

1972

Home Range and Movement of Fox Squirrels in East Central Illinois

Michael D. Sliva

Eastern Illinois University

This research is a product of the graduate program in [Zoology](#) at Eastern Illinois University. [Find out more](#) about the program.

Recommended Citation

Sliva, Michael D., "Home Range and Movement of Fox Squirrels in East Central Illinois" (1972). *Masters Theses*. 3940.
<https://thekeep.eiu.edu/theses/3940>

This is brought to you for free and open access by the Student Theses & Publications at The Keep. It has been accepted for inclusion in Masters Theses by an authorized administrator of The Keep. For more information, please contact tabruns@eiu.edu.

PAPER CERTIFICATE #2

TO: Graduate Degree Candidates who have written formal theses.

SUBJECT: Permission to reproduce theses.

The University Library is receiving a number of requests from other institutions asking permission to reproduce dissertations for inclusion in their library holdings. Although no copyright laws are involved, we feel that professional courtesy demands that permission be obtained from the author before we allow theses to be copied.

Please sign one of the following statements:

Booth Library of Eastern Illinois University has my permission to lend my thesis to a reputable college or university for the purpose of copying it for inclusion in that institution's library or research holdings.

Aug. 12, 1972
Date

I respectfully request Booth Library of Eastern Illinois University not allow my thesis be reproduced because _____

Date

Author

HOME RANGE AND MOVEMENT OF FOX SQUIRRELS

IN EAST CENTRAL ILLINOIS

(TITLE)

BY

Michael D. Sliva

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Master of Science

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1972

YEAR

I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
THIS PART OF THE GRADUATE DEGREE CITED ABOVE

10 Aug 72
DATE

10 Aug. 1972
DATE

The undersigned, appointed by the Head of the Department of Zoology,

have examined a thesis entitled

HOME RANGE AND MOVEMENT OF FOX SQUIRRELS

IN EAST CENTRAL ILLINOIS

Presented by

Michael D. Sliva

a candidate for the degree Master of Science

and hereby certify that in their opinion it is acceptable.

Home Range and Movement of Fox Squirrels
in East Central Illinois

Michael D. Sliva

Abstract: Home ranges and movements were determined for 11 fox squirrels (Sciurus niger) and analyzed with respect to the distribution of mast trees and den trees on a $12\frac{1}{4}$ acre wooded plot in east central Illinois. Average home range size for all squirrels was 0.9 acres. The home range of adult squirrels averaged 1.5 acres while juveniles averaged 0.8 acres. * Females had larger home ranges (1.4 acres) than males (0.6 acres). The average distance moved within the home range was 360 feet for all squirrels. The average distances moved by adults and juveniles was nearly the same (275-280 feet), but females moved farther (340 feet) than males (170 feet). Home ranges were lineay in shape. Linearity was greatest for juvenile females (1:2.7); greater in juveniles (1:2.2) than adults (1:1.4), and greater in females (1:1.8) than males (1:1.5). Seventy-eight percent of all available den trees and sixty-five percent of all available mast trees were located within the home ranges of the 11 observed squirrels.

The life history of fox squirrels (Sciurus niger) is well documented. Little information however, is available concerning their home range and movements. Existing data in these two areas are quite diverse due primarily to differences in habitat throughout the fox squirrel's range in midwestern states. The objectives of this study were to determine the home range and movements of fox squirrels on an isolated plot in east central Illinois and to correlate those home ranges with the distribution of available mast and den trees.

STUDY AREA

The study was conducted on a $12\frac{1}{4}$ acre tract located between Charleston and Mattoon in Coles County, Illinois ($W.\frac{1}{2}$, $S.W.\frac{1}{4}$, $N.E.\frac{1}{4}$, Sect.1, T.12N., R.8E.). The center 10 acres, Burgner Acres Natural Area, had been maintained by Eastern Illinois University since 1955. Burgner Acres is a mixed mesophytic community well isolated from the surrounding farm area (Henderson and Damann 1966). Burgner Acres (Figure 1) is divided into three well defined areas by Sycamore Creek. A $3\frac{1}{4}$ acre, wooded plot (Area D) west of Burgner Acres and a $1\frac{1}{2}$ acre plot east of Burgner Acres (Area E) were included in the study area. Both areas were roughly bordered by Sycamore Creek and included trees of similar species and sizes as Burgner Acres.

METHODS

All five divisions of the study area were staked off into 50 foot quadrats. Stakes were identified with letters and numbers and were used as reference points for recording the location of traps and observations of trapped or marked squirrels.

Squirrels were live trapped in Hav-A-Hart traps (Hav-A-Hart, 118-T Water Street, Ossining, New York), guillotine traps, and the wooden box trap described by Taber and Cowan(1963). Traps were set at locations deemed likely to capture squirrels in all five parts of the study area. If no squirrels were taken in a trap after about two weeks, the trap was moved to a new location. The traps were baited with ear corn and checked daily.

