THE DENSITY AND DISTRIBUTION OF GRAY SQUIRRELS IN A SUBURBAN ENVIRONMENT

by

Kenneth K. Andersen

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Stevens Point, Wisconsin

APPROVED BY THE GRADUATE COMMITTEE OF:

Kirk H. Beattie

Kirk H. Beattie, Advisor

Assistant Professor of Wildlife

James W. Hardin

James W. Hardin

Associate Professor of Wildlife

Charley White

Charley M. White

Professor of Biology

ABSTRACT

The density and distribution of gray squirrels in a suburban environment were studied from October 1980 through November 1981 on Oak Park Estates, Plover, Wisconsin. Environmental variables potentially affecting density and distribution included location of gardens and birdfeeders, amount and type of artificial feed available, season of feeding squirrels, and presence or absence of pets and children.

Vegetation of the study area and an adjoining buffer zone is predominately red oak (Quercus rubra) and white pine (Pinus strobus). Black cherry (Prunus serotina) and blackberry (Rubus allegheniensis) dominate the understories. Production of acorns was good in 1980, but the acorn crop in 1981 was poor.

Population estimates based on Schnabel's mark-recapture formula were calculated for 5 trapping periods beginning in January 1981 and ending in November 1981. Estimates were highest for the winter, spring, and summer of 1981 and lowest for the September and November trapping periods 1981. The high winter population may have been a result of squirrel immigration and low emigration off the study area and presence of feed in birdfeeders. Population averages were higher for traps located near gardens ($\bar{x}$=7.4) versus traps located large distances from gardens ($\bar{x}$=5.7).

Males were dominant during all trapping seasons except early summer 1981. Male gray squirrels may be over-represented, because they generally have larger home ranges and are more active year-round than females. Adults outnumbered juveniles during all seasons except winter and early summer 1981.

Gray squirrels were well distributed throughout the study area. The majority of captures on an adjoining buffer zone occurred along the southern edge, which may have been a result of close proximity to a major woods and less disturbance by pets and children. Adult and juvenile males were captured most often. Trap success was highest near gardens and bird feeders. Trap success was reduced by disturbance from pets and children, trapping of squirrels by residents, and consumption of bait by songbirds.

Home range appears to be larger for suburban gray squirrels than wild squirrels. Adult males had the largest home range followed by adult females, juvenile males, and juvenile females, respectively. Average home range size of all gray squirrels was nearly 6 times that of wild squirrels in Michigan. Influencing factors on a suburban gray squirrel's home range appear to be social rank, presence of birdfeeders and gardens, and pets.

A questionnaire survey of area residents was conducted to obtain data on environmental variables possibly affecting gray squirrel densities and distributions. No statistical relationships were established due to a limited sample size of homes. There appears to be a relationship between locations of gardens and bird-feeders, and movements and concentrations of suburban gray squirrels. The influence of birdfeeders appears to be related to type and quantity of feed made available. Sunflower seeds, provided in large quantities year-round, attract the greatest number of squirrels to feeders. Other factors that may influence suburban gray squirrels are pets, season of feeding at feeders, type of vegetables in gardens, and children.

The most common complaint residents of Oak Park Estates have concerning gray squirrels is the eating of, and damage to, garden vegetables. Damage of property was next in occurrence on questionnaires. Approximately 25% of all residents indicated they have had no problems with squirrels. The majority of Oak Park Estate residents indicate that there is about the right number of gray squirrels on their respective properties.

Problems encountered in this study included trap disturbance by pets and children, removal of marked squirrels by residents, and a small sample size of homes which prohibited statistical analysis.

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INTRODUCTION

Wildlife in suburban environments is increasingly gaining the attention of natural resource personnel. Increased interest is due primarily to the expansion of America's cities into rural areas, causing a loss of wildlife habitat in some instances. One wildlife species that promises to expand with cities is the gray squirrel (Sciurus carolinensis).

With the expansion of urban America and the great demand to observe nongame wildlife (i.e., wildlife that is not hunted or fished for consumptive purposes), studies of this nature are becoming imperative. The overall intent of this study was to examine the habitat requirements, behavior, and population dynamics of gray squirrels in a suburban environment.

Specific objectives were to:

1) Estimate the density of gray squirrels in a suburban environment;

2) Determine movements and concentrations of gray squirrels in a suburban environment; and

3) Identify vegetative and human variables that may affect gray squirrel density and distribution.

LITERATURE REVIEW

Life History

The gray squirrel has been subjected to an array of land use changes since the first settlers came to America. In some cases, clearing of forested land for agriculture led to the replacement of gray squirrels by fox squirrels (Sciurus niger) (Baker 1959).

Maximum longevity in the wild is reported to be 12.5 years for female gray squirrels and 9.0 years for males (Barkalow and Soots 1975). The average lifespan for an unexploited population of wild gray squirrels is 6 years in North Carolina (Barkalow and Soots 1975), which does not agree with Barkalow and Shorten (1973) who feel an average lifespan of 1 year to 18 months is more realistic in Britain. Dubock (1979a) observed an average lifespan in gray squirrels of 3 to 4 years of age in Britain.

Reproduction

Breeding in the gray squirrel may occur twice each year. Third litters may occur during years of mild weather conditions and good mast yields. Peaks in breeding generally occur between January and March and from June through August; females are receptive anytime between January and October (Brown and Yeager 1945, Goodrum 1940, Nixon 1965, Uhlig 1955a). Peaks in parturition were observed by Nixon and McClain (1975) from 14 February to 9 March and 1 July to 1 August, which generally agrees with Allen (1943), Thompson (1977), and Uhlig (1955a).

Redmond (1953) observed peak lactation by females in March-April and August-September. Uhlig (1955a) found lactating females most

prevalent from mid-February to mid-October. A gestation period of 44 to 45 days is generally reported for female gray squirrels (Nixon 1965, Taber 1971, Thompson 1977, Redmond 1953, Uhlig 1955a). Nestling squirrels begin to wean during the seventh week of life (Allen 1943, Uhlig 1955a). Weaning periods are generally 10 to 12 weeks in length (Mosby 1969, Mosby et al. 1977, Redmond 1953, Weekes 1977). Young venture outside the nest at 7 to 8 weeks of age and are seen on the ground at approximately 3 months (Allen 1943).

Male gray squirrels mature at a later age than do females (Barkalow and Soots 1975). Males are sexually mature at 10 to 11 months, while females may breed as early as 6 months of age (Hoffman and Kirkpatrick 1956). Gray squirrels born in the spring will mate the following spring but will not breed that summer after birth (Uhlig 1955a). Litter sizes range from 2 to 4 and average 3 (Allen 1943, Dubock 1979b, Hoffman and Kirkpatrick 1959, Longley 1963, Nixon and McClain 1975, Redmond 1953). Shorten (1951:428) stated that: "If the diet can affect the size of litters produced, a larger autumn (summer) litter than spring litter might be expected". This idea has been supported to some degree by Brown and Yeager (1945) and Hibbard (1935).

Dubock (1979b) and Thompson (1977) indicate that litter production may be related to geographical location. Shorten (1951) provides further evidence resulting from transporting of gray squirrels to the southern hemisphere where the breeding season became reversed. Hoffman and Kirkpatrick (1959) further state that light and temperature may be responsible for breeding behavior in gray squirrels.

Behavior

Horwich (1972) studied the development of gray squirrel behavior from the post-embryonic stage and reported that the most important period is from 41 to 70 days. Seasonal variation in gray squirrel behavior was observed by Bakken (1959) and Thompson (1977). Variation existed in 1) amount of time per day that squirrels were active; 2) the time of onset and cessation of behavior; and 3) home range size. Both males and females are most active in summer. Bland (1977) found peak activity periods in fall and spring in Minnesota. He also found that snow cover and/or extremely cold weather during winter and spring inhibited squirrel movement. Similar responses were observed during rainy weather in summer. A high correlation between activity of gray squirrels and maximum temperature, relative humidity, and wind speed was reported by Whitehead (1976). Bakken (1959) observed a seasonal activity peak in October in Wisconsin. Bakken also reports that males were more active than females from January through March. Females were most active from April through September.

