HABITAT REQUIREMENTS OF FOUR SELECTED SPECIES IN THE URBAN ENVIRONMENT

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ABSTRACT

HABITAT REQUIREMENTS OF FOUR SELECTED SPECIES IN THE URBAN ENVIRONMENT

By

Darrell Lee Cauley

Much of the research involving wildlife in urban areas has dealt with the elimination or reduction of species considered health hazards or pests. There has been little or no research to determine the ecology of urban wildlife, or resident attitudes toward wildlife in our cities. In this study, the techniques of radio telemetry, capture-recapture, vegetative analysis, and resident interviews were employed to determine the movement, activities, ecology, and desirability of cardinal (*Richmondena cardinalis*), blue jays (*Cyanocitta cristata*), raccoons (*Procyon lotor*), and fox squirrel (*Sciurus niger*) in an area in Taylor Township, a suburb of Detroit, Michigan.

Cardinals in my study had significantly smaller mean home ranges, and higher populations than those in natural habitat reported in the literature. Seventy four percent had an active feeder within their home range, and several appeared to expand their ranges to include a feeder. Cardinals nested in areas whose total leafy volume varied from 279,589 to 2,254,247 cu. ft./acre, and as a result appeared plastic in their habitat requirements. Movement in the vertical stratum, however, did not vary significantly between the habitat types.

Blue jay densities in my study were similar to those reported for other urban areas at this latitude. All the blue jay ranges contained at least one active feeder station, and jays appeared to alter their utilization of the vertical stratum to take advantage of feeders.

These birds nested exclusively in sections with mature deciduous vegetation, and their nesting heights were significantly higher than those reported in the literature.

Raccoon densities in this study are significantly higher than those reported for wild Michigan populations and they appear to have smaller home ranges than those reported for wild raccoons. This compression of home range and increased density is probably due to the abundance of food in urban areas (i.e., refuse, gardens).

Fox squirrels in my study area had a population density which approximated that reported for wild Michigan squirrels. Home ranges, however, were significantly smaller than those reported in the literature. The smaller home ranges, but equivalent density indicates space available for expansion of squirrel numbers into unused habitat. This lack of expansion is probably caused by the overall scarcity of cavity dens in urban areas due to frequent pruning and removal of dead trees.

Resident response to the questionnaire was strongly in favor of wildlife in the city. Approximately 88 percent of those interviewed regularly observed wildlife on their property. All of the study species were considered desirable by at least 75 percent of those interviewed.

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INTRODUCTION

The study of urban wildlife is important partly because it is a field that has been overlooked in the past and little is known about animals in urban areas, and also because it could lead to the proper management of these animals to the benefit of man. The 1970 Federal census revealed that three fourths of our country's population is located in metropolitan areas, and that this figure is increasing rapidly. The majority of people therefore, receive much of their appreciation and knowledge of wildlife from those species inhabiting the cities. This same majority constitutes the political force which can effect conservation practices throughout our country. If urban dwellers are to make the environmental decisions, it is vital that they become aware of the mechanisms of the ecosystem and the role that they play in that system.

Many researchers (Davey, 1967; Twiss, 1967; and, Stearns, 1967) feel that one way of educating the public is to increase the amount of exposure of city dwellers to a variety of wildlife species. Although there are large numbers of birds and mammals in our urban areas, many are considered pests or health problems (starlings, pigeons, and rats, for instance). Management in the past, therefore, has been concerned primarily with reducing or eliminating many of these species. Very little is known about the habitat requirements or population dynamics of some of the more desirable wildlife found in cities. Grosvenor (1916), Whitaker (1916), and Pitelka (1942) have published reports of high wildlife densities in the vicinity of man's establishments, and there are numerous texts and government extension service publications (Baker, 1943; Davison, 1967; Tenes, 1968; Courtsal, 1969; McAtbe, 1943; Longnecker and Ellarson, 1960; USDA, 1969) which describe methods of attracting wildlife by means of plantings, nest boxes, and feeding stations. None, however, are species specific concerning habitat requirements and other ecological considerations, and most exclude mammals. Davey (1970) has stated that, "The accumulation and analysis of available information on breeding populations of birds and mammals within urban areas is an early need."

There are other human preferences that must be analyzed. Do urbanites want wildlife? Are they willing to pay the costs? Finally, which species should we manage? The first two questions can be answered by data accumulated through the National Recreational Survey. There were about 98 million activity days in nature walks in the summer of 1960, as compared to 117 million activity days for the summer of 1965, or an increase of 19 percent in five years. The membership of the Wilderness Society quadrupled between 1957 and 1967 (9,000 to 36,000), and the 1965 survey of outdoor recreation activities reported that there were over eight million bird watchers and three million wildlife photographers in this country. Obviously, people are becoming more interested in wildlife. That national sales of commercial bird seed have soared in the past ten years also indicates that many are willing to pay to draw wildlife to them. The third question, what species should we manage, will have to be answered in part by the people living in the city.

The objectives of this study were:

(1) to determine the composition and structure of an urban vegetative community;

(2) to examine environmental factors associated with the four study species: raccoon (*Procyon lotor*), fox squirrel (*Sciurus niger*), blue jay (*Cyanocitta cristata*), and cardinal (*Richmondena cardinalis*);

(3) to describe the cultural effects of urban areas on wildlife;

(4) to suggest possible management techniques for the four study species; and

(5) to determine resident attitudes toward wildlife.

STUDY AREA

The study site is approximately 159 acres located in Taylor Township on the southwestern fringe of the Detroit, Michigan, metropolitan area. Primarily a residential community of middle-class homes, it is surrounded on three sides by subdivisions; the southern terrain is bordered by light industry. The soil is predominantly Pawamo loam, with a gentle 0 to 2 percent slope. These soils contain a calcareous silty clay loam which drains poorly. Kibbie fine sand was also present, but it constituted less than 10 percent of the total soil. A small rolling area of 6 to 12 percent slope abutted the only large woodlot on the site. The runoff from these slopes and the poor drainage of the soils created flood conditions in the woods during wet periods. Potholes of water were present in the woodlot throughout the summer months.

Five distinct community types are present within the study site (Figure 1). The first two are non-natural and include a housing subdivision of 20 acres, or 12.5 percent of the total land area, and a widely spaced urban residential section with homes along Wick Road and Mortonview Avenue. The urban residential (UR) area is 65 acres or 41 percent of the total land space. Three natural plant communities are present: a lowland deciduous woodlot of 20 acres (12.5 percent), a shrub community of 6 acres (4 percent), and two open field communities totaling 48 acres (30 percent).

Homes on the site were not evenly dispersed, with 63 percent of the total 146 dwellings located in the subdivision. These houses,

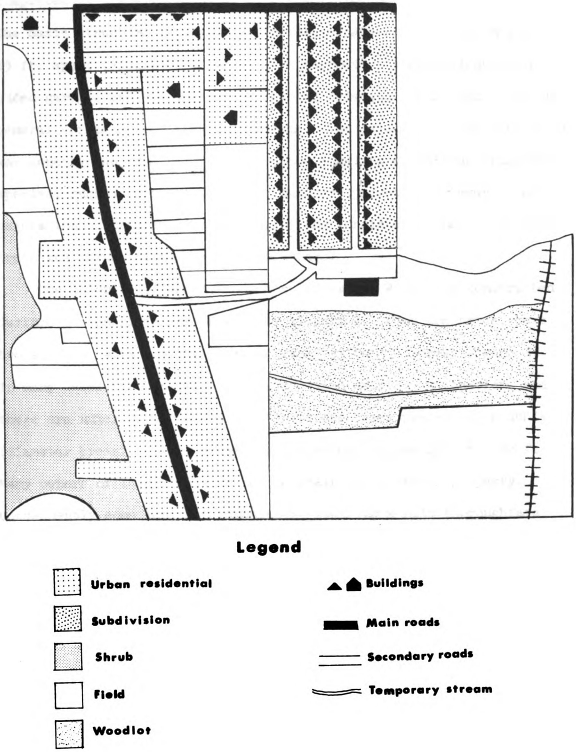


Figure 1. Habitat types and distribution of houses in the study area.

completed in the early 1950's, have a uniform lot size of 65 X 135 feet. The basic structure is identical; brick, single-storied, and spaced 15 ft. apart (Figure 2). Twenty five percent of the residents have added garages and various out-buildings; swimming pools, etc., but the general configuration remains constant. The majority of the landscaping was done by the original contractor and consists of various ornamental species, such as spruce, barberry, juniper, privet, and cedar. The vegetation in this section was sparse and consisted primarily of low trees and shrubs planted around buildings.

The majority of homes along Mortonview and Wick were constructed during the immediate post World War II period. Most are brick, have two stories, with lot size varying from .33 to 3.2 acres (Figure 3). In many cases the construction incorporated existing vegetation, and there are numerous deciduous and coniferous trees present with dbh's (diameter breast height) exceeding 30 inches, and heights to 102 ft. Many owners of larger lots do not maintain all of their property. Consequently some land not immediately abutting a main thoroughfare has undergone natural plant succession. This section had the second highest vegetative volume and appeared to have a good distribution and diversity of plant species.

The deciduous woodlot was dominated by sycamore (Plantanus occidentalis), silver maple (Acer saccharinum), and white ash (Fraxinus americana). This section received heavy use by neighborhood children. Much of the understory was trampled or damaged by chopping, bark stripping, and ground fires.

The shrub community also received damage similar to that found in the woodlot. The dominant plant species of the community included

Figure 2. Aerial photograph of houses in the subdivision.

Figure 3. Aerial photograph of houses in the urban residential section.

slippery elm (Ulmus fulva), hawthorne (Crataegus sp.), ash-leaved maple (Acer negudo), and various dogwoods (Cornus sp.).

A large part of the open fields adjacent to houses in the Mortonview-Wick area was planted to vegetable gardens. The most southern field community was formerly a pasture and consisted of various weeds, grasses, and forbs. Both areas did not undergo normal plant succession due to cultivation or frequent cutting.

There were no permanent streams on the study site. The woodlot, as stated, underwent seasonal flooding, and contained potholes of water that remained throughout the summer, as well as, a seasonal stream. Water was also available to wildlife from decorative ponds, swimming pools, bird baths, and similar sources. It is doubtful that water was a limiting factor for any of the species studied.

METHODS

During the spring and summer of 1972, linear transects were established to determine the relative abundance of the various song bird species. A map of the study area was used to locate each bird sighting and to obtain composites of activity centers. The data included:

1. species
2. height observed
3. total height of cover utilized
4. location

The cardinal and blue jay were selected as study species based upon the frequency and number of sightings, visibility, and variety of habitat utilized.