All squirrels trapped were sexed, aged as either adult or juvenile and marked permanently for identification by toe clipping(Taber 1963). In order to identify individual squirrels from a distance, a combination

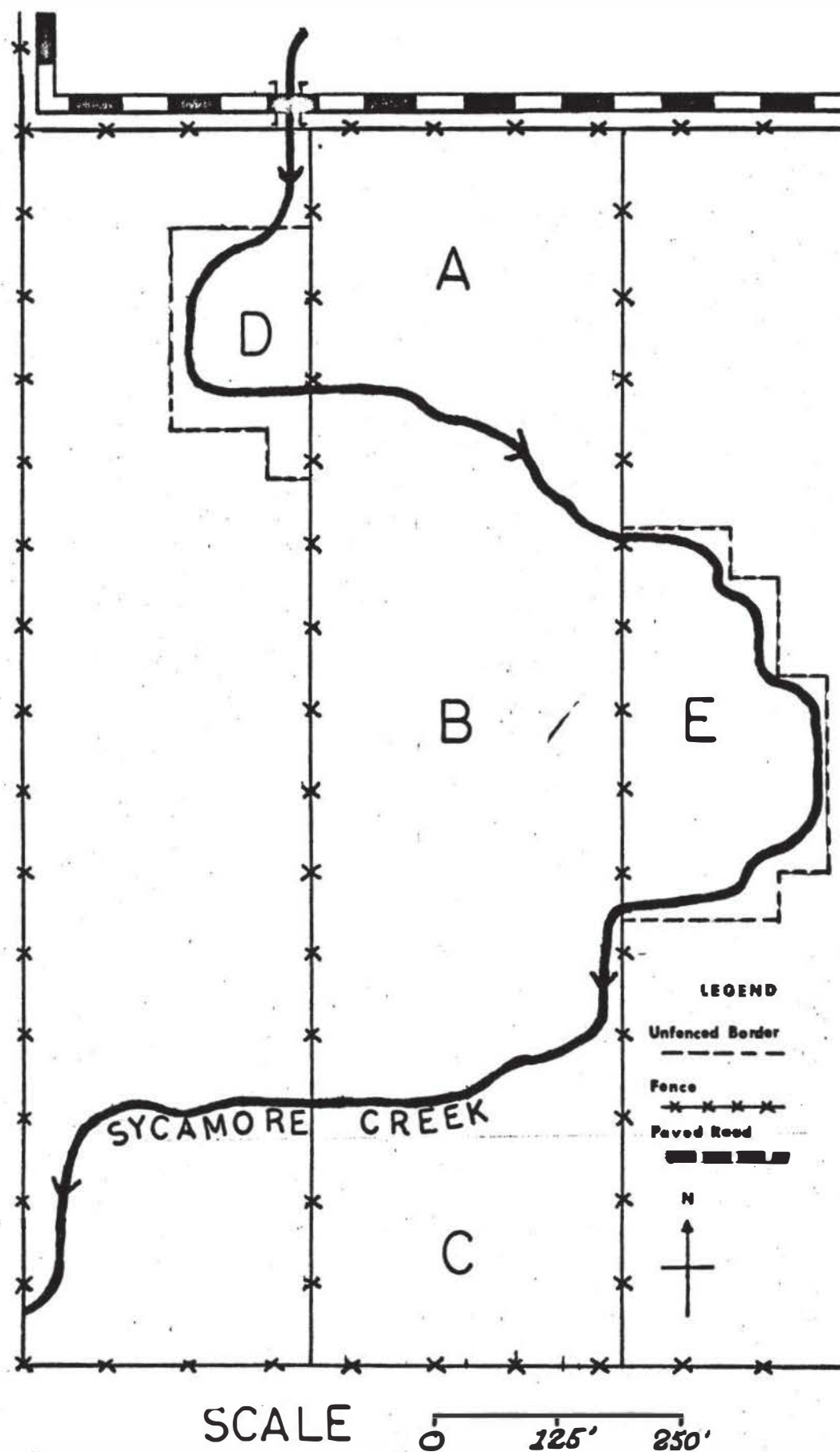


Figure 1. Burgner Acres Study Area in Coles County Illinois. Letters A through E designate areas in which squirrel movements were studied.

of tails, heads, and bodies were dyed with a permanent black dye, Nyanzol A(#5657, Nyanzol Colors and Chemical Company, Division of Textile Aniline and Chemical Company, Lawrence, Massachusetts). Marked squirrels were released at the point of capture.

Movements of squirrels were determined by retrapping, and by direct observation of color-marked squirrels. All captures or sightings were used to determine home range except the movements of squirrels released from traps. Observations were made during different periods of the day to insure complete coverage of squirrel movements throughout the day.

Home ranges were determined by the "minimum home range method" (Flyger 1960) based on five or more separate captures or observation points. The center of activity(Hayne 1949) and long axis(Stumpf and Mohr 1962) of each range was determined and composite maps of the home ranges of each sex and age group were produced by aligning the linear axes and centers of activity. Movements and home ranges of squirrels were analyzed with respect to the distribution of den and mast trees on the study area.

RESULTS

Eighteen traps were set for 150 trap nights from November 1966 to February 1968. Squirrels were trapped only during the months of November through April, 1966-67 and October through February, 1967-68. Traps were set at a total of 34 different sites in all five areas, 7 in Area A, 16 in Area B, 5 in Area C, 3 in Area D, and 3 in Area E. Trapping effort was not the same at each site since traps were moved depending upon trap success.

Twenty-two squirrels were captured. Four squirrels were dead in the trap; eighteen were toe clipped, marked with Nyanzol A, and released.

Eleven of the color-marked squirrels were trapped or observed at five or more separate points (Table 1). Five of these squirrels were recaptured, four once, one twice. The eleven color-marked squirrels were seen or trapped from 5 to 25 times (average 11.3).

Home ranges were determined for each sex-age class rather than individual squirrels by aligning the center of activity and long axis of the range of individuals in that class. Home range was measured both on the basis of all capture-sighting points and on the basis of omitting the outer 10% of the points (Table 2). Calculated either way, adult females had the largest home ranges, adults had larger home ranges than juveniles, and females had larger home ranges than males.

