat status. Home range size and stability relative to other populations were assessed to determine whether bobcat populations in Illinois were functioning similarly. Additionally, we evaluated causes of mortality and sex- and season-related differences in survival because these data would lend insight into potential limiting factors.

RESULTS

Scent Stations

We monitored 7 sites in mid October, each containing 1-9 individual scent stations depending on site location, habitat, land ownership boundaries, and topography. Hydrated lime was used exclusively as the station substrate and produced highly identifiable tracks when dry.

Also, the white color enhanced visibility of the station. During 61 scent station nights, 47 (77%) were visited and 9 (15%) destroyed by people. Raccoon (*Procyon lotor*), opossum (*Didelphis virginiana*), fox (both red and grey), coyote (*Canis latrans*), domestic cat, domestic dog, white-tailed deer (*Odocoileus virginianus)*, squirrel (*Sciurus* sp.), cottontail rabbit (*Sylvilagus floridanus*), and bobcat visited the stations. Foxes were the most frequent visitor.

In late October, we evaluated 10 scent station sites; 5 were new locations and 5 were the best localities from our earlier route. Amorphous silica and rock dust were used as the station substrate. These materials were off white to grey and also were highly visible against the surroundings. During 98 scent station nights, 54 (55%) were visited and 24 (24.5%) were destroyed. Raccoon, opossum, fox, coyote, domestic cat, domestic dog, and white-tailed deer visited stations. Again, foxes were the most frequent visitor.

Sightings and Surveys

Surveys of firearm and archery deer hunters exhibited similar trends in each of the 5 years comparative data were available (Table 13). Although the directions of change were comparable among the firearm and archery surveys, the 2 survey types detected different magnitudes of change and it was not consistent which survey produced the greater apparent change. Archery surveys resulted in a greater magnitude of annual change between 1992-93 and 1993-94, but in the 3 years following, the firearm deer surveys fluctuated more. The survey of spring turkey hunters did not reveal the same trend as the other surveys in 3 years when comparisons were possible (Table 13). Spring turkey hunter surveys indicated a positive trend in 1993-94 followed by a negative trend the next year and a positive trend the year after. This pattern was opposite that of the 2 surveys conducted in fall (Table 13). However, the overall trend of the spring turkey surveys was in agreement with the positive trends of the other 2 surveys.

Field Studies

We found that individual bobcats in Illinois require similar amounts of space relative to other populations. Further, most (93%) adults tracked for <2 yr maintained stable home

Table 13. Annual proportional changes in sighting reports of bobcats in Illinois, 1992-98.

	Year					
Survey	92-93	93-94	94-95	95-96	96-97	97-98
Firearm Deer	+0.45	-0.09	+1.02	-0.58	+2.92	+0.28
Spring Turkey	+0.34	+0.17	-0.07	+0.10	+0.16	+0.32
Archery	+0.87	-0.21	+0.54	-0.46	+1.61	—

ranges and 3 of 4 juveniles that dispersed long distances survived to establish new home ranges. Annual survival rates (0.792 - 1.000) were among the highest reported, and natural mortality from lack of prey or disease was not detected. Of 14 mortalities, all but 1 were attributed to human causes; however, most (n = 9) occurred from vehicle collisions and not incidental or illegal harvest. Further, we found no differences in survival between males and females. When males and females were pooled, survival was lowest during winter as influenced by 2 cases of incidental or illegal harvest.

DISCUSSION

We reviewed the literature on various procedures to determine relative abundance of furbearers (especially bobcats) to select those techniques that might be most appropriate to apply in Illinois. We did not consider any technique based on harvest because the bobcat currently is protected and there are no immediate plans to allow harvesting. Surveys based upon solicited or unsolicited reports of observations were examined, but we agree with Clark and Andrews (1982) that such methods provide little information beyond geographic distribution. Our request for sighting information in IDNR's Digest of Hunting and Fishing Regulations each year during 1995-98 provided very useful location data that helped to map distribution and validate habitat models, but was not useful for tracking relative abundance.