Live trapping for birds began on 15 April and ended 15 July, 1973. Birds were captured using a modified decoy trap designed by the USDI. Each trap was 3 X 3 X 5 ft and constructed of 1 inch mesh welded wire. Four traps were initially employed, but one was stolen from the woodlot during the first trap day, and bird trapping in this area was discontinued. The remaining three bird traps were checked at two to three hour intervals to discourage further theft. Traps were spaced to insure maximum coverage of the study area. Random spacing of bird and mammal traps was not possible because residents frequently denied permission to place traps on their property and because each location had to include a suitable structure to secure the trap. Traps were, therefore, placed to achieve optimum coverage of each habitat type (Figure 4).

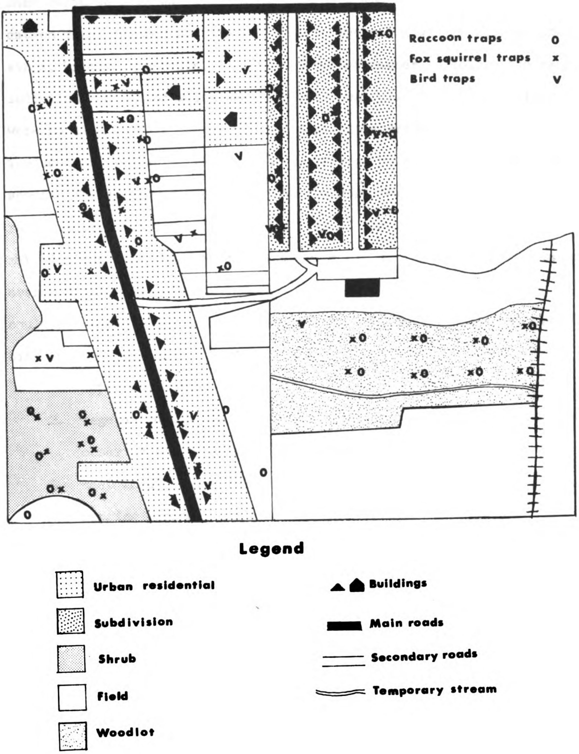


Figure 4. Locations of bird and mammal trap positions.

Each captured bird was dyed using Nyanzol A and was banded for identification using colored plastic leg bands. Nyanzol A was applied to the wings, breast, and tails, in a predetermined manner to color code each individual, a method which was highly successful. Twenty one birds were handled in this manner with no apparent adverse effects. Baits included cracked corn, whole corn, commercial bird seed, and sunflower seeds. The sunflower seeds provided the best cardinal-blue jay capture rates and reduced the number of captures of the smaller bird species. Marked birds were observed for periods of two to three hours continuously over a minimum two week period, or until home ranges or territories could be mapped (Odum and Kuenzler, 1955). The data recorded for both bird species include:

1. capture location
2. vegetative and non-vegetative cover utilized to include heights observed and total height of cover
3. nest location and heights
4. singing perches
5. feeding areas

Mammal trapping began on 9 July and was concluded on 29 October, 1973. Squirrels were captured using a Mowhawk Model 104 live trap (6 X 6 X 24 inches). When possible, traps were spaced to achieve the maximum coverage of each habitat type (Figure 4). Ten squirrel traps were set out during each trapping period. The traps were placed in one of the four habitat types (shrub, urban, residential, woodlot, and subdivision) for three to four days at three week intervals. The location of every capture was marked, and each individual was sexed, aged (juvenile-adult), and color dyed (Nyanzol A) for identification.

The squirrels were anesthetized using ether in a variable sized anesthetizing chamber described by Schinner and Cauley, 1974. This permitted the coded dyeing and the attachment of transmitter collars. Baits for the fox squirrel included sunflower seeds, loose corn, and dried ear corn. The ear corn provided the best capture frequencies. Squirrel traps also had to be closely monitored (2 hours or less) to prevent theft. Squirrel trapping in the woodlot was discontinued after 16 trap days, since teenagers were observed tampering with traps, releasing animals, and removing baits. Squirrel trapping was conducted in the shrub areas only where traps could be secured to large trees because of the amount of activity in that area.

Raccoons were captured using a Mowhawk Model 108 live trap (11 X 12 X 32 inches). The raccoon traps were spaced so that maximum coverage could be achieved for each habitat type (Figure 4). Traps were picked up each morning and were replaced after dark to reduce tampering by neighborhood children. A mixture of sardines and dog food was used as bait (Schinner and Cauley, 1974). Each raccoon was anesthetized using the technique previously mentioned for fox squirrels. The location of capture, relative age (juvenile-adult), and sex were noted. Each animal was also toe clipped for identification.

Selected squirrels and raccoons were radio tracked to determine home ranges, movement, and activity patterns. Transmitters were essentially those described by Cochran and Lord (1967) with the copper collar serving as a transmitting antennae (Figure 5). The receiver was portable, 12 channeled, with a three element Yagi antenna. Position sitings were taken at 30 minute intervals over a minimum seven-day period for each radio tracked animal. The number of separate radio fixes varied from 26 to 77 for fox squirrels and 46 to 77 for raccoons. The data recorded for both species included:

Figure 5. Photo of completed squirrel and raccoon transmitters.

1. position
2. onset and termination of activity
3. den sites
4. feeding areas
5. nesting heights
6. tree species
7. dbh
8. total height of den trees

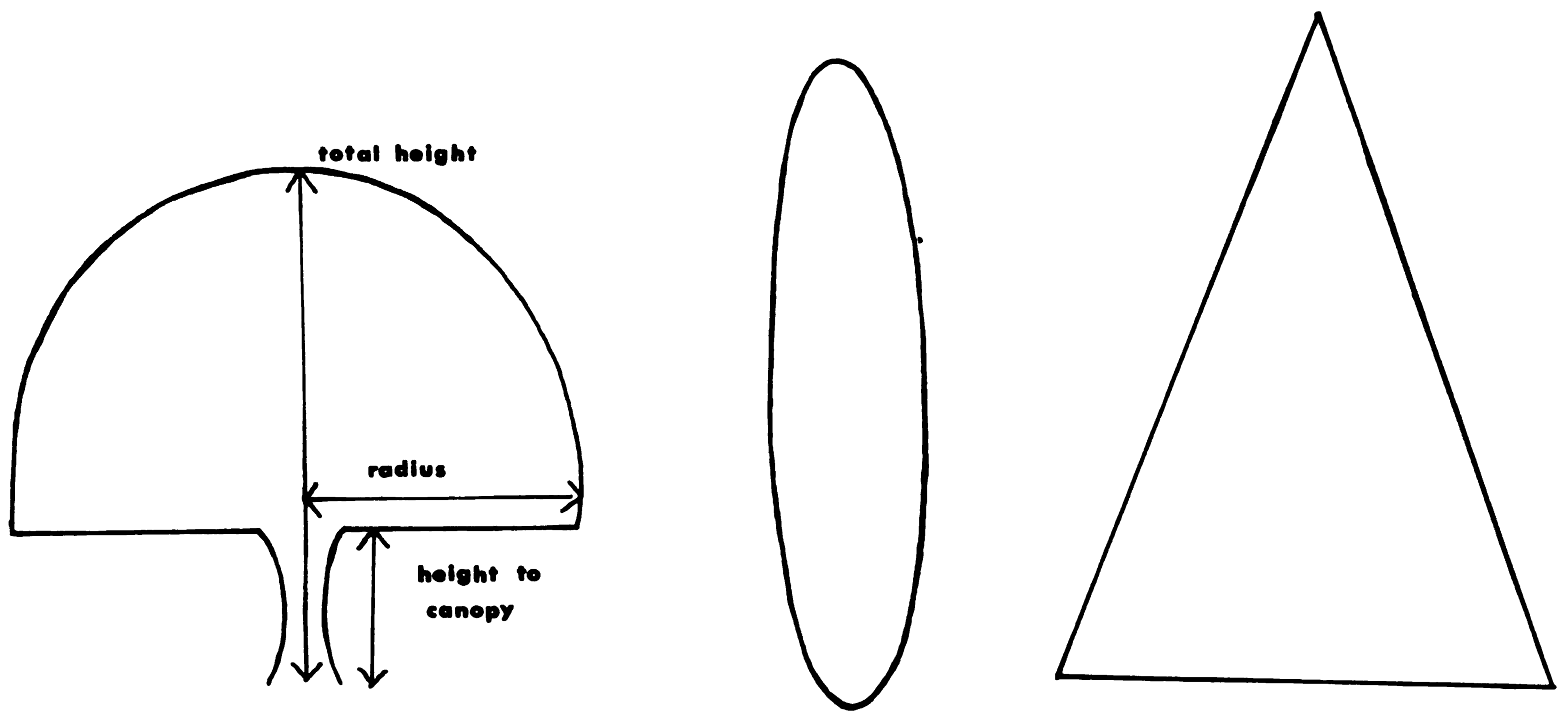
Radio fixes were accurate to the exact location of the squirrels tracked, since visual verification was possible. Raccoon sightings were accurate to $\pm$ 10 ft. in both the woodlot interior and the shrub area as verified by walk-ups on tracked individuals. The accuracy varied directly with the proximity of the receiver to the transmitter. Position sightings, therefore, were made only when the signal strength meter (on the receiver) indicated that the operator was very near the transmitter ($<$ 100 yards). Squirrels were monitored from 30 minutes before sunrise to 30 minutes after sunset. Raccoons were tracked from 30 minutes before sunset to 30 minutes after sunrise. In addition, frequent daytime sightings were made to verify raccoon den locations and to determine any movement during the daylight hours.

VEGETATIVE ANALYSIS

A simple 20 X 50 ft. plot was used to sample the woodlot and the shrub area (Cain and Castro, 1959) and plots were spaced at 100 foot intervals. Measurements were made in ten plots in the woodlot, and in four in the shrub area for a total sample of two percent of each habitat type. Further sampling was unnecessary because of the low number of new species encountered in each subsequent sample. Both the woodlot and the shrub sections were relatively uniform habitat types. The vegetative data collected included:

1. species
2. height
3. height to crown
4. radius
5. shape
6. relative density
7. cavity and leaf nests heights

The crown volume of every tree sampled was calculated in the following manner. The basic shape of all trees in the study area was recorded as a profile class with three basic profiles: truncated sphere, cylinder, and cone (Figure 6). The radius of each tree was considered circular in horizontal cross section, or determined by an average of two measurements. Overall height and height to canopy were measured to the nearest foot using a Haga altimeter. These data were



Truncated sphere   Cylinder   Cone

Figure 6. Profile classes of trees in the study area

applied in a computer program supplied by Allen Tipton (Fisheries and Wildlife Department, Michigan State University), to formulas based on the various geometric shapes to yield the total leafy volume of each tree in the sample. Shrub volumes were estimated by reducing the shape of each plant to a box and performing the appropriate calculations.