Shape of the home range for 100% and 90% of the capture-sighting points showed a distinct pattern of linearity for all classes (Table 3). The proportions of the ranges varied from 1:1.4 to 1:6.3 for 100% of the encompassed area of the composite maps, and 1:1.1 to 1:2.7 for 90% of the encompassed area. Linearity was greatest for juvenile females (1:6.3); greater in juveniles than adults and greater in females than males.

Another indication of linearity was the maximum distance moved within the home ranges. These measurements indicate only the longest distances moved over a period of time, usually several weeks, and not necessarily daily movements. When all capture-sighting points were considered, juvenile females travelled farther than all other classes (Table 2). When the outermost 10% of the capture-sighting points were omitted, adult females travelled farther than all other classes and females travelled farther than males (Table 2).

There was a relationship between the distribution of den trees and the distribution of fox squirrels on Burgner Acres. Twenty-seven den trees were located in the Burgner Acres study area (Figure 2).

Table 1. Squirrels live trapped and released on the Burgner Acres
Study Area in Coles County Illinois.

	Number trapped	Number released	Number recaptured or seen at 5 or more sites
Male			
Juvenile	5	5	2
Adult	3	2	1
Female			
Juvenile	7	5	4
Adult	<u>7</u>	<u>6</u>	<u>4</u>
Total	22	18	11

Table 2. Home range size and maximum distances travelled for 11 squirrels on the Burgner Acres Study Area.

	Number of squirrels	Average home range size in acres*		Average maximum distance travelled in linear feet*	
Squirrel classes		100%	90%	100%	90%
Females					
Juvenile	4	1.7	0.8	690	260
Adult	4	2.7	1.6	410	310
Total	8	4.1	1.4	690	340
Males					
Juvenile	2	0.8	0.7	270	220
Adult	1	0.3	0.2	130	100
Total	3	0.8	0.6	270	170
All Juveniles	6	2.1	0.8	690	280
All Adults	5	2.7	1.5	415	275
Grand Total	11	4.4	0.9	690	360

* Area used by squirrels based on all(100%) of the capture-sighting points or on the innermost 90% of the points.

Table 3. Linearity of home ranges of 11 fox squirrels on the Burgner Acres Study Area expressed as a ratio of width to length.

Squirrel classes	Number of squirrels	100% of the home range area	90% of the home range area
Females			
Juvenile	4	1:6.3	1:2.7
Adult	4	1:1.5	1:1.4
Total	8	1:2.4	1:1.8
Males			
Juvenile	2	1:2.2	1:1.8
Adult	1	1:1.4	1:1.1
Total	3	1:2.2	1:1.5
All Juveniles	6	1:5.3	1:2.2
All Adults	5	1:1.5	1:1.4
Grand Total	11	1:2.5	1:2.6

Twenty-one of the den trees, or 78% of all available den trees, were located within the home ranges of the 11 squirrels observed. Two more of the den trees were located within 25 feet of an established home range boundary. Only one squirrel, a juvenile female, had no den tree located within her observed home range or within 25 feet of any outside point of her range.

There was also a relationship between the distribution of squirrels and the distribution of mast trees on Burgner Acres. Mast trees used included all species of hickory and oak, black walnut, and Osage Orange (considered here as a local, seasonal food staple completely utilized) which had a DBH of 12 inches or more. A total of 222 mast trees were found on the study area, of which 144 or 65% were located within a home range area. Area A (Figure 1) had 18 mast trees, 62% of which were located within a home range area, Area B had 97, with 86% of them within a home range area, Area C had 58, with 1% within a home range area, Area D had 28, with 100% located within a home range area, and Area E had 20, of which 80% were in a home range area.

DISCUSSION

Home range has been defined as an area over which animals normally travel for activities of food gathering, caring for young, and shelter (Burt 1943). Home range boundaries, however, are diffuse rather than sharply outlined and are difficult to determine by trapping. Home range boundaries vary with changes of conditions causing changes in use areas, and with interference of trapping (Stickel 1954). Trapping records alone indicate only certain selected points of activity and do not necessarily show the normal activity of the animal in relation to its home range

