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Populations of Some Mammals of Oak Forests in Southwestern Michigan

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POPULATIONS OF SOME MAMMALS OF OAK FORESTS IN SOUTHWESTERN MICHIGAN

by

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INTRODUCTION

The present study was an attempt to secure information about mammal populations of oak forest in southwestern Michigan. One approach to the study of mammalian populations under natural conditions is by using live traps. Small mammals, and especially small rodents, have frequently been effectively studied in this manner. Some of the first to develop these methods were Burt (1940), Chitty (1937), and Bole (1939). Recent papers by Brown (1962) and Sanderson (1966) contain discussions of methods and interpretation of results. A study closely related to what is attempted here is that by Manville (1949), who made a quantitative analysis of eight forest types. In addition, an attempt was made to obtain information on some of the larger mammals.

The object of this paper is twofold: (1) to study the species composition and density of mammal populations of the oak forest community and (2) by apportioning sampling among recognizable variations of the general oak forest type, to attempt to draw conclusions regarding habitat selection by various species.

Field work was done in five study areas located in Allegan County in southwestern Michigan. The duration of the study was from April to August, 1967, with preparatory work done the year before.

METHODS AND MATERIALS

Arrangement of Plots

The five study areas (Fig. 3) were chosen as examples of the most prominent types of variation in the second-growth oak forest occupying former pine areas. The areas, ranging from 9.6-18.4 acres, were established (spring, 1966) within reasonably uniform stands of each vegetation type. Similar vegetation extended beyond each study area, usually for 200 feet or more. For the purposes of the present study, two plots were located within each of the five general study areas. These small plots, measuring 100 x 200 feet, were laid out in April and May, 1967, with compass and steel tape on level ground (except the large pine area) and marked with wooden stakes at 25-foot intervals.

Traps and Baits

For live-trapping, both collapsible and non-collapsible Sherman small mammal traps were used. They measured 3 x 3 x 9 inches and were constructed of aluminum. The collapsible trap was less satisfactory because the trip mechanism was less sensitive and because notches were present in the upper corners of the doors which made it possible for a confined animal to gnaw its way out. Both traps were generally effective in capturing small mammals and some larger ones, but the larger animals (red squirrels) were closely confined and were sometimes killed by the heat of the sun

(Blair, 1941) (thirty-two per cent of the captures on red squirrels captured resulted in their death). Box traps (Allen, 1943:80) measuring 1x 1 x 2 feet and covered with 16 gauge galvanized hardware cloth (half-inch mesh) were used to capture large mammals (woodchucks, opossum, and raccoons). Snap traps were of two types: snap-back mouse traps and "museum specials".

Baits for the Sherman and snap traps consisted of a mixture of peanut butter and rolled oats. It appeared to be an attractive bait in all weather conditions and was satisfactory for various animals including a blue racer (Coluber constrictor), ovenbirds (Seiurus aurocapillus), and many invertebrates. Live traps were always heavily baited to insure ample food supply for the captured animal. Large traps were initially baited with peanut butter and rolled oats, an ear of corn, and a fresh fish. Finally only peanut butter-rolled oats and an ear of corn were used.

Trapping Methods

The Sherman traps were laid out in a regular grid pattern of twenty-five foot intervals with 45 traps in each of the two 20,000 square foot plots. Each trap was placed by a numbered stake. No attempt was made to place the traps near presumably favorable trapping sites such as stumps, logs, or burrows. Both plots of a given area were trapped simultaneously. Sufficient traps were available to trap two areas (four plots) at the same time. Traps

were left open continuously and checked twice daily, before 8:30 A.M. and 5:00 P.M. The large mammal traps (ten traps inclosing an area of 3.7 acres) were set at 200 foot intervals within the general study area and also left open continuously. They were checked once daily, usually in the morning. Snap traps were checked once in the morning. Live traps were rotated between areas after eleven days (990 trap nights except one trapping period in the small pine area of 1035 trap nights and one trapping period in the large oak area of only 900 nights). Table I of the appendix illustrates the rotation pattern. Large mammal traps were rotated every two weeks (except for the large oak area in which the trapping period was only one week). There was one trapping period for large mammals in each area. Each area was live-trapped for small mammals three different times (total of 2970 trap nights in each of the five areas). All areas were snap-trapped simultaneously for four days (total of 360 trap nights in each of the five areas).

Small mammal live-trapping was begun on April 28 and large mammal trapping on June 18. Snap-trapping was begun on August 11 and lasted four days.

Each small mammal, when first captured, was marked by a system of ear-notching or toe-clipping similar to that used by Burt (1940). A small scissors was used. No anesthetic was employed because it might have weakened the animal. Ear-notching was generally satisfactory, but on occasion an animal with large

ears such as Peromyscus injured its ear making further identification difficult. Mice (Peromyscus), chipmunks (Tamias), flying squirrels (Glaucomys), red squirrels (Tamiasciurus), and a house mouse (Mus) were marked exclusively by ear-notching. A shrew (Blarina) and a vole (Microtus) were marked by toe-clipping. No infections or ill effects due to these markings were apparent. Mice were taken from the trap with long forceps. Chipmunks, squirrels, weasels (Mustela), shrews, and voles were removed by dropping them into a burlap bag, from which they could easily be taken by hand.

Sex, age, reproductive condition, pelage, trap number, marking number, and evidence of disease of each small mammal were noted at each capture. The criterion for classifying Peromyscus as adult, subadult, or immature was color of pelage (gray, gray-brown, brown) and size. A reproductive condition was assumed in males if the testes were scrotal, and in females if the mammary glands were conspicuous. The resulting estimates of the numbers of reproductively active animals are conservative because the testes can be withdrawn into the abdomen of a sexually active animal (Jameson, 1950) and the mammary glands of some reproductively active females may not be particularly prominent. These limitations, however, should not seriously affect estimates of the extent of breeding season. Criteria for classifying ages (juvenile or adult) and reproductive activity for Tamias, Tamiasciurus, and Glaucomys were similar to the methods used by D. Allen (1943) for fox squirrels,

Sciurus niger, and E. Allen (1938) for chipmunks. The remaining species were aged according to body size and external genital development. Animals were released at the spot where taken.

Each large mammal, when first captured, was marked with a system of ear-notching, when possible, and color coding. Ear-notching was done with a hog ear notcher and followed the pattern of small mammals. Color coding was done with fast-drying enamel spray paint of three different colors (red, yellow, and white). This method was satisfactory for the two-week periods and made identification at a distance possible. Methods for removing large mammals from traps varied. The docile opossum (Didelphis) was occasionally removed by seizing the tail, but a hardware mesh cone similar to that used by Steuwer (1943) was used to handle raccoons (Procyon) and woodshucks (Marmota). This was placed across the opening of the trap and the animal driven into it. A burlap bag was then forced in behind the animal and held in position by steel rods. The animal had limited movement and was more easily handled. These animals were then examined for the same characters as the small mammals and released at the point of capture.

At the end of the live-trapping schedule, one trapping plot in each study area, chosen at random, was snap-trapped. Two traps were placed at each marker stake. Each animal after capture was tagged, placed in a small plastic bag, and frozen (-15°C) for later

weighing.

Home Range Determinations

Home range, as applied to mammals, has been defined by Burt (1943) as that area traversed by the individual in its normal activities of food gathering, mating, and caring for young.

Home range estimates for Peromyscus were based on data gathered over the entire 1967 season. Blair (1941) recommended using shorter time periods, but in this study there were no indications that home ranges shifted. The "exclusive boundary strip" method, as recommended by Stickel (1954), was used. Figure 1 illustrates how home ranges were calculated from trapping records. Below seven captures estimated home range size was strongly correlated with the number of captures (Fig. 2) accordingly animals captured fewer than seven times were not used in home range determinations. Animals with more than 30 per cent of their captures on marginal rows were also omitted because their home ranges may have extended some distance beyond the area trapped.

Home range determinations for the other mammals were not feasible owing to the small size of the trapping plots or the low frequency of capture or both.