The same data were collected in the urban residential and subdivision areas. The plot sizes in these sections were determined by property boundaries. Plot size, therefore, varied from 8775 sq. ft. to 1.2 acres. Eight samples were taken in the urban residential section and 15 in the subdivision, for a total area of 6.81 and 3.01 acres, respectively. This provided a sample of 10.5 percent of the UR section and 15.1 percent of the subdivision. Additional information gathered in the residential areas included:

1. volume
2. water sources
3. areas of grass, gardens, and bare ground
4. location of bird feeders and bird houses

Approximately 17 percent of the study area homes were randomly selected for interviews to determine resident attitudes toward wildlife, the extent of supplementary feeding, shelter, and water available, and the identity of birds and mammals most frequently observed. The surveyor used a prepared questionnaire and interviewed the head of household or a resident adult (age 18 years or older).

RESULTS

Birds

Ninety three trap days were recorded for cardinals and blue jays, for a combined capture frequency of 22.58 percent. Thirteen cardinals were captured and marked during the study (Table 1). The cardinal breeding density was 5.03 pairs per 100 acres (prs./100 acres). The mean home range for this species was 3.6 acres, with a variance of .96 to 7.27 acres. Eight home ranges were found in the study area; five in the urban residential section, two in the shrub section, and one in the woodlot (Figure 7). Six ranges contained at least one active bird feeder.

Three hundred and forty nine measurements were made of cardinal positions in the vegetative and non-vegetative strata of the four habitat types. The cardinal activity heights over the entire area varied from 0 to 60 ft., with a mean of 12.63 ft. Ninety percent of the height measurements were within a range of 0 to 25 ft. (designated the high activity stratum). The mean activity heights for the four habitat types were compared using the Student-Neuman-Keuls (SNK) test for means of unequal sample size. The least significant range (LSR) value was 4.61 (at .05). The LSR is that range within which there is no significant difference between the compared means. The observed range of cardinal heights in the four habitat types was 4.48 ft., or within the LSR value.

Table 1. Cardinal trapping data.

Identification Number	Sex	Relative Age	Capture Location	Status	Home Range In Acres
1	male	adult	woodlot	resident	2.42
2	male	adult	UR	transient	
3	female	adult	UR	transient	
4	male	adult	sub-division	resident	7.27
5	male	adult	woodlot	transient	
6	female	adult	sub-division	transient	
7	male	adult	UR	resident	.96
8	male	adult	UR	resident	2.13
9	male	adult	UR	resident	2.06
10	male	adult	woodlot	resident	6.81
11	male	adult	woodlot	transient	
12	male	adult	UR	resident	4.0
13	male	adult	UR	resident	3.14

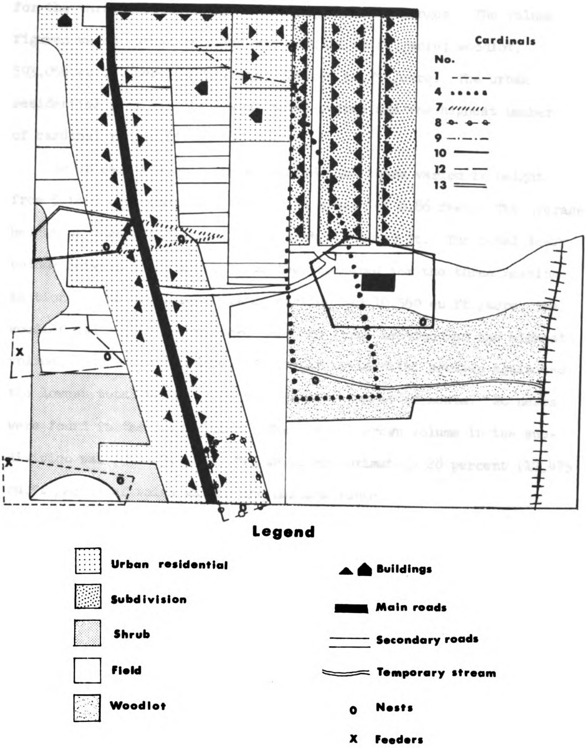


Figure 7. Cardinal home ranges in the study area.

The crown volume within the high activity stratum was compared for the three habitat types containing cardinal ranges. The volume figures were: urban residential, 122,123 cu.ft./acre; woodlot, 593,056 cu.ft./acre; and, shrub, 729,640 cu.ft./acre. The urban residential area had the lowest total volume and the highest number of cardinal ranges (five).

Seven cardinal nests were located, and these varied in height from 5 to 9 feet (nearest foot), with a mean of 6.86 feet. The average height of vegetation containing a nest was 10.29 ft. The total leafy volume between 5 and 10 feet was then compared for the three nesting sections. The urban residential section had 10,560 cu.ft./acre, the woodlot had 35,920 cu.ft./acre, and the shrub section had the highest volume, 108,083 cu.ft./acre. The urban residential section again had the lowest total volume with the greatest number of nests. No nests were found in the subdivision. The overall crown volume in the subdivision was low, 63,182 cu.ft./acre, approximately 28 percent (17,475 cu.ft./acre) of which was in the nesting range.

Eleven blue jays were captured and marked during the study (Table 2). The blue jay breeding density was 2.5 pr./100 acres. Four home ranges were located in the study area, and they varied from 8.40 to 26.0 acres, with a mean of 15.9. The largest blue jay range contained three active feeders, another held two, and the remaining two home ranges had one each (Figure 8).

Two hundred and forty three measurements were made of blue jay positions in natural and non-natural habitats. These heights ranged from 0 to 70 ft., with a mean of 21.48 ft. Approximately 80 percent of the measurements were within a 10 to 40 ft. range (high activity stratum). All of the blue jay home ranges overlapped several habitat

Table 2. Blue jay trapping data.

Identification Number	Sex	Relative Age	Capture Location	Status	Home Range In Acres
1	male	adult	UR	resident	8.40
2	female	adult	UR	resident	
3	male	adult	woodlot	resident	
4	female	adult	woodlot	resident	
5	male	juvenile	UR	resident	
6	male	adult	UR	resident	26.0
7	female	adult	UR	resident	10.0
8	female	adult	sub-division	resident	
9	male	adult	UR	resident	
10	N/D*	juvenile	sub-division	resident	19.2
11	N/D	juvenile	sub-division	resident	

* Sex not determined.

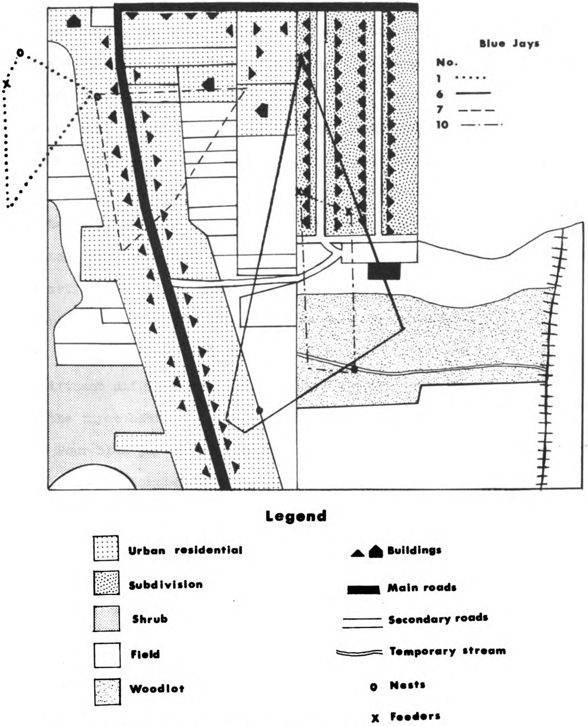


Figure 8. Blue jay home ranges in the study area.

types; therefore, it was not possible to compare leafy volume between the sections. The mean heights of blue jay activity, however, were compared for the three habitats utilized. The shrub area was deleted due to insufficient data. The same SNK test, previously described, was applied, and a LSR value of 7.54 ft. determined at the .05 level. The observed range was 15.02 ft. indicating a significant difference. The source of variance was determined by systematically deleting a habitat type from the comparison. The subdivision contained the greatest deviation from the observed high activity stratum. Figures for artificial perches (such as, fences, roofs, telephone wires, TV antennae, etc.) were deleted from the data, and a new LSR value of 9.62 ft. calculated. The observed range was 7.4 ft. indicating no significant difference between the mean heights of blue jay activity for the three habitat types.

Four blue jay nests were located during the study; three were in the urban residential section, and one was in the woodlot. All nests were in deciduous trees, the mean height of which was 42 ft. The mean nesting height was 34.33 ft. with a range of 27 to 41 ft. The leafy volume between 27 and 42 ft. was compared for the two habitat types containing nests. The urban residential section had 104,176 cu.ft./acre, and the woodlot had a much greater volume of 790,353 cu.ft./acre.

Mammals

Nine raccoons were captured and marked during the study period; four juvenile males, two juvenile females, two adult females, and one adult male (Table 3). Six animals were captured in the woodlot, two in the shrub section, and one in the urban residential section. There

Table 3. Trapping and radio telemetry data collected for raccoons.

Identification Number	Sex	Relative Age	Number of Fixes	Tracking Period	Days Tracked	Onset of Activity	Termination of Activity	Home Range In Acres
3	female	adult	7	7/20	1			
5	female	adult	77	7/20 to 8/4	7	30-150 min. after sunset	90-130 min. before sunrise	24
6	female	yearling	58	7/26 to 8/17	7	110-130 min. after sunset	10-40 min. before sunrise	21
8	male	juvenile	4	9/20	1			
9	male	juvenile	20	9/20 to 9/23	2	90-130 min. after sunset	10-30 min. before sunrise	
1	male	juvenile						
2	female	juvenile						
4	male	juvenile						
7	male	adult						

were no captures recorded in the subdivision, despite 156 trap nights in that area. Four hundred and seventy-eight trap nights were recorded during the study, with a capture frequency of approximately 1.9 percent. Five raccoons were equipped with transmitters to monitor movements and estimate home ranges (Table 3). Two animals left the study area during the first two nights of tracking. Both were juveniles, who may not have been residents. Raccoon number three was dropped because of radio interference caused by citizen's band radios and power lines within its range. Two raccoons did provide sufficient data to plot their home range. Raccoon number 5, an adult female, had a home range of approximately 26 acres (Figure 9). The nightly activity pattern began by exiting a den between 30 and 150 minutes after sunset. Three dens were located for this animal, two in the woodlot and one adjacent to a dry creek bed approximately 150 yards south of the woodlot (Figure 9). One of the woodlot dens was located in a dead basswood tree; the other was in an abandoned groundhog den. After departing its den, raccoon five frequently foraged entirely within the woodlot. On one occasion this animal was detected behind the dwellings along the western border of the woodlot apparently foraging in the garbage cans. Raccoon five frequently used an exposed limb of an apple tree as a den site. This tree was located adjacent to a dry creek bed south of the woodlot. There were feeding signs beneath the tree, and this animal probably used this tree as a foraging site and a den. Raccoon five was always at her daytime resting site 30 minutes prior to sunrise. The earliest denning occurred 90 minutes before sunrise. The center of activity for this raccoon was the woodlot where approximately 86 percent of its radio fixes were located. Most of the movement within the woodlot

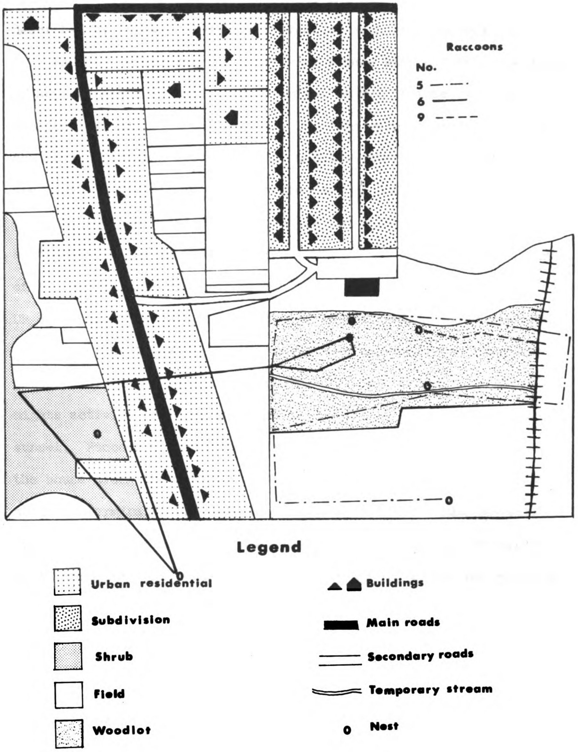


Figure 9. Raccoon home ranges in the study area.

appeared to be at random or similar to the meandering foraging pattern described by Stuewer (1943) as typical of Michigan raccoons.