Since gray squirrels appear to be non-territorial, they may exhibit overlapping home ranges (Cordes 1965). Males average larger home ranges than females of the same age class, with younger squirrels exhibiting larger home ranges than older squirrels. However, Flyger (1960) observed that older squirrels had the largest home ranges in Maryland. Socially dominant squirrels (large adult males) have priority in mating and feeding, and suffer less from shock, compared to low-ranking individuals (e.g. dispersed juveniles) (Pack et al 1967).

Feeding by gray squirrels begins in early morning before daybreak with a second feeding period occurring in late afternoon (Barkalow and

Shorten 1973). Goodrum (1940) reported that 59% of all food eaten by gray squirrels was acorns and 3.5% was insects. Nixon (1970) considered insects to be a more important food item for subadults and juveniles than for adults. He reasoned that in late spring and early summer, plant seeds are scarce and insects fulfill the need of spring litters for high amounts of protein. Nixon et al. (1968) states that squirrel foods are selected seasonally with acorns being the preferred food in all seasons.

Habitat

The feeding behavior of the gray squirrel has been reported to be a good indicator of habitat requirements (Brown and Yeager 1945, Madson 1964). Optimum gray squirrel habitat in Texas consists of bottomland hardwoods intermixed with a variety of vines, shrubs, and herbaceous plants (Goodrum 1940). Middle-aged or mature trees are preferred as they furnish the largest amount of food, the best rearing sites, and optimum opportunities for play and exercise (Goodrum 1940, Madson 1964). Allen (1943) observed the most consistently productive gray squirrel habitat in Michigan was a mature oak-hickory woodland broken into units of 2 to 8 ha (5-20 A). Allen states that these units should be irregular in shape (creating edge) and connected with lines of trees or strips of woodlands that serve as travel lanes. These woodlots should be interspersed with upland and lowland thickets and fertile fields. Oaks and hickories, with walnut, elm, beech, and maple were major components of importance to gray squirrels in Michigan.

Nixon et al. (1968) state that all-age silvicultural harvest methods do not seem to impair food production for squirrels. Even-age

silviculture (clearcutting followed by intermediate thinnings and harvest clearcutting) may prove to be detrimental. Goodrum (1937) states further that gray squirrels prefer forests that were not heavily grazed.

Age and Sex Determination

Individual weights have been used to determine age (Allen 1943, Barkalow and Shorten 1973, Taber 1971, Uhlig 1955b). Weights of squirrels vary depending on location of the population and mast production (Nixon and McClain 1975). Body lengths, eye lens weights, cementum annuli of teeth, and fusion of the distal epiphyses also have been used to determine age in squirrels (Brown and Yeager 1945, Dubock 1979a, Fogl and Mosby 1978, Taber 1971, Uhlig 1955b). The most common technique to age gray squirrels has been the use of tail pelage characteristics (Barrier and Barkalow 1969, Sharp 1958, Uhlig 1955b, Whitehead 1976). Observation of female mastology and scrotal development in males is used to determine sex of gray squirrels (Mosby 1969, Taber 1971).

Urban Gray Squirrels

Literature regarding the urban/suburban gray squirrel is relatively scarce. Flyger (1974) noted factors related to tree squirrels in urbanizing environments including the relationship of squirrels to urban dwellers, problems, disease, management, and the possibility as a research tool. Hathaway (1973) conducted research on gray squirrels in an urban cemetery. He recorded a high population of squirrels (5.5/A) on the 297 ha (733 A) cemetery. In contrast, Caughley (1974) observed a small number of fox squirrels (n=2) within a 64 ha (159 A) housing area near Detroit, Michigan.

STUDY AREA

Research conducted from October 1980 through October 1981 on Oak Park Estates, a subdivision located in the Town of Plover, approximately 9.6 km (6 miles) south of Stevens Point, Wisconsin (Fig. 1). The study area encompasses 20-ha (50-acres) that has been developed for suburban housing. Located directly east, south and west of the study area is a 8-ha (20-acres) buffer zone. The buffer zone consists of tree species in plantations, with jack pine (Pinus banksiana) dominant in the eastern and southern zones, and jack pine and white spruce (Picea alba) dominant in the western zone. Understory is lacking in all buffer areas except in the eastern area where black cherry (Prunus serotina) dominates. The buffer zone was used to monitor squirrel movement to and from the study area.

The climate of Portage County is characterized by marked seasonal changes. Winters are cold and snowy. Summers are usually warm with brief periods of hot and humid weather. Spring and fall are sometimes short with variable climatic conditions (USDA 1978).

Approximately 60% of the annual precipitation falls between May and September, with June being the wettest month and late August the driest. Average precipitation is 76 cm (30.1 inches) per year. Temperatures range from an annual high of 34° C (93° F) to an annual low of -31° C (-24° F). The annual mean temperature is 5° C (41.5° F). The growing season (number of days between the last freeze in spring and the first freeze in fall) averages 142 days (USDA 1978).

The soil type on Oak Park Estates is a Plainfield loamy sand. Due to level topography, water permeability is rapid and water-holding

