# The Bobcat in Illinois

Alan Woolf and Clayton Nielsen • Southern Illinois University Carbondale • 2002





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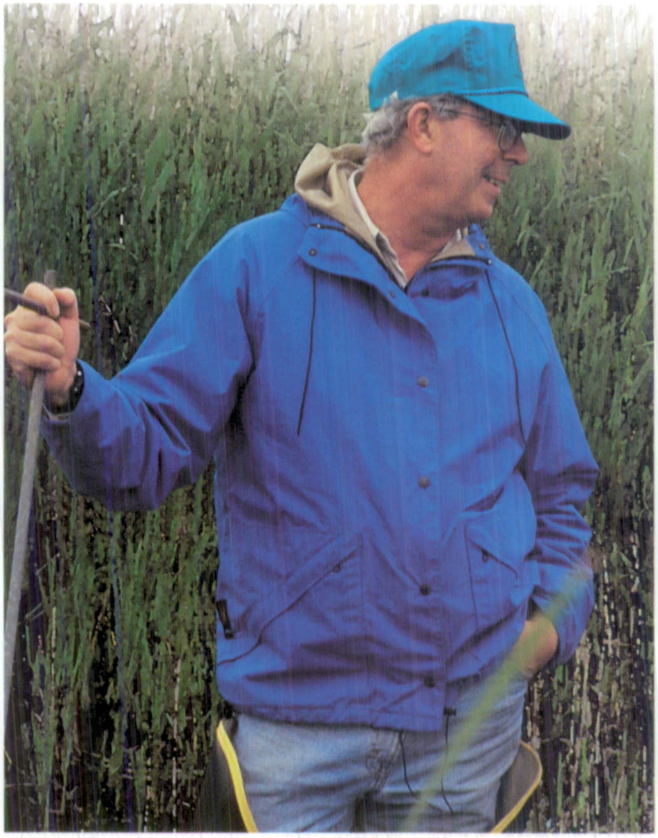
# About the Authors



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Alan Woolf is director of the Cooperative Wildlife Research Laboratory and professor of zoology at Southern Illinois University Carbondale. He was the principal investigator on the bobcat project and advised the graduate students who participated.

**Clayton Nielsen**

Clayton Nielsen received his Ph.D. in zoology from SIUC working on the bobcat project. He currently is an assistant scientist (adjunct) at the Cooperative Wildlife Research Laboratory and operates two wildlife consulting firms — Holterra Wildlife Management and Kinetic Conservation Group.

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# Forward

*The impetus for the research project that forms the basis of this monograph began in the early 1980s when the status of the bobcat in Illinois was far from clear. Reports of bobcats were widespread throughout the state, but generally the species was thought to be rare and thus was classified as a state "threatened" mammal. One of my students (Rhea 1982) shared my interest in this secretive predator and sought to assess its status by evaluating sighting reports and mapping potential habitat. She concluded that the bobcat was indeed rare in the state and "threatened" status was justified. Rhea laboriously reviewed 1:20,000 aerial photographs of the entire state and available 1:250,000 United States Geological Survey quadrangle maps (the powerful tools of satellite imagery and GIS were not yet widely available) to assess quantity and distribution of suitable wooded habitats. Her conclusions are valid today: the largest quantity of suitable habitats were in western and southern Illinois, and the best habitats were distributed in northwestern Illinois, the west side of the lower Illinois River, the Kaskaskia River bottoms, and the Shawnee Hills in southern Illinois.*

*By early 1990 it was becoming apparent that bobcats were more abundant than they had been in the previous decade, but the evidence was equivocal and scattered among records from many sources. The Furbearer Program of the Illinois Department of Natural Resources (IDNR), Division of Wildlife Resources identified the need to research the status and ecology of the bobcat in Illinois so management options could be defined. In response to this need, the Illinois Department of Natural Resources, Division of Wildlife Resources and the Cooperative Wildlife Research Laboratory (CWRL), Southern Illinois University Carbondale (SIUC) began a cooperative research project in July 1995 supported by Federal Aid to Wildlife Restoration (Illinois Federal Aid Project W-126-R, Status of the Bobcat in Illinois; Woolf and Nielsen 1999).*

*The research project was very much a team effort that included staff from both cooperating agencies; SIUC graduate research assistants, researchers, and undergraduate students; and cooperating trappers and landowners in southern Illinois. Much of the research was conducted by CWRL graduate students in partial fulfillment of requirements for graduate degrees in Zoology at SIUC. Cooperating trappers helped live-capture bobcats for radio telemetry; we could not have been so successful without them. Our cooperating landowners allowed us access to their property, offered protected trap sites, and often helped us monitor traps; they too were instrumental to our success.*

*During 4 late December-March trapping sessions, project staff and cooperators recorded 145 captures of 96 different cats; 76 were radio collared and monitored. Data from these animals and from necropsy of 146 recovered carcasses submitted to the CWRL were the foundation of the biological and ecological findings we describe. Research methods are not fully described in this monograph, but can be found in the project reports, publications, and theses listed in Appendix A. This report represents a compilation and synthesis of the multi-faceted research we conducted to document the status and ecology of the bobcat in Illinois. Our goal is to share knowledge gained from our research with the citizens of Illinois and others interested in this charismatic predator. We hope the information contributes to science-based management of this species that survives, and in some regions flourishes, in the human-dominated landscape of Illinois.*

Alan Woolf, Director, CWRL, SIUC - June 2002

# History and Distribution in Illinois

The landscape and land cover of pre-settlement Illinois undoubtably provided excellent habitat for the bobcat and historical records suggest they were found throughout the state. However, the prairies, forests, and wetlands that comprised pre-settlement Illinois gave way to agriculture, industry, and urban land uses. Woolf and Hubert (1998) presented an overview of the changing status of the bobcat in Illinois. A brief review of the history and status of the bobcat can be conveniently grouped into the following periods.

## PRE-SETTLEMENT

Before 1820, the area that is now Illinois was composed mainly of forest (38%) and prairie. Waterways and wetlands broke up the expanses of forests and prairies and created a mosaic of diverse habitats. This landscape certainly offered a rich prey base to meet the needs of the bobcat, a medium-sized predator that, by all accounts, is a versatile habitat generalist. The historical record is not intact and leaves little account of species abundance during the pre-settlement period, however, the bobcat likely inhabited the length and breadth of Illinois. Rhea (1982) examined historical records as far back as 1809, and these documented bobcats inhabiting 72 of Illinois' 102 counties. Bobcats likely had little competition in the niche they occupied and fared well in habitats supporting rabbits, squirrels, and mice that constituted the bulk of their diet.

## CLEARING FOR AGRICULTURE (1820-1925)

Illinois was settled during this period and the landscape that greeted settlers rapidly underwent dramatic change as land was cleared and drained for agriculture, wood products, homesteads, and growing urban centers to meet the needs of the increasing number of human inhabitants. Illinois' 38% forest cover declined to only about 9% of the state (Iverson et al. 1989); prairies and wetlands experienced even greater losses (Ill. Dep. Energy and Nat. Resour. 1994). By 1900, the conversion of the landscape from wilderness to agriculture had peaked and the census reported 4,821,550 people lived in the Prairie State.

Wood (1910) associated bobcats with the timbered areas of the state and noted that they were still common in southern Illinois where forest habitat predominated. Cory (1912) thought the bobcat had disappeared from settled areas and was rare in northern Illinois after 1900. However, he noted they were occasionally killed in scattered localities and remained common in southern Illinois. According to Brown and Yeager (1943), a rapid decimation of bobcats began in 1910 due to habitat loss, hunting, and trapping. However, bobcats certainly persisted in the state, and Mohr (1943) documented records in a number of southern Illinois locales.

## 1950-1960s

Prior to 1950, the Illinois landscape was characterized by small, diversified farms that provided plenty of edge habitat and undisturbed marginal areas. Few accounts of bobcat distribution in Illinois exist for this period, but habitats would seem to be suitable, if not excellent, for the adaptable predator. Young's (1958) account of the bobcat in North America noted records from 47 states and the District of Columbia and he thought that bobcats were increasing throughout most of their range. The distribution map in Young's account included records for Illinois, but there were few. Klimstra and Roseberry (1969) documented sightings during this period from southern Illinois counties and speculated that the bobcat was more widely distributed in Illinois than generally recognized. Harvest data compiled by Novak et al. (1987) listed very high numbers for Illinois; an average of ~1,100 pelts were reported for the 4 seasons 1966-67 through 1969-70. These high numbers suggest that bobcats were abundant in Illinois, especially by the late 1960s. However G. F. Hubert, Jr. (Furbearer Project Manager, IDNR, Div. Wildl. Res., pers. commun.) believed the numbers were an inflated estimate. Although the extent of their distribution and abundance are matters of speculation that the record cannot resolve, bobcats indeed were present in Illinois throughout this period.

## 1970-1980s

Bobcats were thought to be scarce in Illinois as the 1970s began and they were fully protected by the Wildlife Code of 1971 (P.A. 77-1781, Ill. Rev. Stat. 61, § 2.30) effective 1 July 1972. The Illinois Endangered Species Protection Board held a public hearing 12 October 1977 after which the Board voted to declare the bobcat threatened in Illinois effective 31 December 1977. During this period, the status of the bobcat in Illinois was not unlike that elsewhere in the midwest, where a survey by Deems and Pursley (1978) concluded they were not present in large portions of some midwestern states. Bowles (1981) thought the bobcat was widespread but endangered in Iowa, and in neighboring Indiana, bobcats were designated endangered in 1969. Erickson et al. (1981) attributed the population declines of the bobcat in the Midwest to the widespread adoption of a more intensive, "fencerow-to-fencerow" style of agriculture.

Status of the bobcat in Illinois during this period was largely based on speculation, but Rhea (1982) could only find 89 reports of bobcat sightings from 52 Illinois counties from 1979-82. It seemed that nearly a decade of full protection in Illinois had not resulted in an obvious increase in numbers and distribution of bobcats (Woolf and Hubert 1998). As the 1980s came to a close, bobcats still seemed relatively scarce in Illinois.

## 1990s

The 1990s marked the return of the bobcat to a secure place among Illinois' fauna. Bobcats were reported from 33 counties without previous historic reports (Gibbs 1998), and from 1992 through 1998 there was a general upward trend (Fig. 1) in the number of reported sightings (Woolf and Nielsen 1999). Bobcats were reported from 99 of Illinois' 102 counties and 91 counties had >3 sightings which suggested that bobcats resided in the area.

Southern Illinois historically contained the largest area of highly suitable habitat and even when they were thought to be absent or rare in the north, bobcats were commonly reported in the southern Illinois counties of Alexander, Gallatin, Jackson, Pope, and Randolph (Cory 1912). Our surveys during the 1990s confirmed the importance of southern Illinois as bobcat habitat. Woolf and Nielsen (1999) found that bobcats seemed to be increasing throughout the state, but the 16 counties that comprise southern Illinois experienced a greater increase than did the remainder of the state. At the beginning of the surveys in 1992, 40% more bobcats were reported from the 16 southern counties compared to the remainder of Illinois, whereas at the end of the period, 97% more were reported from the south. Over the same period, total sightings from southern Illinois increased 334% versus a 209% increase elsewhere (Woolf and Nielsen 1999).

As the 1990s drew to a close, strong evidence suggested that bobcats were widely distributed in Illinois, and likely occupied much of the available suitable habitat. In addition to the 16-county southern region, bobcats were concentrated in the Kaskaskia River basin, the Illinois River valley, and northwestern Illinois. It is highly likely that viable populations inhabit these regions of Illinois, and because of their wide distribution and relative abundance the bobcat was removed from the state's list of threatened and endangered species in 1999.


**Fig. 1. Trends in bobcat sightings from 1992 to 1998.**

**Fig. 2. A motionless bobcat blends in with the background and can be difficult to spot at first glance. (Woolf)**

# Description

## TAXONOMY

The bobcat inhabiting Illinois is classified as *Lynx rufus rufus* (Schreber). According to Whitaker and Hamilton (1998), the subspecies ranges from Maine south to Florida and Louisiana. Young (1958:14) shows the subspecies range to extend west to the eastern border of the mountain states. However, we agree with McCord and Cardoza (1982) who pointed out that the various number of subspecies described comprise few realistically distinguishable taxa that have biological importance.

## APPEARANCE AND MORPHOLOGY

The mature bobcat is a medium-sized animal that often appears larger than it really is. Height at the shoulder ranges from 50-60 cm. In Illinois, adult males average about 11 kg and females about 7 kg. The largest bobcat that we examined in Illinois was a male that weighed 14.5 kg. The body weights of Illinois bobcats approximate those reported for bobcats throughout their range (Young 1958:18-20). Young knew of only 15 bobcats that weighed >16 kg; the largest was a male killed in Colorado in 1951 that reportedly weighed 31.4 kg (Young 1958:17) which is greater than twice the weight of the largest cat we examined.

The bobcat is cryptically colored as befitting a predator that depends on concealment and stealth to capture prey. If motionless, the bobcat can be nearly impossible to see, even when not concealed by vegetation. (Fig. 2) The coloration as described by various authors (Young 1958, McCord and Cardoza 1982) fits the appearance of the bobcat in Illinois. The pelt ranges from a buff, tawny, or reddish-brown to a dull gray color. There is dark brown to black streaking, or more often spots along the back and sides; underparts are white with black spots and the inside of the legs may have black barring. According to McCord and Cardoza (1982:730), "Pelts in the northwestern portion of the range tend to be more colorful and the spots more distinct than those of eastern or southern bobcats." In Illinois, we have seen the range from brightly colored and well-marked animals to those less colorful with indistinct spots and pale barring. There is seasonal variation as well; gray tends to dominate in winter, whereas colors are brighter and tend to be more reddish-brown following the spring molt.

One distinctive feature of the bobcat is the pointed, prominent ears which are capped with a small tuft of black hair at the tip. Lightly colored on the inside and front hairs, the back of the ear has a characteristic white triangle completely edged in black. The white patch on the back of the ear is even conspicuous in newborn kittens that are otherwise nearly all gray-black (Fig 3).

The so-called bobbed tail that led to its common name is another truly distinctive feature of bobcats. The tail, which is somewhat shorter in the female than in the male (but about the same size proportional to body length), is rarely shorter than 11 cm and can be 18 cm or slightly longer. The tail markings are truly distinctive and distinguish the bobcat from its close relative, the lynx (*Lynx canadensis*). The bobcat's tail is colored like the coat and has several black bars on the upper surface with a distinct black tip on the upper side and outer edges tipped with white hairs; the tail's underside is uniformly whitish. The lynx has a shorter tail with no bars and a completely black tip.

Standard measurements of bobcats reveal the dimorphism that exists between males and females. McCord and Cardoza (1982:730-731) averaged standard measurements reported in 9 studies and found the mean total length of males was 869 vs. 786 mm for females, tail length was 148 vs. 137 mm, hind foot length was 170 vs. 155 mm, and ear length was 66 mm for both sexes. Measurements for Illinois' bobcats are similar; adult males averaged 920±52 mm long compared to females that averaged 858±38 mm. Weight and measurement data from live-trapped adult Illinois bobcats are summarized in Appendix B.