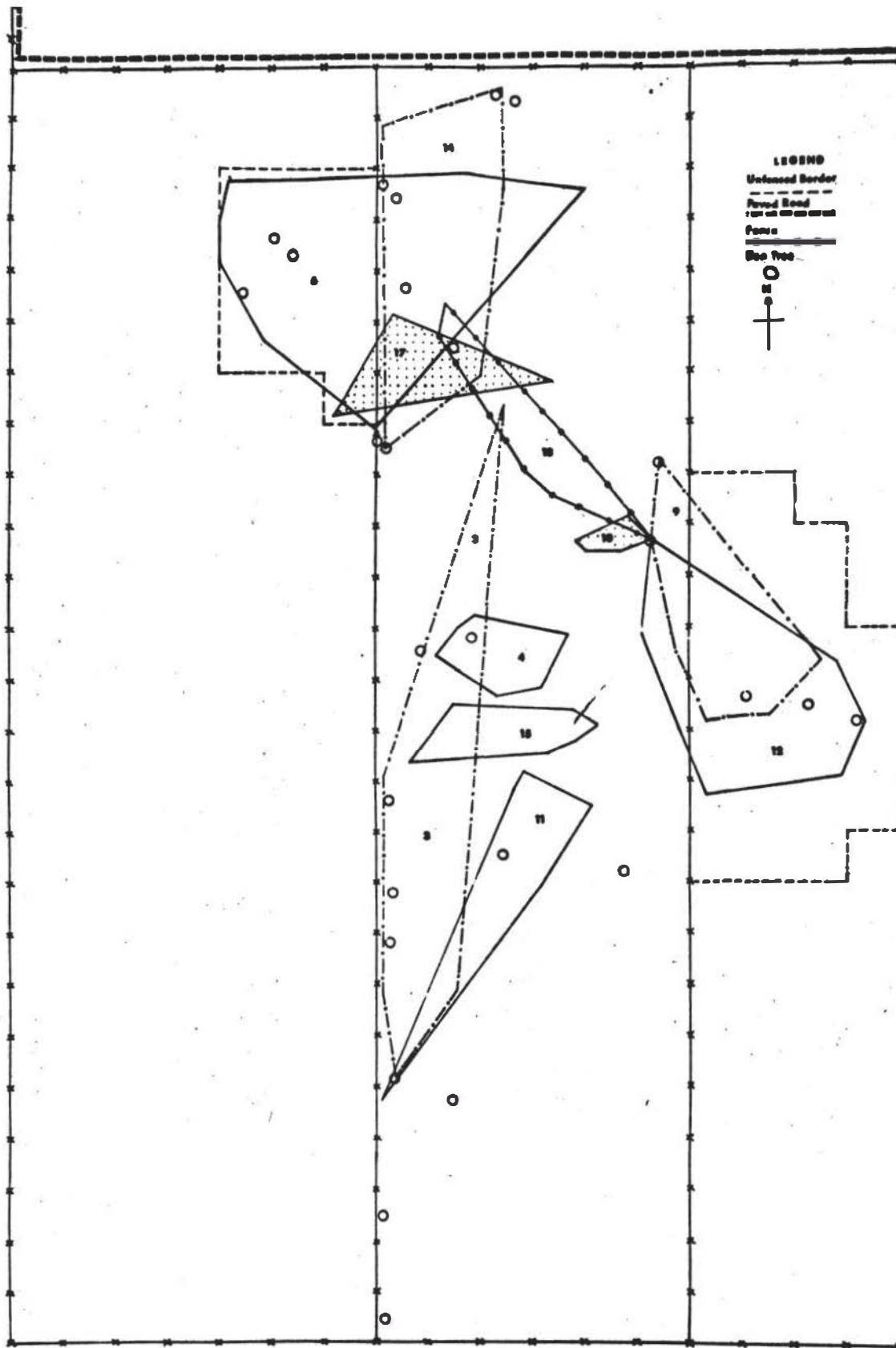


Figure 2. Distribution of home ranges and den trees for fox squirrels on the Burgner Acres Study Area.

(Hayne 1949). The difficulty of determining home range was reduced somewhat in this study by employing trap-retrap data in combination with direct observation of marked squirrels. In this way points other than trap sites could be utilized to produce a more accurate measurement of home range. The home ranges calculated in this study included the areas in which squirrels were known to have been present. The findings were limited, like those based only on trapping data, by the possibility that fox squirrels travelled outside the observed home range without having been trapped or observed.

There is little information on specific sizes of home ranges of fox squirrels. Most activity occurs within 2-3 acres (Baumgartner 1943). and often in the vicinity of one or a small group of food trees (Brown and Yeager 1945). Cockrum (1962) states that male fox squirrels have an average home range size of 154 yards and females have an average home range size of 130 yards. In this study, comparative calculations of home ranges were grouped for specific sex and age classes rather than for individual squirrels in an attempt to give a more accurate indication of home range. The study conducted on Burgner Acres indicated that females had larger home ranges than males (Table 3). These results do not agree with those of others (Sanderson 1966, Cockrum 1962, Packard 1956, Donohoe and Beal 1972, Baumgartner 1943) and may not represent the actual situation since only one adult male fox squirrel and two juvenile males were studied. Also, data on the single adult male were collected between the winter and spring breeding seasons when males are least active. Results of this study are in agreement with others (Sanderson 1966, Cockrum 1962, Packard 1956) in that adults have larger home ranges than juveniles. No data were available for comparison of home range size among individual sex and age classes. I found that juvenile females had larger home

ranges than juvenile males. This difference may have been due to competition between adult males and juvenile males for females and favorable habitat resulting in somewhat smaller, less established home ranges for juvenile males than for juvenile females. Also, much less data were collected for juvenile males than for juvenile females.

Studies of home range size in different fox squirrel populations and different habitats will differ since home range is influenced by several factors. Size and favorability of habitat(Packard 1956), population density(Sanderson 1966, Trippensee 1948, Baumgartner 1943), size of the individual(Sanderson 1966, Cockrum 1962), and intraspecific strife coupled with food competition and breeding seasons(Burt 1943) appear to be the major factors determining home range size among fox squirrels. Packard(1956), and Trippensee(1948) both found that fox squirrels living in smaller, more favorable habitat had smaller home ranges than squirrels living in larger, less favorable habitat. Sanderson (1966) states that if all requirements of a species can be provided in a small area, its home range will probably be smaller than the average found for the species. I found that the home range size for fox squirrels on Burgner Acres was somewhat smaller than typical for the species(Packard 1956, Trippensee 1948, Baumgartner 1943). I feel that this was due primarily to the optimum habitat provided by Burgner Acres in the form of available mast and den trees and the restriction of the sharp, physical boundaries of this isolated forest island. Nearly all home ranges for fox squirrels on the study area followed and bordered Sycamore Creek along its course through Burgner Acres. Although Area C had 26% of all the available mast trees and 3 unused den trees, there were no squirrels located in this area. I feel that the absence of water, one factor of prime habitat, and the somewhat higher, drier elevation of land through

the majority of this area were the main reasons for not finding any squirrel with a home range within Area C.

Little comparative data are available on the average distances travelled by individual sex and age classes of fox squirrels. Daily crusing radii for seasons other than the mating period usually don't exceed 700-800 feet, with an average of 400 feet (Trippensee 1948).