Raccoon number six was a yearling female with a total home range of approximately 21 acres. This animal denned in three different sections; woodlot, shrub, and UR. Two dens were located in the woodlot, one in an abandoned groundhog den, and the other in the same basswood tree used by raccoon five. A ground den was also located in the shrub section, and the final den site was in the attic of a garage along Mortonview Avenue in the UR section (Figure 9). Ninety-eight percent of the radio fixes for this animal were located in the woodlot and the UR sections. Fifty-four percent were in the woodlot which was used exclusively as a denning area. There were no meandering, foraging patterns displayed by raccoon six while in the woodlot. A typical nights activity began by exiting the den 110 to 130 minutes after sunset. Raccoon 6 then moved directly to her feeding sites behind the house along the western side of Mortonview Avenue. It's nightly activity terminated as early as 40 and as late as 10 minutes before sunrise. This animal never used the same den on successive nights. If it denned in the woodlot the previous day, it's next den would be either in the shrub or UR sections.

A total of 394 trap days were recorded for fox squirrels in this study. Ten squirrels were caught and marked for a capture frequency of 2.54 percent (Table 4). All captures occurred in the urban residential section. The shrub section had 76 trap days and the subdivision had 158 trap days without a capture. Trapping in the woodlot was halted due to tampering and frequent theft of traps. Six fox squirrels were equipped with radio transmitters, and five of these

Table 4. Trapping and radio telemetry data collected for fox squirrels.

Identification Number	Sex	Relative Age	Number of Fixes	Tracking Period	Home Range In Acres	Days Tracked
5	female	juvenile	28	9/5 to 9/20	.8	7
6	male	juvenile	32	9/7 to 9/22	2.5	7
9	female	adult	77	10/5 to 10/24	7.89	13
10	male	adult	34	10/7 to 10/18	2.61	8
3	female	juvenile	38	9/13 to 9/27	1.85	7
1	male	juvenile				
2	male	juvenile				
4	female	adult				
7	male	juvenile				
8	female	juvenile				

provided sufficient data to plot their home ranges and activity patterns (Figure 10). The largest home range was recorded for squirrel number nine, an adult female with a home range of 7.89 acres. The smallest home range belonged to a juvenile female (.8 acres). The mean size of all squirrel home ranges was 3.13 acres. The means of nesting heights, dbh's of nest trees, and total heights of trees selected as nest locations were compared between the urban residential and woodlot sections. No significant differenct (SNK 1, .05) was discovered for any of the nesting parameters.

Squirrels in the urban residential section frequently used non-natural cavity dens. One burrowed beneath a chimney grate to enter and nest (Figure 11). Another chewed through the eaves of a second floor attic and denned in the space between the roof and ceiling (Figure 12). A resident reported three squirrels entering the exhaust ductwork of his gas furnace and making their way into his basement to den in the storage shelves. Tree cavities in the urban residential section were uncommon. Of the five squirrels tracked, only two made regular use of tree cavity dens. A survey of the urban residential section revealed that there were just four trees with cavities that appeared suitable for squirrel dens.

Fox squirrel activity was plotted to determine peak activity periods. Squirrels in this study were most active at noon and 3:00 p.m. (Figure 13). They were least active between 8:00 and 9:00 a.m., and between 6:00 and 7:00 p.m. Their activity began as early as 68 minutes and as late as 345 minutes after sunrise. The mean time for peak of activity was 165 minutes after sunrise.

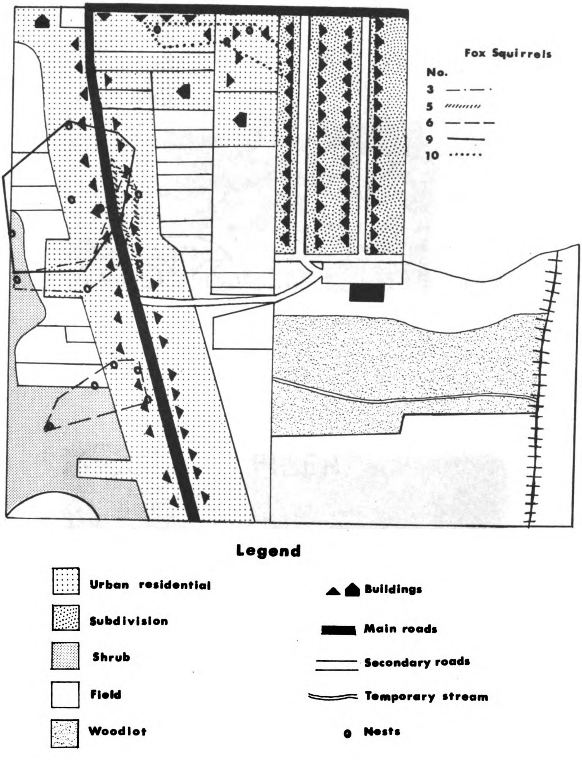


Figure 10. Fox squirrel home ranges in the study area.

Figure 11. Chimney squirrel den located in the urban residential section.

Figure 12. Squirrel den located in the eave of a building in the urban residential section.

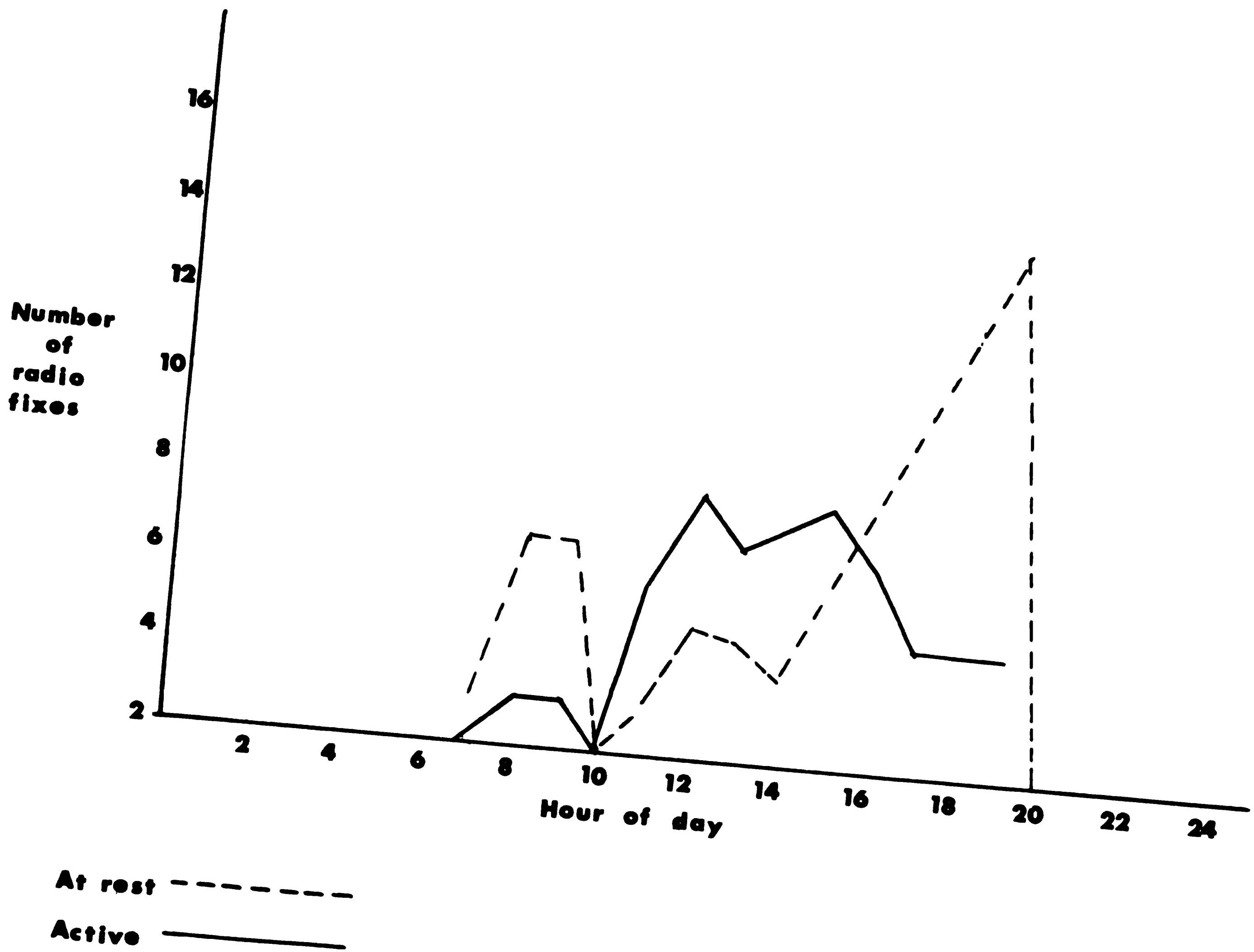


Figure13. Fox Squirrel daily activity

Vegetation

The woodlot was a second-growth stand of all aged deciduous trees consisting primarily of water tolerant species. Historical records for this section are unclear, but the area was logged over, probably within the past 55 to 70 years. The total leafy volume of woody species was 2,252,155 cu. ft./acre. This section had the broadest distribution of leafy volume of any habitat type studied (Figure 14). No single 5 foot stratum between 0 and 85 ft. contained more than 12 percent of the volume. The woodlot was a mixed age stand consisting of 14 deciduous species (Table 5). Sycamore (*Plantanus occidentalis*), silver maple (*Acer saccharinum*), red oak (*Quercus rubra*), and white ash (*Fraxinus americana*) made up approximately 68 percent of the leafy volume (Table 5). There were no coniferous species present. The trees in this section were mature and relatively dense as indicated by the basal area, 90.87 sq.ft./acre. Many contained squirrel nests and two had cavities large enough to accomodate a raccoon. Forty-two trees had at least one leaf nest, not all of which appeared to be active. Six trees had cavities, detectable from the ground, which appeared suitable for a squirrel nest. Thirteen different woodlot species contained some type of squirrel nest, leaf or cavity (Table 6). White ash was most frequently utilized with 21.34 percent of the total nests occurring in this species. Table 6 summarizes nest and den utilization by fox squirrels in the woodlot. The mean dbh for all trees was 17.83 inches. The mean tree height was 62.56 ft., and the mean height to leaf nests and cavity dens was 32.51 and 33.4 ft., respectively. White ash, basswood, and silver maple had the highest frequency of overstory species in the ten sample plots (Table 5). Approximately 40 percent