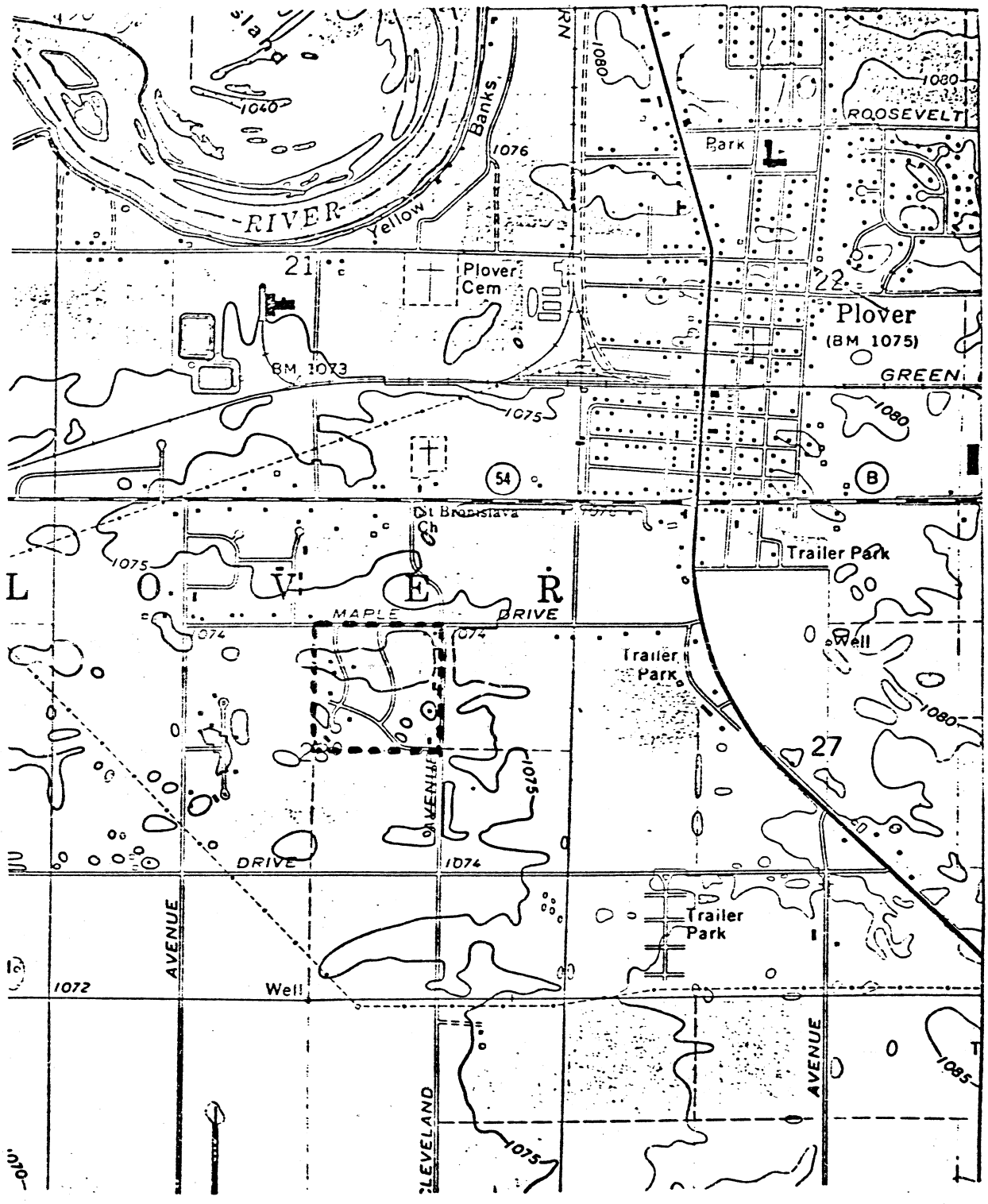

Fig. 1. Oak Park Estates, indicated by dashed lines, located in SW¼ NE¼ Section 28, Township 23N, Range 8E, Town of Plover, Portage County, Wisconsin (USGS 1974).

capacity is low. The Plainfield loamy sand is capable of producing good habitat for most species of wildlife (USDA 1978).

Oak Park Estates has largely mixed deciduous-conifer vegetation. Tree species include red oak (Quercus rubra), hill's oak (Q. ellipsoidalis), bur oak (Q. macrocarpa), white pine (Pinus strobus), jack pine (P. banksiana), and red pine (P. resinosa). The understory is predominately black cherry (Prunus serotina) and blackberry (Rubus allegheniensis). Ornamental shrubs are represented by Japanese yew (Taxus cuspidata) and white cedar (Thuja occidentalis).

Presently, 7 vegetable gardens are interspersed throughout the study area along with numerous bird feeders within yards. Three streets dissect Oak Park Estates and 2 streets border the study area on the north and east. Vacantly owned woodlots located adjacent to some homes are used for firewood or left undisturbed.

METHODS AND MATERIALS

Vegetation cover typing was conducted according to Stoddard (1978) on 24 and 25 October, 1981. Ten sample plots, 277 m^2 (100 $feet^2$), were chosen based on a random numbers table. A numbered dot grid was then placed over a map of the study area. Basal area of tree species and number of trees per acre were determined using a 10 power prism and a range finder. Black cherry plants were recorded in each plot to determine general densities. Species of herbaceous vegetation were recorded as to their presence.

Collections of acorns to evaluate mast availability were made in the last week of September in 1980 and 1981. Ground counts were conducted to obtain an estimate of acorn availability on the study and buffer areas using a method similar to Dalke (1953). Acorns were collected at 28 m (100 foot) intervals in sample squares 2 m by 2 m (7 feet by 7 feet). Distance between transects was 55 m (200 feet).

Gray squirrel densities on the study and buffer areas were estimated using the Schnabel mark-recapture formula (Schnabel 1938). Study and buffer areas were divided into approximately 0.81-ha (2-acres) squares, nearly the size of 1 wild gray squirrel's home range (Fig. 2). Livetrapping was conducted using 50 small box traps (Mosby 1955). Traps were placed randomly within the square plots with at least 1 trap but no more than 2 per plot. Traps were pre-baited for 3 days with a variety of baits including peanut butter, sunflower seeds, and a mixture of oatmeal, molasses, brown sugar, and peanut butter. Sunflower seeds were the most economical and attractive bait.

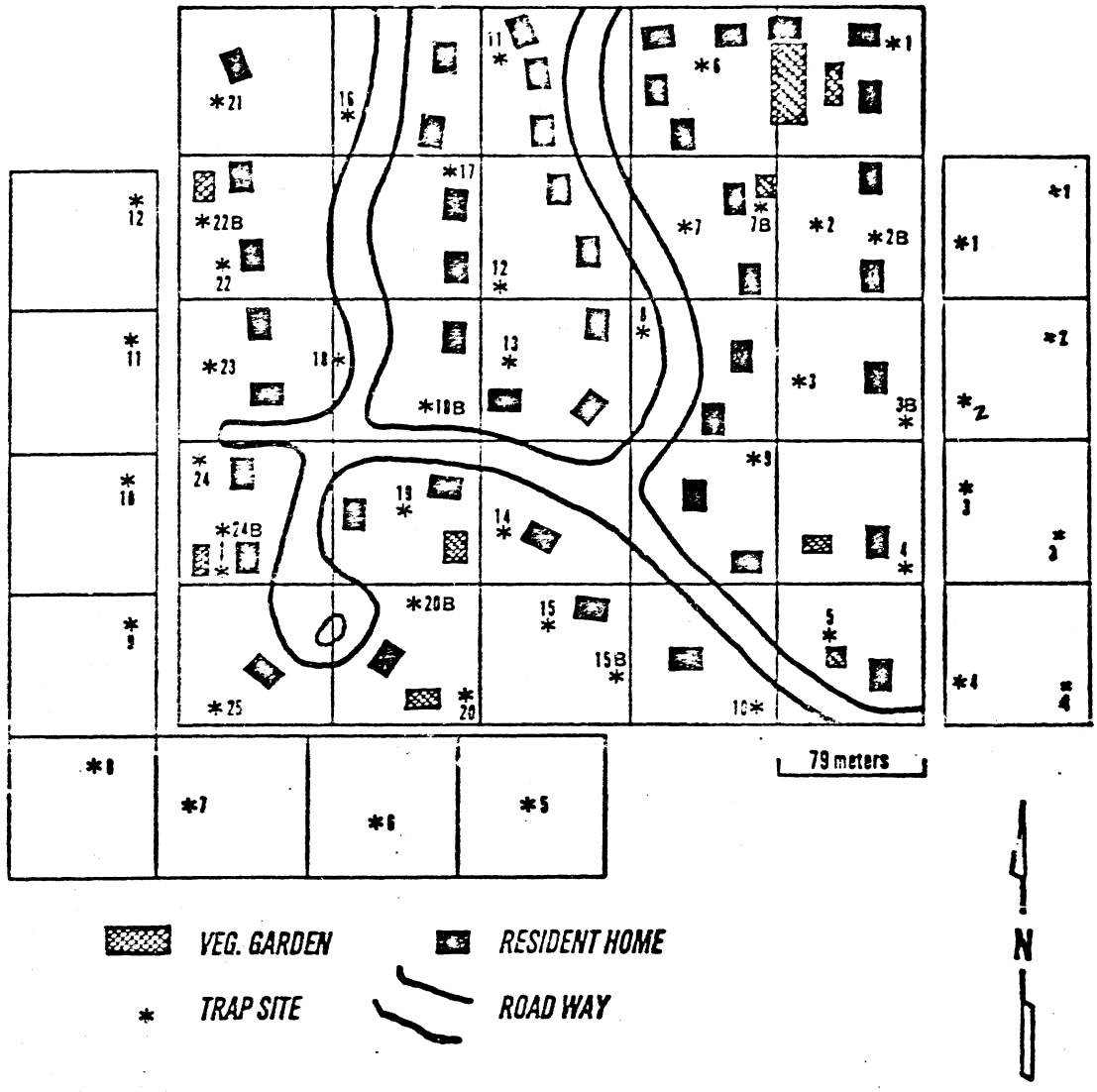

Fig. 2. Gridded study and buffer areas indicating approximate trap locations on Oak Park Estates, Plover, Wisconsin, 1980-1981.