Trapper surveys produced information that was inconsistent with that obtained from surveys of deer hunters and spring turkey hunters. The firearm deer and archery surveys provided trend data that agreed in direction although not magnitude of change; the overall trend of spring turkey surveys agreed with the deer hunter surveys, but yearly trends did not agree. We are more confident in the trends depicted by the surveys of deer hunters and recommend they be used to track bobcat population trends. However, no survey technique we examined seemed able to reliably measure magnitude of annual population fluctuations. Our findings and conclusions are consistent with reports in the literature (see review by Rolley 1987); we simply cannot offer a biological explanation to account for year-to-year variability, nor can we relate population density to the indices based on bobcat sightings.

Scent-station surveys are frequently used to monitor bobcat populations (Johnson and Pelton 1981, Rolley 1987). When Johnson and Pelton (1981) conducted their survey, 10 of 11 states conducting annual statewide surveys of furbearer population trends used scent-stations and bobcat was among the species emphasized. Biologists at that time expressed reservations concerning the technique, but emphasized need for further evaluation. Little progress seems to have been made; Woolf and Hubert (1998) reviewed the status and management of bobcats in the United States and reported that 62.7% of biologists surveyed desired more reliable survey methods.

Our test application of scent stations did attract bobcats as well as other species, but their utility was severely constrained by land ownership patterns and human disturbance in addition to the routine factors like track surface and weather. It would be logistically difficult to gain permission to establish scent stations on private lands. Those placed on public lands (or immediately adjacent to public secondary roads) were subject to disturbance and the high percentage destroyed during the second trial period suggests that human disturbance will limit utility of the technique in Illinois.

We conclude that surveys of hunters offer the most cost-effective technique to monitor bobcat population trends. Better understanding of bobcat density-habitat relationships that we anticipate acquiring during the next phase of this project may allow us to better understand survey fluctuations so they may serve as a more reliable population index. For now, we recommend that the firearm deer and volunteer archery surveys of bobcat sightings continue to establish a long-term data base of annual fluctuations and population trends. Other surveys offer less useful data for monitoring bobcats; whether or not they should be continued should be decided by other management considerations.

Relative to other bobcat study areas, the southern Illinois landscape has a high proportion of agricultural land use, restricted harvest, and higher human and road densities. Hence, we quantified home ranges and survival of radiocollared individuals and compared our results to other studies, which provided us with insight on bobcats status in Illinois.

Results from field studies provide further evidence that bobcats in Illinois are abundant and faring well. Individual bobcats in Illinois appear to require similar amounts of space relative to other populations and social organization is also maintained similarly. High survival and long-distance travels of dispersing juveniles also suggests that separate populations may be connected despite high road densities and discontinuities in favorable habitat.

We found that Illinois bobcats were not limited by natural factors, and incidental or illegal harvest was relatively uncommon. Most mortalities were attributed to vehicles, an unavoidable feature of the Illinois landscape. These data will be incorporated into a spatially-explicit population model that will simulate a variety of management scenarios. This model may ultimately be the best way to guide management of bobcats in Illinois.

LITERATURE CITED

Clark, W. R., and R. D. Andrews. 1982. Review of population indices applied in furbearer management. Pages 11-22 *in* G. C. Sanderson, editor. Midwest furbearer management. Proceeding Symposium 43rd Midwest Fish and Wildlife Conference, Wichita, Kansas, USA.

Johnson, K. G., and M. R. Pelton. 1981. A survey of procedures to determine relative abundance of furbearers in the southeastern United State. Proceedings of the Annual Conference of Southeast Association Fish and Wildlife Agencies 35:261-272.

Rolley, R. E. 1987. Bobcat. Pages 672-681 *in* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. Wild furbearer conservation and management in North America. Ontario Ministry of Natural Resources, Toronto, Canada.