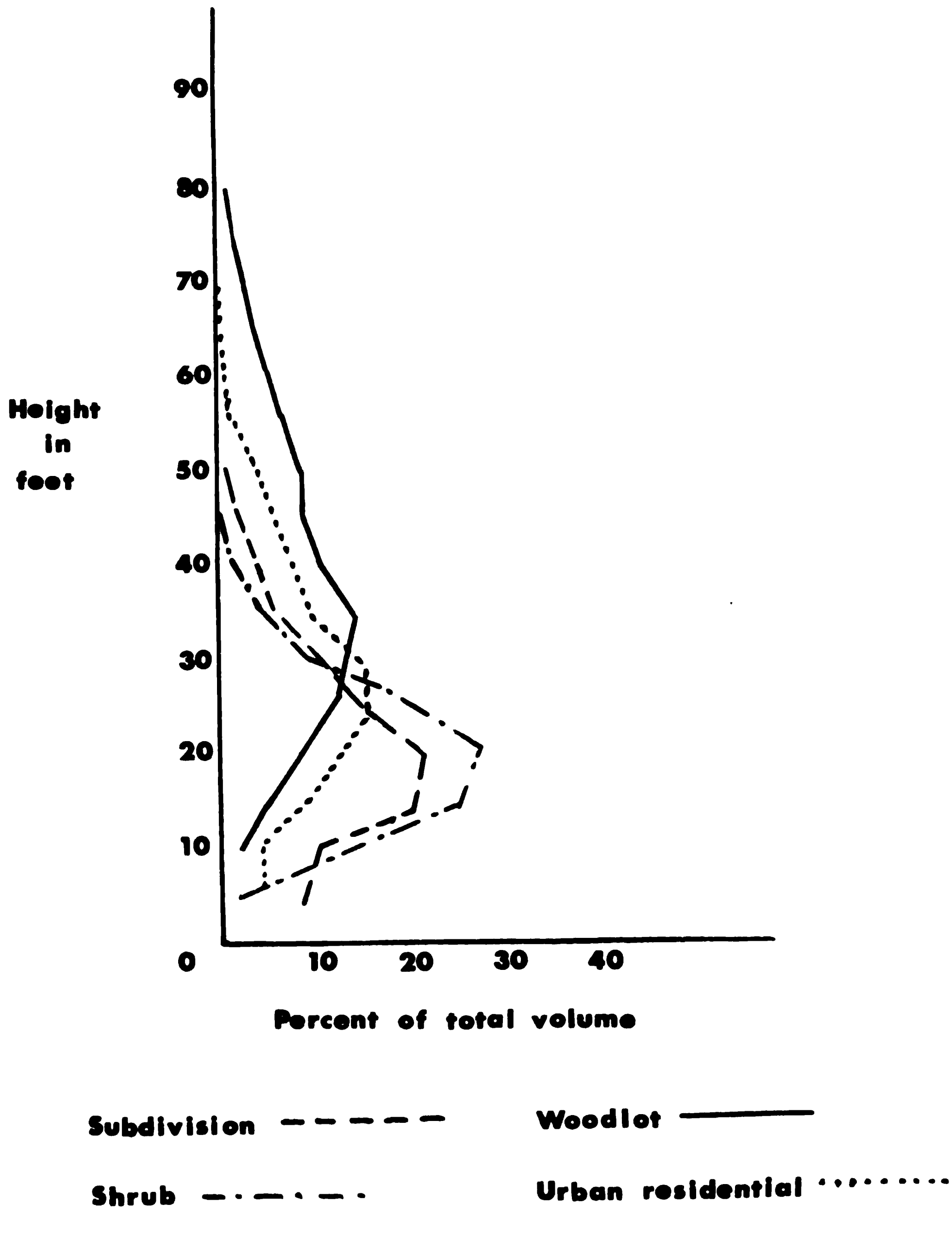


Figure 14. Height disribution of vegetative volume by percent

Table 5. Woody species in the woodlot during the vegetative sampling.

Species	Number In Sample	Frequency Percent	Mean Hgt (ft)	Mean dbh (inches)	Basal Area in sq. ft./acre	Vol. in cu. ft./acre	Percent of Total Volume
Ash, White (*Fraxinus americana*)	13	50	31.83	3.75	5.88	247913	11.01
Basswood (*Tilia americana*)	9	60	32.22	9.56	8.23	103568	4.60
Beech, Blue (*Capinus virginiana*)	13	50	22.46	3.14	3.4	149136	6.62
Crabapple (*Pyrus coronaria*)	2	20	32.5	8.5	3.44	104104	4.62
Elm, Slippery (*Ulmus rubra*)	4	30	23.25	3.5	1.09	24002	1.07
Hawthorne (*Crategus* sp.)	2	20	25.0	4.0	.48	25400	1.13
Hop Hornbeam (*Ostrya virginiana*)	1	10	30.0	4.0	.38	16422	.73
Maple, Silver (*Acer saccharinum*)	13	50	34.12	4.77	17.38	443297	19.68
Maple, Sugar (*Acer saccharum*)	3	20	30.0	5.5	1.96	58627	2.6
Oak, Bur (*Quercus macroura*)	4	10	32.6	6.0	3.58	67766	3.01
Oak, Red (*Quercus rubra*)	11	40	37.6	6.0	14.37	388446	17.25
Oak, Swamp-white (*Quercus bicolor*)	7	40	40.67	5.17	4.95	156454	6.95
Spicebush (*Lindera benzoin*)	1	10	23.0	4.0	.38	6242	.28
Sycamore (*Plantanus occidentalis*)	3	20	4.35	18.67	25.35	460778	20.47
TOTAL	86		32.93	5.1	90.87	2,252,155	100.03

Table 6. Squirrel leaf nests and den cavities in the woodlot.

Tree Species	Number	Mean Tree Hgt. in Ft.	Mean dbh of Tree in Inches	Mean Hgt. to Nest or Den in Ft. N	D	Percent of Total Dens and Nests
Ash, White	9	58.11	13.78	38.0		21.43
Basswood	5	62.0	13.8	39.60		11.90
Cherry, Black	1	32.0	4.0	30.0		2.38
Cottonwood	6	88.17	25.67	38.17		14.29
Crategus	4	26.0	5.50	23.0		9.52
Elm, American	1	110.0	34.0	35.0	58.0	2.38
Elm, Slippery	3	36.33	5.67	24.67		7.14
Maple, Red	1	78.0	23.0		33.0	2.38
Maple, Silver	3	73.67	25.67	38.0	22.0	7.14
Oak, Bur	4	89.0	32.25	51.0		9.52
Oak, Pin	2	68.0	12.0	40.0		4.76
Oak, Red	1	63.5	11.0	38.5		2.38
Oak, White	2	80.0	30.5	28.0	32.0	4.76
TOTAL	42					

of the squirrel nests were located in this group, which may indicate that fox squirrels were taking advantage of the most available tree species. Sycamore had the greatest volume, 20 percent of the total, yet sycamore did not contain a squirrel nest. The frequency for sycamore was 20 percent, indicating a narrow dispersal range. The absence of nests in this species may be the result of selection against sycamore by fox squirrels in this study. Six nests (14.29 percent) were located in cottonwood which was totally absent from the sample plots. These trees were clumped in the southeastern portion of the woodlot, and it may be that squirrels in this section selected for cottonwood or utilized this species because of its high frequency in this particular area.

Less than 6.4 percent of the woodlot volume occurred between 0 and 15 ft. (Figure 14), versus 16 percent in the urban residential, 37.3 percent in the subdivision, and 37.7 percent in the shrub section. This low figure may be typical of woods undergoing seasonal flooding but is probably augmented by the amount of damage resulting from human activity.

The urban residential section (UR) had a total leafy volume of 279,589 cu. ft./acre, 5005 cu. ft./acre of which was coniferous. Buildings in this section occupied 43,229 cu. ft./acre or a ratio of crown to building volume of 6.47:1. The vegetation varied to 95 ft. in height and was well distributed with no five foot stratum comprising more than 14 percent of the volume (Figure 14) This section had 28 tree species. Silver maple was the dominant, and accounted for approximately 36 percent of the total volume.

There were a number of ornamental and fruit species present, and these made up for much of the vegetative diversity (Table 7). Pear

Table 7. Woody species observed in the urban residential section.

Species	Number In Sample	Mean Hgt. Ft.	Mean dbh Inches	Basal Area In Sq. Ft./Acre	Volume/Acre In Cu. Ft.	Percent of Total Volume
Apple (*Pyrus* sp.)*	21	23.4	10.7	2.29	17011	6.08
Ash, Green (*Fraxinus pennsylvanica*)	1	23.0	4.0	.013	199	.07
Ash, White (*Fraxinus americana*)	14	44.68	11.22	1.28	28310	10.11
Birch, White (*Betula papyrifera*)	7	31.14	5.38	.18	2679	.95
Cherry sp. (*Prunus* sp.)	10	19.13	7.63	.41	319	1.14
Elm, American (*Ulmus americana*)	7	47.0	15.29	.39	13644	4.87
Elm, Slippery (*Ulmus rubra*)	4	23.33	4.0	.06	249	.09
Hawthorne sp. (*Crategus* sp.)	16	24.33	9.73	.30	9478	3.38
Locust, Black (*Robinia pseudo-acacia*)	1	20.0	1.0	.001	155	.05
Maple, Ash-leaf (*Acer negundo*)	28	29.12	9.54	.77	19447	6.95
Maple, Silver (*Acer saccharinum*)	64	46.16	13.18	9.02	100060	35.76
Maple, Sugar (*Acer saccharum*)	10	29.67	9.22	.41	10434	3.72
Oak, Bur (*Quercus macrocarpa*)	2	38.5	8.0	.11	241	.08
Oak, Red (*Quercus rubra*)	9	50.38	9.0	.90	22333	7.98
Osage-Orange (*Maclura pomifera*)	9	32.9	6.9	.36	6383	2.28

Table 7 (cont'd).