Squirrels were livetrapped over 7 6-day trapping periods from October 1980 through November 1981. Captured gray squirrels were handled in a wire cone as described by Schemnitz (1980:66). Squirrels were aged from observation of secondary hairs located on the ventral surface of the tail, mastology of females, testes development of males, and body weights of the squirrels (Allen 1943, Schemnitz 1980, Uhlig 1955b). Squirrels were then assigned an age class of either adult or juvenile. Determination of a subadult age class was difficult due to inconsistencies in the literature as to the reliability of aging techniques.

Gray squirrel movements and home range size were determined from captures and recaptures at trap sites using the inclusive boundary strip method (Blair 1940, Stickel 1954). In this method, a boundary strip equal in width to half the distance between traps is laid off around the minimum area and the area enclosed is measured. External points of capture are considered centers of rectangles, the sides of which equal the distances between traps.. Exterior corners of these rectangles are then connected. A planimeter was used to measure home ranges for 16 gray squirrels captured a minimum of 5 times.

A questionnaire was distributed to each resident of Oak Park Estates (n=47) to examine variables that may influence gray squirrel density and distribution. The questionnaire consisted of 27 questions on either nominal (yes or no type), ordinal (too few, too many, or about right type), or interval (how many dogs or cats on lot) scales (Appendix A). Question type was then used to determine the appropriate statistical analysis that would be applied to the data.

Permission was obtained from each resident of Oak Park Estates to conduct the study. Permission was granted by all residents to livetrap and handle gray squirrels on the respective properties.

RESULTS AND DISCUSSION

Vegetation

A vegetation cover-type map was prepared for the study area representing tree species and their relative densities (Fig. 3). One plant community dominated the area. Red oak and white pine were dominant, not only in square feet per acre but in density as well (Table 1). Bur oak occurred on most sample plots, with jack pine, hill's oak, and red pine, comprising the remainder of all plots, respectively. Tree species in the understory included red oak, white pine, jack pine, and black cherry. Red pine was found only as a plantation.

Black cherry plays a role in the understory in the form of travel lanes and as a minor food source for gray squirrels. On 7 of 10 sample plots, over 30 black cherry seedlings, saplings, and small trees were counted. Black cherry may comprise 0.5 to 2% of the eastern gray squirrel's diet in Illinois (Martin et al. 1951). Co-dominant in the understory with black cherry was blackberry. Both of these plant species may have an influence on the dynamics of a suburban forest community as they intercept light and precipitation that may penetrate the canopy. Intolerants that might normally grow cannot thrive. Other common understory plants observed in selected areas include butter-and-eggs (Linaria vulgaris), solomon's seal (Polygonatum biflorum), nightshade (Solanum dulcamara), and staghorn sumac (Rhus typhina) (Table 2).

In contrast to more mesic forest types, the oak-pine habitat of Oak Park Estates is relatively unstable. In a suburban area such as

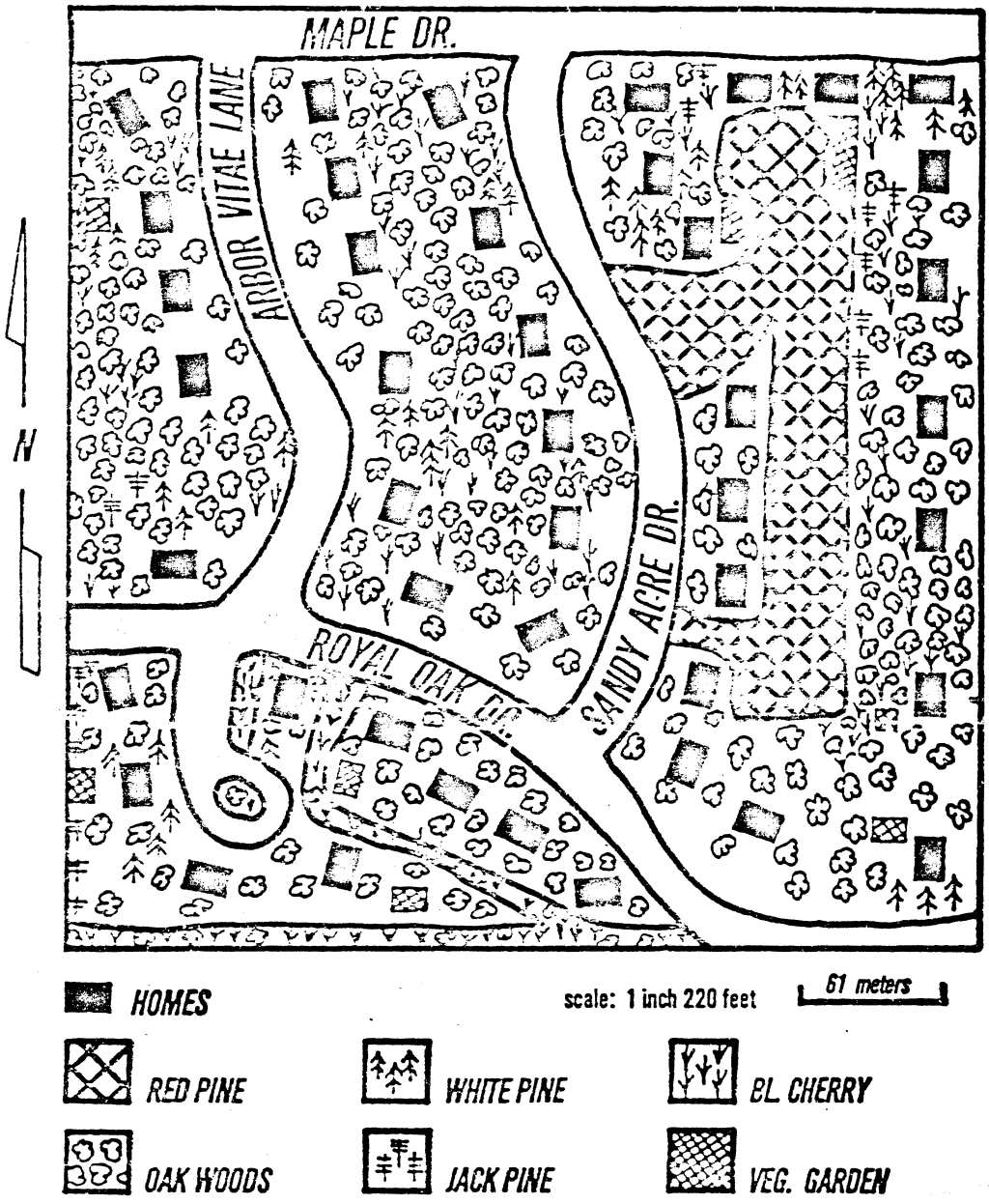

Fig. 3. Vegetation cover type map of study area on Oak Park Estates, Plover, Wisconsin, October 1981.

Table 1. Density and basal areas of canopy tree species on Oak Park Estates, Plover, Wisconsin, 1980-1981.

Tree Species	Trees Per Acre	Square Feet of Basal Area Per Acre
Red Oak	26.0	37.0
White Pine	26.0	35.0
Bur Oak	25.0	25.0
Jack Pine	9.0	17.0
Hill's Oak	9.0	12.5
Red Pine	7.0	1.0

Table 2. List of plant species for Oak Park Estates, Plover, Wisconsin, 1980-1981.