**Fig. 3. Even kittens sport the conspicuous white triangle on the back of the ear. (Woolf)**

# Capturing and Handling

## TRAPPING TECHNIQUES AND SUCCESS

### Methods

We used cage-type and foot-hold traps to capture bobcats during trapping periods that began in late December and ended no later than 30 March each year. We used both manufactured and homemade cage-type traps constructed of galvanized wire mesh measuring ~38 x 38 cm x ~90 cm long. 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. We placed these traps in baited dirt-hole sets, frequently in combination with commercial bobcat lures and visual attractants. Cage traps were baited with whole or partial carcasses and chunks of meat from a variety of mammals stored frozen until use. We generally used a visual attractant to help attract animals to the trap.

We systematically placed traps either where people reported seeing bobcats, or at locations where we thought bobcats would encounter our traps. Each trap was assigned a unique identification number. Traps were checked daily and trap nights of operation recorded for all operable traps. Trapping was conducted under provisions of an IDNR Endangered Species Permit (#95-14S) issued to the principal investigator (PI); all project staff and cooperating trappers followed trapping protocols established by the PI to live-capture, radio-collar, and release bobcats. Also, the trapping and handling protocol (95-040-98) was reviewed and approved (Animal Assurance #A-3078-01) by Southern Illinois University Carbondale's Animal Care Committee.

### Bobcats Captured

During 4 winter (Dec-Mar) trapping periods between December 1995 and March 1999 we had 145 captures of 96 different bobcats. The 96 different bobcats included 43 males and 42 females; 11 were not

**Top: Cage-trap capture Bottom: Foot-hold**

examined to determine sex. Captures included 29 juveniles (estimated to be <1 yr old); 13 male, 8 female, and 8 of unknown sex.

Twenty-one bobcats were recaptured 2 or more times; 4 bobcats were recaptured twice (19%), 10 were caught 3 times (47.6%), 5 were trapped 4 times(23.8%), and 1 cat was caught 5 times and another 7 times. Males were much more likely to be recaptured (16 of the 21) and twice as many adults (14) were recaptured as juveniles. The 2 record setting recaptures (5 and 7 times) were both juvenile females. Recaptures included animals caught in both cage-type and foot-hold traps and recaptures at different locations were the norm.

## Capture Success

Our capture success was within the range of other studies reported (citations in Rucker and Tumilson 1985), but factors influencing capture success are so variable that comparisons between studies are rather meaningless. However, capture success is an interesting record and does document our experiences. Our capture success varied by year and type of trap (Table 1), but that variability must be judged by the fact that our trapping methods, purpose, and efforts were not standardized year-to-year. For example, in the first year, we very judiciously placed cage traps where reliable sightings indicated bobcats were present. In contrast, foot-hold traps were deployed in a variety of settings and often there were multiple traps deployed at a site. The following year, we selectively placed both types of traps in sites known to be frequented by bobcats. During the third trapping season, we spent great effort trying to fill in "gaps" in areas trapped and between known resident female bobcats. During the final trapping season, we were again more selective in trap placement.

Overall trapping success (Table 1) suggests that it was twice as easy to capture bobcats in cage-type versus foot-hold traps. Clearly, cage-type traps were more effective than foot-hold traps, but the magnitude of difference indicated between the 2 trap types is probably not valid because of the biases in methods employed and purposes. Also, the data do not reflect capture success of our cooperators (they mainly used cage-type traps and more selectively placed them) who enjoyed even greater trapping success with both trap types, but did not maintain reliable records to allow comparisons each year. In the final year, our staff trapping success was 1 bobcat/69.8 cage-

**Table 1. Captures of bobcats in southern Illinois 1995-99 by year and trap-type. Success is shown parenthetically as number of bobcats/100 trap-nights.**

| | Total Captures[a] | |
|---|---|---|
| Capture Season | Cage-Traps | Foot-hold Traps |
| 1995-96 | 9 (3.1) | 9 (0.2) |
| 1996-97 | 41 (2.6) | 7 (1.2) |
| 1997-98 | 21 (0.7) | 12 (1.0) |
| 1998-99 | 37 (1.4) | 9 (1.8) |
| Totals | 108 (1.6) | 37 (0.8) |

[a]Includes all new captures and recaptures.

trap nights, but the combined effort of cooperators and our staff was 1/36.8 trap nights. Staff and cooperators used similar traps and bait, but cooperators limited trapping effort to locales known to be inhabited by bobcats. Their measure of success probably best reveals the effort needed to capture bobcats in cage traps in areas they are known to be present. We can only speculate why capture success for cage-type traps was greater than for foothold traps, but an important reason may have been that the quantity of bait employed in the cage trap was a strong sensory attractant and appealed to a carnivore seeking a meal, especially one that viewed cage traps with apparent curiosity rather than fear (Fig 4).

### Capture Locations

We trapped at 356 total sites and succeeded in catching a bobcat at 68 (19%) locations and had multiple captures of different cats at 21 (31%) of the successful trapping sites. The greatest number of multiple captures was 5, and that occurred at 2 trap sites. One site was on a nursery property near the confluence of 2 major creeks in Jackson County; we captured 3 juveniles and 2 adults at the site. The other place was a 2 ha patch of woods less than 50 m from a busy state highway and about the same distance from a home in Jackson County; we also captured 3 juveniles and 2 adults at this location. In addition, still a different juvenile male bobcat was captured at another property we trapped ~100 m away. Thus it appears that some areas seemed to attract bobcats (or were routinely visited by bobcats) more than others, but we could not distinguish attributes that clearly identified these very successful trap sites. Certainly, experienced trappers recognize so-called "hot spots" (Ricketts 1987) where bobcat activity seems to be greater than other areas, but we found it difficult to distinguish such sites from others we thought would surely be good locations for traps.

**Fig. 4. Curious bobcat inspecting a cage-type trap at night.**

Although the habitat surrounding trap locations varied extensively throughout the study, the typical trap site we selected was along an obvious travel lane; for example, a dirt road, trail, stream, or fence line. The presence of bobcat tracks or scat called for nearby trap placement, but many times we just placed the trap at an intersection, or at the corner of a patch of cover. Because bobcats often hunt in open fields and orchards, as well as thick patches of vegetation, we often placed traps at or near field edges and patches.

We didn't find any features that were particularly unique to successful trap sites, but proximity to water did seem to positively influence success. Bobcats frequently visited the perimeters of farm ponds, small water holes in woodlands, and stream crossing points. We speculate that denser vegetation associated with water features in the landscape provided optimal hunting and/or travel cover. Many authors have noted that rock outcroppings are important habitat features to bobcats where they occur, and we did find that traps located near rock outcrops were more likely to capture bobcats than were other traps. Interestingly, proximity of traps to human development did not seem to adversely affect capture success. We captured many adult bobcats within 100 m of human dwellings and 1 of our 2 most successful trap sites was so located.

## HANDLING PROCEDURES

Non-target animals were released without further handling, except they were manually restrained with a body-gripping device or a snare pole to facilitate release from foothold traps. Captured bobcats were chemically immobilized for handling using a combination of ketamine hydrochloride (HCl) and xylazine HCl. When drugged bobcats no longer responded to touch, we removed them from the trap, determined sex, and weighed them to the nearest 0.1 kg with a spring scale. Bobcats were aged as juvenile (<1 yr old) or adult based on size, mass, and examination of teeth. Next, we fitted them with the radio collar and examined them for injuries and ectoparasites. We then took anatomical measurements with a cloth tape or plastic ruler, recorded appearance of the pelage and overall physical condition. Body temperature, respiration, and pulse were monitored during the handling period. Bobcats were then placed in a shaded location 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 second.

The methods we used were effective and no bobcat was seriously injured by capture or handling. Single injections of the drug combination successfully immobilized 68% of female bobcats and 58% of the males. These animals became immobile after rapid induction periods that averaged <8 min. Overall, 80 and 81% of females and males, respectively, were immobile enough to be safely handled <15 min from the time they received their first injection of drug and their induction periods were smooth and uneventful (Appendix C summarizes drug dosages and responses). Most animals recovered well enough to at least stagger away from the capture site within an hour of the initial injection. Trap injuries were uncommon and included minor cuts and bruises. Radio monitoring revealed that bobcats resumed their normal movements and activities within 24 hours of recovery.

**(Top right) Fig. 5. Sedated adult male bobcat fitted with radio-transmitter.**

## RADIO TELEMETRY

Adult bobcats captured were fitted with ~125-g radio transmitters (Fig. 5) that included mortality sensors (Telonics, Mesa, Arizona, USA; Wildlife Materials, Carbondale, Illinois, USA). Most juveniles were not fitted with transmitters because we were reluctant to place a collar on that was either too loose, or had potential to choke an animal when it achieved full growth. Selected juvenile females and males >5 kg were fitted with collars with a circumference that could accommodate growth to adult size. A foam insert held them firmly in place.

We located bobcats regularly to plot locations by triangulation using standard telemetry techniques. Most (91%) locations were determined by obtaining >2 bearings from known stations located <2 km from the bobcat's suspected location. We entered data into a computer program (LOCATE II, Nams 1990) to estimate location coordinates. The program also calculated bearing error (4.2 ± 0.02°) and location error polygons (1.6 ± 0.1 ha); the latter were especially important to know when we related locations to habitat use. We obtained remaining locations by "homing" to the cat's actual location (5%), capture sites (2%), visual observations (1%) and aerial locations (1%) that were plotted on 7.5 minute series (1:24,000) United States Geological Survey topographic maps.

We radio-tracked most (87%) bobcats for >1 year ( = 477.2 ± 25.6 days/bobcat) and averaged 83.4 ± 11.6 annual locations per animal. These locations of radio-collared bobcats provided the data necessary to estimate home range size, determine movements and dispersal, study habitat use, detect den sites, and estimate survival rates.

# Habitat Characteristics

## DISTRIBUTION OF SUITABLE HABITAT

Although Illinois' rural land use is dominated by row-crop agriculture, we found that bobcats were widely distributed throughout the state. Woolf et al. (2000) reviewed 3,123 sightings of bobcats in Illinois reported between 1982-98 and there were reports from 99 of Illinois' 102 counties; only DeKalb, Piatt, and Stark counties had no bobcat sightings during the study period. However, this wide distribution is probably more a reflection of the bobcat's adaptability than it is a reflection of the distribution of suitable habitat. Rolley (1987) noted that intensively cultivated areas appear to be unsuitable habitat, and we agree. Although we documented a widespread distribution, >60% of the sightings were from the 16 southern Illinois counties that comprise only 11% of the land area of Illinois.

We used habitat modeling techniques to better define the distribution of so-called suitable habitat in Illinois, and attempted to assign some measure of quality to the habitats we defined. Details of the methods we used are reported in Woolf and Nielsen (1999) and Woolf et al. (2002). Briefly, we used stepwise logistic regression analysis to model bobcat habitat suitability statewide according to the scale of bobcat home ranges we determined from telemetry. A set of 78 potential predictor variables was developed from Illinois land cover information derived from Landsat TM imagery (Lumen et al. 1996); stream, road, and human population densities and land ownership data created by the Illinois Department of Natural Resources (1996); USGS DLG hypsography to derive slope; and landscape and class metrics (FRAGSTATS; McGarigal and Marks 1995) derived from land cover classes. We used a subset of 17 predictor variables for model building by retaining those that differed significantly between 100 bobcat sighting locations (buffered with a 2.85-km radius to correspond to an average home range size) obtained from a bobcat survey and 100 randomly selected locations that did not contain sightings and did not overlap with sighting locations. Finally, we computed the probability of a bobcat occurring in a 0.5 $km^2$ area surrounding a focal point in Illinois and mapped the resulting *P*-values statewide.

The result was a map where *P*-values close to 0.99 represented highest suitability and lower values reflected lower suitability (Fig. 6) *see back inside cover.* We found that 29% of Illinois had "suitable" habitat and 13% had "highly suitable" habitat. These habitats were found primarily in southern Illinois, along the Illinois River, and in northwestern Illinois. Although less suitable habitats comprised 71% of Illinois, patches of more suitable habitats were scattered in that matrix.

Although our classification of relative quality and distribution of habitats is based on a model, we did test the model's validity with an independent set of bobcat sighting locations. Distribution of the sightings not used to construct the model within the probability classes compared favorably; 66 and 84% of sightings were located within the $P > 0.75$ and $P > 0.50$ categories, respectively. Notably, only 4% of the sightings fell within the $P < 0.25$ class that we ranked the poorest habitat.

## SPECIES-HABITAT RELATIONSHIPS

We examined species-habitat relationships at landscape and home range scales to determine if there were important features in Illinois that required understanding so as to contribute to management of the bobcat and its habitats in Illinois. We used canonical discriminant function (CDF) analysis to model bobcat presence or absence and relative abundance at the landscape scale of Illinois counties (Gibbs 1998, Woolf et al. 2002). The models we created (Woolf et al. 2002) offered insight into habitat features and composition important to bobcats. Further, Nielsen (2000) used stepwise logistic regression to identify habitat variables associated with size of bobcat home ranges and core areas, and as a basis for habitat-population density models. Finally, Nielsen and Woolf (2001) examined the influence of humans on how bobcats use their available habitat.

## The County Scale

Preliminary analyses identified 9 predictor variables (Table 2) for CDF models to predict bobcat presence or absence and relative abundance at the county scale. The 2-class CDF model differentiated between counties with bobcats present vs. absent according to all predictor variables except the proportion of developed land. The most important predictor variables we used for targeting counties with bobcats were proportion of woods, woods patch density, and proportion of county with slope >18%. For each variable, counties with bobcats present had higher values for these variables than found in counties with bobcats absent. Our presence/absence model correctly classified counties as having bobcats present 81% of the time, but predicted absence only 67% of the time. We also used 200 independent locations to test model accuracy (Fig. 7) and 179 points (90%) were located within correctly classified counties; only 5 locations (3%) were in counties classified as absent.

**Table 2. Predictor variables used to model presence/absence and relative abundance of bobcats in Illinois at the county scale.**

| Variable Definition (units) |
|---|
| Percentage of developed land |
| Percentage of grassland |
| Density of non-intermittent streams (km/km²) |
| Density of rural roads (km/km²) |
| Simpson's diversity index of the landscape |
| Percentage of land with ≥ 18% slope |
| Percentage of federal- and state-owned timberland |
| Percentage of woodland |
| Patch density of woods (No./100 ha) |

Most variables were calculated using FRAGSTATS software (McGarigal and Marks 1995).

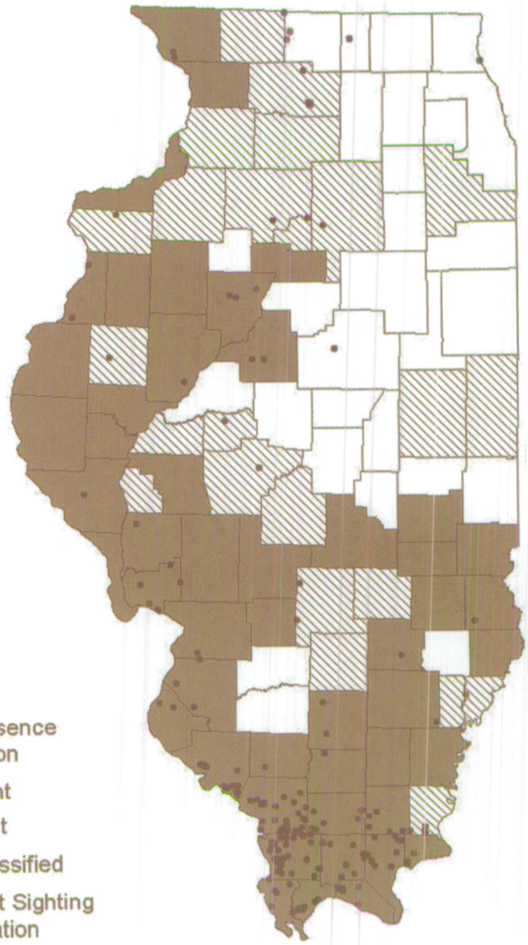



**Fig. 7. Illinois counties with predicted occurrence of bobcats. The 200 locations shown were independent sightings used to test model accuracy.**

Predicting bobcat relative abundance in a county was more subjective, but the 3-class CDF model did a fair job. The 3 variables that contributed most to this model were rural road density, proportion of woods, and publicly owned timberland. In this model, counties with high abundance of bobcats had lower rural road densities and greater proportions of woods and publicly owned timberlands than did counties with lower bobcat abundance. Although the map based on this model (Fig. 8) is similar to the depiction of habitat distribution shown in Figure 6 *back inside cover*, we think the latter map better illustrates habitat availability in Illinois.