Species	Number In Sample	Mean Hgt. Ft.	Mean dbh Inches	Basal Area In Sq. Ft./Acre	Volume/Acre In Cu. Ft.	Percent of Total Volume
Pear sp. (Pyrus sp.)	9	20.1	10.0	.78	3074	1.09
Pine, Red (Pinus resinosa)	1	34.0	12.0	.12	276	.09
Pine, Scotch (Pinus sylvestris)	1	30.0	10.0	.08	262	.09
Pine, White (Pinus strobus)	1	28.0	10.0	.001	44	.01
Plum sp. (Pyrus sp.)	3	17.33	4.33	.01	534	.19
Poplar, Tulip (Liriodendron tulipifera)	1	37.0	11.0	.003	22	.00
Spruce, Blue (Picea menziesii)	19	23.84	7.21	.12	1830	.66
Spruce, White (Picea glauca)	9	18.11	6.67	.38	573	.20
Tree of Heaven (Ailanthus altissima)	2	24.0	4.0	.01	224	.08
Walnut, Black (Juglans niger)	17	43.73	9.47	.69	20018	7.15
Willow, Weeping (Salix babylonica)	1	30.0	19.0	.03	968	.34
Cottonwood (Populus deltoides)	6	66.5	14.25	.67	6637	2.37
Ornamental shrubs					11285	4.03
TOTAL	273	34.15	9.77	19.39	279589	

*Scientific Names are according to Petrides (1972).

(*Pyrus* spp.), white birch (*Betula papyrifera*), blue spruce (*Picea menziesii*), mock orange (*Philadelphus coronarius*), and juniper (*Juniperus communis*) were the most common. This section had a number of mature trees, but these were scattered, as indicated by the basal area, 19.39 sq. ft./acre. Nineteen trees had at least one fox squirrel nest (Table 8). There were four tree cavities, detectable from the ground, that appeared suitable for a fox squirrel den. None of the trees in this section had cavities large enough to accomodate a raccoon. (Several raccoons, however, were reported using garages and out-buildings as den sites. One raccoon, number six, was frequently radio tracked to a garage den in the southern portion of the UR section). Silver maple, ash-leaf maple, and chinese elm were the trees most frequently utilized by fox squirrels for leaf nests. Approximately 78 percent of the tree nests/dens were located in these three species. As stated, silver maple was the dominant species in the UR section. Since the sample plots varied with the size of the individual lot (.3 to 3.2 acres), it is not possible to compare the frequency of tree species. Silver maple, however, was well distributed over the UR section. Fox squirrels were probably utilizing the most available nesting habitat rather than selecting for silver maple, ash-leaf maple and chinese elm were not well distributed, but clumped in two separate areas. The apparent nesting preference for these two species may be a reflection of the high availability, resulting from clumping, or selection on the part of fox squirrels. The sample size in both the woodlot and UR sections, however, was too small to statistically evaluate nest site preference.

The UR section had a large area of vegetable gardens, approximately 7003 sq. ft./acre. Thirty-eight percent of the UR residents annually

Table 8. Fox squirrel leaf nests and den cavities in the urban residential section.

Tree Species	Number	Mean Hgt. In Ft.	Mean dbh In Inches	Mean Hgt. To Nest or Den In Ft. N	D	Percent of Total Dens and Nests
Apple	1	35.0	23.0	33.0		4.76
Cottonwood	2	67.5	22.0	30.0	26.0	9.52
Elm, American	1	60.0	15.0	40.0		4.76
Elm, Chinese	3	62.0	24.33	34.67		14.29
Locust, Black	1	40.0	17.0		25.0	4.76
Maple, Ash-leaf	4	53.5	18.5	40.25		19.05
Maple, Silver	6	58.5	21.17	33.17		28.57
Dead tree	1	20.0	8.0		15.0	4.76
Non-natural cavities*	2	30.0			22.0	9.52
TOTAL	21	54.79	20.05	35.44	22.0	99.99

*Non-natural cavities deleted from mean estimates.

planted vegetables on some portion of their lot. All gardens were non-commercial and consisted of common varieties of household produce.

The shrub section was in an early succession stage, as evidenced by the basal area, 34.49 sq. ft./acre. The vegetative diversity was low, with a total of five tree species (Table 9). The dominant species was hawthorne (Crategus sp.) with 33.42 percent of the total volume. Slippery elm (Ulmus rubra) had 30.20 percent, and ash-leaf maple 25.89 percent of the leafy volume (Table 9). The vegetation was clumped between 10 and 25 ft. with approximately 70 percent of the volume occurring at this range (Figure 14). The total decisuous volume was 877,211 cu. ft./acre, and there were no coniferous species present. Two squirrel leaf nests were observed in the shrub section. One was found in a hawthorne, and the other in a cottonwood tree. Both nests appeared to be in use (squirrel number five was radio tracked on two occasions to the cottonwood leaf nest). No tree cavities suitable for either mammal species were detected from the ground. Raccoon number five, however, was radio tracked on two occasions to a ground burrow in this section. Approximately 93 percent of the crown volume was 30 ft. or less in height. This fact, as well as the low frequency of mast species (Table 9) probably precluded any significant fox squirrel densities. The mean height and dbh of all trees in the sample was 27.63 ft. and 4.0 inches, respectively.

The subdivision had a total crown volume of 59,489 cu. ft./acre, 3012 cu. ft. of which was coniferous. The volume of structures in this section was 90,241 cu. ft./acre, for a ratio of .63 cu. ft. of crown per cu. ft. of building. The vegetation varied to 65 ft. in height, but the majority (approximately 64 percent) was clumped between 10 to

Table 9. Woody species observed in the shrub section.

Species	Frequency Percent	Number In Sample	Mean Hgt. Ft.	Mean dbh Inches	Basal Area In Sq. Ft./Acre	Volume/Acre In Cu. Ft.	Percent of Total Volume
Elm, Slippery (*Ulmus rubra*)	75	14	30.4	9.27	17.60	264910	30.20
Hawthorne (*Crategus* sp.)	75	6	30.67	4.83	8.96	293170	33.42
Maple, Ash-leaf (*Acer negundo*)	75	10	22.3	3.4	4.45	227122	25.89
Oak, Pin (*Quercus palustris*)	25	1	36.0	7.0	2.94	66146	7.54
Walmut, Black (*Juglans niger*)	25	1	23.0	9.0	.54	25864	2.95
TOTAL		32	27.94	4.24	34.49	877211	100.00

30 ft. (Figure 14). There were a total of 14 tree species in this section, with a combined basal area of 8.33 sq. ft./acre. Silver maple, and weeping willow were the dominant species, with approximately 36 and 24 percent, respectively, of the leafy volume (Table 10). Ornamental and fruit species accounted for much of the plant diversity in this section. Apple trees, however, were the only species, other than those previously mentioned, which represented a significant percentage of the total volume. There were no mast species present, and no squirrel dens or nests were observed. Fox squirrel number ten did frequent the area to take sunflower seeds from a bird feeder. There were also no trees present with cavities suitable for raccoons.

Approximately 27 percent of the residents had vegetable gardens. The average size was 726 sq. ft., and the total area of garden per acre of subdivision was 998 sq. ft.

Questionnaire

In any survey, such as this, the data analyzed are only as accurate as the information received from those people interviewed. The data are presented as absolute values but should be considered as approximations.

Seventy-six percent of those interviewed in the study area enjoyed having wildlife on their property. Sixteen percent were indifferent, and four percent disliked all forms of wildlife. The majority of homeowners (88 percent) frequently to occasionally observed animals around their residences, and 72 percent regularly made food available to wildlife at some time during the year. Food was distributed in all seasons, with the greatest volume of feeding during the winter months.

Table 10. Woody species observed in the subdivision.

Species	Number	Frequency	Mean Hgt. In Ft.	Mean dbh In Inches	Basal Area Per Acre (Sq. Ft.)	Volume Per Acre (Cu. Ft.)	Percent of Total Volume
Apple spp. (*Pyrus* sp.)	4	6.67	22.0	12.0	1.05	6957	11.96
Ash, White (*Fraxinus americana*)	1	6.67	10.0	1.0	.002	19	.03
Birch, Paper (*Betula papyrifera*)	2	6.67	18.0	4.0	.06	350	.59
Birch, Yellow (*Betula lutea*)	1	6.67	30.0	8.0	.12	2397	4.03
Cedar, Red (*Juniperus virginiana*)	3	20.0	8.33	2.67	.05	67	.11
Elm, Chinese (*Ulmus* sp.)	1	6.67	66.0	27.0	1.32	1398	2.35
Maple, Ash-leaf (*Acer negundo*)	1	6.67	37.0	26.0	1.22	749	1.26
Maple, Silver (*Acer saccharinum*)	21	80.0	25.25	6.35	2.29	21606	36.32
Maple, Sugar (*Acer saccharum*)	5	33.33	24.0	6.20	.33	2316	3.89
Pear sp. (*Pyrus* sp.)	1	6.67	19.0	6.0	.07	476	.80
Plum sp. (*Pyrus* sp.)	1	6.67	14.0	4.0	.03	144	.24
Spruce, Blue (*Picea menziesii*)	8	26.67	13.5	4.25	.47	938	1.58
Spruce, Norway (*Picea abies*)	1	6.67	22.0	6.0	.07	680	1.14
Willow, Weeping (*Salix babylonica*)	2	6.67	53.0	18.50	1.25	14512	24.39
Ornamental Shrubs						6881	11.57
TOTAL	52		23.75	7.36	8.33	59489	99.99

The type of food varied from table scraps, bread crumbs, and dried corn to commercial bird seed. Forty-five percent of those feeding wildlife used seed distributed from feeders. Two thirds of this group fed 50 pounds (lbs.) or less per year; 22 percent fed 51 to 100 lbs.; and the remainder annually distributed more than 100 lbs. of commercial bird seed. These figures extrapolated over the total study area population indicate that approximately two tons of commercial seed is available to wildlife in a given year. Additional food was also available in the numerous vegetable gardens in the area. Approximately 6.35 percent of the total land space was annually planted to gardens. The largest were in the urban residential section where the area per acre was 7005 square feet (sq. ft.). All of the gardens were non-commercial, and contained a wide variety of produce. The subdivision had a much lower area of garden (998 sq. ft. per acre), obviously reflecting the smaller amount of available land. Approximately 26.7 percent of this group planted vegetables, versus 37.5 percent in the urban residential section.

Twenty four percent of those interviewed had bird baths, and twenty eight percent had bird houses on their property. The highest percentage of bird houses and bird baths were found in the urban residential section. Neither of the species studied used bird houses, nor did they nest under artificial cover of any type (eaves, ledges, etc.). Both species, however, were frequently seen at bird baths, artificial ponds, wading and swimming pools where they took water.