Calculations of Populations

The number of individuals of any species on a given area is

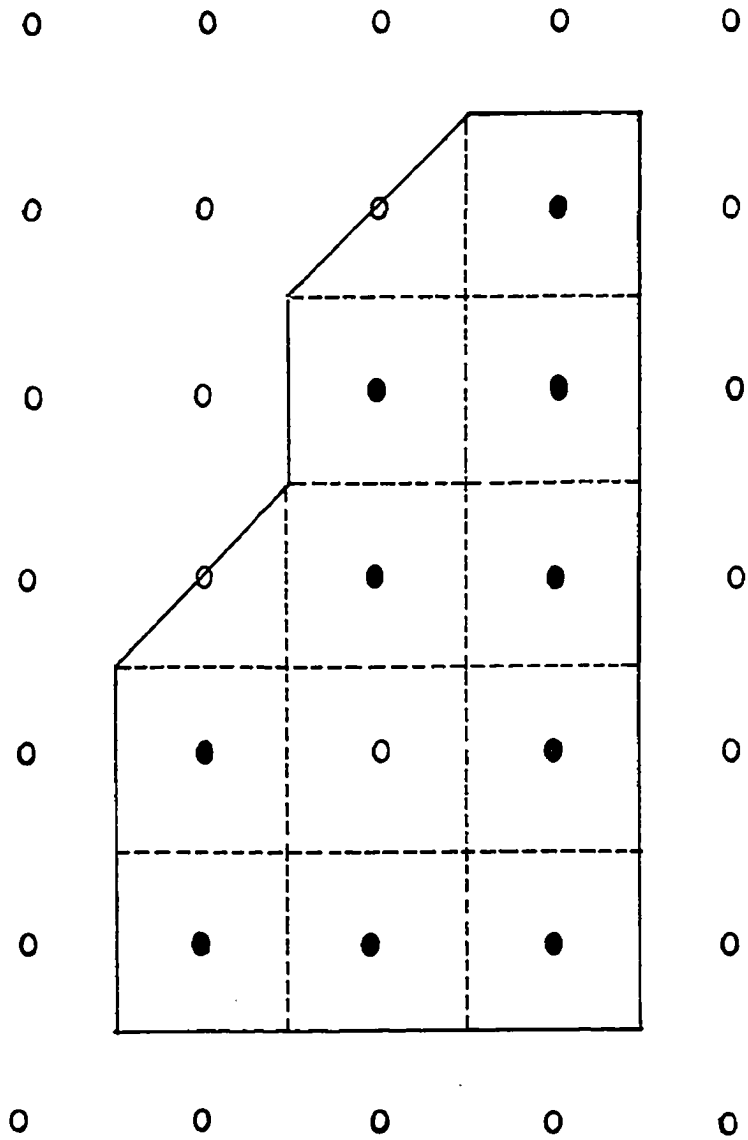

Figure 1 An illustration of the exclusive boundary strip method (Stickel, 1954) for the determination of home ranges. The clear centered circles are trap sites and the solid circles are points of capture. The solid line encloses the estimated home range.

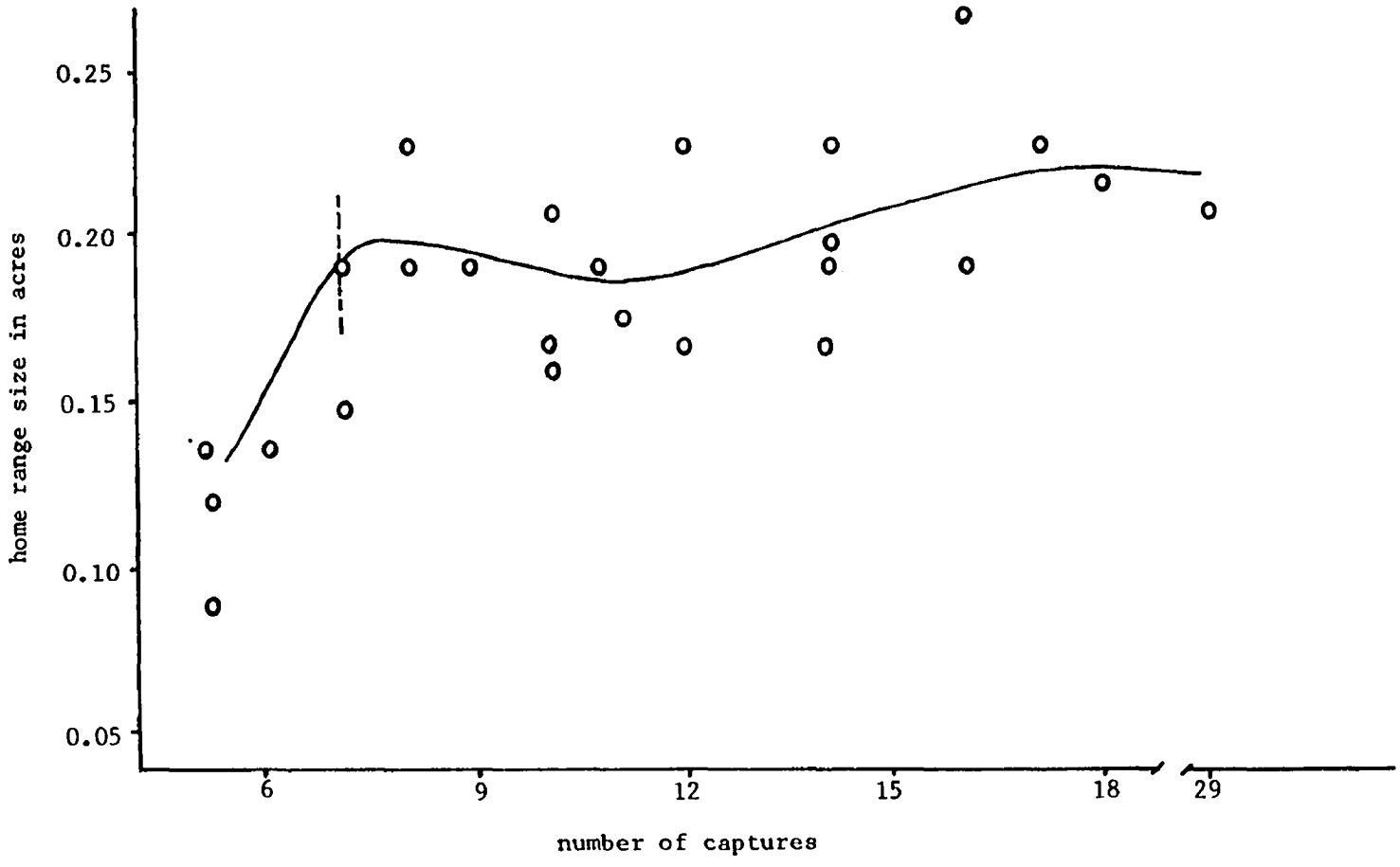

Figure 2 Correlation between numbers of captures and home range size of Peromyscus leucopus. Line was fitted according to averages computed on units of three captures (6-9, 10-12 captures, etc.).

continually changing. Therefore, any calculation of populations on an area should be made over a relatively short period of time. Blair (1941) suggested that a one-week period is satisfactory for most mammal populations. The author used periods of eleven days. Population numbers (all individuals present) were calculated on each study plot for each trapping period. In determining density, average home ranges for each area were computed and half the width of this was added to the size of the trapping area (Blair, 1941). Estimates for the literature were used for home ranges of species other than Peromyscus leucopus.

All Peromyscus captured were classified as to degree of residency. Those caught only once and those caught only twice if on consecutive nights were considered "partial residents". Hence, during an eleven-day trapping period an individual captured once was one-eleventh resident; and an animal captured only on two consecutive nights was two-elevenths resident. Captures other than the partial residents were considered as "full residents". An animal captured at least once in each of the three trapping periods was a full resident for all periods. Because of their larger home ranges and the small size of the trapping plots, an individual of the remaining small mammal species, even if captured only once was considered a full resident.

Vegetation Sampling

The trees of the green brier area were sampled during the summer of 1966 by Ted B. Gottshall and Alvin Brink. The large oak area was sampled during the winter of 1967 by a graduate plant ecology class from Western Michigan University, and the large pine area during the summer of 1967 by the writer. The small oak and small pine areas were sampled the autumn of 1968 by David A. Boyce. The trees were divided into two categories; those with diameters at breast height (dbh) greater than 5.0 inches and those with diameters at breast height between 1.5 and 4.99 inches. At 16 randomly placed points 100-200 feet apart (14 points in the small oak and small pine areas), both categories of trees were sampled by the point-centered quarter method (Cottam and Curtis, 1956). A total of 66 points in all study areas was sampled.

Ground cover vegetation was sampled during July and August, 1967. In each of the small mammal trapping plots, five randomly placed milacre quadrat samples were taken. In total 50 quadrats were sampled. Plants were categorized as (a) those with stem heights up to one foot; (b) those with stem heights greater than one foot but less than two feet; and (c) those that were above two feet in height but less than 1.5 inches dbh. Stem counts were made of all species present. The first two categories were later grouped together.