Achillea millefolium	Yarrow
Ambrosia artemisiifolia	Ragweed
Carex spp.	Sedge
Comptonia peregrina	Sweetfern
Cornus canadensis	Bunchberry
Corylus cornuta	Beaked hazelnut
Hieracium aurantiacum	Orange hawkweed
Linaria vulgaris	Butter-and-eggs
Pinus banksiana	Jack pine
Pinus resinosa	Red pine
Pinus strobus	White pine
Plantago major	Common plantain
Pleurozuim spp.	Shiny moss
Poa pratensis	Bluegrass
Polygonatom biflorum	Solomon's seal
Populus tremuloides	Trembling aspen
Prunus serotina	Black cherry
Quercus ellipsoidalis	Hill's oak
Quercus macrocarpa	Bur oak
Quercus rubra	Red oak
Rhus typhina	Staghorn sumac
Rumex spp.	Sorrel
Rubus allegheniensis	Blackberry
Solanum dulcamara	Nightshade
Viola spp.	Violet

this, interruptions of natural succession are commonplace. Construction of homes and associated structures, thinning or clearing of woodlots, and introductions of exotic plant species are all examples. Presently, the area is experiencing oak wilt fungus (Chalara quercina) within the oak tree population. Many residents are removing diseased trees and replacing them with such species as sugar maple, a further interruption of natural succession that may affect gray squirrel density and distribution.

Mast Yields

Acorn crops varied from excellent in 1980 to poor in 1981. Only general trends in mast yields for 1980 and 1981 can be presented, because acorns were collected on the ground in October of each year and many of the available acorns had been removed or buried by squirrels by that time. What may be indicated is that the mast crops were lower in 1981 than in 1980, which may have caused a greater movement to adjoining areas and higher use of feeders on the study area in 1981.

Population Estimates

Gray squirrel population estimates were established for 5 of 7 trapping periods. Period 1 (fall 1980) had no recapture data from a previous trapping period and could not be used in Schnabel's formula. In period 5 (July 1981) a resident homeowner livetrapped and removed 25 marked squirrels from the study area.

Winter 1981 provided the largest estimate of gray squirrels on Oak Park Estates (Table 3). Three reasons for high success were that squirrels were unfamiliar with traps (being only the second trapping period), mating chases were beginning, and squirrels may have been

Table 3. Density of gray squirrels per acre January 1981 through November 1981 on Oak Park Estates, Plover, Wisconsin.

	Winter 1981	Spring 1981	Summer 1981	September 1981	November 1981
Study Area (50 acres)	3.46	2.30	3.24	1.80	0.82
Buffer Zone (20 acres)	1.92	1.82	1.90	0.70	0.05
Total Area (70 acres)	3.02	2.16	2.86	1.49	0.69

attracted to bird feeders. The slight drop in numbers in spring 1981 may be due to overwinter mortality and dispersal of juvenile squirrels (summer born 1980). The increase in numbers during summer 1981 (June) can be attributed to spring litters. The dramatic drop in squirrel captures in September and November of 1981 is due to one resident's livetrapping activities, juvenile dispersal, and depressed reproduction in late summer because of poor mast crops. Low mast yields would also account for a larger dispersal of juveniles.

Overall, there was little fluctuation in gray squirrels per acre on either the study or buffer areas until September and November 1981. Average number of gray squirrels per acre was slightly lower than those found by Hathaway (1973) in an urban cemetery. Estimates of individual plots by season more closely agreed with Hathaway's average per acre (Table 4).

Sex and Age Distributions

The high number of captures and recaptures in the early trapping periods may indicate unfamiliarity with traps by gray squirrels (Table 5). Males outnumbered females approximately 2:1 in all trapping periods except the summer (June) of 1981. The higher sex ratio is partly due to the larger home ranges and generally greater activity of males. Sex ratios are somewhat higher than in a wild gray squirrel population studied by Whitehead (1976) in Tennessee. Equal sex ratios in summer 1981 can be explained by juvenile dispersal and increased activity by adult females. Data from September and November 1981 are affected by such factors as livetrapping and removal of squirrels by one resident, juvenile dispersal, and low summer reproduction.

Table 4. Population density of gray squirrels on plots located on Oak Park Estates, Plover, Wisconsin, 1980-1981.

Plot Number	Trapping Season					Average/Plot Between Seasons
	Winter	Spring	Summer	Sept.	Nov.	
1[a]	0	0	0	0	0	0
2	0	10.5	5.3	3.0	2.5	3.5
3	10.0	8.0	1.8	3.7	1.2	4.1
4[a]	15.0	7.0	16.0	6.5	8.7	8.9
5[a]	8.0	15.0	8.0	6.7	7.5	7.5
6[a]	0	0	0	0	0	0
7[a]	25.0	27.0	23.0	6.6	7.0	14.8
8	6.0	4.5	1.7	0	2.0	2.3
9[a]	4.0	6.0	0	0	0	1.6
10	8.0	4.0	0	0	0	2.0
11	0	12.0	7.0	0	4.0	3.8
12	0	0	0	0	0	0
13	0	7.0	0	0	7.0	2.3
14[a]	10.0	8.0	12.0	3.2	7.0	6.7
15[a]	16.0	6.0	5.0	4.0	5.3	6.0
16	8.0	2.5	10.0	0	9.0	9.9
17	0	0	10.0	20.0	0	5.0
18	0	32.0	28.0	9.5	8.0	12.9
19[a]	0	24.0	10.0	5.5	4.0	7.3
20[a]	56.0	28.0	31.5	14.4	11.1	23.5
21	0	0	0	0	0	0
22[a]	9.0	7.0	22.5	21.0	8.5	11.3

Table 4. Continued. Population density of gray squirrels on plots located on Oak Park Estates, Plover, Wisconsin, 1980-1981.

Plot Number	Trapping Season Winter	Spring	Summer	Sept.	Nov.	Average/Plot Between Seasons
23	6.0	8.0	0	3.0	3.0	3.3
24[a]	12.0	8.0	12.2	9.2	4.0	7.5
25[a]	9.0	5.0	12.0	4.0	4.0	5.6
Average/Plot Within Season	8.0	8.9	8.6	4.8	4.1	5.7

[a]Garden located within or is proximal to grid.

Table 5. Sex and age distribution of gray squirrels eartagged and recaptured on Oak Park Estates, Plover, Wisconsin, from October 1980 through November 1981.

	Fall 1980			Winter 1981			Spring 1981		
	Tagged	Recap.	Total	Tagged	Recap.	Total	Tagged	Recap.	Total
Adult Male	23/9[a]	15/3	38/12	13/4	7/1	20/5	14/7	14/4	26/11
Adult Female	19/5	6/3	25/8	12/2	2/0	14/2	11/7	2/2	13/9
Juvenile Male	15/2	11/0	26/2	21/9	17/2	39/11	10/3	6/0	16/3
Juvenile Female	7/3	2/0	9/3	9/3	1/2	10/5	5/0	3/0	8/0
Total	64/19	34/6	98/25	56/18	27/5	83/23	40/17	23/6	63/23

[a] Indicates buffer area captures/recaptures.

Table 5. Continued. Sex and age distribution of gray squirrels eartagged and recaptured on Oak Park Estates, Plover, Wisconsin, from October 1980 through November 1981.

	Summer 1981			September 1981			November 1981		
	Tagged	Recap.	Total	Tagged	Recap.	Total	Tagged	Recap.	Total
Adult Male	11/6[a]	3/0	14/6	13/1	3/1	16/2	9/3	3/0	12/3
Adult Female	9/4	3/0	12/4	7/0	2/0	9/0	7/0	1/0	8/0
Juvenile Male	16/3	3/0	19/3	7/3	3/0	10/3	6/2	3/1	9/3
Juvenile Female	15/0	6/0	21/0	0/0	0/0	0/0	2/0	0/0	2/0
Total	51/13	15/0	66/13	27/4	8/1	35/5	24/5	7/1	31/6

[a] Indicates buffer area captures/recaptures.

Age distributions were dominated by adults in all seasons except winter and summer 1981. High juvenile numbers in the winter and summer 1981 may be the result of high fall reproduction, immigration, and an attraction to birdfeeders. The higher number of adults is somewhat surprising, since wild squirrel populations are usually characterized by higher subadult and juvenile animals. High adult numbers may indicate gray squirrels are surviving longer in the suburban area, or lowered reproduction and greater dispersal by juveniles.