The density of household pets in the combined UR subdivision sections was; dogs, 1 per 3.6 acres, and cats, 1 per 5.33 acres. The dogs in the study area were not permitted to roam freely, all were either chained, kept in enclosures, or under supervision while being exercised. All dog owners interviewed had fences around some part of their property where they kept their pets. Most of these enclosures were back yard property line structures where pets remained for long periods unrestrained. All of the cats in the area, however, were frequently permitted to roam freely. This density of potential wildlife predators may have been a factor in habitat selection for some of the study species.

There was a combined residential total of 1.20 children (under 15 years) per household. The UR section was low with .61 children per household, and many of the homes in this section were occupied by retired or semi-retired persons. Approximately 45 percent of the UR section were 50 years or older. None of the subdivision residents interviewed were 50 years or older. The child density in this section was 1.83 per household, or three times that of the UR section. The density of children may be a factor in habitat selection and mortality of some wildlife species. Children were observed in the woodlot with a variety of weapons; rifles, shotguns, B.B. guns, and air rifles. There was also evidence of vegetative damage from bark stripping, trampling, and ground fires. The total estimated human density for this area was 3.56 per acre, considerably lower than that in the tract housing surrounding the study area.

DISCUSSION AND CONCLUSIONS

Birds

Cardinal

The cardinal density in this study (5.03 prs./100 acres) was similar to that found by Graber and Graber (1963) in their survey of urban areas in Illinois. Dow (1968) found "wild" Ontario populations of .48 prs./100 acres. He stated that Elmira, Ontario is peripheral to the cardinal's geographic range, and therefore, should contain low densities, due to limited occupancy of the habitat. This appears to be the case in my study. Four cardinal home ranges abutted, but no intra-specific territorial interactions were observed. Laskey (1944) describes the cardinal as a "non-pugnacious defender of its territory", but the total absence of territorial defense suggests a population well below the carrying capacity.

Cardinal home ranges in this study were significantly smaller than that reported for wild populations. This condensation may have been caused by the large amounts of available food. The mean size of home ranges in my study was 3.05 acres versus 46.48 acres reported by Dow (1968). Hilden (1965) correlated pair density of birds with the quantity of food available in the environment. Cardinals in this study had food available from the many feeders in the area. More than two tons of commercial bird seed was annually placed out for wildlife (see questionnaire results). Approximately 74 percent of all cardinal home ranges contained an active feeder. Supplementary food was also available from vegetable gardens and fruit trees, which were common in the residential sections.

Many of the cardinals in my study appeared to expand their home ranges to include an active feeder. The mean distance from nest sites to feeders, in those home ranges containing a feeder, was 766 ft. Using this figure as the radius of a circle, a mean home range of 10.57 acres would be predicted, or slightly more than three times that actually observed. A pair of cardinals whose nest was located in the woodlot traveled a linear distance of approximately 1100 ft. to a feeder in the subdividion. A female, nesting in the UR section, utilized this same feeder although her mate never left their normal home range. Feeders, therefore, appear to play a significant role in habitat selection and utilization by cardinals in this study.

Nesting heights in this study did not vary significantly from those reported for wild populations by Laskey (1944), Taylor (1965), and Dow (1969). The mean height for seven nests in this study was 6.86 ft. (SD 1.35 ft.). The crown volume between 5 and 10 ft. was compared for the four habitat types studied. The subdivision did not contain a nest, and had a nesting stratum volume of 5,806 cu. ft./acre between 5 and 10 ft. The UR section had five nests and a leafy volume of 10,560 cu. ft./acre. The shrub and woodlot sections had one nest apiece, with a volume of 108,083 cu. ft./acre and 35,920 cu. ft./acre, respectively. The broad range of crown volume at the nesting stratum, in those areas containing a nest (10,560 to 108,063 cu. ft./acre), indicates that there is no correlation between total leafy volume at the nesting heights and nest site selection. The absence of cardinal nests in the subdivision is probably due to a combination of factors.

Burr and Jones (1968) have correlated human activity with an increase in nesting heights and a reduction in density of shrub nesting species. The intensity of human activity, frequent pruning of vegetation, and the low crown volume were probably factors in the absence of nests in the subdivision.

There was no significant difference between the mean activity heights for cardinals in the four habitat types studied (SNK .05). Cardinals confined their activities to the same vertical stratum despite the fluctuation in vegetative volume and human density. Total leafy volume for the four habitat types varied from 64,624 cu. ft./acre in the subdivision to 2,254,247 cu. ft./acre in the woodlot, yet cardinals frequented all four habitat types. Cardinals in my study, therefore, appeared plastic in both nesting and habitat requirements, but fairly rigid in their utilization of the vertical height stratum.

Blue Jay

The blue jay density in this study (2.5 prs./100 acres) was lower than that reported by Graber and Graber (1963) in their summer study of three Illinois urban areas. Their report did not include a detailed description of the study areas, and it may be that they worked in a more uniform habitat than described in this study. The urban environment is a mixture of habitat types particularly when applied to larger, mobile species, such as blue jays and raccoons, whose ranges generally encompass a large area. Urban population estimates, therefore, may be misleading in that they include habitat types not preferred or even devoid of individuals of a given species. The Grabers also stated that Illinois jay densities have increased in urban areas between 1909 and 1957, and decreased in previously preferred forest habitat over the same period. They stated that the ecology of the blue jay is apparently changing, but the cause as yet is not apparent. Kendeigh (AFN, 13) found a steady increase in jay density as Dutch Elm disease opened the interior of a forest. Certain urban areas may offer the type of open canopy apparently preferred by blue jays. Woolfender and Rohwer (1969) found a density of 114 prs./100 acres in a Florida plot. Their study area was a woodlot completely surrounded by subdivision, and it is implied that jays made use of available food and cover from these areas. This high Florida density and the trend toward increasing urban jay populations indicates that this species can achieve high densities in urban areas where requirements of food and cover are met.

Bird feeders in this study had the effect of altering blue jay utilization of the vertical stratum. All of the jay home ranges contained at least one active feeder, and 76 percent of all jay activity in the subdivision occurred at or around a feeder. The subdivision mean activity height for jays was 17.04 ft., versus 24.66 ft. in the UR section, and 32.06 ft. in the woodlot (shrub section data was omitted due to insufficient sightings). The difference between the three means was significant (SNK .05) at the 95 percent level. When height data at and around feeders was deleted from the comparison, there was no significant difference in the mean activity heights for the three habitat types surveyed. The fact that all blue jays home ranges contained an active feeder, and that an alteration in vertical height utilization occurred as a result of the presence of feeders indicates that feeders play a significant role in habitat selection and utilization by jays in this study.

Blue jay's nests in my study were higher than those reported for wild populations. Taylor (1965) found the majority of Louisiana jays nesting between 7 and 15 ft. Bent (1940) describes 20 ft. as the height most frequently utilized by nesting jays. The lowest nest in this study was 27 ft., with a range to 41 ft. and a mean of 34.33 ft. The same factors of human activity and management (Burr and Jones, 1968) affecting cardinals may have also influenced the nesting heights of jays. For example, the lowest jay nest in this study (27. ft.) was found in the woodlot where there was no management and comparatively little human traffic. The higher nests were located in the UR section, and none were found in the subdivision where human traffic and management were most intense.

Mammals

Raccoon

Urban raccoon populations apparently achieve much higher densities than wild populations. The number of captures and recaptures in the study was too low to estimate the population, but if we use the nine raccoons marked as the total, the density would be one per 17.67 acres. This figure is much higher than the 1 per approximately 44 acres reported by Stuewer (1943) as typical of wild Michigan raccoon populations. Schinner and Cauley (1974) reported monthly densities as high as 1 per 2 acres for Cincinnati raccoons. One reason for these high densities may be the abundance of food in urban areas. In the Cincinnait study, all ten of the raccoons radio tracked used garbage as their primary food source. Both animals in this study also depended on garbage as an important source of their food.

Raccoons in this study arrived earlier and departed later from their overnight dens than those reported in the literature. Berner and Gysel (1967) reported Michigan raccoons denning in a farm woodlot as departing dens shortly after sunset, and returning shortly before sunrise. Raccoons in this study departed overnight dens an average 62 minutes after sunset and re-denned an average 31 minutes before sunrise. Cincinnati raccoons (Schinner and Cauley, 1974) also departed dens much later and returned earlier than those reported by Berner and Gysel (1967). Food availability is probably a factor in the shorter foraging period of urban raccoons. Human traffic may also influence raccoon activity by restricting movement until lulls occur.

Both raccoons in this study had significantly smaller home ranges (21 and 26 acres) than those reported by Stuewer (1943). Stuewer correlated home range size with age, and found means of 503 acres for adult males, 268 acres for adult females, 260 acres for juvenile males, and 111 acres for juvenile females. Stuewer's estimates were also much higher than those observed in Cincinnati (Schinner and Cauley, 1974). Raccoons home ranges in Cincinnati varied from .5 to 50 acres, with a mean of 20.6 acres. The compression of raccoon home ranges in urban acres is probably due, in part, to the large quantity of food available in the form of refuse.

Four of the five raccoons in this study used ground burrows for either escape cover or overnight denning sites. Utilization of this type den is probably due to the apparent lack of suitable tree cavities large enough for a raccoon, and one of these, a dead basswood, was frequently used by both raccoons five and six. There were no trees with suitable cavities in any of the other sections studied. Dead limbs of trees in the UR section and subdivision were removed so that cavities could not be formed. Trees in the woodlot and shrub section did not receive this type of care, but generally had dbh's too small to accomodate a raccoon den. Several residents had raccoons denning in their attics and garages. Raccoon six was radio tracked to the attic of a garage in the UR section three separate nights. The lack of natural den sites probably results in raccoons denning in buildings and ground burrows, and may be a factor in the low population density observed in this study versus the Cincinnati research.

Squirrels

The density of fox squirrels in this study, one per 11.36 acres, is lower than that reported by Allen (1943) for either late winter or fall populations in Michigan. My estimate, however, was based on the total acerage of the study area. The shrub and subdivision sections supported very little squirrel activity. One fox squirrel did have a nest in the shrub section along the border abutting the UR section. This animal was radio tracked for seven days, however, and was never tracked to the interior of the shrub section. The fox squirrel activity in the subdivision section was confined to the western fringe, where a single squirrel took sunflower seed at a bird feeder. The number of fox squirrels per acre of woody cover in this study, therefore, approaches the one per 5 to 6 acres described by Allen (1943) as typical of late winter Michigan populations.