Statistical procedures followed Steel and Torrie (1960). The average captures per day during any given trapping period were used for evaluating habitat selection. An analysis of variance, was used to determine any significant difference between population densities and trapping periods. Chi square tests were used to determine differences in sex ratios and Student "t" tests were used to test difference in home range sizes.

Determinations of soil pH were done colorimetrically on samples from the A_1 horizon. Precipitation data were collected at the Allegan Field Office, Federal Weather Station 206401, which is located in the Allegan State Game Area. Temperatures were taken with a minimum-maximum thermometer located within each study area.

DESCRIPTION OF THE STUDY AREAS

The study plots lay in the approximate center of the Allegan State Game Area, Allegan County, Michigan (Fig. 3). The county borders on the eastern shore of Lake Michigan, about fifty miles north of the Michigan-Indiana state line.

Prior to settlement, the forest cover of the Allegan State Game Area was a mixture of white and black oaks and white pines. The white pines were lumbered during the terminal portion of the nineteenth century, the last local stand being harvested in the 1890's. Repeated fires and, in some areas, clearing of the land occurred after logging. Some areas were farmed, but most soils were too poor to support normal agriculture.

The soil types are of two major associations: the Plainfield-Oakville and the Coloma-Hillsdale. The Plainfield-Oakville association is a deep, well-drained, level to undulating soil found on old glacial river deltas. The Coloma-Hillsdale association is a deep, well-drained, undulating to rolling soil found on till plains or moraines. Both associations are low in moisture supply capacities and in natural fertility. The soils are acid, with A_1 pH values ranging from 4.4-6.4 (Table III of the appendix). During the period of study, the mean daily minimum temperature was 76.4°F (Table II of the appendix). Total precipitation from April 1 to August 31 was 14.9 inches.

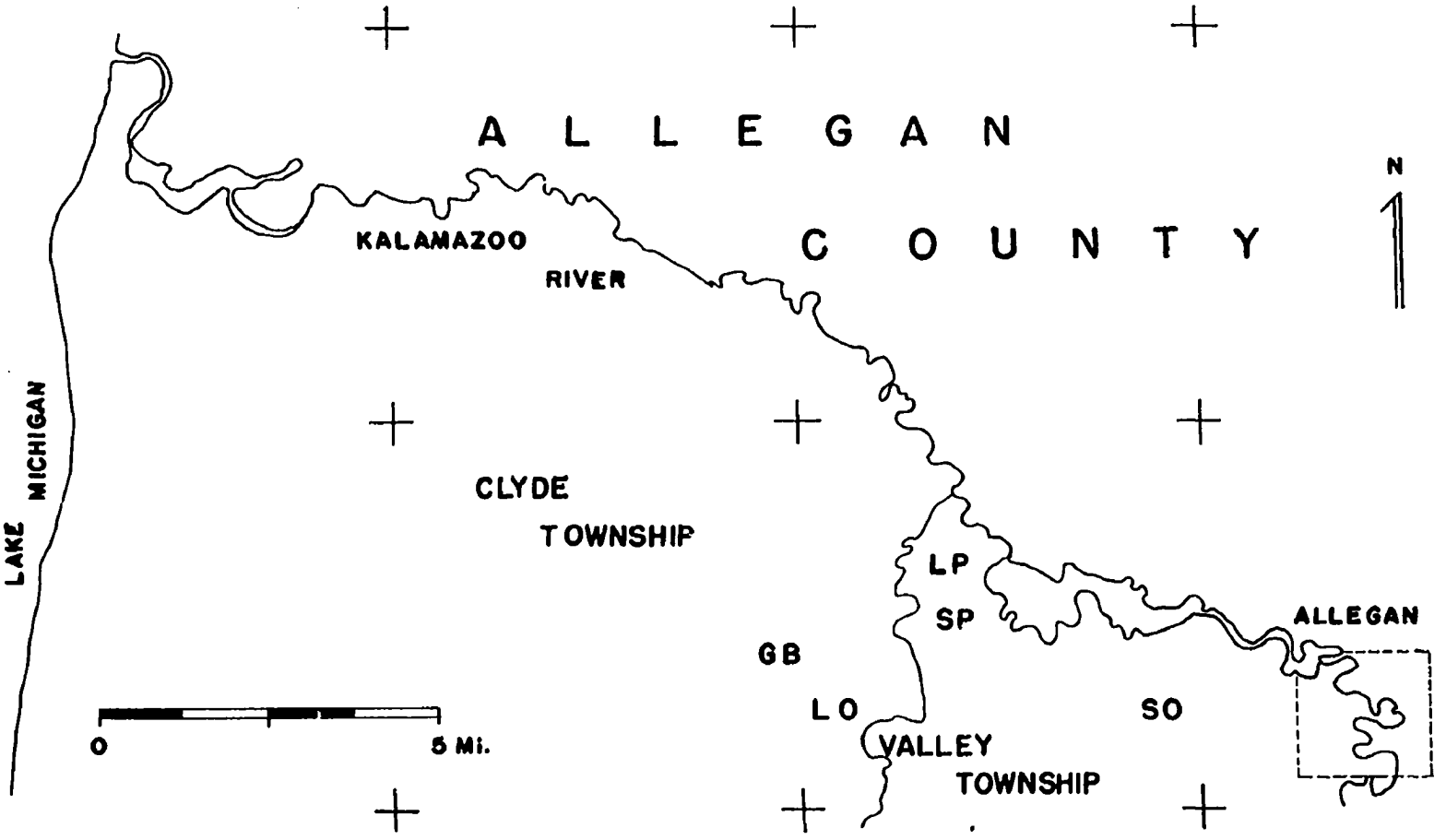

Figure 3 Location of the study plots in Allegan County, Michigan (small oak, SO; large oak, LO; small pine, SP; large pine, LP; and green brier, GB).

The study areas were named in relation to a dominant feature of their physiognomy; e.g. the green brier area had a high percentage of Smilax in its ground cover vegetation.

Small Oak

This plot parallels 37th Street and lies about one-half mile south of the Kalamazoo River in Section 24 of Valley Township, Allegan County, Michigan. The area is on dry, well-drained undulating sandy soil of moraine and glacial river delta. Large trees numbered 246 per acre (Table IV) and averaged 8.4 inches dbh. White and black oak were most abundant. White oak had an importance value (Cottam and Curtis, 1956) of 191.6 and black oak 108.3 (Table V). White oak was the most important of the smaller trees and averaged 248.0 per acre. It had an importance value of 213.8. Of the other tree species, dogwood was the most important, numbering 87.0 per acre. Black cherry and white pine were present in smaller numbers. Total small tree density was 347.0 trees per acre and averaged dbh was 3.0 inches. The total tree density was 593.0 trees per acre. Dogwood seedlings dominated the ground cover vegetation (averaging 15,900 stems per acre) with Carex and species of similar growth form, rose, and sassafras next in abundance (Table VI). White and black oak seedlings were generally distributed. Areas with little or no ground cover vegetation were common.

Table IV

Density per acre of trees of both classes on all study plots.

species	small trees					large trees				
	sm.* oak	lg. oak	sm.* pine	lg. pine	gr. brier	sm.* oak	lg. oak	sm.* pine	lg. pine	gr. brier
Quercus alba	248.0	218.8	410.0	302.5	326.9	180.0	38.0	80.0	77.5	42.8
Quercus velutina	6.0	26.3	---	37.1	45.4	66.0	90.0	40.0	77.5	42.8
Cornus florida	87.0	30.5	29.0	43.3	7.7	---	---	---	---	---
Prunus serotina	---	---	---	12.2	15.0	---	---	5.0	2.7	---
Prunus virginiana	---	---	---	---	---	---	---	---	---	---
Pinus strobus	6.0	4.5	326.0	---	---	---	---	2.4	---**	---
Populus granididentata	---	---	14.0	---	7.7	---	---	2.4	13.4	18.2
Acer rubrum	---	---	14.0	---	22.5	---	---	2.4	---	1.7
Nyssa sylvatica	---	---	---	---	22.5	---	---	---	---	---
Sassafras albidum	---	---	---	---	15.0	---	---	---	---	---
totals	347.0	280.1	792.0	395.2	435.7	246.0	128.0	132.0	175.3	105.5

* Total of 14 points sampled.