In Kansas, Packard (1956) found that on a 28 acre plot male fox squirrels travelled farther in general than females. Juvenile males moved farthest, 780.7 linear feet, followed by adult males, 601.4 linear feet, juvenile females, 514.5 linear feet, and adult females, 481.2 linear feet. Baumgartner (1943) found that on a 26.7 acre woodlot, all fox squirrels travelled an average distance of 391.8 feet, and on a 88 acre plot, the average distance travelled was 490.8 feet. Baumgartner also found that on a woodlot of undetermined size, males moved farther than females, 462.7 feet to 389.1 feet.

The Burgner Acres study shows quite different results (Table 2). The data seem most significant when 90% of the capture-sighting points are used. The extremely long distance of 690 linear feet travelled by one juvenile female probably represents a random wandering outside her actual home range. This type of random movement may be reduced or eliminated to produce a more realistic description of home range by omitting the outermost 10% of the capture-sighting points.

The average distance travelled by all sex-age classes of fox squirrels on Burgner Acres were much shorter than averages found by other researchers (Packard 1956, Baumgartner 1943) for several reasons. The average distances travelled by fox squirrels in this study indicate movements made only over a short period of time, usually several weeks, rather than daily movements over an entire year. Also, the small size,

limited physical boundaries, and prime habitat of the study area reduced squirrel movements somewhat. The Burgner Acres study indicates that females travelled farther than males while other researchers (Packard 1956, Baumgartner 1943) indicated that males travelled farther than females. Here again, limited data on only one male adult and males in general, may have caused the existing contrast between this study and others. It is possible that adult females moved farther than all juveniles because of already having established home ranges while juveniles were restricted in their movements to establish permanent home ranges by adults. However, the average distance travelled by all squirrels on the study area, 360 linear feet, closely parallels the average distance of 400 feet noted by Trippensee (1948) and 391 feet noted by Baumgartner (1943). I found that the home ranges of fox squirrels on Burgner Acres were distinctly linear in shape. There were no data available for comparison on linearity of home ranges among fox squirrels. However, linearity of home range for fox squirrels may be expected since it has been reported for many other animals. Stumpf and Mohr (1962) reported that linearity of home range was a common condition for groups of animals as diverse as mice, armadillos, birds, rabbits, moose, and reptiles. Allen (1954) reported linear ranges among Indiana grey squirrels that were quite narrowed but fairly compact. Since fox squirrel home ranges appear to center around several mast trees and/or a den tree, movements outward from these fixed points tend to be linear. Juvenile fox squirrels on Burgner Acres had linear patterns of home range that were longer than those of adults. I feel this is due primarily to the fact that adults have established home ranges which restrict juveniles to longer, narrower movements in an attempt to establish their own home ranges. Stumpf and Mohr (1962) stated that the less favorable the area, the longer and

narrower the home range will be. Although adult fox squirrels on Burgner Acres showed distinct patterns of linearity in their home ranges, these patterns were rather compact and not overly longer or narrower than they were wide. Here again, I feel that the prime habitat offered by Burgner Acres was a factor restricting the linear patterns of home range.

ACKNOWLEDGEMENTS

I wish to thank my advisor, Dr. Richard Andrews, who helped with the initial field work and research, reviewed the paper, and guided this study to completion. Dr. John Ebinger provided unpublished data on the flora of the Burgner Acres Natural Area. Dr. Leonard Durham, Dr. Garland Riegel, Dr. Harry Peterka, and Dr. Richard Andrews reviewed this thesis and served on my graduate committee. Mr. Randall Madding, Ron DeHollander, Dr. Richard Sikora, and Michael Corn assisted in conducting the field work. I especially thank my parents for their prolonged guidance, understanding, and faith in me.

LITERATURE CITED

- Allen, J.M. 1954. Gray and fox squirrel management in Indiana. Ind. Dept. Cons., Div. Fish and Game. Pittman-Robinson Bull. 1.
- Baumgartner, L.L. 1943. Fox squirrels in Ohio. J. Wildl. Mgmt. 7:193-202.
- Blackmore, B.K. and J.E. Ebinger. 1967. Vegetation survey of Burgner Acres, east-central Illinois. Trans. Ill. Acad. Sci. 60:72-79.
- Brown, L.G. and L.E. Yeager. 1945. Fox and gray squirrels in Illinois. Ill. Nat. Hist. Surv. Bull. 23(5):449-532.
- Burt, W.H. 1943. Territoriality and home range concepts as applied to mammals. J. Mamm. 24:346-352.
- Cockrum, E.L. 1962. Introduction to mammalogy. The Ronald Press Co., New York. viii+ 455 pp.
- Donohoe, R.W. and R.O. Beal. 1972. Squirrel behavior determined by radiotelemetry. Ohio Dept. Nat. Resources, Div. Wildlife. Ohio Fish and Wildlife Report 2.
- Flyger, V.F. 1960. Movements and home range of the gray squirrel Sciurus carolinensis in two Maryland woodlots. Ecology. 41:365-369.
- Hayne, D.W. 1949. Calculation of size of home range. J. Mamm. 30: 1-17.
- Henderson, D. and K.E. Damann. 1966. Burgner Acres natural area of Eastern Illinois University. Trans. Ill. Acad. Sci. 59:281-286.
- Hicks, E.A. 1949. Ecological factors affecting the activity of the western fox squirrel. Ecol. Monogr. 19:287-302.
- Packard, R.L. 1956. The tree squirrels of Kansas: ecology and economic importance. Univ. Kans. Mus. Nat. Hist. Misc. Publ. 11:1-67.
- Sanderson, G. C. 1966. The study of mammal movements-a review. J. Wildl. Mgmt. 30:215-235.
- Stickle, L.F. 1954. A comparison of certain methods of measuring ranges of small mammals. J. Mamm. 35:1-15.
- Stumpf, W.A. and C.O. Mohr. 1962. Linearity of home ranges of California mice and other animals. J. Wildl. Mgmt. 26:149-154.
- Taber, R.D. 1963. Criteria of sex and age. Chap. 6, In: H.S. Mosby(ed.), Wildlife investigational techniques, 2nd. ed. Edwards Brothers Inc., Ann Arbor, Michigan. xxxiv + 419 pp.