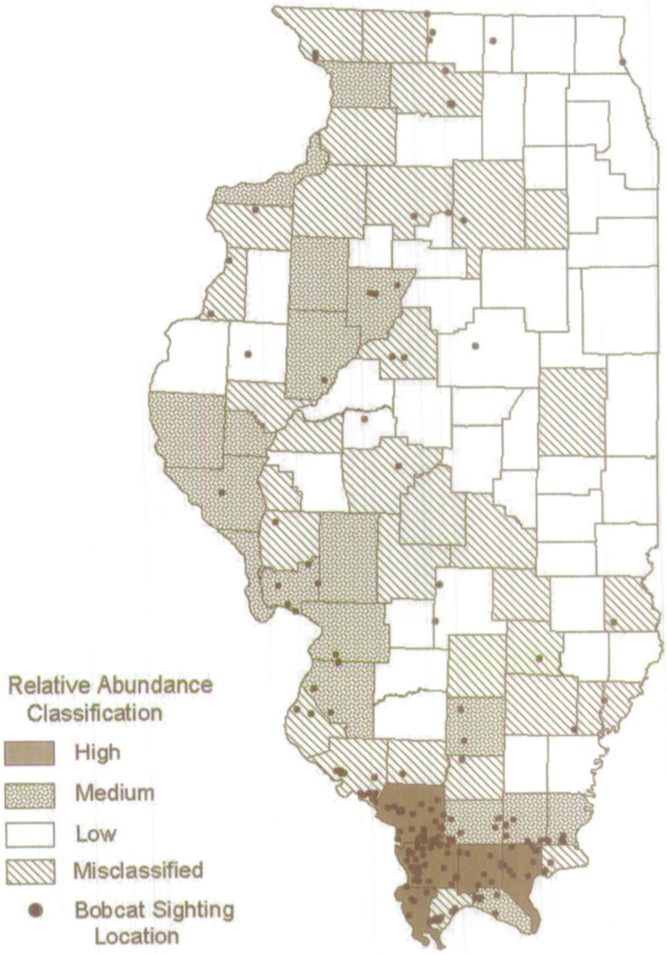



**Fig. 8. Relative abundance of bobcats in Illinois counties. The 200 locations shown were independent sightings used to test model accuracy.**

### Home Range and Core Area Scales

Nielsen (2000) identified habitat variables that accounted for a large amount of the variation in size of male and female home ranges and core areas within home ranges. Male home ranges and core areas both were predicted primarily by edge and compositional variables, but habitats used by females were more associated with landscape variables. Overall, the largest shape index of forest cover, patch density of the landscape, and total core area index of the landscape were important predictors of both home range and core area sizes for both sexes. The largest shape index is a variable that quantifies the percentage of a unit of area comprised by the largest patch while patch density expresses the number of patches per specified area. Both of these indices were negatively correlated with bobcat home ranges and core areas; in other words, areas used by bobcats were larger when (1) large forest patches comprised relatively small portions of an area, and (2) overall landscape patchiness was low. These findings indicate that bobcats seemed to thrive best in more patchy landscapes that provided a variety of needed resources in close proximity to each other.

Bobcat core areas were comprised primarily of forest cover (70%) with agricultural and grass cover types accounting for the remaining 30%. In contrast, the southern Illinois region had a more even mix with 36% of cover agricultural, 29% forest, and 22% grass. Although we found bobcats using agricultural cover, it was infrequent relative to forest and grass cover types. When agricultural cover was present in bobcat core areas, they were larger and included more preferred cover types.

Recall that we previously said rural road density was negatively correlated with bobcat relative density at the county scale (the 3-class CDF model, Fig. 8), and other studies have found bobcat home ranges were influenced by traffic levels and types of roads (Lovallo and Anderson 1996). We did find the percent of transportation cover (e.g., roads and railroads) was lower in bobcat core areas (3.5%) than in the entire study area (4.8%); however, at the home range and core area scales, it was not apparent that roads were an important influence on habitat use. For example, Nielsen (2000) found that proportions of road (and railroads) present in both male and female bobcat home ranges and core areas were similar, and Kennedy (1999) did not detect that roads were a movement barrier. There is a relatively high road density in southern Illinois (1.4 km/km$^2$) and it may be that the bobcat has simply adapted to the presence of roads (even if they are an important source of mortality).

To summarize, most studies of bobcat habitat use have reported the importance of woody cover as a component of bobcat habitat (Anderson 1987, Rolley 1987), and our studies are no exception. Our county and larger scale models disclosed that a higher proportion of woods increased apparent habitat suitability as reflected by the likelihood of higher bobcat abundance. Mean patch size of forest and percent forest cover were the variables most highly correlated with habitat suitability based on analyses of components of home ranges and their core areas.

### Human Influences on Habitat Use

Roseberry and Woolf (1998) described white-tailed deer (*Odocoileus virginianus*) habitat relationships in Illinois and noted that areas with most suitable habitat and abundance were those less intensively farmed. We believe this general relationship also describes habitat suitability for bobcats in Illinois. Our findings emphasize that although bobcats are habitat generalists doing well in Illinois' human-dominated landscape, they do need habitats not intensively used by humans to meet their needs for shelter and prey, and to continue to thrive as a component of our landscape.

Aside from the obvious loss of habitat as humans develop and otherwise alter the landscape for their use, human presence alone could influence how bobcats use remaining habitats. The issue is not just increasing human populations, but increasing expansion into rural areas leading to more human-wildlife contact and conflict in shared space. We think it is unlikely that any bobcat in Illinois lives free of human disturbance so we explored that influence on habitat use (Nielsen and Woolf 2001).

Bobcats are secretive animals that are generally thought to avoid humans (Anderson 1987), and the premise is supported by how infrequently people see bobcats even in areas where bobcats are common. But there are enough exceptions to this generalization to suggest that sometimes bobcats seem to accept, or at least tolerate, human presence. For example, we are aware of several sightings that involved a seemingly placid bobcat sitting in a backyard with a well-manicured lawn observing people. Also, we know of one instance of a bobcat raising kittens in a barn with frequent human use. But these truly were exceptions to the norm and we sought more reliable data to assess habitat use relative to human dwellings, and to determine whether bobcats avoided dwellings located in preferred habitats (bobcat home ranges and core areas).

We studied a group of radio-marked bobcats living within a portion of a 1,000-$km^2$ study area in Jackson and Union counties in southern Illinois (Nielsen and Woolf 2001). Human population density in the area was 17.8 people/$km^2$ and road density was 1.4 km/$km^2$. We used radio locations ($n$ = 1,648) to derive home ranges and core areas for 9 male and 12 female adult bobcats. We then analyzed how these bobcats used their habitats relative to 954 human dwellings within their home ranges. For the analysis, we buffered each dwelling with a 1.2-$km^2$ area based on the mean distance from the nearest bobcat location to a dwelling and assumed this liberal sized buffer represented the zone of potential human influence. Finally, we retained zones of human influence ($n$ = 198) with >70% forest cover (that matched the bobcat habitat use we measured from the radio-marked sample), and randomly selected the same number of comparable zones that lacked dwellings for comparisons.

The number of dwellings ranged from 4-559 within bobcat home ranges and the number within core areas ranged from 0-29. When corrected for size differences between home ranges and the smaller core areas within the home ranges, there were proportionally more dwellings within home ranges than within core areas ($2.8 \pm 1.9$ vs $1.9 \pm 1.8$; Nielsen and Woolf 2001). Also, random areas contained significantly more bobcat locations (656) than locations in zones containing dwellings (369).

We conclude that although anecdotal evidence indicates at least some individual bobcats tolerate human presence and influences, they appear to select core areas that may offer a retreat from human activity; perhaps this is a mechanism by which bobcats coexist with humans. However, human presence in otherwise suitable bobcat habitat does not appear to have been detrimental to bobcat population viability in southern Illinois. After all, both bobcats and humans seem to be coexisting at relatively high densities throughout the region.

## SPECIAL HABITAT NEEDS

We assumed that habitat variables associated with prey and cover resources would be the most important to the well-being of bobcats. But, we also assumed that males and females might require habitat components unique to their life histories, that dens used by females to raise young (natal dens) might represent a special need, and that habitat composition and structure at the micro-habitat level (the area immediately surrounding an individual's location) might be an important consideration. Following are our findings regarding each of these issues.

### Male and Female Home Ranges

Male and female home ranges differ in size, but do they differ in composition to meet special needs? We speculated that they might and to examine that possibility we used home ranges and core areas determined from radio-marked bobcats as the basis of comparison. Nielsen (2000) describes our analyses in detail, but briefly, we identified 69 potential habitat variables that might be important and used statistical tests to determine if they differed among male and female home ranges or core areas. We found that only 5 of 69 habitat variables differed among the categories by sex. Three of the variables were associated with agriculture and were highly correlated (see Nielsen 2000 for details), but basically female home ranges contained a greater proportion of agricultural cover than did male home ranges. Two variables associated with forest cover differed; male core areas included higher indices of interspersion and juxtaposition of forest cover than did female home ranges, but the differences were not significant in comparisons of male and female core areas. Finally, female home ranges had more forest edge habitat than did male home ranges.

The bottom line is that some habitat factors did, in fact, differ between male and female home ranges, but the differences were not dramatic. It may be that the differences reflect the life history requirements unique to each sex, such as kitten-rearing activities that guides female habitat use. At the same time, a section on home ranges that follows later will describe a high degree of male:female overlap, therefore, it is not surprising to find similarities in habitat factors associated with their respective home ranges.

### Natal Dens

We examined 8 sites used by females with kittens as dens; 6 were located with radio telemetry, and 2 were reported by local residents who happened upon the dens. Locations ranged from hay stacks in a barn to crevices or other openings in rock outcrops. Most were standing trees with hollow bases (Fig. 9), or downed hollow logs. In one instance, a female bobcat used the tangled top of a large downed tree to hide her litter (Fig. 10). Sites chosen as dens were not particularly unique from the surrounding area (Fig. 11) other than they all offered shelter from inclement weather and they were not conspicuous.

**Fig. 9. Tree with hollow base used by female bobcat with two kittens.**

Fig. 10. Den site used for several weeks by a bobcat with three kittens.

We did not specifically study denning ecology, but did record the following general observations. Often, den sites were located where herbaceous or woody understory vegetation was thickest. This finding is consistent with that of studies conducted throughout the bobcats' range; they repeatedly have been found to use areas with dense understory vegetation (Rolley 1987). Just like we found in Illinois, bobcats in Tennessee (Kitchings and Story 1984) used the bases of trees and brush piles for natal dens. Rock outcrops were used as natal dens in Illinois as they reportedly were in Missouri (Hamilton 1982), but perhaps they were less important den sites for our bobcats than elsewhere. McCord (1974) found bobcats in Massachusetts used rock outcrops for natal dens when available and Bailey (1979) concluded they were preferred den sites in Idaho. The bottom line seems to be that the versatile bobcat may have preferences for natal den sites, but they are hard to discern. At least in Illinois, they will take advantage of whatever feature offered adequate shelter. Even the tangled tree top where we found a den provided sufficient shelter to keep the kittens dry and hidden.

### Microhabitats

Previously, we noted the bobcat is a habitat generalist with a widespread distribution. We described habitats associated with bobcats in Illinois at landscape and home range scales. Research throughout the bobcats' range, and our findings in Illinois support the hypothesis that bobcats select habitats where prey are plentiful. However, full understanding of species-habitat relationships demands knowledge of habitat needs at multiple spatial scales so a component of our research included a study to determine important variables influencing microhabitat use during summer and winter seasons in southern Illinois (Kolowski 2000, Kolowski and Woolf 2002).

Fig. 11. Hollow-based tree den site at the Union County Conservation Area, Illinois.

### Methods

Microhabitat analyses were based on locations of individuals plotted to 10 m accuracy; they included visual observations, den locations, and telemetry locations. The latter were only used when consecutive multiple bearings from progressively closer distances resulted in a visual sighting or certainty of a location within a small circle that could be plotted within 10 m. Twenty-two vegetative and topographic characteristics were measured at summer (1 May-30 Sep) locations and compared to the same variables at random locations. The random locations were chosen from areas included within the known home ranges of 52 (22 male, 30 female) radio-collared bobcats (Nielsen 2000). Further, the selection was done in such a manner that proportions of habitat types (e.g., forested wetlands) describing summer locations and random locations were similar (see Kolowski 2000 for details of methods).

A subset of 14 of the 22 variables measured at summer locations were selected to study winter microhabitats. The same random locations chosen for summer locations were used, but only variables not dependant on season were analyzed. Methods of analysis and seasonal comparisons were described in detail by Kolowski (2000).

### Results

In general, summer homing locations were associated with more log/woody debris, more shrub and vertical vegetation cover, and less leaf litter cover than were random locations. The summer locations also were characterized by higher stem densities (thicker cover), proximity of a distinct edge (change in cover-type), and were closer to permanent streams and water sources than were random locations. However, only 21% of summer locations were near rock outcrops compared to 35% of random locations. In winter, specific locations used by bobcats were associated with higher understory stem density, rock ground cover, and log/wood ground cover than were random locations. Winter locations also were closer to water sources than were summer locations. Comparisons between summer and winter season

**Fig. 12. A bobcat was radio-tracked to this thick cover used as a daytime resting site.**

locations revealed that presence of rock outcroppings increased the probability of predicting a winter location; other predictor variables (log/wood cover and understory stem density) had less influence.

We were not able to determine the bobcat's behavior at the time we recorded their location, but our methods likely targeted habitat used by a resting animal. First, we only attempted to get locations from animals that were not moving. Also, most locations were taken between 0730-1645 hrs when other studies (Kennedy 1999) found the bobcats were largely inactive. The thicker cover that characterized summer locations of bobcats in Illinois (Fig. 12) is consistent with findings from other research studies. For example, Anderson (1990) found higher levels of vertical cover associated with daytime loafing sites of bobcats in Colorado, and Hamilton (1982) described summer retreats of Missouri bobcats as located in regenerating woodlands; or if mature woods, where brush piles, thickets, or downed trees provided concealment. A notable difference between our findings and other studies was that rock outcrops or other rocky terrain did not seem to be important sources of cover to bobcats in our study area.

In both winter and summer, the bobcats we studied were likely to be resting in tall, dense grass or brush. In winter, increased structural cover became more important. This finding is consistent with findings reported by other researchers (Knowles 1985, Litvaitis et al. 1986). Without the protection that foliage offers, bobcats seem to select more permanent structural features for the cover they offer both for resting and areas to find prey.