** 44 large white pines (4.2 per acre) were present on the study area but did not appear in the sample.

Table V

Comparisons of Curtis' (1959:47) importance values for both categories of trees from all study areas.

species	small trees					large trees				
	sm. oak	lg. oak	sm. pine	lg. pine	gr. brier	sm. oak	lg. oak	sm. pine	lg. pine	gr. brier
Quercus alba	213.8	223.6	164.4	214.4	202.2	191.6	86.2	154.6	121.7	99.0
Quercus velutina	9.1	35.8	---	43.1	33.7	108.3	213.8	6.0	151.4	146.8
Cornus florida	70.5	33.8	12.4	30.0	5.1	---	---	---	---	---
Prunus serotina	---	---	---	12.5	9.2	---	---	12.2	5.7	---
Pinus strobus	6.5	6.7	109.6	---	---	---	---	5.9	---*	---
Prunus virginiana	---	---	---	---	---	---	---	---	---	---
Populus grandidentata	---	---	7.4	---	6.0	---	---	5.7	21.2	45.3
Acer rubrum	---	---	6.1	---	16.8	---	---	5.8	---	8.9
Nyssa sylvatica	---	---	---	---	16.6	---	---	---	---	---
Sassafras albidum	---	---	---	---	10.1	---	---	---	---	---
totals	299.9	299.9	299.9	300.0	299.7	299.9	300.0	300.0	300.0	300.0

* 44 large pine were present on the study areas but did not appear in the sample.

Table VI

Ground cover vegetation in stems per acre on all study areas. Each table value is 1/100th of the actual number of stems present. The small grouping (sm.) are those individuals with a height less than two feet. The large grouping (lg.) are those individuals with a height greater than two feet but having a dbh less than 1.5 inches.

species	study plots									
	small oak		large oak		small pine		large pine		green brier	
	sm.	lg.	sm.	lg.	sm.	lg.	sm.	lg.	sm.	lg.
Quercus alba	16	7	18	12	31	3	17	1	13	--
Quercus velutina	15	--	20	1	18	2	32	1	10	--
Sassafras albidium	90.5	47	74	3	99	1	65	3	23	3
Cornus florida	151	8	295	10	131	7	160.5	3	--	--
Pinus strobus	1	1	--	--	1	4	21.5	10	--	--
Prunus serotina	12	1	6	--	36	2	26	3	12	1
Prunus virginiana	--	--	2	--	3	--	4	2	--	--
Salix sp.	--	--	--	--	--	--	--	--	2	1
Acer rubrum	--	--	--	--	--	--	--	--	3	1
Comptonia peregrina	--	--	--	--	--	--	--	--	6	1
Smilax rotundifolia	--	--	--	--	--	--	--	--	198	28
Carex pensylvanica*	107	--	320	--	1919	--	886	--	423	--
Rosa sp.	33	--	8	--	29	--	14	--	--	--
Rubus hispidus	3	1	13	--	76	--	27	--	27	--
Vaccinium sp.	2	--	151	--	10	--	27	--	160	--
Gaylussacia baccata	--	--	15	--	--	--	--	--	2	--
Chimaphila umbellata	3	--	--	--	--	--	--	--	--	--
Gaultheria procumbens	--	--	21	--	--	--	--	--	636	--
Smilacina stellata	7	--	29	--	2	--	3.5	--	13	--
Fragaria sp.	2	--	--	--	23	--	10	--	--	--
Ceanothus americanus	--	--	9	--	25	--	13	--	12	3

Table VI continued

species	study plots: small oak sm.	small oak lg.	large oak sm.	large oak lg.	small pine sm.	small pine lg.	large pine sm.	large pine lg.	green brier sm.	green brier lg.
Pteridium aquilinum	2	--	5	--	7	--	9	--	38	8
Solidago caesa	--	--	13	--	--	--	10	--	5	--
Panicum sp.	--	--	--	--	20	--	46	--	2	--
Galium sp.	--	--	--	--	11	--	5	--	--	--
Geranium sp.	--	--	--	--	1	--	52	--	--	--
Potentilla sp.	--	--	--	--	16	--	--	--	--	--
Monarada fistulosa'	--	--	--	--	27	--	--	--	--	--
Viburnum acerifolium	--	--	--	--	10	3	17	2	--	--
Maianthenum canadense	--	--	2	--	--	--	143	--	--	--
Euphorbia corollata	5	--	2	--	--	--	--	--	--	--
Antennaria plantaginfolia	--	--	--	--	4	--	--	--	--	--
Viola sp.	--	--	--	--	--	--	6	--	--	--
Carpinus caroliniana	--	--	--	--	--	--	6	--	--	--
Desmodium paniculatium	1	--	--	--	17	--	1	--	--	--
Desmodium nudiflorum	--	--	37	--	2	--	3	--	--	--
Desmodium rotundifolium	--	--	--	--	8	--	--	--	--	--
Basal leaves of compositae	1	--	--	--	22	--	6	--	--	--
totals	451.5	65	1040	26	2548	22	1610.5	25	1585	46

* Also includes Stipa avenacea and possibly other species of similar growth form.

Large Oak

This plot parallels 48th Street and lies about one-third mile east of Crooked Lake in Section 30 of Valley Township, Allegan County, Michigan. It is level and on dry, well-drained sandy soil of glacial river delta. Large trees numbered 128 per acre (Table IV) and averaged 10 inches dbh. White and black oak were the only large trees present with black oak predominating and having an importance value of 213.8 (Table V). White oak was the most important of the small trees having an importance value of 223.6 and numbering 218.8 per acre. Of the remaining small trees, black oak (26.3 per acre) and dogwood (30.5 per acre) were generally distributed. White pine was scarce. Small tree density was 280.1 trees per acre and average dbh was 2.5 inches. Total tree density was 408.1 per acre. The principal ground cover vegetation (Table VI) included Carex and species of similar growth form (averaging 32,000 stems per acre) and dogwood seedlings (averaging 30,500 stems per acre) with sassafras and Vaccinium next in abundance. Desmodium, wintergreen, Rubus, and black and white oak seedlings were generally distributed. Other herbaceous plants appeared on the area in lesser numbers.

Small Pine

This plot parallels 118th Avenue and lies approximately three-fourths mile west of the Kalamazoo River in Section 16 of Valley Township, Allegan County, Michigan. The area is level and on dry, well-drained sandy soil of glacial till plains. Large trees

numbered 132.0 per acre (Table IV) and averaged 6.75 inches dbh. White oak was the most abundant and had an importance value of 154.6 and numbered 80.0 per acre (Table V). Of the remaining species, black oak predominated with an importance value of 116.0 and numbered 40.0 per acre. Large-toothed aspen, red maple, black cherry, and white pine were of minor importance contributing only about 9.2 per cent to the total density. Small tree density was 792.0 trees per acre and averaged 2.54 inches dbh. White oak and white pine were the most abundant of the small trees; white oak had an importance value of 164.4 and numbered 410.0 per acre while white pine had an importance value of 109.6 and numbered 326.0 per acre. The most common of the remaining tree species was dogwood numbering 29.0 per acre. Red maple and black oak each numbered 14.0 per acre. Total tree density was 924.0 trees per acre. The principal ground cover vegetation (Table VI) including Carex and species of similar growth form (averaging 191,900 stems per acre) with sassafras seedlings next in importance (averaging 100,000 stems per acre). Rubus, black cherry seedlings, strawberry, dogwood seedlings, and Monarda were abundant. White and black oak seedlings, rose, Ceanothus, Potentilla, and Desmodium were generally distributed. Other herbaceous plants appeared on the area in lesser numbers. White pine stumps were common.

Large Pine

This plot lies about one-half mile west of the Allegan Dam Road and about one-half mile southwest of the Kalamazoo River in Section 16 of Valley Township, Allegan County, Michigan. The area is undulating and on dry, well-drained sandy soil of old glacial river delta. Relief is greater than on the other four plots. Large trees numbered 171.3 per acre (Table IV) and averaged 8.0 inches dbh. White and black oak were most abundant, both numbering 77.5 per acre and having importance values of 121.7 and 151.4 respectively (Table V). The remaining large trees (black cherry and large-toothed aspen) were of minor importance contributing only 9.4 per cent to the density. White pine did not appear in the sample but there were about 44 (4.2 per acre) on the 9.6 acre study area. Small tree density was 395.2 per acre. White oak was the most abundant of the small trees averaging 302.5 trees per acre and having an importance value of 214.4. Black oak was next in importance numbering 37.1 per acre and having an importance value of 43.1. Black cherry and dogwood were generally distributed. Total tree density was 570.1 per acre. Of all the study areas, this plot had the greatest diversity of ground cover vegetation. The principal species of the ground cover vegetation (Table VI) included Carex and species of similar growth form (averaging 88,600 stems per acre), Canada mayflower (averaging 14,300 stems per acre), and dogwood seedlings (averaging 16,350 stems per acre).