- Taber, R.D. and I.McT. Cowan. 1963. Capturing and marking wild animals. Chap. 10, In: H.S. Mosby(ed.), Wildlife investigational techniques, 2nd. ed. Edwards Brothers Inc., Ann Arbor, Michigan. xxiv + 419 pp.
- Trippensee, R.E. 1948. Wildlife management. McGraw-Hill Book Co., Inc., New York. x + 479 pp.

LITERATURE REVIEW

Geographic Distribution: The fox squirrel, Sciurus niger(Linnaeus), has a range extending from Delaware and southern Pennsylvania westward through southern Minnesota, Nebraska, and much of Texas, and southward to the Gulf of Mexico(Hoffmeister and Mohr 1957). Ten subspecies are found within the range of the species. The fox squirrel found throughout Illinois is S. n. rufiventer(Geoffroy). The range of S. n. rufiventer extends from western Pennsylvania, western West Virginia, and eastern Tennessee, westward to the extremes of the range of the species and southward through Oklahoma to northern Texas, central Arkansas and Tennessee(Hall 1959).

Reproduction: There are two periods of reproduction for fox squirrels in the midwest(Brown and Yeager 1945, J.M. Allen 1954, D.L. Allen 1942). The first period is from middle December through early January and the second from late May through late June. Males appear to remain in breeding condition from late fall up through midsummer(Brown and Yeager 1945). Females two years or more of age produce two litters per year while younger females produce only one litter. Spring-litter females first breed the following winter at eleven months of age while summer born females first breed during the following summer breeding season at approximately one year of age(Brown and Yeager 1945, J.M. Allen 1954). The gestation period for fox squirrels is 44-45 days(J.M. Allen 1954, Brown and Yeager 1945). The average litter size varies from 2.51 to 3.70 young per litter(Brown and Yeager 1945).

Age Classes: Three distinct periods of development can be recognized, juvenile, subadult, and adult (Brown and Yeager 1945, Taber 1963).

Juveniles are individuals too young to breed and still distinguishable from breeding adults by external characteristics (Taber 1963). Usually, the term subadult includes two subclasses of individuals, those born during the summer and those born in the spring of the preceeding year. However, these two subclasses can be distinguished only by the use of X-ray of the distal epiphyses of the radius and ulna up until the twelfth month (Taber 1963). Taber states that "These two age-groups reach sexual maturity at the same season."

The three age classes may be distinguished from one another by the appearance of the ventral tail pelage. Taber (1963) states that juvenile squirrels have two to three dark lines running through reddish-brown primary hairs of the tail. The proximal one-third of the tail is naked beneath, not covered with hair. Subadult squirrels have dark lines like the juveniles but the proximal one-third of the tail is covered with short appressed hairs. Adult squirrels have no bars or lines running through the primary hairs and the tail bone is completely covered by appressed secondary hairs that radiate out over and partly obscure the primary hairs of the tail. Adult squirrels may also be distinguished from juvenile and subadult squirrels by the overall shape of the tail. The tail of adults is rectangular, block-shaped, and has sides that are parallel or nearly so. Juveniles and subadults have tails that are pointed, triangular, and have unparallel sides (Taber 1963).

External characteristics of the genital organs of fox squirrels may also be used to determine age classes. Brown and Yeager (1945) state that adult male fox squirrels have a scrotum that is generally free of hair

with the ventral surface and posterior end being black. Juvenile and subadult male fox squirrels have a scrotum which has only the posterior end black or brown, smooth, and hairless. Summer born males up to approximately three months of age may have testes that are abdominal with the skin just beginning to pigment. Adult female fox squirrels have large, conspicuous mammary glands with black-tipped teats. Juvenile and summer born subadult females have inconspicuous teats usually hidden beneath a growth of hair.

Habitat: Optimum habitat is quite diverse since it has been described as ecotone areas (Hicks 1949), open woodlots in rural agricultural areas (J.M. Allen 1954, Trippensee 1948, Baumgartner 1943), and wooded uplands (Brown and Yeager 1945). Size of the woods is not critical. Trippensee (1948) indicates that an area of 10 acres is optimum while Baumgartner (1943) states that fox squirrels utilize farm woodlots of 5-300 acres with areas of five acres of size with 20 trees per acre, mostly oaks, being a typical optimum habitat. Brown and Yeager (1945) state that wooded uplands offer the highest quality habitat due to the larger percentage of mast trees within them.

In such habitat fox squirrels utilize a vast number of different plants in their diet although only a few plant groups make up their staple food sources. Brown and Yeager (1945) list hickories, oaks, pecans, walnuts, elms, mulberry, osage orange, and field corn as the most preferred foods of Illinois fox squirrels. The nuts of hickories, pecans, oaks, and walnuts are utilized from late August or early September until exhausted, sometimes lasting all year. The buds and seeds of American elm are utilized in February and March, and in April and May. Corn is utilized all year.