A surprising outcome of our microhabitat studies was the lack of significance and contradictory findings regarding the importance of rock outcrops (Kolowski 2000) given the importance attributed to these structures in other studies. However, although locations near outcrops did not differ significantly from random locations, 30% of winter locations were near outcrops. Also, analyses of trap locations (Kolowski 2000) did reveal that presence of rock outcrops increased the likelihood of capture success. Thus, it may be that rock outcrops are important components of bobcat habitat and our analyses underestimated their importance.

Overall, our findings underscore the importance of thick cover to bobcats, both for its contribution to their security and as an important component of prey habitat. Extensively cultivated areas are widely considered to be unsuitable habitat (Rolley 1987), and our findings illustrate that fact. Only 20 (9.2%) of the 216 known bobcat locations where we described microhabitats were located in row crop areas and all 20 locations were detected in unharvested fields. The results of our microhabitat analyses in Illinois, especially with respect to vegetative variables studied, largely confirmed the results of other studies throughout the bobcats' range. The fact that none of our models (Kolowski 2000) were able to predict with >70% accuracy bobcat use locations based on microhabitat data alone probably is a reflection of the bobcat being such a successful habitat generalist.

# Social Organization and Behavior

## HOME RANGES

Home range refers to the area used by an individual for everyday activities, such as foraging, breeding, and rearing offspring. In addition to describing the habitat attributes of bobcat home ranges (see HABITAT CHARACTERISTICS), we determined the size of annual and seasonal (breeding season = Nov-Apr, kitten-rearing season = May-Oct) home ranges. We analyzed radio telemetry locations of 22 adult male and 30 adult female bobcats to estimate home range size based on the minimum convex polygon method (i.e., connecting the outermost locations with lines, creating a convex polygon). More details on methodology are reported in Nielsen and Woolf (2001).

Average annual home ranges of the 22 male and 30 female bobcats we studied (Table 3) were comparable to other bobcat studies conducted at similar latitudes in

**Table. 3. Mean (± SE) sizes (km²) of annual and seasonal 100% minimum convex polygon home ranges of bobcats in southern Illinois, 1995-99**

| Sex/season | n | Size |
|---|---|---|
| **Males** | | |
| Annual | 22 | 52.4 ± 7.4 |
| Kitten[a] | 20 | 31.5 ± 3.8 |
| Breeding[b] | 13 | 27.5 ± 2.2 |
| **Females** | | |
| Annual | 30 | 16.0 ± 2.2 |
| Kitten[a] | 17 | 15.8 ± 3.2 |
| Breeding[b] | 14 | 12.5 ± 1.8 |

[a]Parturition-kitten-rearing season (1 May-31 Oct)
[b]Breeding-gestation season (1 Nov-31 Apr)

Missouri (Hamilton 1982), Oklahoma (Rolley 1983), and Tennessee (Rucker et al. 1989). Not surprisingly, male home ranges were larger than those of females annually and seasonally, but home ranges of both sexes did not differ seasonally. Theoretically, male home ranges should be larger during the breeding season when they are seeking a mate or prey and some other studies have reported this. However, male bobcats in Illinois may not have needed to enlarge their home ranges during the breeding season because of high female availability on the landscape. Indeed, in several instances individual male home ranges overlapped those of 3 or 4 females. Thus, males did not need to move greater distances during the breeding season and home range size did not expand.

Female home range sizes did not differ seasonally, which also is contrary to other studies. Females commonly decrease home range size during the kitten season due to denning activities. However, we found females with kittens used multiple dens. These dens were often separated by >1 km; thus, over the entire season, home-range size likely did not decrease appreciably.

Overall, we found that bobcat home range size and spacing in our southern Illinois study area was stable, both annually and seasonally. Bobcats adequately met their needs for energy and reproduction without the need to shift, expand, or contract their home ranges seasonally.

## SPATIAL SEPARATION and INTERACTIONS

Bobcats maintain a type of territoriality called "mutual avoidance" in which they don't actively defend territories. Rather, distance between individuals is maintained by visual means and scent marking. Although many individual bobcat's home ranges may overlap, temporal avoidance is generally the rule within these areas. We assessed bobcat spatial separation and temporal interactions based on overlap of home ranges, fidelity to home ranges, and straight-line distances between individual bobcats.

Home range overlap among pairs of bobcats (male:male, female:female, or male:female) was calculated as the percentage of shared areas of the total combined areas of the 2 respective home ranges. Home range shift was defined by a bobcat moving from a stable home range and establishing a new home range completely outside the boundaries of the former. We calculated ratios of maximum distance between seasonal home range centers and the outermost home range boundaries to assess relative shifts in seasonal home ranges. Also, we calculated a ratio of distance between pairs of adjacent bobcats to the maximum span of overlapping annual home ranges to assess annual and seasonal spacing of individuals. Distances were determined between adjacent individuals when locations were separated by <3 hours (see Nielsen and Woolf 2001 for details of methodology).

Annual home range overlap was 36%, 47%, and 54% for female:female, male:male, and male:female pair-groups, respectively. We found relatively high levels of intrasexual home range overlap for both male and female bobcats compared to other studies. This unique pattern of spatial organization may be due to several factors, but could result from greater bobcat densities in southern Illinois (see POPULATION ECOLOGY).

High levels of home range overlap may have implications for social encounters in bobcats. However, whether "mutual avoidance" occurs in areas with a dense bobcat population is unknown. Theoretically, aggression may be high when densities are elevated and overlap is extensive. We had 2 sources of data to assess potential aggression: temporal spacing data and home range fidelity. Examination of 1,572 simultaneous locations between adjacent individuals revealed mean distance between pairs of bobcats was about 3.5 km; only 52 locations (3%) were <0.50 km apart. Thus, although bobcats in Illinois seem to have a high level of overlap, they were still spaced widely enough to prevent aggression in most cases. Although both radio telemetry locations and visual sightings did reveal some bobcats in close proximity to one or more other bobcats, with the exception of breeding and females with kittens (and possibly juvenile litter mates) most bobcats lead a solitary lifestyle maintained by temporal if not spatial separation.

Males shifted home range centers 1.7 km between seasons and females shifted home ranges 0.8 km between seasons. Given the large size of home ranges, it is likely that these temporal separation distances indicate mutual avoidance. Further, a high rate of home-range fidelity (92%, or 48/52 bobcats staying in their home range), suggested low levels of aggression.

## MOVEMENTS and JUVENILE DISPERSAL

### Movements

Researchers have found that daily movements of bobcats are influenced by factors such as sex (breeding strategies and kitten rearing), weather, and prey abundance; the latter is especially important throughout the year, whereas the other factors take on seasonal importance. Prior to the advent of radio telemetry, daily movement of bobcats could only be studied by snow-tracking. One of the first such studies (Rollings 1945) found that over a 24-hr span, bobcats traveled an average of 8.5 km/day (range 4.8-11.3 km) and other snow-tracking studies found similar ranges of daily movements. Radio telemetry increased opportunity for studies of bobcat activity and movements and many such studies were conducted. This tool allowed researchers to closely monitor animals to determine rates of travel as well as travel distances. Unfortunately, comparisons between the studies were of limited value because estimated movement rates were based on location intervals ranging from 1-24 hrs. Also, studies revealed that factors influencing movements varied across geographic regions (McCord and Cardoza 1982), and few studies were conducted across the central and southern Midwest region (none in Illinois). Therefore, we studied a subset of our radio-marked bobcats to determine their movement patterns in the Illinois landscape (see Kennedy 1999 for details).

We monitored bobcats during spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov) seasons during 2 tracking periods (1600-0100 and 0100-1000 hrs) that coincided with maximum bobcat activity. Bobcats were located by triangulation at 30-min intervals during the sampling periods and their locations plotted on topographic maps. Although in some cases we knew otherwise, we assumed that bobcats traveled in a straight line between movements to calculate total linear distance traveled and the hourly rate of movement.

**Table 4. Mean (± SD) total linear distance traveled (km) by adult bobcats in southern Illinois between 1600-0100 and 0100-1000 hours in spring, summer, and fall periods in southern Illinois.**

| Season | *n* | Male | *n* | Female |
|---|---|---|---|---|
| **Spring** | | | | |
| 1600 - 0100 hrs | 8 | 6.2 ± 3.4 | 8 | 3.7 ± 2.3 |
| 0100 - 1000 hrs | 8 | 4.9 ± 2.5 | 8 | 3.0 ± 1.7 |
| **Summer** | | | | |
| 1600 - 0100 hrs | 8 | 3.9 ± 2.2 | 8 | 2.8 ± 1.2 |
| 0100 - 1000 hrs | 8 | 4.7 ± 1.6 | 8 | 3.4 ± 1.2 |
| **Fall** | | | | |
| 1600 - 0100 hrs | 8 | 4.8 ± 1.7 | 8 | 3.2 ± 1.3 |
| 0100 - 1000 hrs | 6 | 3.8 ± 1.9 | 7 | 2.4 ± 1.4 |
| **Total** | 46 | 4.7 ± 2.3 | 47 | 3.1 ± 1.6 |

We found that males traveled farther than females during both time periods and all seasons (Table 4). The distances traveled were variable; males ranged from 0.4-12.5 km while females ranged from 0.8-7.1 km. Overall, the longest travel distances were by males during the spring which likely was due to increased movements associated with the peak of breeding season. Males also traveled faster than females; hourly rate of movement for males was 601 ± 301 m/hr compared to 300 ± 151 m/hr for females. We found other evidence that males traveled more, further, and faster than females. The patterns of movements we observed we clumped (within 5 ha), local (5-10 ha), or movement paths (directional travel). Males traveled further and faster than females when in movement paths, and

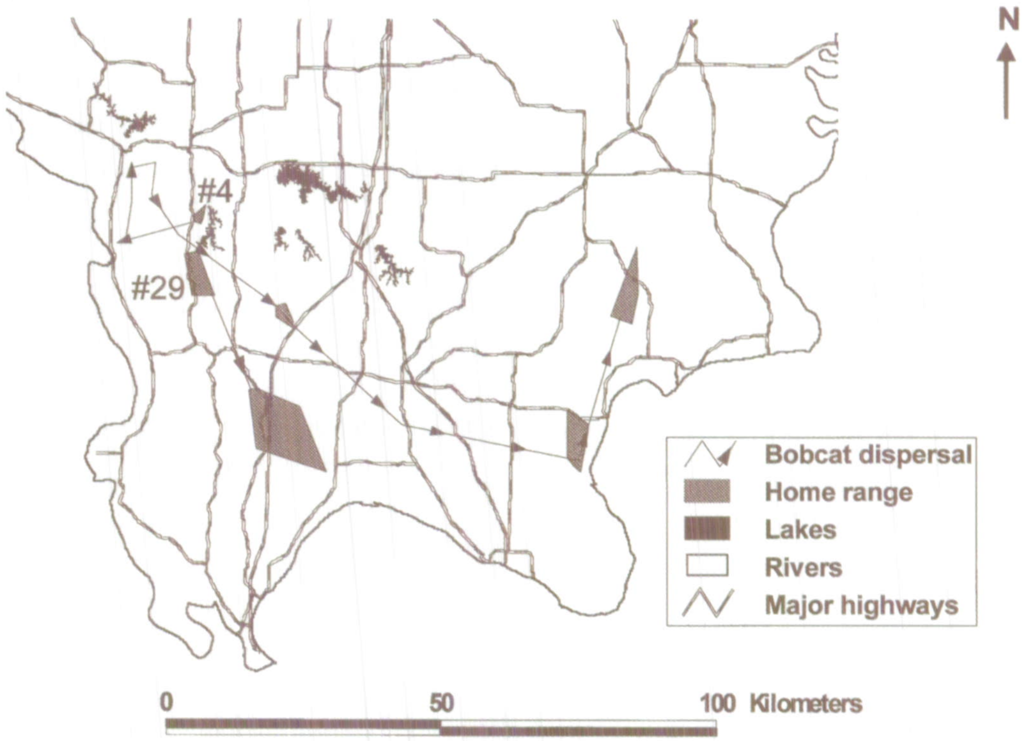



**Fig. 13. Dispersal patterns of juvenile male bobcats in southern Illinois.**

spent more time (43% were >2.5 hrs duration) in movement paths than females (16% were >2.5 hrs duration).

It was difficult to quantify how bobcats moved across the landscape, but we did observe some general patterns in how bobcats used (or responded to) topography, land cover, and roads/railroads. Bobcats used stream valleys and their associated ridges extensively as travel paths; 10 of the 12 animals monitored used such features. It also was obvious that the patchy landscape influenced bobcat movements; they generally traveled through wood or along wood edges. The bobcats rarely traveled through open areas, and when they did it was usually fast-paced and of short duration. Roads did not seem to serve as travel lanes, nor did they hinder bobcat movements. On the other hand, railroad rights-of-way (both active and abandoned) were favorite travel lanes. One particular male was observed for 3 hrs traveling 2.2 km along an abandoned track, and although he meandered from side to side, he was rarely off the right-of-way. The instances we documented of bobcats being killed by trains (see MORTALITY CAUSES and RATES) further attests to bobcats using these travel paths.

As previously stated, comparisons between studies are difficult because of differences in methods of gathering and analyzing data. However, our findings in Illinois generally were similar to those reported in other studies of bobcat movements. They reveal a mobile animal that can traverse its home range with ease while seeking prey and mates.

## Juvenile Dispersal

Dispersal of juvenile males is influenced by a variety of ecological phenomena, and is the norm of behavior among bobcats. Knowledge of dispersal characteristics provides insight into the level of isolation of separate populations, and from a management standpoint can be used to help delineate management boundaries.

We radio-tracked 6 juvenile male bobcats; all of whom dispersed from their natal home ranges (Fig. 13) between March and September. Straight line distance from capture site to final home range establishment was 43 km; these dispersal distances were similar to most other studies. However, overall known dispersal movements were >100 km for >2 bobcats. Although a few studies have reported straight-line dispersal distances of >80 km, bobcats in southern Illinois were constrained (but probably not completely restricted) by the Ohio and Mississippi rivers to the south, east, and west, and primarily unsuitable agricultural habitat to the north. Most bobcats dispersed in a south-southeast direction within the most suitable habitat (i.e., primarily forest cover).

At the outset of our study, we hypothesized that roads may limit bobcat dispersal movements by causing excessive mortality. Although the annual vehicle-caused mortality rate of southern Illinois bobcats was 10% (see POPULATION ECOLOGY), major highways and relatively high road and human densities were not barriers to juvenile dispersal. Four bobcats survived until their radio-collars wore out and 2 bobcats died <275 days post-capture; 1 from unknown causes, and the other from a vehicle collision.

Bobcats we studied exhibited 2 types of dispersal (Fig. 14): a relatively fast straight-line dispersal pattern or a longer, more erratic dispersal pattern. Three bobcats exhibited the former dispersal pattern, traveling <40 km before establishing new, stable home ranges <2 months following dispersal initiation. Dispersal of 3 bobcats were highly erratic, of relatively long duration (>6 months), and in one case consisted of the establishment of 3 small, temporary home ranges. Although bobcat dispersal patterns are thought to be influenced by vacancies created by death, we only documented one instance when a bobcat settled in an area left vacant when the radiomarked resident adult was killed by a vehicle.

As noted by others, there is little information on social interactions influencing dispersal in juvenile bobcats. We did record an incidence of an adult female that led her male offspring 10 km outside of their shared home range. She immediately returned to her home range and remained for >1 year; whereas, he initiated erratic dispersal movements. However, just what behavior was underlying the activity we recorded remains unknown. Was it care-giving maternal behavior, or that of a female aggressively forcing her offspring to disperse?