Woolf, A., and G. F. Hubert, Jr. 1998. Status and management of bobcats in the United states over three decades: 1970s-1990s. Wildlife Society Bulletin 26:287-293.

JOB 1.4. ANALYSIS AND REPORT

Objective: Provide recommendations to improve management of the bobcat in Illinois.

INTRODUCTION

The expected benefits and results of this study were: statistically reliable information about the relative abundance and distribution of the bobcat in Illinois, criteria and methods to monitor the species on a regular basis, and maps and ecological information that will make it possible to delineate ecologically-based population management zones. Data derived from Jobs 1-3 allowed us to provide recommendations that can be the basis of improved management of the bobcat in Illinois.

METHODS

Methods described for Jobs 1-3 resulted in data and products that were summarized quarterly, annually, and in this final report. Recommendations to improve management of the bobcat in Illinois were based on analyses of data derived from Jobs 1-3.

RECOMMENDATIONS

- A statewide habitat suitability model constructed with logistic regression predicted that ~31% of Illinois offered habitat classified as good to excellent, and a canonical discriminant analysis model indicated that bobcats occurred in moderate to high numbers in nearly 40% of the state. Further, surveys of hunters to compile bobcat sightings provide evidence that bobcats are increasing in abundance throughout the state. Therefore, we conclude that the bobcat no longer meets the definition of a state-threatened species and support the recommendation to de-list the species.
- Since 1982, bobcats have been reported from 99 of 102 (97%) Illinois counties; 90 counties (88%) had $\geq$3 sightings indicative of a potential resident population and 21 counties (21%) reported >30 sightings indicative of a high resident population. However, 55% of the habitat we classified as good or excellent is found in the 16 southern Illinois

counties (11% of Illinois' area). We recommend that any proposed bobcat management strategy recognize landscape-level population units and that the most important unit is the 16-county southern Illinois region.

- The distribution of bobcats in Illinois other than the 16-county southern region is concentrated in the Kaskaskia River basin, the Illinois River valley, and northwestern Illinois. However, data are lacking to define population management units with confidence in these areas. We recommend that population viability analyses be used in conjunction with existing habitat models to define management units outside the southern Illinois region.
- Surveys of successful firearm deer hunters at check stations, and the volunteer archery hunter survey should continue as presently designed to monitor population trends throughout the state. Numbers of sightings each year from all survey types other than firearm deer hunters are too small to monitor trends by defined population management units, but data should be analyzed by region as we defined southern and northern Illinois. Firearm deer hunter surveys of bobcat sightings should be retroactively examined by population management units once they are better defined.
- Bobcat sighting reports solicited in the IDNR Digest of Hunting and Fishing Regulations provided important information and spatial detail, but the information no longer is necessary to construct and validate habitat models. The information is not useful to track population trends because the effort is difficult, if not impossible, to standardize. This survey can be discontinued.
- Field studies of 76 radiocollared individuals indicate that bobcats are currently faring well in Illinois. Social organization and home range size are similar to other populations in the region. Lack of legal harvest and low mortality from natural factors have resulted in high survival rates. However, factors influencing bobcat populations, such as prey densities, land use, or potential interactions with sympatric species (e.g., coyotes and foxes) will

undoubtedly fluctuate over time. Thus, we recommend that managers consider a follow-up study to define these issues.

- We plan to develop a spatially explicit population management model for the southern Illinois region in the next project segment that will better define density-habitat relationships. We anticipate this will be the most appropriate tool for managing bobcats in Illinois. Also, the model should contribute to validating sighting data from surveys of hunters. Until this tool is developed and validated, we recommend that existing hunter surveys be conducted with the same procedures and degree of effort as in past years so results are as comparable as possible.

LITERATURE CITED

Gibbs, T. J. 1998. Abundance, distribution, and potential habitat of the bobcat in Illinois. Thesis, Southern Illinois University, Carbondale, Illinois, USA.

Attachment: Manuscript (Woolf et al. 1999)

Attachment: Statewide habitat map