Black and white oak seedlings, sassafras seedlings, and black cherry were next in abundance. Geranium, strawberry, Ceanothus, were generally distributed as were species of Panicum, Galium, and Potentilla. Other herbaceous plants appeared on the area in lesser numbers. White pine stumps were common.

Green Brier

This plot lies about 200 yards south of Mud Lake and parallels 116th Avenue in Section 25 of Clyde Township, Allegan County, Michigan. The area is level and on dry, well-drained sandy soil found on old glacial river deltas. Large trees numbered 105.5 per acre (Table IV) and averaged 10.7 inches dbh. White and black oak were in equal abundance numbering 42.8 per acre and having importance values of 99.0 and 146.8 respectively (Table V). Of the remaining trees, large-toothed aspen was the most important numbering 18.2 per acre and having an importance value of 45.3. Black cherry was scarce. This plot had the greatest small tree diversity of all the study areas. Small tree density was 435.7 per acre and averaged 2.7 inches dbh. White oak was the most abundant of the small trees numbering 326.9 per acre and having an importance value of 202.2. Sour gum, black oak, sassafras, and red maple were generally distributed and collectively averaged 26.4 trees per acre. Large-toothed aspen, black cherry, and dogwood were of minor importance contributing collectively only 6.3 per cent to the total density. The total tree density was 541.2 trees

per acre. Wintergreen (averaging 63,600 stems per acre), Carex and species of similar growth form (averaging 42,300 stems per acre), and green brier (averaging 22,600 stems per acre) were the most abundant ground cover vegetation (Table VI). Sassafras, Rubus, and bracken fern were generally distributed. Other herbaceous plants appeared on the area in lesser numbers.

Comparison of Plots

The five plots were not distinctively different plant associations but were physiognomically distinct variants of xeric oak or oak-pine forests. Differences were primarily in the number or size of particular species rather than in their presence or absence.

All plots, except the small pine and small oak areas (dominated by white oak) were dominated by canopy black oaks. According to Curtis (1959), oak reproduction is associated with the shade tolerance of the species. White oak is more shade tolerant than black oak, thus white oak predominated in the subcanopy. Small white pines were virtually absent in the green brier area and scarce in the small oak area. In the small pine area, white pines had been interplanted in 1938 and formed a conspicuous stratum below a layer of white oak.

Of the ground cover vegetation, Carex and species of similar growth form were the most abundant in the small and large pine areas. In the ground cover of the small and large oak areas

dogwood seedlings predominated. Wintergreen was the most numerous plant of the green brier area and Smilax was conspicuous. Of total species representation (both ground cover and trees) the small oak area had the lowest diversity (20 species) and the large pine area the highest (33 species).

RESULTS

There were 503 individual animals (1414 total captures) marked and released on the Allegan State Game Area. These represented 11 species: Peromyscus leucopus noveboracensis (Fischer) 334, Glaucomys volans volans (Linnaeus) 49, Tamiasciurus hudsonicus loquax (Bangs) 34, Tamias striatus rufescens Bole and Moulthrop 60, Microtus pennsylvanicus pennsylvanicus (Ord) 1, Blarina brevicauda kirtlandi Bole and Moulthrop 1, Mus musculus domesticus Rutty 1, Mustella frenata noveboracensis (Emmons) 3, Marmota monax rufescens Howell 3, Didelphis marsupialis virginiana Kerr 5, and Procyon lotor lotor (Linnaeus) 16. Names of mammals follow Hall and Kellson (1959). Eight of these species are in the present discussion; too few data were gathered to provide the basis for adequate treatment of Mus, Blarina, Microtus, and Mustella.

Peromyscus leucopus

Peromyscus was the most abundant mammal of all study areas, totaling 78.8 per cent of the total small mammal live captures. The population was small in May when trapping began. In the first trapping period on all study areas, a total of 4950 trap nights, only 45 individuals were captured. During this period there were as few as seven individuals (2.07 per acre) captured on the small pine; whereas, the greatest number was 12 individuals (3.95 per acre) captured on the green brier area. Numbers increased to an

apparent high during July in the oak areas and in August in the remaining areas, (August captures were by snap-trap and for only four day periods). The highest population during an eleven-day period, including all Peromyscus present, was 12.97 per acre on the large oak area from July 3 to 12. Of these, juveniles reached a density of 4.07 per acre and adults 7.90 per acre. The highest total population of the summer was reached during August in the large pine area (13.80 per acre). Following the population on all areas during each trapping period, an average of 9.8 per cent of the total seasonal population was present in May, 24.3 per cent in June, 31.6 per cent in July, and 34.2 per cent in August. Throughout the study, populations of all Peromyscus present on all areas ranged from a low of 2.07 per acre in May (small pine area) to a maximum of 13.80 per acre in August (large pine area). Total captures, number of individuals, and densities of Peromyscus are presented in Tables VII, VIII, and IX.

During May, there were 33 adult and 11 juvenile Peromyscus on all study areas with the small pine area having the largest percentage of adults (Fig. 4). The proportion of juveniles increased during June until they out-numbered adults (62-51). During this period 64 per cent of the population were juveniles in the small oak and green brier areas, with only 38 per cent juveniles in the large oak area. Ratios became more uniform in July when the greatest proportion of juveniles was 59 per cent (small pine area) and the least was 32 per cent (green brier area).

Table VII. Comparison of individual small mammals live-trapped on all study areas.

species	trapping period	study areas: small oak	large oak	small pine	large pine	green brier
all species caught*	1	10	10	11	9	17
	2	42	27	29	20	32
	3	53	57	68	38	39
Peromyscus leucopus	1	8	9	6	8	14
	2	23	22	22	19	28
	3	32	46	34	29	34
Tamias striatus	1	2	1	--	--	1
	2	6	5	1	--	4
	3	5	8	3(9)**	7(2)	6
Glaucomys volans	1	--	--	--	--	1
	2	12	--	2	--	--
	3	17	1	15	1	--
Tamiasciurus hudsonicus	1	--	--	5	--	--
	2	--	--	3	--	--
	3	--	--	16(10)	--	--

* Includes Mus, Blarina, Microtus, and Mustella captured a total of 6 times on 4 study areas.

** Numbers captured in the large mammal traps are in parenthesis.

Table VIII

Comparison of total live captures made of small mammals on all study areas.

species	Trapping period	Total captures: small oak	large oak	small pine	large pine	green brier	Per cent of total captures: small oak	large oak	small pine	large pine	green brier
all spp. caught*	1	23	23	19	25	51	1.7	1.7	1.4	1.8	3.8
	2	123	51	66	56	115	9.1	3.8	4.9	4.1	8.5
	3	184	209	198	109	105	13.6	15.4	14.6	8.0	7.7
Peromyscus leucopus**	1	21	21	13	25	48	1.6	1.6	0.9	1.9	3.6
	2	89	45	61	55	111	6.6	3.3	4.5	4.1	8.2
	3	111	180	98	91	95	8.2	13.3	7.3	6.7	7.0
Tamias striatus	1	2	2	--	--	1	0.1	0.1	---	---	0.07
	2	16	6	1***	--	4	1.2	0.4	0.1	---	0.3
	3	27	26	6(10)	16(9)	9	2.0	1.9	0.4	1.2	0.7
Glaucomys volans	1	--	--	--	--	1	---	---	---	---	0.07
	2	18	--	2	1	--	1.3	---	0.1	0.07	---
	3	45	1	24	2	--	3.3	0.07	1.8	0.1	---
Tamiasciurus hudsonicus	1	--	--	6	--	--	---	---	0.4	---	---
	2	--	--	3	--	--	---	---	0.2	---	---
	3	--	--	71(14)	--	--	---	---	5.3	---	---

* Totals include Mus, Blarina, Microtus, and Mustella captured a total of six times on four study areas.

** Percentages for only those animals represented on the table.

*** Numbers in parenthesis are mammals captured in the large mammal traps.

Table IX

Numbers per acre and sex and age composition of Peromyscus leucopus on all study areas.