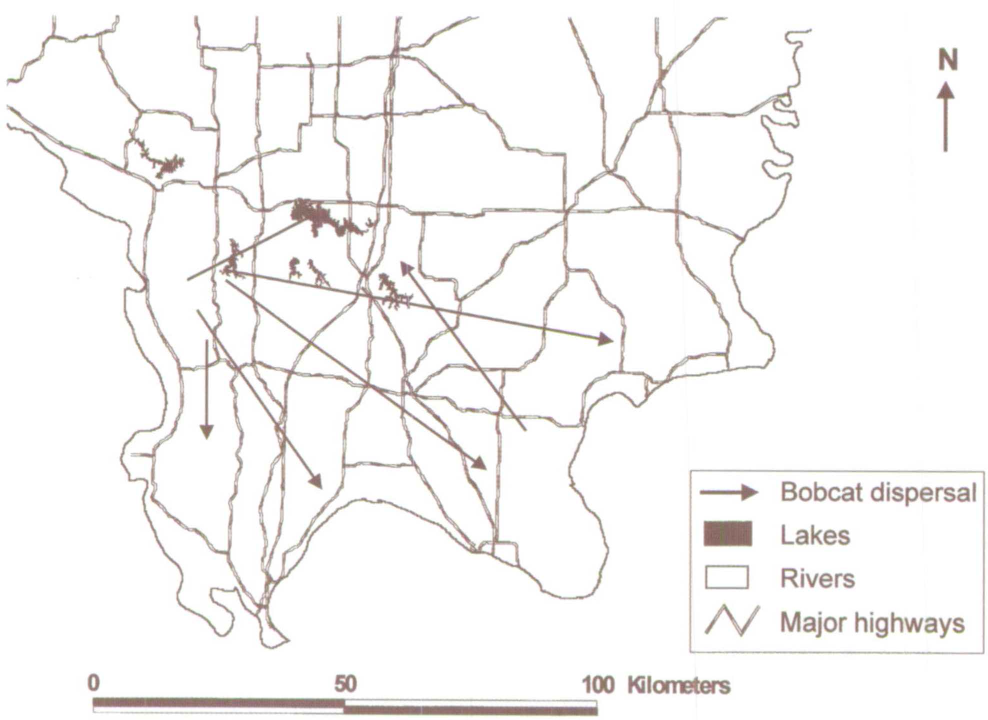



**Fig. 14. Examples of juvenile male bobcat dispersal in southern Illinois.**

# Food Habits

The distribution and abundance of predators is closely linked to availability of a suitable prey base to meet their metabolic demands. Optimal foraging theory is based on the notion that a predator seeks prey that maximizes energy gained per expenditure of effort. The bobcat is a "habitat generalist" as reflected in its wide geographic distribution and its ability to exploit a variety of habitats. Not surprisingly, the bobcat also can exploit a variety of prey found in these habitats to efficiently meet energetic demands for maintenance and reproduction.

The importance of prey species varies with geographic region. Lagomorphs dominate the bobcat diet in most regions (Fritts and Sealander 1978, Bailey 1979, Story et al. 1982, Parker and Smith 1983) and white-tailed deer are an important food source to northern and northeastern populations (Anderson 1987). In addition, squirrels and voles are regularly consumed throughout the bobcat's range, although they rarely comprise a high percentage of the bobcat diet (Progulske 1955, Koehler and Hornocker 1989).

Prey distribution and abundance have been associated with bobcat habitat use (McCord 1974, Litvaitis et al. 1986, Leopold et al. 1995), social organization (Bailey 1981) and demography (Knick 1990). These findings illustrate how knowledge of bobcat diets may provide insight into their status and ecology. Further, bobcats are known to prey on domestic animals and game birds, but the impact of this predation varies regionally (Bailey 1979, Parker and Smith 1983, Anderson 1987). While numerous studies of bobcat food habits have been conducted throughout its range, none have been conducted in Illinois. Therefore, our objective was to document the diet of the bobcat in southern Illinois to gain insight into their habitat use and their role as a predator.

## METHODS

We determined bobcat food habits based solely on examination and identification of the stomach contents of animals found dead and submitted for necropsy; we did not examine scats or intestinal contents. Contents of 85 bobcat stomachs (all collected from the 16 southernmost Illinois counties) were analyzed to determine food habits. Researchers removed the stomach from thawed carcasses and weighed the wet contents on an electronic balance. The contents were sorted and identified following procedures recommended by Korschgan (1980). Most prey items were identified macroscopically by anatomical components such as teeth, skulls, tails, and feet. Sticks, bark, leaves, and grass were noted, but not considered prey items. If prey remains could not be identified by gross appearance, hair samples were prepared as wet mounts for microscopic examination of the cuticular scales and medulla. Identification was based on comparison with pictures and descriptive text in Spence (1963), or direct comparison with a reference collection of mounted hair specimens of Illinois mammals.

## DIET IN ILLINOIS

It appeared that few bobcats in southern Illinois were going without a meal; we found food items and recorded content weights in 86 of the 91 (54 male, 37 female) stomachs we examined. Average weight of male bobcat stomach contents (265.2 g) was heavier than the average for females (164.8 g), but when standardized by body mass, the differences were not significant. Likewise, adult stomach contents weighed more than juveniles (230.4 vs. 192.1 g), but the difference was not significant when standardized by body mass.

We were able to identify food items in 85 of the stomachs examined (Fig. 15, Appendix D). Small rodents in the family Muridae were by far the favorite prey item of bobcats living in southern Illinois appearing in 32.8% of stomach contents. The single most frequently occurring prey item in this group was *Microtus* spp. (voles) found in 21% of stomachs. Next in importance (22.7%) was the cottontail rabbit (*Sylvilagus floridanus*) followed by squirrels (19.3%). Large mammals and birds were found in 10.9 and 10.1%, respectively, of the stomachs we examined. We were unable to identify species of most avian remains, but nearly all were passerines. White-tailed deer were present in just 3 (2.5%) of

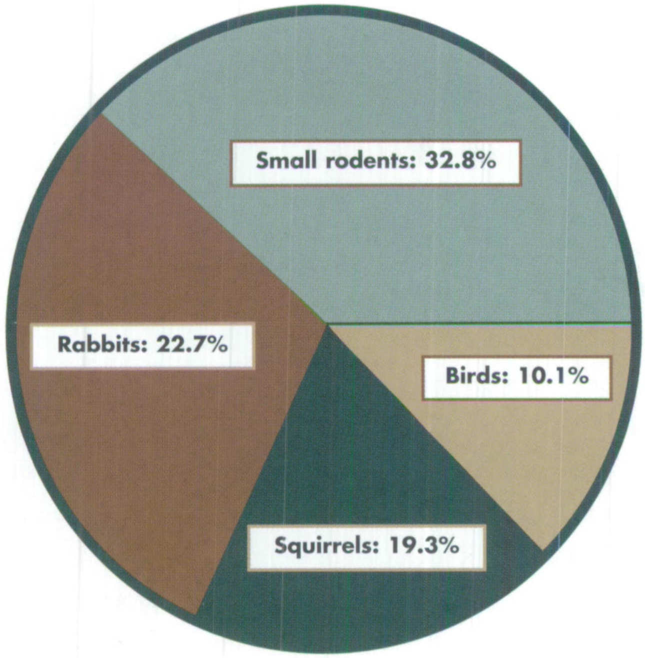



**Fig. 15. Major food items in Illinois bobcat diet.**

the stomachs, whereas opossum (*Didelphis virginiana*) were the most frequent (5%) dietary item in the group we called large mammals.

Male bobcats consumed rabbits more frequently (28.6 vs. 14.3%) and small rodents less frequently (28.6 vs. 38.7%) than did female bobcats and the differences were significant. In contrast, other prey items did not differ between the sexes. Forty-one (49.4%) stomachs with identifiable remains contained >1 prey item (all the same species); 24 (28.9%) contained 3 or more items. Bobcats were opportunistic predators; 32.9% of the stomachs contained >1 species with 2 the most common number when multiple species were present. Only 6 stomachs (7%) contained 3 species, and that was the most recorded.

Although lagomorphs are often thought to be the most important prey for bobcats (see Rolley 1987 for a brief review of bobcat food habits), it is not surprising that Muridae, especially voles, were important in Illinois because of their availability. A small species like the vole (20-40 g) can be an energetically profitable prey item if the predator has developed a successful and efficient hunting technique to catch the species. Story et al. (1982) speculated bobcats had developed the needed prowess and reported *Microtus* species were found in 22% (second in occurrence) of stomachs and scats sampled in Tennessee. Our findings in Illinois support the premise that bobcats efficiently hunt and capture voles. Eleven of 27 stomachs containing *Microtus* had >3 individuals, 2 stomachs contained >6 individuals, and 1 contained ~13. Further evidence that a diet consisting mostly of voles and other small rodents is a successful foraging strategy for bobcats in southern Illinois is provided by necropsies which revealed all but a few cats were in good to excellent condition with expected body mass and fat reserves.

We frequently think of the food items in a predator's stomach as prey, and most likely do represent prey, especially the small species (rodents, lagomorphs, and birds). Whether white-tailed deer remains we found in 3 stomachs represented prey or carrion feeding is subject to debate. Frequency of deer reported in bobcat diets in this region ranges from 8% in Missouri (Korschgen 1957) to 20% in Tennessee (Buttrey 1979), but some studies did not find any deer in bobcats' diet (Fooks 1961, Fritts and Sealander 1978). Further, investigators have suggested that the majority of deer are fed on as carrion, as evidenced by increased frequency of deer in bobcat diets during deer hunting seasons (Fritts and Sealander 1978, Buttrey 1979). Our findings support this speculation; the 3 instances of deer in bobcat stomachs were recorded during the archery deer season. Also, we have received anecdotal reports of bobcats feeding on deer carcasses, and our research staff observed a radio-collared animal along a roadway feeding on a deer that had been struck and killed by a vehicle.

In summary, the diet of bobcats in southern Illinois is similar to that reported for other populations in the midwest region. In general, the bobcat food habits we observed revealed their ability to exploit the varied prey base available in southern Illinois. Habitat composition of southern Illinois is characterized by high interspersion of wooded and open habitats. The 2 leading components of the diet we documented (small murid rodents and lagomorphs) were closely associated with the grasslands, orchards, and early successional fields found throughout the region and documented as important components of bobcat home ranges (Nielsen 2000). Squirrels were next in dietary importance and fox (*Sciurus niger*), gray (*S. carolinensis*), and flying (*Glaucomys volans*) squirrels are common in the woodlands throughout the region. Other dietary items likely represented opportunistic encounters. Given the availability of efficiently exploited rodents and lagomorphs, it is not surprising that deer and avian species are not important to the bobcats' diet in our region.

# Population Ecology

A population is a cohesive unit of breeding animals living within a particular space. This level of ecological study offers insights into the species in question; in this instance, the bobcat in Illinois. Both the population and individuals that compose it have shared biological attributes that give each population and individual within it a unique life history. However, at the population level, there are group attributes (such as birth rate, death rate, and age structure) that apply just to the population (not the individuals that compose it) and ultimately determines its size relative to the space it occupies, and its persistence in the community. The following discussion describes some important biological attributes of bobcats in Illinois, and group attributes of the population that inhabits southern Illinois.

Our primary sources of data were from radio telemetry analysis and bobcat carcasses submitted to our laboratory for necropsy. These data, in combination with habitat analyses, provided insight into bobcat population ecology and status. The population biological attributes addressed are physical condition, health, reproduction, and mortality factors. Group attributes determined include mortality rates, age structure, population density, and population stability.

## PHYSICAL CONDITION AND HEALTH

There is little evidence that bobcat populations anywhere have experienced outbreaks of infectious diseases (those caused by living organisms, including parasites). McCord and Cardoza (1982) attributed this to bobcats' solitary behavior and frequent changing of dens and resting areas. Such behavior lowers risk of exposure to infectious agents, or transmission of such organisms to other susceptible hosts. This is not to say that individual bobcats are not susceptible to a variety of infectious diseases (see McCord and Cardoza 1982), but they do not appear to pose serious risk to bobcat populations in Illinois. On the other hand, we did assume that physical condition of individuals was a reflection of the available prey base, and that well-nourished individuals were indicative of overall population health. These assumptions were the bases of our approach to assessing the health of Illinois' bobcats based on physical examination of live animals captured for radio-tagging and necropsy of dead animals that we found or were submitted to our laboratory.

### Methods

All captured animals (145 captures of 96 individuals) were at least visually inspected for evidence of trauma, condition of pelage, and physical condition as evidenced by estimated body mass and well-muscled appearance. Animals that were chemically immobilized ($n$ = 86) were more closely examined by looking for obvious infestations of ectoparasites (fleas and ticks), or skin lesions that might be caused by ectoparasites (especially mites); examination of the mouth to note condition of teeth and gums; weighed to accurately determine body mass; and examined by palpation and moving limbs to evaluate condition, joint function, and detect evidence of trauma.

We necropsied bobcats according to a standard protocol that included thorough external and internal examinations. Major organ and tissue systems (except the central nervous system) were carefully examined by palpation and dissection to determine cause of death and presence of disease as evidenced by visible lesions (changes in the appearance of organs and tissues). We preserved tissue sections and examined them by histopathology if lesions were detected or suspected. Searches for macroparasites (visible to the naked eye) were extensive, but not intensive. We examined organs carefully enough that abundant parasites or parasitic disease would not have been missed, but infection with relatively few parasites causing no tissue changes could easily escape detection. Culture to detect microorganisms, or procedures to detect protozoan parasites or ova/larvae of any parasite were not attempted. We did not screen blood samples for presence of antibodies as evidence of exposure to infectious disease. Animals with advanced autolysis were not completely examined; usually the carcass only was examined for signs of trauma and lesions in major organs.

## Findings

### Physical Condition

All of the 86 live bobcats we carefully examined while they were anesthetized were judged subjectively to be in "good" or "excellent" condition. None of the animals were thin or emaciated to a degree that would lead us to suspect they were not healthy. However, 2 bobcats (both adult males) had multiple fresh wounds that we attributed to fighting with other bobcats; 1 bobcat had wounds serious enough that we arranged treatment (wound cleansing and suturing) by a veterinarian before release.

We necropsied 146 bobcats and trauma was the cause of death of all but 2 animals. Generally, the bobcats were in excellent condition as evidenced by normal body mass, pelage, and fat reserves. Weights of adult bobcats recorded at necropsy illustrate the point. The average weight of adult males was 9.7 ($\pm$ 1.5, range 6.0-14.5) kg; only 9 of 57 (16%) weighed <8.2 kg (1 standard deviation [SD]) from the mean weight. To put this in context, most were only a rabbit-size meal away from the average weight. Three of the 9 male bobcats that weighed less than 1 SD from the mean weighed <7 kg; 2 were obviously emaciated and their poor condition could be explained, and 1 was a 5-6-year old male in excellent physical condition, just small (6.98 kg) and with a nearly empty stomach. Weight data from adult female bobcats that were necropsied led to the same conclusions. Only 4 of 37 (11%) weighed below 1 SD of the average weight (7.2 $\pm$ 1.1, range 5.6-10.7 kg); none were emaciated.