Movements and Home Range

The gray squirrel population of Oak Park Estates is well distributed as evidenced by the distribution of captures at traps in the study area. The same cannot be said for the buffer zone. A total of 92 gray squirrels was captured on the buffer zone, representing 24.4% of total captures. Of these, 19 were recaptures. A pattern of captures was observed on the southern edge of the buffer zone. The pattern may be due to squirrels having easier access to travel lanes and traps were proximal to major woods south of the study area. Hathaway (1973) observed similar circumstances in an urban cemetery in a midwest city.

Adult and juvenile males were captured most often, with adult and juvenile females, respectively, captured least often (Table 6). In Toronto, Ontario, Thompson (1977) observed males moved greater distances than females, with adult males exhibiting the greatest movements of all squirrels. In contrast, juvenile males on Oak Park Estates occupied smaller areas than other age/sex classes but may have moved more often. Frequent movements by juvenile males would increase their change of capture as compared to juvenile females which move less often and in smaller areas (Flyger 1960).

Table 6. Frequency distribution of gray squirrel captures on Oak Park Estates, 1980 through 1981.

Number of Times Captured	Adult Males	Adult Females	Juvenile Males	Juvenile Females	Total
1	16	6	20	3	45
2	14	5	8	5	32
3	5	6	6	4	21
4	3	1	6	1	11
5	3	1	3	0	7
6	2	2	1	2	7
7	1	0	0	1	2
8	3	3	2	0	8
9	2	2	1	0	5
10	0	1	3	0	4
11	0	1	0	0	1
12	0	0	1	0	1
13	2	0	0	0	2
18	0	1	0	0	1
Total	51	29	51	16	147

Total number of captures on the study and buffer areas (n=338) divided by the number of trap days (n=36) yields a high ratio of squirrels captured each day ($\bar{X}$=9.4). The number of squirrels captured each day on Oak Park Estates is much higher than that of Whitehead (1976) in a wild gray squirrel population in Tennessee. Despite the high number of captures in periods 1 and 2, capture per trap is still low. As many as 45 of 50 traps during periods 1 and 2 had gray squirrels in them at the same time. Following the fall and winter trapping periods, the number of captures per trap steadily declined. The decline in captures may be due to squirrels becoming familiar with traps and the procedures associated with trapping (Whitehead 1976). Disturbance by children and dogs, and trapping of squirrels by residents may also influence trapability of squirrels at these times. Another problem encountered was the removal of bait by chipmunks, blue jays, black-capped chickadees, white-breasted nuthatches and other songbirds.

Trapping success on individual plots within the study area may provide additional clues concerning squirrel movements. All traps located on plots with seasonal populations greater than 10.0 squirrels were located near gardens or bird feeders that were supplied year-round. Although not substantiated by statistics, gardens and feeders are believed to act as direct attractants to gray squirrels, as well as other forms of wildlife.

Home ranges of suburban gray squirrels appear to be much larger than those of wild gray squirrels (Fig. 4). Wild gray squirrel home ranges vary from 0.49 to 0.86 ha (1.20 to 2.13 A) (Cordes 1965, Flyger 1960, Uhlig 1955a). Home range size ($\bar{X}$=9.4 A) was nearly 6 times that

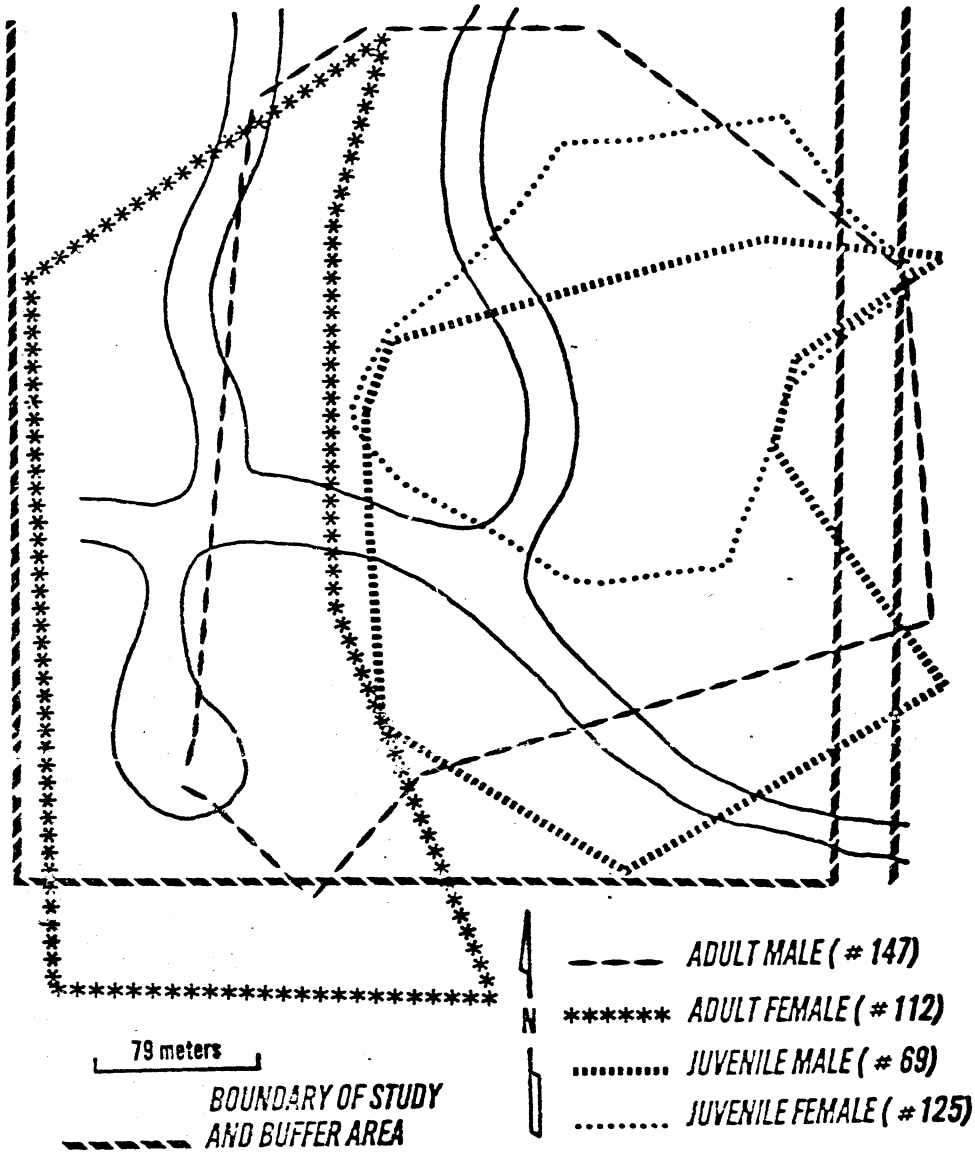

Fig. 4. Home ranges representative of 2 age and sex classes of gray squirrels on Oak Park Estates, Plover, Wisconsin, 1980-1981.

of wild gray squirrels and 3 times that of urban fox squirrels (Caughley 1974) (Table 7).

Adult males seemed to move the greatest distances in the fall and summer on Oak Park Estates. Seasonal movement may be explained by mating chases and increased feeding at bird feeders and gardens. Female adults moved the greatest distances in summer, as also reported by Flyger (1960), and the least during the spring and fall. Summer movements by adult females may be related to mating chases and feeding sites, while shorter movements in spring and fall may be due to preoccupation with young squirrels. Male and female juveniles had greatest movements in early summer following weaning. Greater movements should be expected in the fall by juveniles also but data were limited.

Various factors affect the size of a home range in gray squirrels, including food availability, breeding activity, intraspecific competition, environmental variables, and estimation techniques (Caughley 1974, Mohr 1965, Stickel 1954). In a suburban situation such as Oak Park Estates, man-made variables such as density and spacing of mast and den trees, size and contents of vegetable gardens, bird feeders, type and quantity of feed provided in bird feeders, presence of pets and children, and access to houses and garages for nesting or denning, may further influence a gray squirrel's home range.