		May				June				July				August			
Plot	Ages	m.	f.	tot.	pop/A	m.	f.	tot.	pop/A	m.	f.	tot.	pop/A	m.	f.	tot.	pop/A
	imm.*	--	2	2	0.63	--	--	--	----	1	4	5	1.53	--	--	--	----
	sub.	--	--	--	----	10	5	15	5.37	9	2	11	3.35	--	--	--	----
SO	ad.	4	2	6	1.88	4	4	8	2.86	9	7	16	4.87	5	--	5	4.06
	total	4	4	8	2.51	14	9	23	8.23	1	13	32	9.75	5	--	5	4.06
	imm.	1	1	2	0.70	1	3	4	1.55	2	3	5	1.40	--	--	--	----
	sub.	--	--	--	----	4	--	4	1.55	9	4	13	3.67	--	--	--	----
LO	ad.	2	5	7	2.45	8	5	13	5.06	15	13	28	7.90	9	6	15	11.66
	total	3	6	9	3.15	13	8	21	8.17	26	20	46	12.97	9	6	15	11.66
	imm.	--	--	--	----	5	5	10	3.38	2	3	5	1.40	--	--	--	----
	sub.	1	--	1	0.30	2	1	3	1.01	6	7	13	3.64	--	--	--	----
SP	ad.	2	4	6	1.77	6	3	9	3.05	11	5	16	4.50	7	5	12	10.28
	total	3	4	7	2.07	13	9	22	7.44	19	15	34	9.54	7	5	12	10.28
	imm.	2	--	2	0.78	1	4	5	1.34	3	4	7	1.88	--	1	1	0.83
	sub.	--	--	--	----	3	--	3	0.80	6	4	10	2.69	--	--	--	----
LP	ad.	4	2	6	2.33	7	4	11	2.44	6	6	12	3.24	9	8	17	12.97
	total	6	2	8	3.11	11	8	19	5.08	15	14	29	7.81	9	9	18	13.80
	imm.	2	1	3	0.99	3	2	5	1.37	2	2	4	0.89	--	--	--	----
	sub.	1	--	1	0.33	10	3	13	3.57	4	3	7	1.54	--	1	1	0.69
GB	ad.	4	4	8	2.63	7	3	10	2.76	12	11	23	5.06	8	6	14	10.97
	total	7	5	12	3.95	20	8	28	7.69	18	16	34	7.49	8	7	15	11.66
totals		23	21	44	----	71	42	113	----	97	78	175	----	38	27	65	----
totals %**		52.3	47.7		----	55.4	44.6		----	55.4	44.6		----	58.5	41.5		----

* immature = imm.; subadult = sub.; and adult = ad.

** per cent males and females are based on each trapping period on all areas.

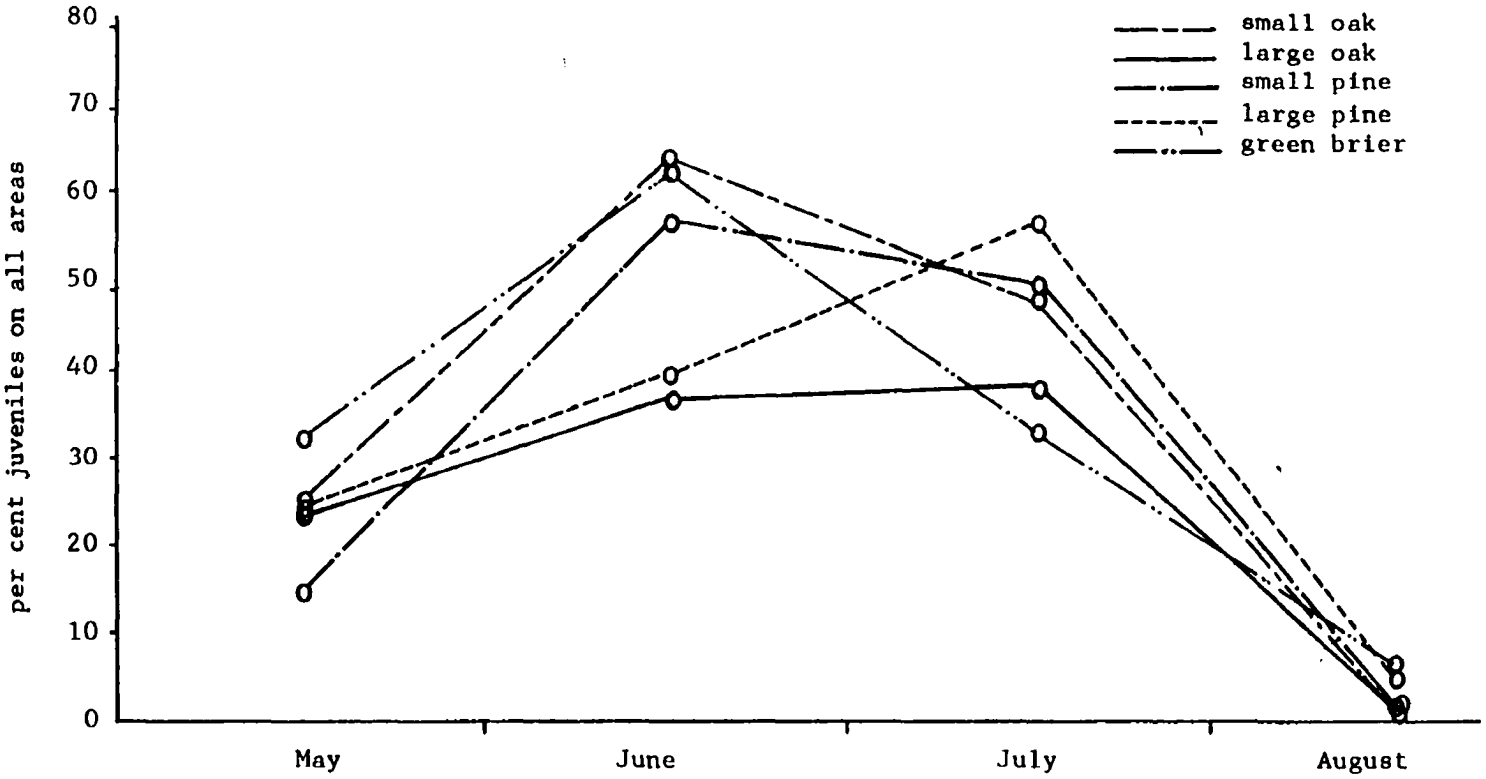

Figure 4. Percentages of juveniles per acre on all study areas May through August.

During August juveniles were few, comprising about six per cent of the population in two areas (green brier and large pine) with no juveniles being captured on the remaining areas. Numbers of individuals according to age group are presented in Table IX.

The sex ratio, based on all individuals, differed significantly ($P < 0.005$) from the expected 1:1 ratio (229 males:168 females). However, when data are considered for shorter periods of time, a seasonal change is indicated (bottom, Table IX). Only in June did males significantly outnumber females ($P < 0.01$).

Considering individuals within particular age classes, immature females were in the majority (25 males:35 females); however, subadult males significantly outnumbered females (65 males: 30 females). For comparison, sex ratios based on adults show 139 males to 103 females. Ratios are statistically significantly different for the subadult class only ($P < 0.005$). Females were relatively more abundant on the basis of immatures only, rather than when subadults or adults only or all age classes combined were considered.

Table X shows the breeding status of adult females. Numbers and percentages of those females considered to be reproductively active were estimated for each eleven-day period. During May, an average of 2.2 juveniles were captured on all study areas. Assuming that those juveniles were about one month old when first captured, and had a twenty-five day gestation period (Manville,

Table X.

Reproductive condition of Peromyscus leucopus from all study areas.

Study area	Trapping period*	Total captured	Number breeding	Per cent breeding
small oak	1	4	2	50.0
	2	9	1	11.1
	3	13	3	23.1
	4	0	0	----
large oak	1	6	2	33.3
	2	8	3	37.5
	3	20	5	25.0
	4	6	4	66.6
small pine	1	4	1	25.0
	2	9	1	11.1
	3	15	1	6.7
	4	5	5	100.0
large pine	1	2	0	----
	2	8	2	25.0
	3	14	3	21.5
	4	9	9	100.0
green brier	1	5	3	60.0
	2	8	1	12.5
	3	16	3	18.7
	4	7	6	85.7

* period 4 = snap trapping period.

1949), it appears that the first spring mating took place in March. Of those adult females captured on all areas during May 34 per cent of them were lactating and in July there was an average of 16 juveniles captured on all areas. From this it appears that a breeding season had occurred in May. Only 19 per cent of the females were reproductively active in June. A small percentage of juveniles were captured in August, and from this it appears that few females were breeding in June. Of those adult females captured in August, an average from all areas (except the small oak area where no females were captured) of 88 per cent were reproductively active. During this period 100 per cent of the captured females of both pine areas were reproductively active. From these data it appears that the main breeding seasons were May and August with a smaller percentage of females breeding during other periods.