Of the total of 232 trapped or necropsied bobcats we examined, only 2 were in poor physical condition, and both happened to be radio-collared animals that we knew to be in excellent condition when captured and offer some history. One male bobcat weighed 10.4 kg when captured 13 January 1998 and only weighed 6 kg (a 57.7% loss of body mass) when found dead 43 days later on 25 February. Necropsy revealed severe cachexia (a state of generalized ill health) as evidenced by anemia, generalized muscle atrophy, and the prior existence of fat reserves evident only by serous atrophy of remaining traces. The bobcat's stomach was dilated and occluded with a 143.7 g dry, dense hair mass and there were 6 (8-15 mm diameter) ulcers of the stomach mucosa (inner wall) near the pylorus. There was evidence that the ulcers had previously perforated resulting in peritonitis, but healing was nearly complete and there was no active infection.

The animal had been recaptured twice (24 and 28 Jan) before it died; although nothing unusual was noted, it was not carefully examined because it was released without chemical immobilization. While we cannot discount the possibility that capture and handling contributed to the animal's death, it is unlikely because no lesions were found suggestive of trauma during capture, or capture myopathy from handling. Also, radio monitoring of the animal post-release revealed normal movements and behavior until shortly before its death. Clearly the mass of bobcat hair in the stomach and the ulcers with associated peritonitis contributed to this animal's death, but the underlying cause of those lesions was not determined. However, the process was chronic rather than acute and evidence did not suggest cause was an infectious agent.

The other animal in poor condition was found dead in May 2001 alongside a highway that bisected its home range. We first captured the bobcat in December 1996 and it weighed 10.5 kg. We recaptured the male in January 1999 and he had increased in weight to 13 kg. When he died after being struck by a car, he only weighed

6.6 kg. Tooth sections revealed the bobcat's age was 8-10 years and his teeth were worn nearly to the gum line. Although both ecto- and endoparasites were present in greater numbers than commonly encountered, we considered the modest level of parasitism more of an effect of poor condition rather than a cause. The lack of other lesions leads to the speculation that his poor condition was attributable mainly to his relatively old age.

### Parasites

Fleas and ticks were present on some animals, but none had infestations that we considered potentially deleterious. Ticks were the primary ectoparasite (external parasite) and they were relatively common on carcasses examined during spring and summer. Ticks mainly were found on the ears, the head, and dorsal neck. The most found on a single animal was ~25 and most were under the radio collar of an animal killed by a vehicle in April 2001. Radio-collared animals recovered in the spring and summer usually had ticks under the collar and more ticks than were found on animals without radios attached. This was of some concern as an undesirable side effect associated with the radio collars; but, there were no lesions caused by the ticks other than mild localized reactions to attachment sites in a few animals. We suspect the ticks were a source of discomfort, but did not pose a serious health risk to the bobcats.

**Table 5. Prevalence of tapeworm and roundworm endoparasites in Illinois bobcats.**

| | Number examined | Number (%) of bobcats with parasites: Tape worms | Round worms | Both |
|---|---|---|---|---|
| **Male** | | | | |
| Juvenile | 16 | 11 (68.8) | 5 (31.3) | 5 (31.3) |
| Adult | 54 | 39 (72.2) | 21 (38.9) | 15 (27.8) |
| **Female** | | | | |
| Juvenile | 23 | 20 (86.9) | 9 (39.1) | 9 (39.1) |
| Adult | 33 | 22 (66.7) | 6 (18.2) | 4 (12.1) |

We did not screen for protozoan parasites; therefore, we cannot comment on their prevalence. However, we never detected gross lesions that could be attributed to infections with protozoa and thus discount them as a serious health concern for Illinois bobcats. In fact, parasite infections overall were not judged a serious health problem based on the bobcats we examined.

We identified only 4 species of endoparasites (internal parasites), and 2 were rarely encountered. A female bobcat had 7 2-3 mm nodules on her lungs containing a nematode (roundworm) identified as *Troglostrongylus wilsoni*; this was the only case encountered. Trematodes (flukes) identified as *Paragonimus kellicotti* was found in the lungs of 2 male bobcats. Four pockets containing a total of 13 flukes were found in one cat and 5 flukes were found in the other.

The most prevalent (number of cases/number examined) endoparasites were tapeworms (cestodes) and roundworms that were found in the intestinal tract. The tapeworms were identified as *Taenia rileyi*, and the roundworms as *Toxocara cati*. Other roundworms may have been present and not identified, but if so, that was not a common occurrance. Tapeworm parasitism was far more prevalent than was roundworm, and prevalence of both types of parasites in a single animal mirrored that of roundworms (Table 5). Intensity of parasite infections (number of parasites/animal with parasites) was low except in a few instances when moderate numbers were present. Only 7 (17%) bobcats had >8 roundworms present and 5 cases ranged from 9-20 worms. Two adult males had the greatest number; 1 had >50<100 and the other ~100. Both were in excellent condition. Likewise, most bobcats with tapeworm infections had <8 present; 10 (11%) had more with 18 being the most present.

### Population Health

The excellent health of the Illinois bobcat population we studied was evidenced by the live captured sample of bobcats examined and further evidenced by the normal behavior and survival exhibited by the 76 bobcats that were radio-collared and monitored. Necropsy data supported the finding of overall excellent health. Lesions that would be associated with chronic disease were rare and most bobcats were well groomed and in overall excellent physical condition. Prevalence of parasitism was rather low with few species represented. Further, the animals with parasites had relatively few present; none were judged to be suffering from parasitic disease and we concluded the parasite-host relationship evident was not detrimental to the bobcat.

## REPRODUCTION

Natality (birth rate) is an important population attribute determined by a variety of factors that may affect the reproductive performance of the individuals that compose the population. A population's birth rate is determined by the number of reproducing females, average litter size, and number of litters produced by each female. Although the maximum (potential) reproductive performance is an attribute of a species' biology, that actually achieved is a consequence of an individual's response to variations in a number of factors, especially those that relate to an individual's condition. Habitat quality and its influence on prey abundance may be the most important factor in determining whether or not a population in a particular locale achieves its reproductive potential.

Bobcat reproductive biology has been described in a number of studies (see Rolley 1987), but it varies geographically and has not been described in an unexploited population occupying habitats such as found in Illinois. Our goal was to understand the reproductive biology and performance of the Illinois bobcat population so we could have valid data for a regional population management model and provide comparative data from our region that would contribute to better overall understanding of bobcat reproductive biology.

### Methods

We relied on necropsy of accidently killed specimens to determine most reproductive parameters. Breeding season and litter size were determined from a sample of adult females that was monitored by radio telemetry. We evaluated reproductive performance in necropsy specimens by noting ovarian activity, uterine enlargement, presence and number of corpora lutea, placental scars, embryos, and evidence of lactation. Uterine horns were opened their entire length and examined to detect placental scars that appeared on the mucosa as distinct, dark- pigmented zones. If embryos were present, their crown-rump length was measured and they were weighed.

Ovary lengths were measured to the nearest mm. Ovaries that were small (<15 mm long) and lacked follicles >1 mm or other ovarian structures were classified inactive and discarded. Ovaries not classified as inactive were fixed at least 24 hrs in 10% neutral buffered formalin then sectioned at 1-mm intervals to count and measure largest diameter of the light-colored structures that Crowe (1975) considered to be corpora lutea (CL) of the current season. We noted the presence of the dark grayish to brownish structure variously called luteal bodies or corpora albicantia (Crowe 1975) and follicles, but only used the current CL as a measure of ovulation rate.

We located dens by telemetry or incidental reports. We examined dens to determine litter size, but did not otherwise disturb the litter (e.g., the kittens were not handled and examined). Litter size was estimated only from den counts, not reported sightings of females and young. We estimated breeding season by the distribution of females with current CL or embryos, and by backdating litters ~60 days to approximate month of conception.

### Breeding Season

Rolley (1987) reported that various studies described the breeding season for bobcats ranging from December through April, but southern populations may breed during any month of the year. The latter situation probably comes closest to describing the breeding season in southern Illinois where we obtained most of our information. Corpora lutea

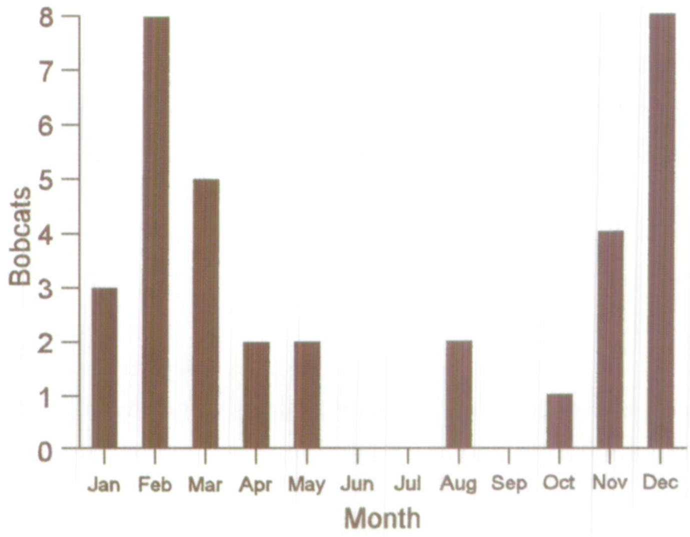



**Fig. 16. Monthly distribution of female bobcats that recently ovulated.**

that indicated recent ovulation were found in bobcat ovaries every month except June, July, and September (Fig. 18). However, only 2 bobcats were examined June/July and none in September. Four bobcats with fetuses were found; 3 in March and 1 in April suggesting breeding dates of January or February. Peak numbers of CL were found November-March, (see Fig. 18) so that period of time likely represents the peak breeding season in southern Illinois. Litters were reported to us in every month except January, February, and June; however, age of litters was unknown so it was not possible to estimate breeding dates. We did find 6 dens with very young kittens; the earliest was 3 March and the latest 15 September.

The sum total of evidence from all data supports the conclusion that bobcats in southern Illinois indeed breed year around, or nearly so. We have records of ovulation or breeding for every month except September. However, the peak of breeding probably occurs November through March. This pattern is not surprising given that we have relatively mild winters and early springs so food availability is not a limiting factor. Nevertheless, timing of breeding is such that most litters are born in early spring which corresponds to a time when a number of prey species have their litters.

## Reproductive Biology

We examined reproductive tracts of 64 female bobcats with known ages (36 >2 years old, 28 < 2 years old). Most (94.4%) of the 36 adult females were examined had CL present indicating reproductive activity. Only 12 of the 28 (42.9%) juvenile bobcats examined had CL. The average number of CL was $5.4 \pm 2.3$ and $3.2 + 2.0$ per reproductively active adult and juvenile female, respectively. The largest number of CL found in any animal was 10. These findings mirror those reported for other regions of the country (McCord and Cardoza 1982). Our findings also illustrate that juvenile females do ovulate and are capable of breeding during their first year of life. However, all do not attain sexual maturity and breed, and those that do ovulate at lower rates than sexually mature adults.

We examined 22 reproductive tracts with placental scars present and found an average of $2.8 \pm 1.5$ scars per female. This number too falls within the range (2.5-3.9) summarized from other studies by McCord and Cardoza (1982). Only 4 pregnant females were examined; they had a total of 19 CL and 12 embryos. The difference between the 2 numbers reflects the number of shed ova (37%) that either were not fertilized, or failed to properly implant and develop into an embryo. These findings are expected and do not reflect any problems in reproductive performance; indeed, data indicate that southern Illinois bobcats are normal in every aspect of reproductive biology.

## Recruitment

Recruitment of new individuals to the population is best indicated by the number of kittens produced that survive to breeding age. Litter size measured in utero (in our sample 3, which was the average number found in the 4 pregnant bobcats examined) is a poor indication because it fails to account for newborn kittens that die, or those that fail to reach puberty. Even the number of very young kittens only represents the number born, not those that reach puberty. We only found 7 dens where we could determine litter size; there were 13 kittens in the 7 dens (range 1-3).

Records of observed litter sizes from all sources (that includes everything from neonates to near-adults) provide one estimate of recruitment. The 21 litters we observed had an average size of 2.3 ± 1.0 kittens. Trapping data from 1995-99 provide another way to estimate recruitment. We captured 0.63 kittens per female (32 females and 20 kittens); the proportion of kittens in the entire sample (76 bobcats) was 0.26.

The average litter size we observed very likely overestimates recruitment because it fails to account for mortality of the younger kittens observed (unfortunately, we have virtually no data upon which to base an estimate). The proportion of kittens per live-trapped female is a more realistic estimate of recruitment, because this sample included kittens that were >5-6 months old and beyond the age when most juvenile mortality likely occurs. We used this estimate (0.63 kittens/female) as our high estimate of recruitment in population models that will be described in a following section (SIZE/DENSITY). Other evidence presented in that section suggests that actual population recruitment ranged between 0.40 and 0.63.

## MORTALITY FACTORS AND RATES

Bobcat survival and causes of mortality have been studied in populations throughout most of their range. However, southern Illinois provided a unique setting to study survival of a protected bobcat population living in a rural landscape dominated by humans. We used radio telemetry data to estimate annual and seasonal survival rates; causes of mortality were determined by field investigation and necropsy.

Details of methods can be found in Nielsen and Woolf (2002). Briefly, transmitters we used had mortality sensors that activated if the transmitter was motionless for 8 hours. When we detected mortality signals, we immediately searched for the carcass to confirm and determine cause of death. We classified mortalities into 4 categories based on field observations and necropsy information: vehicle-caused (i.e., automobiles and trains), accidental harvest (i.e., trapping), natural, or unknown.

Seventy-five bobcats (39 F, 36 M) were used for survival analysis. Nineteen radio-collared bobcats died (11 M, 8 F) during the study; 10 (52%) were struck by automobiles, cause could not be determined in 3 (16%) cases, 2 (11%) were hit by trains, 3 (16%) were accidentally trapped, and 1 (5%) was natural. Most mortalities (63%) occurred during November-April (breeding season); the others (37%) occurred during May-October (kitten-rearing season).

Annual and seasonal survival rates of males and females were similar and ranged from 84-95%. Pooled male and female mortality rates were 10%, 1%, 3%, and 3% for vehicle-caused, natural, accidental harvest, and unknown causes, respectively.

Human activities were the primary cause of mortality, resulting in 15 of 19 (79%) diagnosed deaths and an annual mortality rate of approximately 13%. In addition, we documented the highest reported rates of vehicle-caused mortalities for bobcats which we suspect is attributable to the relatively high road density in southern Illinois. Compared to other unharvested populations, we detected a lower rate of mortality from incidental or illegal harvest. This may be attributable to fewer licensed trappers operating in Illinois relative to other studies.

Despite high road densities and human populations, annual survival rates for bobcats living in southern Illinois were among the highest reported in the scientific literature. We attribute this to the relatively low incidence of accidental harvest and natural mortality. We recorded only one natural mortality among our radio-marked sample, and our necropsy data set confirmed a healthy population.

Several studies have reported that male and female bobcat survival rates differed, but this was not the case in southern Illinois. Annual survival is often lower for males than females in exploited populations because males travel more and thus are vulnerable to harvest.

Bobcats in southern Illinois live in a landscape that contains relatively high densities of roads and humans, but they are thriving in what appears to be a relatively stable environment that offers plentiful prey and highly suitable habitat. Although human influence is not currently an adverse influence on the bobcat population in southern Illinois, there is concern given increasing trends in rural development. While we can't predict the amount of rural development that will pose a threat to the well-being of bobcats, clearly at some level of development and human activity, mortality rates will increase to a point that causes population decline.

## AGE STRUCTURE

Wildlife ecologists often use age structure data for population modeling. We assessed age structure of bobcats collected primarily as vehicle kills in the 16 southernmost counties of Illinois. Unlike harvested populations that contain a majority of young-of-the-year and year-old bobcats, over half of the bobcats we examined were >4 years old (Fig. 17). The oldest individual was a radio-collared female aged at 13 years old.