Environmental Variables

Identifying variables relating suburban wildlife and their interaction with people was 1 aspect of this study. A total of 43 of 47 households (91%) responded to questionnaires. The responses were then categorized into frequencies of occurrence. Due to a small sample

Table 7. Home ranges of 16 gray squirrels on Oak Park Estates, Plover, Wisconsin, 1980-1981.

	Number of Individuals	Average Home Range (ha)
Adult Male	4	5.44 (13.43)[a]
Adult Female	4	3.84 (9.47)
Juvenile Male	4	3.35 (8.27)
Juvenile Female	4	2.64 (6.53)
Total	16	3.81 (9.42)

[a]Acres in paranthesis.

size of households, no significance could be inferred concerning any variables.

Average lot size on Oak Park Estates is 0.34 ha (0.84 A). As determined from questionnaires, all lots are somewhat wooded ($\bar{X}$/lot=36.5%), with the remainder being in lawn ($\bar{X}$/lot=34.0%), buildings, or gardens. Eighteen of 43 respondents (42.0%) grew vegetable gardens in 1980 and 1981 that ranged from 2.7 to 332 m^2 (10 to 1,200 $feet^2$) and averaged 93.0 m^2 (336 $feet^2$) in size. Most common vegetables planted were tomatoes, beans, peppers, squash, cucumbers, peas, and carrots, respectively. Preferred locations for gardens were the southeastern, southwestern, eastern, and western parts of lots. Of all gardens, 11 (61.0%) were fenced in an effort to exclude gray squirrels and other small mammals. One of 11 residents indicated that fencing was successful in preventing entry by animals. A comment by many residents was that they would not attempt to garden any longer or had stopped gardening in the past because of gray squirrel and cottontail rabbit damage to plants.

Twenty-four residents of Oak Park Estates (55.8%) maintained bird feeders on their lots in 1980 and 1981. Twenty-two of these residents (91.6%) have observed gray squirrels at their feeders at one time or another. As with gardens, many residents have given up on the idea of feeders for birds because gray squirrels ate most or all of the feed put out.

The most common type of feed in feeders is a commercial bird feed mixture (83.0% occurrence). Sunflower seeds, suet, bread, corn, peanuts, and popcorn, in order of frequency used, were also present in feeders. The majority of residents feed wildlife in the winter (62.5%),

with fall (37.5%), spring (25.0%), and summer (4.1%), representing seasons of lower feeding occurrence by residents. Nine feeders (37.5%) were supplied year-round with feed of some type. The quantities of feed ranged from 2.3 to 545 kg (5 to 1,200 pounds) and averaged 68.6 kg (151.2 pounds) per feeder per year. Eleven residents (45.8%) made no attempt to control gray squirrels at feeders. Of the 13 residents that attempted to control gray squirrels at feeders, 10 (41.6%) felt they were unsuccessful. The most commonly observed control measure was an inverted conical piece of sheet metal attached to the feeder pole approximately 0.8 to 1.1 m (3 to 4 feet) above the ground (Fig. 5). The inverted sheet metal cone seems to be the most successful if feeders are placed an adequate distance from trees or other structures from which squirrels can jump onto feeders. One resident reported that there had been no problems with gray squirrels at either his feeder or garden since he had placed an electric insect killer in a nearby tree. The same resident employed no other control, i.e., metal on feeders, but did have a dog that may have acted as a control to some extent. Some residents have completely enclosed gardens to prohibit squirrel entry as another control measure on Oak Park Estates (Fig. 6).

Questions were asked as to number of children at home and their ages in an attempt to determine if children may affect gray squirrel denisty and distribution. Thirty-seven residents of Oak Park Estates (86.0%) had children living at home in 1980 and 1981 ($\bar{X}$=2.2 children/home). Mean age of children was 12.8 years with 30 homes having 2 children at home, 10 having 3, and 3 having 4 children at home in 1980 and 1981.

Fig. 5. A wildlife feeder with gray squirrel control measures on one woodlot, Oak Park Estates, Plover, Wisconsin.

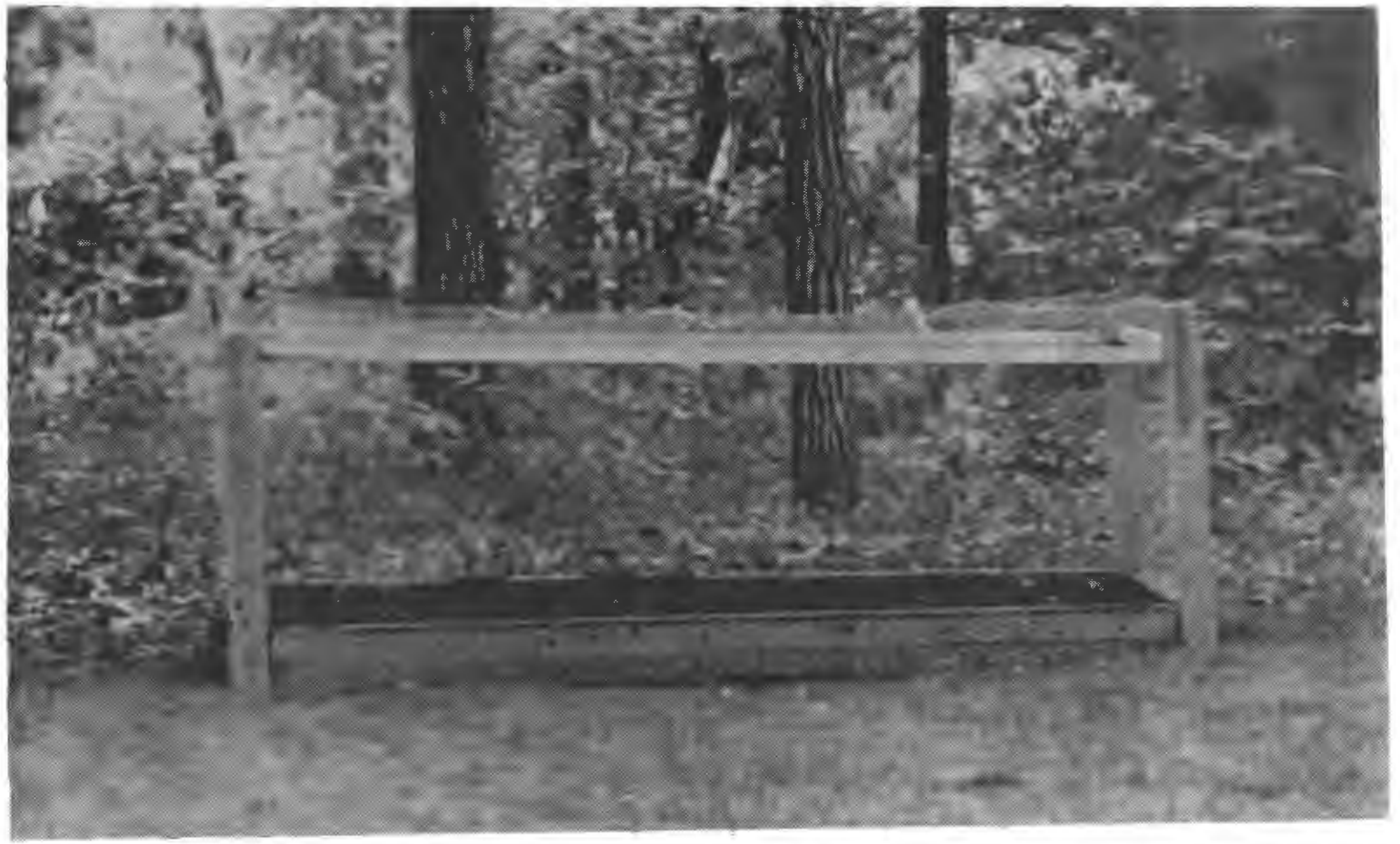

Fig. 6. A completely enclosed garden as a control measure to prohibit entry by gray squirrels on Oak Park Estates, Plover, Wisconsin.