Home ranges as calculated from the data available are listed in Table XI. Although 334 Peromyscus were live captured, home ranges could be estimated for only 15 males and 6 females. Of these, males were captured an average of 13.1 times and females 11.8 times. The home ranges of adult males varied from 0.17 acre to 0.23 acre with a mean of 0.19 acre. The home ranges of adult females ranged from 0.17 acre to 0.24 acre with a mean of 0.20 acre. Juvenile male home ranges varied from 0.17 acre to 0.27 acre with a mean of 0.21 acre and juvenile females had home ranges ranging from 0.18 acre to 0.19 acre with a mean of 0.18 acre. Home ranges of adults averaged 0.10 acre and juveniles 0.20 acre. Differences

Table XI.

Calculated home ranges of *Peromyscus leucopus* on all study areas.

Adults (when first captured)						Juveniles (when first captured)					
indiv.*	study area	trap period	study plot	no. cap.	home range (acre)	indiv.	study area	trap period	study plot	no. cap.	home range (acre)
1 m	gr. brier	1,2,3	1	29	0.21	3 m	sm. pine	1,2,3	1	10	0.17
4 m	lg. pine	1,2,3	2	7	0.15	3 m	lg. pine	1,2,3	2	16	0.19
9 m	lg. oak	1,2,3	1	14	0.23	5 m	lg. pine	1,2,3	2	15	0.27**
13 m	lg. oak	1,2,3	1	14	0.20	10 m	sm. oak	2,3	1	12	0.17
19 m	sm. pine	2,3	2	9	0.19	11 m	sm. oak	2,3	2	14	0.19
21 m	gr. brier	2	2	8	0.19	14 m	gr. brier	2,3	1	18	0.22
22 m	sm. oak	2,3	1	10	0.16	18 m	gr. brier	2,3	2	8	0.23
						22 m	gr. brier	2,3	2	12	0.23
4 f	sm. oak	1,2,3	1	14	0.17						
6 f	gr. brier	1,2,3	2	17	0.24	4 f	sm. pine	1,2	1	7	0.19
6 f	lg. oak	1,2,3	2	10	0.21	9 f	sm. oak	2	1	11	0.18
14 f	sm. oak	2,3	2	12	0.17						
				mean area	0.19					mean area	0.20

* m = male, f = female.

** based in part on 30 per cent marginal row captures.

in home ranges among the sex and age classes were not statistically significant ($P < 0.05$).

Average home range of all individuals on each area varied from 0.17 acre (small pine) to 0.22 acre (green brier), but the differences were not significantly different ($P > 0.05$). In calculations of population density a minimum of 81 feet was added (small pine) to the 200 foot square trapping plots and a maximum of 97 feet was added (green brier).

During the four months of the study, one major parasite was evident. This was the botfly (Cuterebra sp.), the larvae of which develop beneath the skin usually near the inguinal region. Botfly infections occurred late in the summer and in early autumn.

Records showed infections in July and August (Table XII), but infections may have gone unnoticed in the latter part of June because of the small size of the young larvae. Usually one botfly was found in each animal, but two were not uncommon. When more than one botfly was present, they were usually at different stages of development. One animal, a subadult male, had four botfly infections. Botfly larvae, as discerned by external examination, live in the host for about two weeks.

Weights of Peromyscus appear in Table XIII. There were no apparent differences between the sexes nor among the different areas.

Table XII.

Percentage of botfly larvae (Cuterebra sp.) on all age classes of Peromyscus leucopus from all areas.

	July				August*			
Plot	% im ma. infected	% ad. ma. infected	% im. fe. infected	% ad. fe. infected	% im. ma. infected	% ad. ma. infected	% im. fe. infected	% ad. fe. infected
small oak	90.0	33.3	50.0	33.3	----**	20.0	----	----
large oak	11.1	14.3	25.0	16.7	----	45.5	----	40.0
small pine	20.0	16.7	37.5	33.3	----	57.1	----	0.0
large pine	20.0	0.0	0.0	0.0	----	66.7	0.0	33.3
green brier	20.0	8.3	0.0	44.4	----	37.5	0.0	87.5
average %	32.2	14.5	22.5	25.5	----	45.4	0.0	31.8

* snap-trapping period

** no captures made on immature males

Table XIII.

Average weight in grams of small mammals snap-trapped on all study areas. Weights include botfly larvae (Cuterebra sp.) when present.

	Study Areas									
	small oak		large oak		small pine		large pine		green brier	
Species*	m.	f.	m.	f.	m.	f.	m.	f.	m.	f.
Peromyscus	19.1	----	21.1	19.9	20.5	17.5	20.6	18.4	20.1	20.5
Sorex	----	----	----	4.3	----	----	----	----	4.6	----
Blarina	----	13.0	----	----	----	----	----	----	----	17.0

* Sample sizes were Peromyscus, 65; Blarina, 3; and Sorex, 2.

When the average number of captures per day were used as a criterion for habitat preference, there were no significant differences in the number of daily captures among the five areas during any one trapping period.

The per cent of the transient individuals in the population varied greatly among trapping periods (Table XIV, Fig. 5). During May the transient population varied from zero in the pine areas to a high of 12.5 per cent in the small oak area. The per cent of transients increased in all areas, except the large oak, during June, until maximum percentages were reached in July, with the large pine area having the highest percentage (31.0%). Although numbers of transients varied greatly among the study areas during any one trapping period, the total number of transients recorded for the three periods was almost the same for all areas (11-13).

Subadult males were the most abundant transients (36.7%) followed by subadult females (28.3%). Of the adult transients males were the more numerous (23.3%). The appearance of new residents was not correlated with the appearance of the transient individuals (Fig. 5).

Table XIV

Sex and age of transient Peromyscus leucopus from all study areas for each trapping period.*

Sample period	Sex and age	Small oak	Large oak	Small pine	Large pine	Green brier
	sub. male	----	----	----	----	1
	sub. female	----	1	----	----	----
1	ad. male	1	----	----	----	----
	ad. female	----	----	----	----	----
	% transient	12.5	11.1	----	----	8.3
	sub. male	1	----	2	----	4
	sub. female	1	----	2	1	1
2	ad. male	----	----	----	1	----
	ad. female	----	----	----	----	----
	% transient	8.7	----	18.2	10.5	21.4
	sub. male	2	4	4	2	2
	sub. female	----	3	3	4	1
3	ad. male	4	3	2	3	----
	ad. female	3	2	----	----	2
	% transient	28.1	26.1	26.5	31.0	14.7

* transients are considered those animals that were classified as partial residents in the density calculations.