The mean size of fox squirrel home ranges in this study (3.13 acres) was smaller than any reported in the literature. Allen (1943) found the minimum seasonal fox squirrel range in Michigan woodlots to be 10 acres. Donohoe and Beal (1972) found Ohio fox squirrels to have the following mean home ranges: adult males, 40.7; adult females, 7.2;

and juvenile males, 10.5 acres. The largest home range in my study was that of an adult female, 7.89 acres. The next largest home range of 3.16 acres was recorded for a juvenile male. The apparent compression of fox squirrel home ranges in my study was probably influenced by the limited habitat available. Only two sections had a canopy of mature, deciduous trees, UR and the woodlot. All of the fox squirrels captures occurred in the UR section, and those squirrels affixed with transmitters confined 95 percent of their activities to this section. Food appeared to be abundant and this too may have been a factor in the smaller squirrel home ranges observed in this study.

There was no significant difference (SNK .05) between the UR section and the woodlot for any of the nesting parameters, dbh, height to cavity or den, and total height of trees containing a cavity or den (Figure 15). This occurred despite the broad variation in the total leafy volume and density of cover between these two sections. The above data for dbh's was combined and compared with that found for wild Ohio squirrels by Donohoe and Beal (1972). There was no significant difference (SNK .05) between these two studies for the dbh's of trees selected for nests or dens. My study squirrels, however, did appear to nest higher in the canopy than those reported in the literature. The UR and woodlot sections had a mean nesting height of 35.44 ft. $\pm$ 11.39 and 37.68 ft. $\pm$ 12.2, respectively. These heights are approximately 19 percent greater than those reported by Allen (1943) and Montgomery (1941). The same factors of human activity and management reported by Burr and Jones (1968) as causing an increase in nesting heights and densities of shrub species may also be influencing the heights of squirrel nests in this study.

Fox squirrels in my study were radio tracked to chimneys, garage and home attics, and two were even detected in a basement. This frequent

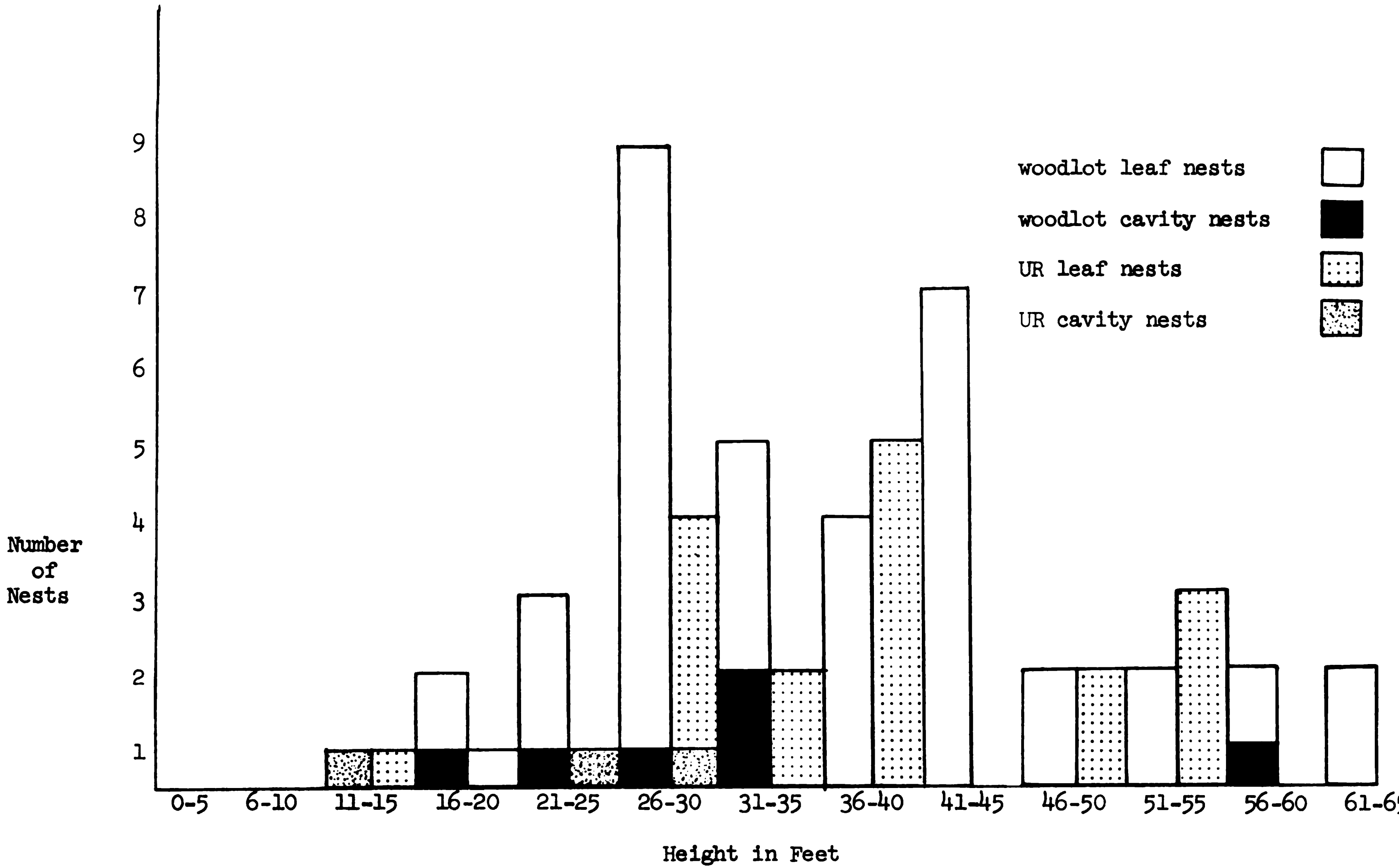


Figure 15. Nesting and denning heights of fox squirrels in the urban residential and woodlot sections.

use of non-natural den sites is an apparent effort to overcome the lack of tree cavities. The constant pruning of limbs and removal of dead and dying trees in the residential areas causes a scarcity of these cavities. Brown and Yeager (1945) have stated that the absence or lack of suitable tree cavities may be a factor in reducing fox squirrel numbers. One obvious management practice for urban squirrels, therefore, would be the installation of nest boxes to increase squirrel numbers and reduce nuisance denning.

Fox squirrels in this study had shorter activity periods and later onset of activity than those reported by Donohoe and Beal (1972). My squirrels had two activity peaks; one occurred between 11:00 a.m. and 1:00 p.m., and the other between 3:00 and 4:00 p.m. (Figure 13). These animals were most active after 10:00 a.m. and remained fairly active until approximately 5:00 p.m. Two peaks of inactivity also occurred: one between 7:00 and 10:00 a.m. and the other between 5:00 and 8:00 p.m. (Figure 13). The inactivity peaks appeared to coincide with increased human traffic. Donohoe and Beal (1972) reported their squirrels (fox and gray) as most active between 8:00 and 11:00 a.m., and least active between 11:00 a.m. and 1:00 p.m. They found another smaller peak occurred at 2:00 p.m., and most activity ceased by 5:00 p.m. The later onset of activity and reduced total hours of activity observed in my study may also be influenced by the abundance of food. Mast species made up approximately 27 percent of the woodlot's and 15.25 percent of the UR section's vegetative volume. Other trees providing squirrel foods, such as white ash, basswood, crabapple, sycamore, slippery elm, osage orange, and cherry were also present in both the UR and woodlot sections (Martin, Zim, and Nelson, 1961). Food was also available from bird feeders, handouts, and vegetable gardens in the UR section.

None of the study species nested or denned in the subdivision where the effects of urbanization were most pronounced (Table 11). All of the species but the raccoon, however, were observed in this section. The raccoon was reported to have been in the area prior to construction of townhouses which now abutt the eastern border of the subdivision (Figure 2). The study species visiting the subdivision were invariably drawn by food. The bird species were particularly influenced by the presence of feeder stations. One management technique for urban birds, therefore, may be the use of feeder stations in conjunction with nesting habitat. Further research will have to be conducted to determine the attractability, food preferences, and distribution of feeder stations. Fox squirrels appear to be the most habitat specific, of the four species studied. They appear to have a strong dependence upon mature deciduous trees for both cover and food. This is a definite liability, when considering management, since the construction of habitat in urban areas would be costly, and require a great deal of time. One squirrel in my study did frequent a feeder station, and several denned in non-natural cavities, indicating a potential for limited management in areas of pre-existing mature deciduous habitat. The evidence in this study is too limited to discuss raccoon management. My data, however, combined with that of the Cincinnati research indicates a strong adaptability by this species to urban habitats. Several residents expressed a strong dislike of raccoons denning in their out-buildings. Two residents also complained of damage to garden crops by raccoons. The questionnaire, however, revealed that just one species, the skunk, was considered a pest by more than 25 percent of those interviewed. As stated, the majority of the residents enjoyed having wildlife on their

Table 11. Space utilization in the four habitat types.

	Woodlot	Shrub	Urban Residential	Sub-division
Vegetative crown volume in cu. ft./acre	2254247	877211	279589	64624
Coniferous volume in cu. ft./acre	0	0	5005	3272
Deciduous volume in cu. ft./acre	2254247	877211	274448	61352
Area of lawn in sq. ft./acre	0	0	27289	21495
Area of vegetable gardens in sq. ft./acre	0	0	7003	998
Building volume in cu. ft./acre	0	0	43229	90241
Area of pavement in sq. ft./acre	0	0	2050	5789

property, and most regularly made food available. The advisability of perpetuating or encouraging raccoons in the city is debatable since their viewability is low. They also present a potential nuisance in denning and foraging in garbage cans, and they are a potential reservoir for canine distemper.

One possible key to the quality of urban habitats may be the ratio of vegetative to building volume. The subdivision section ratio was less than 1:1 and held no nesting study species. In contrast, the UR section's ratio was 6.5:1 and had good densities of all the species in the study. Schinner (unpub. Ph.D. thesis) has stated that a ratio of vegetation to building volume of less than 1:1 was a significant factor in the reduction of bird species diversity in the Detroit area.

PROBLEMS ASSOCIATED WITH URBAN RESEARCH

Certain difficulties were encountered during this research of which future researchers should be aware. There is the obvious necessity of obtaining permission from a large percentage of the residents to utilize their property. This can be difficult, since many will permit trespass but will refuse to allow trapping, a situation which complicates random placement of trap locations. Neighborhood children can also pose a problem. For example, they quickly became familiar with my car and followed me as I set out traps. Five mammal and one large bird trap were stolen, despite the fact that all were chained and padlocked to trees, fences, etc. I also discovered empty traps that had obviously held an animal, and several more were sprung with the bait removed. To minimize theft and tampering, I monitored the traps at a maximum two hour interval, and picked up daily those traps not being used (i.e., raccoon traps during the day). The incidence of tampering and theft was so high in the woodlot and portions of the shrub section that squirrel trapping had to be discontinued in these areas. I was able to recover most of the lost traps by offering a reward. In urban research, it is essential to maintain the cooperation of the residents. Urban researchers, therefore, will have to accept the increased efforts involved. Any attempt to eliminate or reduce difficulties by involving civil authorities or confronting residents regarding thefts and vandalism would surely result in loss of cooperation and interfere with the research.

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