Osage orange is utilized from August through the winter. J.M. Allen(1954) in Indiana, Packard(1956) in Kansas, Baumgartner(1943) in Ohio, and Kline (1964) in Iowa, all found that the more important mast bearing trees were the oaks, hickories, and black walnut along with winter utilization of Osage orange and field corn. However, Trippensee(1948) considered Osage orange to be an emergency winter food rather than an important staple.

Fox squirrels inhabit two general types of homes in their natural habitat. One type is a cavity within a tree; the other type is an external nest constructed mostly of leaves. Brown and Yeager(1945) found that a wide variety of trees could be utilized as den trees but that oaks were the most important.

One squirrel may use two or more den cavities at the same time according to Brown and Yeager(1945). Brown and Yeager(1945) reported that D.L. Allen found that certain individuals may establish and use specific dens for long periods, occasionally for the entire life of the animal.

The location of a den tree may be either high or low(Trippensee 1948). He states that Baumgartner found no dens below 11 feet, or above 62 feet, with an average of 36 feet.

The entrance to an average den is 6 inches high, 5 to 3 inches wide, and the average cavity is 14 inches in depth with an average extension of 29 inches above the entrance hole(Allen 1954).

Nests differ from dens in that they are made up mostly of leaves and are used for only one year. They are built throughout the summer and serve as a place to rear young, a retreat for resting, and as havens of escape(Trippensee 1948, Baumgartner 1943, Brown and Yeager 1945, Packard 1956).

Fox squirrels seem to exhibit no defined choice of tree species for

nest building(Brown and Yeager 1945, Packard 1956), except that nests were always constructed in trees close to food sources. Packard(1956) further stated that the bulk of the nesting material came from the tree in which the nest was build or from another tree of the same species.

Different age classes of fox squirrels build different types of nests. Baumgartner(1943), and Trippensee(1948), found that males and immature females build loose, less compact nests 20 feet above the ground while adult females with young build better, more compact nests higher up.

Both leaf nests and dens may fulfill the year round nesting requirements of fox squirrels. Packard(1956) found that fox squirrels can live through the winter in leaf nests in Kansas. Packard(1956) reported that J.M. Allen found that Indiana fox squirrels survive in many areas without the use of tree cavities for dens. Leaf nests are sufficient for survival in a second growth woods since this type of woods will be devoid of den trees(D.L. Allen 1942). Brown and Yeager(1945) found that fox squirrels built leaf nests even where cavities were present, thus suggesting that the highest quality habitat must possess the possibility of both types of nest.

Activity Periods: Fox squirrels are more active during certain time periods of the day and the year than during others. Hicks(1949) found that the fox squirrel is most active from 6 A.M. to 1 P.M., with peaks from 7-8 A.M., 11-12 A.M., and 6-7 P.M. Brown and Yeager(1945) were in general agreement with Hicks finding activity among fox squirrels to be greater in the morning than in the afternoon. However, they found the morning peaks to be from 6-7 A.M. and 7-8 A.M. and the afternoon peak to be from 4-5 P.M. Donohoe and Beal(1972) found that the most active day-

time periods were 10 A.M. and 2 P.M., and noontime is the least active period for squirrels during the daylight hours.

Fox squirrels remain active throughout the year. However, extremes in the weather do hinder and reduce their activity. Fox squirrels are most active on clear days and retard their activity extensively during heavy rainfall, heavy snow, and extremely hot periods, although activity picks up again immediately after heavy rainfall and during light showers (Hicks 1949, Brown and Yeager 1945). A snow of two inches or less decreases activity to a much less extent than does rain (Hicks 1949). Winter activity among fox squirrels was greatest from 8-9 A.M. and 11-12 A.M. Fox squirrels were most active when temperatures were between 40-49 degrees Fahrenheit. Much evidence was found of digging in snow for nuts and Osage orange, many signs of forage food eaten on stumps, logs, and fences, and mating chases during light snow and snow flurries by fox squirrels (Brown and Yeager 1945). However, Brown and Yeager also found that fox squirrels usually move only 10-15 yards from their dens during stormy weather. Hicks (1949) learned that fox squirrels are most active during December, followed in order by November, October, and January.

Movements and Home Range: Home range has been generally defined as the area over which animals normally travel for activities of food gathering, mating, caring for young, and shelter (Burt 1943, Stickel 1954, Flair 1942, Sanderson 1966). Burt (1943) also states "Occasional sallies * outside the area, perhaps exploratory in nature, should not be considered as in part of the home range."

Variations in home range and local movements of fox squirrels are caused mainly by food conditions and day-to-day travels in feeding and

other routine activities(Baumgartner 1943, Seton 1928, Brown and Yeager 1945). Most of the daily activity among fox squirrels occurs in a small area of not more than a few acres, usually within 2-3 acres (Baumgartner 1943, Trippensee 1948), and often in the vicinity of one or a small group of food trees(Brown and Yeager 1945).

Although the daily limits of travel may be quite small, the areas used may vary considerably in shape(Baumgartner 1943). Fox squirrels shift from one local food area to another throughout the year. Illinois fox squirrels were located in elm lowlands from late February to July, raided adjacent cornfields from midsummer to fall, and frequented upland oak and hickories during fall and winter(Brown and Yeager 1945). However, these shifts involved travels of never more than 200-300 yards. Generally squirrels do not go beyond woodland boundaries unless there is a corn, wheat, or soybean field close by; they may move out into corn and wheat 5-10 yards and out into cut soybeans 40-50 yards(Baumgartner 1943).