Pets may also influence gray squirrels in a suburban area in much the same way as children. Influences include general harassment of squirrels, predation by hunting, and by presence alone. Dogs were observed on numerous occasions digging under traps that contained squirrels. Twenty-two dogs and 12 cats were present as pets on Oak Park Estates in 1980 and 1981. At one time or another, 14 residents (63.6%) who own dogs observed them chasing squirrels. Cat owners observed 5 of 12 cats (41.6%) carrying out similar activities.

Problems and/or damage related to gray squirrels in suburban areas may be one of the better understood areas concerning urban/suburban wildlife because of the number of complaints received by local law and game officials. Comments concerning gray squirrels on Oak Park Estates ranged from having no problems or damage to having multiple complaints (Table 8). Most complaints involved eating garden vegetables, damage to resident property such as chewing through screens and garage doors, and digging in lawns to bury or dig up acorns.

Gray squirrels, a desired wildlife species in most cities (Brown et al. 1979, Dagg 1974), appear to be desired on Oak Park Estates but in controlled numbers. Twenty-four residents (55.8%) feel that there are about the right number of squirrels on their lots, while 18 residents (41.8%) feel there are too many. Only 1 resident felt there were too few squirrels present.

Table 8. Most commonly occurring gray squirrel problems and/or damage on Oak Park Estates, Plover, Wisconsin, 1980 to 1981, as recorded on questionnaires.

Problem or Damage	% Occurrence [a]
None	25.6 (11) [b]
Eat garden vegetables	27.9 (12)
Damage property	25.6 (11)
Dig in lawn	21.0 (9)
Get into garbage	21.0 (9)
Eat bird seed	14.0 (6)
Damage oak trees	7.0 (3)
Run on house (garage)	4.6 (2)
Dig up flowers	4.6 (2)
Nest in property	4.6 (2)

[a] Total occurrence on all questionnaires. Some multiple responses.

[b] Number in parenthesis represents total number of responses.

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Appendix A

Questionnaire used to obtain environmental variable data on Oak Park Estates, 1980-1981.

GRAY SQUIRRELS IN OAK PARK ESTATES

Appendix A

Questionnaire used to obtain environmental variable data on Oak Park Estates, 1980-1981. Continued.

university of wisconsin/stevens point • stevens point, wisconsin 54481

Dear Oak Park Estates Resident:

As you may recall, I have been studying gray squirrels on Oak Park Estates since October, 1980. Part of my research will involve determining what impact neighborhoods and their residents have on squirrels. For example, a family with a lot of cats and dogs may keep squirrel numbers down while another family may feed squirrels year-round and increase the number.

I have developed a questionnaire to better help me to assess the impact of neighborhoods on squirrels. The questionnaire is enclosed. I would very much appreciate it if you could complete the short, easy-to-answer questionnaire and return it to me in the enclosed pre-addressed, pre-stamped envelope at your convenience.

Some of the questions may not seem relevant but they are actually important. For example, question 22 asks if you fertilize your lawn each year. Lawn fertilizers may improve growth of oak trees and result in higher acorn production (squirrel food).

I sincerely appreciate your help with this project. If you have any comments about the questionnaire or my study, please feel free to write them down on the back of the questionnaire.

Sincerely yours,

Ken Andersen

College of Natural Resources • (715) 346-4617

Appendix A

Questionnaire used to obtain environmental variable data on Oak Park Estates, 1980-1981. Continued.

GRAY SQUIRRELS IN OAK PARK ESTATES

1. What is your name and address: _____

_____

Plover, WI 54467

2. What type of house do you live in ?

____ Ranch

____ 2-story

____ A-frame

____ Other (please specify): _____

3. What is the size of your lot in acres ?

____ acres

4. What percent of your lot would you estimate is wooded ?

____ percent

5. What percent of your lot would you estimate is in lawn ?

____ percent

6. Did you plant a garden on your lot in 1980 or 1981 ?

____ Yes, in both years

____ Only in 1980

____ Only in 1981

____ Not in either year

IF YOU ANSWERED NO TO QUESTION 6, PLEASE SKIP TO QUESTION 11

7. What is the size of your garden, in square feet ?

____ square feet

Appendix A

Questionnaire used to obtain environmental variable data on Oak Park Estates, 1980-1981. Continued.

8. What did you plant in your garden in 1980 or 1981 ?

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

9. Where is the garden located on your lot ?

____ Northern part ____ Southern part

____ Northeastern part ____ Southwestern part

____ Eastern part ____ Western part

____ Southeastern part ____ Northwestern part

____ Center of lot

10. If your garden is fenced, do you think the fencing keeps squirrels out ?

____ Yes

____ No

____ Not fenced

11. Do you have any wildlife feeders on your lot ?

____ Yes

____ No

IF YOU ANSWERED NO TO QUESTION 11, PLEASE SKIP TO QUESTION 17

12. What type of food do you put in the feeders ?

____ Commercial bird seed

____ Sunflower seeds

____ Suet

____ Other (please specify): _____

Appendix A

Questionnaire used to obtain environmental variable data on Oak Park Estates, 1980-1981. Continued.

-3-

13. How often do you feed wildlife throughout the year ? (CHECK ALL THAT APPLY)

____ Spring

____ Summer

____ Fall

____ Winter

14. Approximately how many pounds of wildlife food would you estimate you use each year ?

____ pounds

15. Do you try to prevent squirrels from feeding on the wildlife food you put out ?

____ Yes, and it seems successful

____ Yes but it's not too successful

____ No

16. Have you seen squirrels feeding at your wildlife feeders ?

____ Yes

____ No

17. Do you have children at home ?

____ Yes

____ No

IF YOU ANSWERED YES TO QUESTION 17, WHAT ARE THE AGES OF YOUR CHILDREN ?

Child # 1. ____	Child # 6. ____
Child # 2. ____	Child # 7. ____
Child # 3. ____	Child # 8. ____
Child # 4. ____	Child # 9. ____
Child # 5. ____	Child #10. ____

Appendix A

Questionnaire used to obtain environmental variable data on Oak Park Estates, 1980-1981. Continued.

18. How many dogs do you have ?

____ None ____ 4

____ 1 ____ 5

____ 2 ____ 6

____ 3 ____ 7

19. To your knowledge has your dog(s) chased or killed squirrels on your lot in the past 2 years ?

____ Yes

____ No

____ Do not have a dog

20. How many cats do you have ?

____ None ____ 4

____ 1 ____ 5

____ 2 ____ 6

____3 ____ 7 or more

21. To your knowledge has your cat(s) chased or killed squirrels on your lot in the past 2 years ?

____ Yes

____ No

____ Do not have a cat

22. Do you fertilize your lawn each year ?

____ Yes

____ No

23. Do you fertilize your garden ?

____ Yes

____ No

____ Do not have a garden

Appendix A

Questionnaire used to obtain environmental variable data on Oak Estates, 1980-1981. Continued.

24. Please describe any problems or damage you have had with gray squirrels on your lot in the past.

_____

_____

_____

_____

_____

_____

_____

_____

25. Have you previously tried to remove (i.e., trapping, shooting) squirrels from your lot ?
(It is proper for landowners to remove squirrels using prescribed methods)

____ Yes

____ No

IF YES, HOW MANY SQUIRRELS HAVE YOU REMOVED IN THE PAST 2 YEARS ?

____ squirrels

26. How do you feel about the number of gray squirrels on your lot ?

____ Too many squirrels

____ Just about the right number of squirrels

____ Too few squirrels

27. Although it may only be a guess, how many squirrels do you think live on your lot ?

____ squirrels