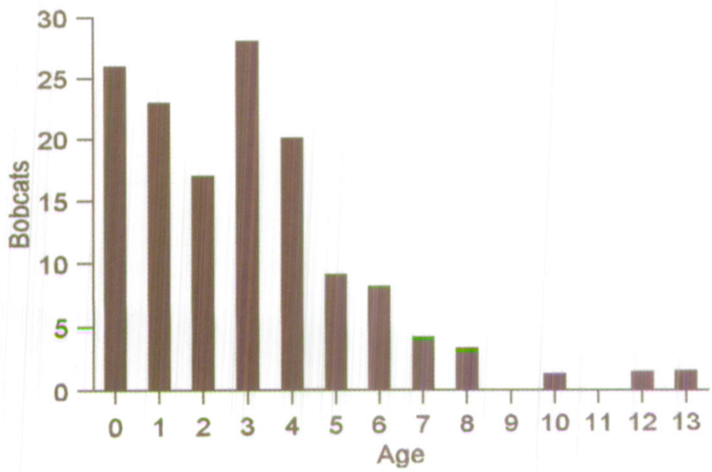



**Fig. 17. Age distribution of bobcat mortalities in southern Illinois.**

## POPULATION CHARACTERISTICS

### Density

Knowledge of population density is crucial for management purposes and important for comparisons to other populations. We calculated population density of bobcats in southern Illinois using several techniques. First, we used 2 home range estimators (i.e., the minimum convex polygon and fixed kernel methods) to estimate bobcat density in areas where most bobcats were radio collared (Jackson and Union counties). We then used data from 33 male:female overlapping pairs of bobcats to calculate density using the formula: density = (1/average core area size) + ([1/average core area size] x percent core area overlap) Population density based on the minimum convex polygon home range estimator was 0.27 bobcats/km$^2$; the fixed kernel method yielded an estimate of 0.34 bobcats/km$^2$. Still another method used by Nielsen (2000) estimated 0.23 bobcats/km$^2$ in our intensive study area.

We also estimated the density of bobcats living in a 300-km$^2$ portion of our intensive study area using the total number of known bobcats from captures, sightings, and necropsies collected during 1995-2001. Eighty-one total bobcats were tallied, resulting in a bobcat density of 0.27 bobcats/km$^2$ which agreed with the estimator calculated from the home range data. Finally, we calculated bobcat density for the 16 southernmost counties of Illinois based on a habitat-relative abundance model (Nielsen and Woolf 2002). Bobcat density according to this model was 0.17 bobcats/km$^2$. A more conservative estimate calculated from the number of radio-collared, sighted, and known dead bobcats ($n$ = 178) was 0.12 bobcats/km$^2$.

These density estimates based on independent data and different methods are relatively similar and all indicate that bobcat population density in southern Illinois is higher than most harvested populations that usually range from 0.05-0.10 bobcats/km$^2$. This is not surprising given that the population is protected, survival rates are high, and quality of habitat is excellent.

### Size

A common question posed to our biologists is, "How many bobcats are there in Illinois?" This is a most difficult question for biologists to answer with confidence, but habitat-density relationships we studied in our southern Illinois intensive study areas, modeling, and some assumptions afford opportunity to speculate. Our calculations (see details in Woolf and Heist 2001) yielded an estimated population of 2,224 bobcats living in southern Illinois south of Interstate Highway 64. If you examine the distribution of bobcat habitat throughout Illinois (see Fig. 6) you will note that quality varies, but our definition of suitable habitat comprises about 29% of Illinois. Clearly the southern Illinois region includes the largest block of our top-rated habitat so the population there is likely the largest in the state. However, where there are areas of ample quality habitat elsewhere, it is fair to assume that bobcat population sizes may be similar to those found in southern Illinois on a per unit area basis.

### Stability

Our earlier discussion of bobcat population trends (HISTORY AND DISTRIBUTION, see Fig. 1) provided evidence of a general increase in numbers of bobcats seen throughout Illinois from 1992-98. However, in our study area, the population now seems to be rather stable. Actually, once we documented the high survival rates and home range fidelity, we predicted bobcat populations and recruitment to be relatively stable. To test this assumption, we used data from captured bobcats, known deaths, and sightings during 1995-99 to assess stability of the population in our intensive study area. We also used capture data to examine variation in kitten recruitment during that time span.

**Table 6. Numbers of known bobcats alive within a 1,000-km² portion of southern Illinois, 1995-99.**

| Year [a] | Radiocollared Bobcats | Known dead bobcats | Sighted bobcats | Total |
|---|---|---|---|---|
| 1995 | 19 | 16 | 11 | 46 |
| 1996 | 28 | 24 | 20 | 72 |
| 1997 | 42 | 25 | 18 | 85 |
| 1998 | 44 | 16 | 14 | 74 |
| 1999 | 28 | 9 | 2 | 39 |

[a]Note: 1995 and 1999 biased by relatively few bobcats with radios; 1999 biased further because IDNR survey ended that year.

**Table 7. Trends in bobcat recruitment (kittens/adult female) 1995-98 within a 1,000-km² portion of southern Illinois, 1995-99.**

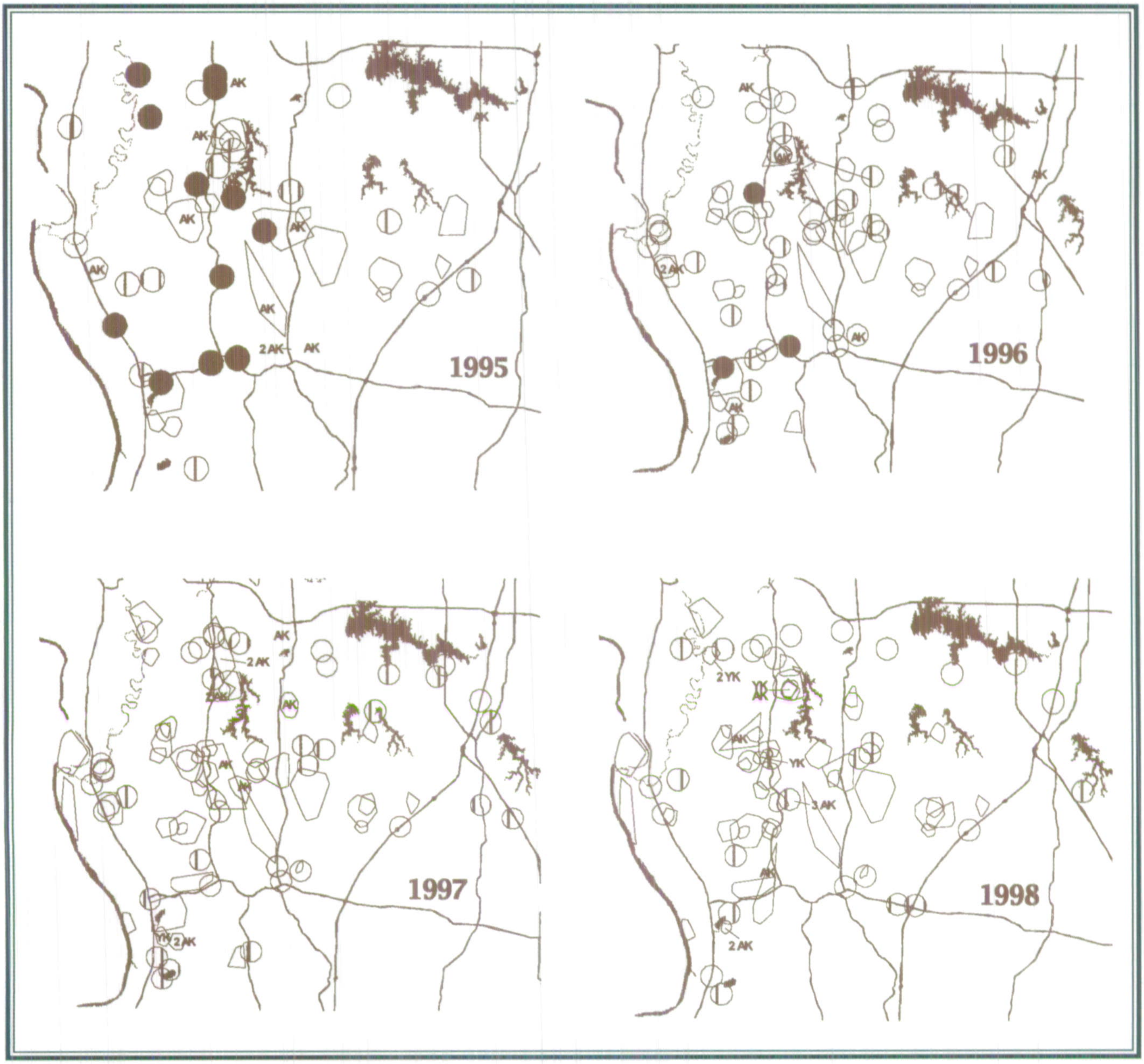
| Year | Kittens[a] | Known females[b] | Unknown females[c] | Recruitment rate |
|---|---|---|---|---|
| 1995 | 9 | 13 | 4 | 0.36 |
| 1996 | 7 | 17 | 1 | 0.39 |
| 1997 | 11 | 26 | 1 | 0.41 |
| 1998 | 12 | 30 | – | 0.40 |

[a]Both AK and YK (see Table 1).
[b]Includes radiocollared and known dead bobcats.
[c]Must have been present based on kitten presence (via capture or sighting).

Indeed, the picture is one of stability. During 1996-98, the period of time during which we had the most reliable data, the minimum number of bobcats in our intensive study area ranged between 72-88 (Table 6), and kitten recruitment rates likewise varied only from 0.36-0.41 (Table 7). The spatial orientation of bobcats in our intensive study area also depicts population stability (Fig.18a-d) *see next page*.

In summary, all the evidence points to widely distributed bobcats inhabiting Illinois. Intensive research conducted on our southern Illinois study areas offers strong evidence of a regional population that is healthy, stable, and exists at a high density per area of habitat compared to many populations elsewhere.

**Fig. 18. Spatial stability of known male and female bobcats alive 1995-98.**




## Legend:

**Hatched circle = sighted bobcats**

**Unhatched circle = known dead bobcats**

**Irregular polygon = radio-collared bobcat core areas**

**AK[b] = "large" kitten, likely near age of recruitment**

**YK[b] = "small" kitten, likely younger than age of recruitment**

**[a]circle size of 4.5 $km^2$, same as average bobcat core area**

**[b]When not within a polygon, an adult female is assumed present**

## Management Issues and Strategies

Approaches to managing the bobcat revolve around its abundance in a particular geographic region or state; its classification (e.g., furbearer, game animal, threatened or endangered, etc.); and management goals created in response to status, classification, and human dimensions issues. For example, the bobcat may be thought of as a furbearer with economic value, a predator that can cause losses to livestock or even domestic pets, a species viewed solely in the context of its intrinsic values (ecological or otherwise), or as a species that serves as a "keystone" and thus has ecosystem values that may even transcend its independent values. An agency's approach to resource management plays an important role in defining issues and influencing strategies

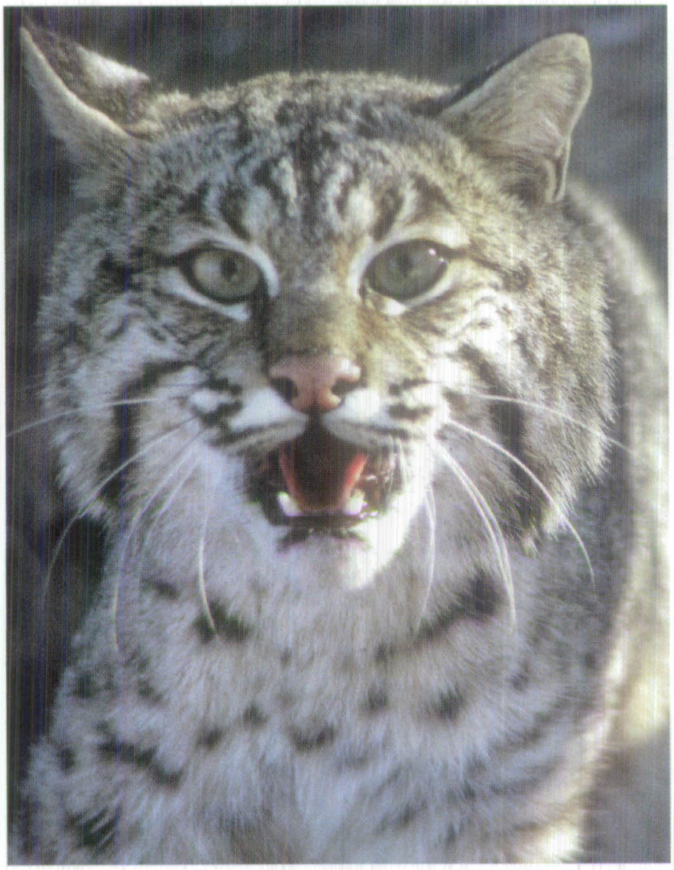
In 1996, 37 of 48 states (Alaska and Hawaii excluded) allowed harvest of bobcats; the species was protected by closed season in 10 states and considered absent in Delaware (Woolf and Hubert 1998). Pennsylvania approved a highly regulated and limited harvest of bobcats in April 2000 (Lovallo 2001). In 1996, Illinois was among 5 states that classified the bobcat as threatened or endangered, but in April 1999 bobcats were removed from Illinois' list of state threatened species. However, they do remain protected by Illinois' Wildlife Code which prohibits their being hunted or trapped. Bobcats are listed as endangered in neighboring Indiana and Iowa, but can be harvested in the other states that border Illinois.

Bluett et al. (2001) summarized the approach to bobcat management in Illinois, and the discussion that follows largely is a summary of that paper. Protection has been the cornerstone of Illinois' bobcat management since they were protected by state law on 1 July 1972 by the Illinois Wildlife Code of 1971 (P.A. 76-1855, Ill. Rev. Stat. 61, § 2.31). Monitoring was a sporadic and minor component of species management at the time of and soon after listing, but in 1991 IDNR began to collect standardized data on distribution and relative abundance. In 1995, the Cooperative Wildlife Research Laboratory at SIUC, in cooperation with IDNR, began a comprehensive research project supported by Federal Aid in Wildlife Restoration to better define the bobcat's status in Illinois, and to provide information on its biology and ecology to serve as a foundation of science-based management. We concluded that the research described here established a solid foundation for state and regional conservation efforts (Bluett et al. 2001).

It seems clear from the data now available (Woolf and Nielsen 1999, Woolf et al. 2000) that bobcats are secure in Illinois. The widely distributed population occurs at moderate densities (~0.27 bobcats/km$^2$ in southern Illinois) and there is no biological reason evident to suggest that bobcats could not stand a regulated, limited harvest in Illinois. Bluett et al. (2001) noted that a harvest season for bobcats would be consistent with existing Illinois statutes that authorize and encourage IDNR to provide opportunities for regulated hunting and trapping. Further, it is clear that IDNR's Furbearer Program has expertise and acquired information that exceed legal and professional standards that prevail and guide bobcat harvest management in the 38 states that now allow harvest.