Seasonal movements are also short except during the breeding season when movements then are made largely by males. These periods of greater movement by male fox squirrels occur in December and January and in May and June, apparently in search of mates(Trippensee 1948). Limited female movements during the breeding season measurably reduces the total activity of the females observed(Packard 1956, Brown and Yeager 1945). Juvenile fox squirrels have no fixed home range until they establish themselves; therefore they may move farther and shift ranges more(Burt 1943).

Home range size is related to several factors. Food supply, cover, and body size influence the size of home range(Blair 1942, Stickel 1954,

Cockrum 1962). Sanderson(1966) states that "As a rule, males range more widely than females, and home ranges of adults are larger than those of juveniles, except when young are travelling with females."

Size of the woodland in which individual squirrels live also influences the size of the home range. The larger the woodlot, the greater the cruising radius of the squirrels(Trippensee 1948).

Baumgartner(1943) found that fox squirrels living in small woodlots had smaller home ranges than those living in large areas.

Home range is also influenced by population density. Most researchers agree that average size of home range decreases as population density increases(Baumgartner 1943, Burt 1943, Trippensee 1948, Sanderson 1966). However, Cockrum(1962) reported that Blair found no evidence that population density had any influence on the size of the individual home ranges.

There is little information on specific sizes of home ranges. Cockrum(1962) states that male fox squirrels have an average home range size of 154 yards while females have an average home range size of 130 yards. Within the home range the daily cruising radii for seasons other than the mating period usually don't exceed 700-800 feet, with an average of 400 feet(Trippensee 1948). Brown and Yeager(1945) state that "When not disturbed by overhunting, fire, drought, or lumbering, individual squirrels may spend an entire year or more in the vicinity of a given nest tree." Packard(1956) reported that Allen found that fox squirrels travelled within 10 acres in any one season and within 40 acres over a period of one year. Donohoe and Beal(1972) found by radiotelemetry that the mean home range size for 3 adult male fox squirrels was 40.7 acres, 7.2 acres for 1 female adult fox squirrel, and 10.5 acres for

1 juvenile male fox squirrel. In Kansas, Packard(1956) found that on a 28 acre plot male fox squirrels travelled farther in general than females. Subadult males ranged farther than all other classes, 812.2 linear feet, followed by juvenile males, 780.7 linear feet, adult males, 601.4 linear feet, juvenile females, 514.5 linear feet, subadult females, 495.0 linear feet, and adult females, 481.2 linear feet. Baumgartner (1943) found that on a 26.7 acre woodlot, the average distance travelled by all fox squirrels was 392.1 feet, on a 41.5 acre plot, the average distance travelled was 391.8 feet, and on a 88 acre plot, the average distance travelled was 490.8 feet. Baumgartner also found that on another study area of undetermined size, the average distance travelled by 129 fox squirrels was 410.1 feet. Sixty males averaged 463.7 feet and 69 females averaged 389.1 feet. These measurements are of little comparative value due to the many factors that influence the size of home range.

LITERATURE REVIEW CITATIONS

- Allen, D.L. 1942. Population and habits of the fox squirrel in Allegan County, Michigan. Amer. Midl. Nat. 27:338-379.
- Allen, J.M. 1954. Gray and fox squirrel management in Indiana. Ind. Dept. Cons., Div. Fish and Game. Pittman-Robinson Bull. 1.
- Baumgartner, L.L. 1943. Fox squirrels in Ohio. J. Wildl. Mgmt. 7:193-202.
- Blair, W.F. 1942. Size of home range and notes on the life history of the woodland deer-mouse and eastern chipmunk in northern Michigan. J. Mamm. 23:27-36.
- Brown, L.G. and L.E. Yeager. 1945. Fox and gray squirrels in Illinois. Ill. Nat. Hist. Surv. Bull. 23(5):449-532.
- Burt, W.H. 1943. Territoriality and home range concepts as applied to mammals. J. Mamm. 24:346-352.
- Cockrum, E.L. 1962. Introduction to mammology. The Ronald Press Co., New York. viii + 455 pp.
- Donohoe, R.W. and R.O. Beal. 1972. Squirrel behavior determined by radiotelemetry. Ohio Dept. Nat. Resources, Div. Wildlife. Ohio Fish and Wildlife Report 2.
- Hall, E.R. and K.R. Kelson. 1959. The mammals of North America. The Ronald Press Co., New York. i-xxx + 546 pp.
- Hicks, E.A. 1949. Ecological factors affecting the activity of the western fox squirrel. Ecol. Monogr. 19:287-302.
- Hoffmeister, D.F. and C.O. Mohr. 1957. Fieldbook of Illinois mammals. Ill. Nat. Hist. Surv. Manual 4.
- Kline, P.D. 1964. Iowa squirrels: Hunting statistics, sex and age ratios, and the influence of mast and agriculture. Ia. Acad. Sci. 71:216-227.
- Packard, R.L. 1956. The tree squirrels of Kansas: ecology and economic importance. Univ. Kans. Mus. Nat. Hist. Misc. Publ., 11:1-67.
- Sanderson, G.C. 1966. The study of mammal movements-a review. J. Wildl. Mgmt. 30:215-235
- Seton, E.T. 1928. Lives of game animals. Literary Guild of Am., Inc., New York. 4: pp.

- Stickle, L.F. 1954. A comparison of certain methods of measuring ranges of small mammals. J. Mamm. 35:1-15.
- Taber, R.D. 1963. Criteria of sex and age. Chap. 6, In: H.S. Mosby(ed.), Wildlife investigational techniques, 2nd. ed. Edwards Brothers Inc., Ann Arbor, Michigan. xxiv + 419 pp.
- Trippensee, R.E. 1948. Wildlife management. McGraw-Hill Book Co., Inc., New York. x + 479 pp.