However, biological considerations and justifications alone will not suffice to guide strategies to manage Illinois' bobcat population. Certain stakeholders will likely oppose any strategy less than continued full protection from harvest in Illinois. Any proposal to initiate a season, however restrictive, to hunt and trap bobcats will likely be opposed in public forums and by legal action. Potential recreation and economic values that could be derived from harvesting bobcats will be weighed in a framework of public perceptions. Because agencies such as IDNR require public support of their policies to effectively manage natural resources, whether or not a bobcat harvest is ever allowed in Illinois will be decided by public opinion rather than biological data.

At the present time, the bobcat population in Illinois is secure; the species is widely distributed, common in many areas, and even abundant in some regions (e.g., southern Illinois). The Illinois Wildlife Code makes adequate provision to protect bobcats. There is little evidence of need to manage habitat, nor is that even a feasible consideration given the ecology of the species. However, there remains a need to continue to monitor the bobcats throughout the state by standardized surveys and incidental observations. Exurban development is occurring at a rapid rate throughout the state, but especially in rural southern Illinois that is now the heart of bobcat range. Predictably, this will lead to more frequent human-bobcat encounters and instances of bobcat predation on domestic animals. It will be necessary to "manage" these encounters and that will become an increasingly important component of bobcat management in Illinois.



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## Appendix A. Bobcat Project Reports, Theses, and Publications

### Theses and Dissertation

Bowles, J. R. 2001. Genetic relationship among populations of bobcats (*Lynx rufus*) determined by analysis of microsatellite loci. Thesis, Southern Illinois University, Carbondale, Illinois, USA.

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Bluett, R. D., G. F. Hubert, Jr., and A. Woolf. 2001. Perspectives on bobcat management in Illinois. Pages 67-73 *in* A. Woolf, C. K. Nielsen, and R. D. Bluett, editors. Proceedings of a symposium on current bobcat research and implications for management. The Wildlife Society 2000 Conference, Nashville, Tennessee, USA.

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## Technical Reports

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Woolf, A., E. Heist, and C. K. Nielsen. 2002. Status of the bobcat in Illinois. Completion report for Illinois Federal Aid in Wildlife Restoration Project W-126-R-7.

Appendix B. Body weights (kg) and measurements (mm) for adult live bobcats trapped in Illinois.

| Sex | Bobcat | Weight | Total Length | Tail | Hind Foot | Ear |
|---|---|---|---|---|---|---|
| Males | 1 | 10.5 | 930 | 145 | 180 | 65 |
| | 2 | 12.0 | 913 | 123 | 165 | 58 |
| | 3 | 13.0 | 988 | 131 | 181 | 56 |
| | 9 | 9.4 | 955 | 152 | 164 | 61 |
| | 12 | 10.3 | 955 | 142 | 178 | 65 |
| | 14 | 9.0 | 935 | 163 | 189 | 63 |
| | 15 | 10.4 | 973 | 137 | 173 | 68 |
| | 16 | 13.0 | 1000 | 142 | 175 | 60 |
| | 17 | 12.4 | | | | |
| | 19 | 10.7 | 956 | 123 | 158 | 69 |
| | 20 | 9.2 | 925 | 134 | 169 | 56 |
| | 21 | 11.8 | 936 | 123 | 170 | 62 |
| | 22 | 10.5 | | | | |
| | 25 | 10.2 | | | | |
| | 26 | 8.4 | 929 | 154 | 160 | 67 |
| | 27 | 14.5 | 1050 | 135 | 185 | 50 |
| | 30 | 10.9 | 992 | 141 | 173 | 69 |
| | 36 | 10.0 | 974 | 164 | 166 | 57 |
| | 41 | 10.4 | 980 | 148 | 165 | 60 |
| | 45 | 12.8 | | | | |
| | 50 | 9.0 | 955 | 155 | 172 | 63 |
| | 51 | 12.6 | 985 | 144 | 193 | 61 |
| | 52 | 8.8 | 930 | 145 | 165 | 69 |
| | 53 | 10.4 | 994 | 147 | 162 | 62 |
| | 54 | 10.5 | | | | |
| | 55 | 10.4 | 935 | 166 | 175 | 61 |
| | 56 | 8.7 | 996 | 140 | 168 | 64 |
| | 71 | 10.4 | 992 | 142 | 174 | 70 |
| | 75 | 10.9 | 906 | 145 | 175 | 64 |
| Avg | | 10.7 | 961.8 | 143.4 | 172.3 | 62.5 |
| SD | | 1.5 | 34.5 | 12.0 | 8.9 | 4.9 |

Appendix B. Continued.

| Sex | Bobcat | Weight | Total Length | Tail | Hind Foot | Ear |
|---|---|---|---|---|---|---|
| Females | 5 | 7.3 | 908 | 139 | 156 | 58 |
| | 7 | 6.9 | 890 | 120 | 175 | 60 |
| | 8 | 6.6 | 793 | 118 | 165 | 60 |
| | 10 (wet) | 7.7 | 860 | 130 | 166 | 58 |
| | 11 | 7.6 | 840 | 130 | 163 | 57 |
| | 18 | 6.1 | 873 | 160 | 155 | 57 |
| | 24 | 6.2 | 802 | 136 | 141 | 60 |
| | 28 | 7.2 | 858 | 121 | 147 | 62 |
| | 32 | 7.3 | 868 | 116 | 154 | 54 |
| | 33 | 7.0 | | | | |
| | 38 | 6.6 | 881 | 120 | 147 | 62 |
| | 39 | 7.2 | 821 | 138 | 159 | 59 |
| | 40 | 6.3 | 912 | 135 | 172 | 62 |
| | 42 | 7.3 | 850 | 142 | 155 | 66 |
| | 44 | 7.6 | | | | |
| | 48 | 6.5 | 871 | 141 | 148 | 62 |
| | 49 | 6.1 | 875 | 134 | 150 | 56 |
| | 57 | 7.0 | 862 | 148 | 155 | 60 |
| | 58 | 7.7 | 895 | 138 | 156 | 57 |
| | 59 | 5.9 | 826 | 121 | 150 | 62 |
| | 60 | 5.4 | 835 | 133 | 150 | 57 |
| | 61 (wet) | 7.5 | | | 165 | 58 |
| | 62 | 6.9 | | | | |
| | 65 | 7.9 | 916 | 152 | 156 | 66 |
| | 67 | 7.0 | 834 | 148 | 151 | 60 |
| | 68 | 6.8 | 821 | 120 | 148 | 62 |
| | 69 | 6.7 | 875 | 138 | 150 | 59 |
| | 60 | 5.9 | 848 | 129 | 150 | 60 |
| | 72 | 5.8 | 810 | 131 | 147 | 63 |
| | 73 | 8.0 | 895 | 130 | 163 | 66 |
| | 74 | 7.2 | | 140 | 156 | 61 |
| | 76 | 6.6 | 866 | 134 | 153 | 60 |
| Avg | | 6.9 | 858.7 | 133.6 | 155.3 | 60.1 |
| SD | | 0.7 | 33.5 | 10.9 | 8.0 | 2.9 |

Appendix C. Dose response (mean ± SD) of bobcats immobilized with a single injection of a ketamine-xylazine combination (mg/kg) administered intramuscularly with a pole or hand syringe. Sample sizes for each sex-age category are shown in parentheses.

| | Ketamine | | Xylazine | | Immobile (min) | |
|---|---|---|---|---|---|---|
| | Pole | Hand | Pole | Hand | Pole | Hand |
| **Male** | | | | | | |
| Juvenile | | 15.0 ± 2.5 (9) | | 1.7 ± 0.3 | | 4.6 ± 2.3 |
| Adult | 14.3 ± 3.3 (4) | 12.8 ± 2.1 (17) | 1.6 ± 0.4 | 1.4 ± 0.2 | 8.0 ± 4.7 | 5.5 ± 3.9 |
| **Female** | | | | | | |
| Juvenile | 20.2 ± 4.4 (4) | 17.2 ± 1.1 (5) | 2.2 ± 0.6 | 1.9 ± 0.1 | 4.4 ± 1.7 | 5.6 ± 2.5 |
| Adult | 15.1 ± 2.4 (7) | 13.1 ± 1.6 (14) | 1.7 ± 0.3 | 1.5 ± 0.2 | 4.5 ± 2.3 | 5.2 ± 3.9 |

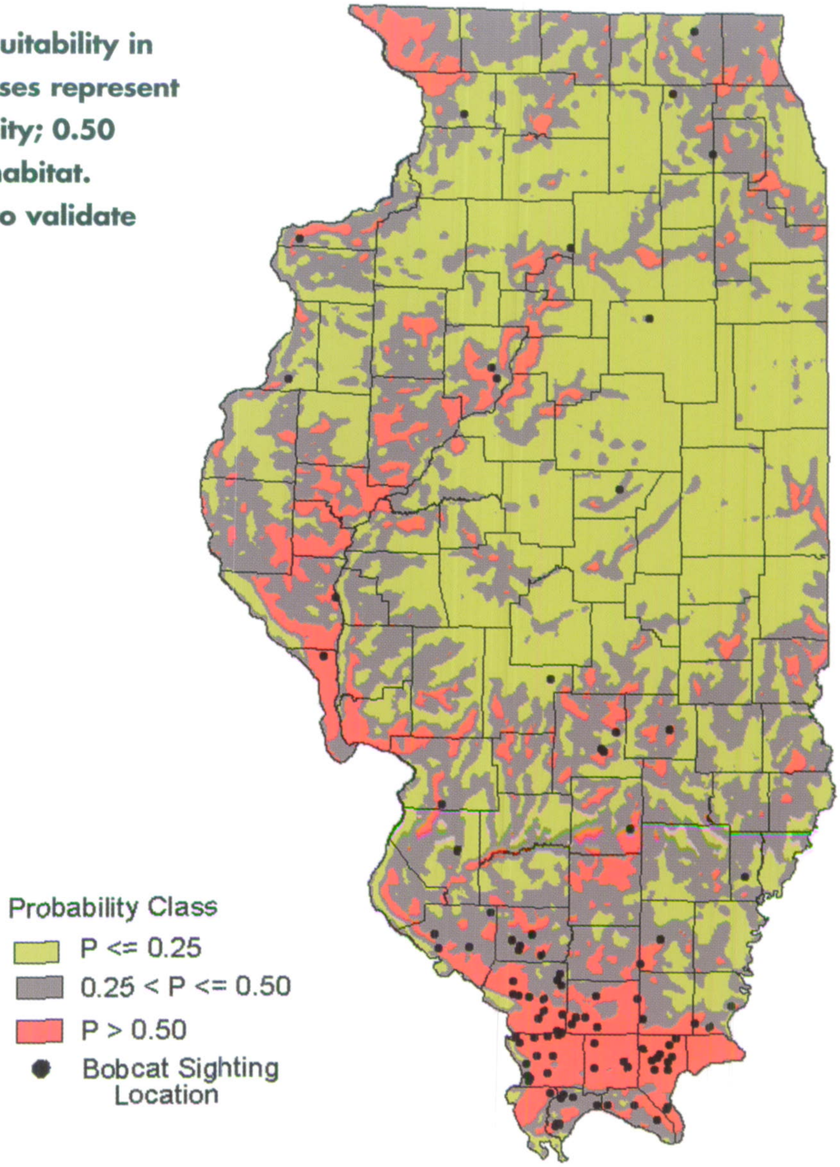
Appendix D. Contents of 85 bobcat stomachs collected from southern Illinois, 1982-2000. Frequencies were calculated from 119 items represented.

| Item | Frequency | Percent Occurrence |
|---|---|---|
| Muridae | | |
| *Microtus* spp. | 25 | 21.0 |
| *M. ochrogaster* | 14 | 11.8 |
| unknown vole | 11 | 9.2 |
| *Peromyscus* spp. | 7 | 5.9 |
| unknown Muridae | 3 | 2.5 |
| *Synaptomys cooperi* | 2 | 1.7 |
| *Mus musculus* | 1 | 0.8 |
| *Ochrotomys nuttali* | 1 | 0.8 |
| **total Muridae** | **39** | **32.8** |
| lagomorph | 27 | 22.7 |
| squirrels | | |
| *Sciurus niger* | 12 | 10.1 |
| unknown *Sciurus* | 6 | 5.0 |
| *Sciurus carolinensis* | 2 | 1.7 |
| *Tamias striatus* | 2 | 1.7 |
| *Glaucomys volans* | 1 | 0.8 |
| **total squirrels** | **23** | **19.3** |
| large mammals | | |
| *Didelphis virginiana* | 6 | 5.0 |
| *Odocoileus virginianus* | 3 | 2.5 |
| *Ondatra zibethicus* | 3 | 2.5 |
| *Procyon lotor* | 1 | 0.8 |
| **total large mammals** | **13** | **10.9** |
| bird | | |
| unknown | 10 | 8.4 |
| cardinal | 1 | 0.8 |
| sparrow | 1 | 0.8 |
| total bird | 12 | 10.1 |
| unknown rodent | 3 | 2.5 |
| *Sorex longirostris* | 2 | 1.7 |

**Appendix D. Continued. Contents of male and female bobcat stomachs collected from southern Illinois, 1982-2000. Frequencies were calculated from 119 items represented (M = 70, F = 49).**

| | Males ($n$ = 51) | | Females ($n$ = 34) | |
|---|---|---|---|---|
| Item | Frequency | % Occurrence | Frequency | % Occurrence |
| lagomorph | 20 | 28.6 | 7 | 14.3 |
| **Muridae** | | | | |
| *Microtus* spp. | 10 | 14.3 | 15 | 30.6 |
| *M. ochrogaster* | 4 | 5.7 | 10 | 20.4 |
| unknown vole | 6 | 8.6 | 5 | 10.2 |
| *Peromyscus* spp. | 6 | 8.6 | 1 | 2.0 |
| *Synaptomys cooperi* | 1 | 1.4 | 1 | 2.0 |
| *Mus musculus* | 1 | 1.4 | 0 | 0.0 |
| *Ochrotomys nuttali* | 1 | 1.4 | 0 | 0.0 |
| unknown Muridae | 1 | 1.4 | 2 | 4.1 |
| total Muridae | 20 | 28.6 | 19 | 38.7 |
| **squirrels** | | | | |
| *Sciurus niger* | 9 | 12.9 | 3 | 6.1 |
| *Sciurus carolinensis* | 1 | 1.4 | 1 | 2.0 |
| unknown *Sciurus* | 4 | 5.7 | 2 | 4.1 |
| *Tamias striatus* | 0 | 0.0 | 2 | 4.1 |
| *Glaucomys volans* | 0 | 0.0 | 1 | 2.0 |
| total squirrels | 14 | 20.0 | 9 | 18.4 |
| **large mammals** | | | | |
| *Didelphis virginiana* | 4 | 5.7 | 2 | 4.1 |
| *Odocoileus virginianus* | 2 | 2.9 | 1 | 2.0 |
| *Ondatra zibethicus* | 2 | 2.9 | 1 | 2.0 |
| *Procyon lotor* | 1 | 1.4 | 0 | 0.0 |
| total large mammals | 9 | 12.9 | 4 | 8.2 |
| **bird** | | | | |
| cardinal | 0 | 0.0 | 1 | 2.0 |
| sparrow | 0 | 0.0 | 1 | 2.0 |
| unknown | 6 | 8.6 | 4 | 8.2 |
| total bird | 6 | 8.6 | 6 | 12.2 |
| unknown rodent | 1 | 1.4 | 2 | 4.1 |
| *Sorex longirostris* | 0 | 0.0 | 2 | 4.1 |

**Fig. 6. Bobcat habitat suitability in Illinois. Probability classes represent relative habitat suitability; 0.50 represents the "best" habitat. Bobcat sightings used to validate the model are shown.**

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