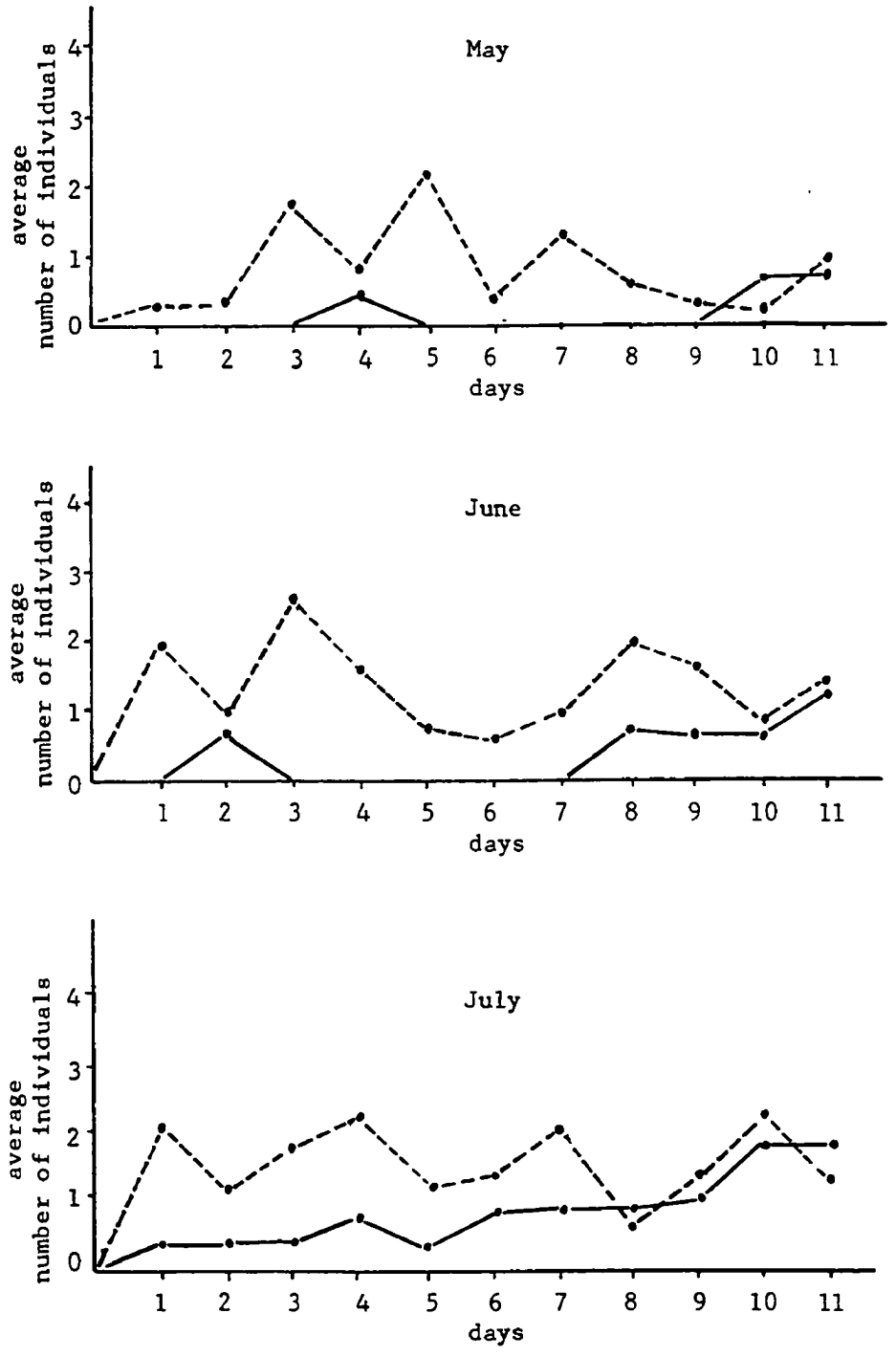

Figure 5 Average number of transient individuals (broken line) and new resident individuals (solid line) captured per day on all study areas.

Tamias striatus

Sixty individuals (captured an average of 2.4 times in small mammal traps) occurred on all plots and constituted about 8.5 per cent (Table VIII) of the season's small mammal live captures. They were most common on the small oak (13 individuals), large oak (14 individuals) and green brier areas (11 individuals). Populations were small in May when trapping began (Table VII).

Following Burt (1946:271), a two-acre home range was assumed. Accordingly a marginal strip (Blair,1941) of 148 feet was included around each plot, so that the areas trapped amounted to 1.88 acres. In the first trapping period on all areas, a total of 4950 trap nights, only four individuals were captured. During this period there were two individuals (0.50 per acre) on the small oak and only one individual (0.25 per acre) each on the large oak and green brier areas. Population densities for each area during each trapping period are presented in Table XV.

Populations increased to apparent highs in July, when 29 individuals were captured on all study areas. The highest population was recorded on the large oak area where 2.02 individuals per acre were present from July 3 to 12. Of these, juveniles reached a density of 1.77 per acre and adults 0.25 per acre. Throughout the study, populations of all Tamias present on an area ranged from a low of zero in May (both pine areas) to a maximum in July of 2.02 per acre (large oak area).

Table XV

Calculated populations of Tamias in numbers per acre.

Trapping period	Study Areas				
	small oak	large oak	small pine	large pine	green brier
May	0.50	0.25	----	----	0.25
June	1.51	1.26	0.25	----	1.01
July	1.26	2.02	0.75	1.77	1.51

The sex ratio (Table XVI) of the forty-nine individuals captured in the Sherman traps did not differ significantly from a 1:1 ratio ($P > 0.01$).

During May no juveniles were captured whereas there were ten captured in June and twenty-three in July. Assuming that juveniles are weaned at 40 days (Palmer, 1954), that they leave the nests shortly thereafter, and that gestation is about 30 days (Palmer, 1954), first breeding probably took place in April. The additional increase of juveniles in July indicates a second breeding season in May for those females that did not breed in April.

Habitat preference was tested in the same manner as for Peromyscus. There was no selection of any one of the five study areas ($P > 0.005$).

Glaucomys volans

Fifty-four individuals (captured an average of 1.7 times) were captured on all areas and constituted about 6.9 per cent (Table VIII) of small mammal live captures. This species was most common on the small oak and pine areas where 29 and 17 individuals, respectively, were captured during the entire season. Populations were low in May when trapping began with only one individual captured on the green brier area (Table VII).

Table XVI

Sex composition of small mammal populations from five study areas. All species captured during each period are recorded (exclusive of Peromyscus and those individuals captured only once).

Species	Trapping period	Study Areas: Small oak m.	Small oak f.	Large oak m.	Large oak f.	Small pine m.	Small pine f.	Large pine m.	Large pine f.	Green brier m.	Green brier f.
Tamias striatus	May	2	--	--	1	--	--	--	--	1	--
	June	3	3	3	2	--	1	--	--	2	2
	July	2	3	4(4)*	4(1)	3	--	6	2	2	3
Glaucomys volans	May	--	--	--	--	--	--	--	--	1	--
	June	5	7	--	--	--	2	--	1	--	--
	July	10	10	--	1	9	6	2	--	--	--
Tamiasciurus hudsonicus	May	--	--	--	--	1	4	--	--	--	--
	June	--	--	--	--	1	2	--	--	--	--
	July	--	--	--	--	8(1)	7(3)	--	--	--	--

* numbers in parenthesis are mammals captured in large mammal traps.

Burt (1946:271) used a home range of four acres and accordingly a marginal strip of 209 feet was included around each plot so that areas trapped amounted to 2.90 acres. Populations increased in June (Table XVII) to a high of 12 individuals (2.07 per acre) on the small oak. Maximum populations were reached (2.93 per acre) between July 14-24 on the small oak and 2.59 per acre between July 1-11 in the small pine areas. During this period there was only one individual (0.17 per acre) in the large oak and large pine areas with no captures made in the green brier area.

Table XVI presents the sex ratio of individuals captured. On all study areas there were 35 adults and 19 juveniles. There was no deviation from the expected 1:1 ratio (27 males:27 females).

Adult males numbered 17 to 18 adult females (48.5 per cent males) and juveniles numbered 10 males to 9 females (52.6 per cent males).

Only one juvenile was captured in June (small oak area); 17 were captured in July. Gestation in Glaucomys is about 40 days and they are weaned about eight weeks later (Palmer, 1954). Data indicated a single breeding season in early April or late March.

Habitat preference was tested in the same manner as for Peromyscus. Twenty-nine individuals occurred on the small oak and 17 on the small pine areas with one each on the remaining areas. A significant preference was shown for the small oak and

Table XVII

Calculated populations of Glaucomys in numbers per acre. Average home range follows Burt (1946:271).

Trapping period	Study Areas				
	Small oak	Large oak	Small pine	Large pine	Green brier
May	----	----	----	----	0.17
June	2.07	----	0.35	----	----
July	2.93	0.17	2.59	0.17	----

pine areas, but there was no significant difference between these two areas ($P > 0.005$).

Tamiasciurus hudsonicus

Red squirrels (thirty-four captured an average of 3.3 times) occurred only on the small pine area (Table VIII). Data were insufficient to calculate a home range because individuals ranged over the entire small mammal trapping plot and too few recaptures were made in the large traps. Doutt, Heppenstall, and Guilday (1966:123) state that an average Tamiasciurus home range has a diameter of about 200 yards (about 2.75 acres). Consequently a marginal strip of 173 feet was added around each plot (Blair, 1941) so that the areas trapped amounted to 2.34 acres. Populations were low in May and June (Table VII) with only five (1.07 per acre) and three individuals (0.64 per acre) being captured respectively. In July populations reached a maximum of 15 individuals (3.42 per acre). Of these, juveniles reached a density of 2.14 per acre and adults 1.28 per acre. Ten individuals were captured during a two week period in August in the large traps (ten traps in an area of 3.7 acres). A figure of 1.60 per acre is obtained.

Table XVI lists the sex ratio of individuals captured. In total there was 15 females to 9 males (37.5 per cent males). Of these, juveniles numbered eight females and five males (38.5 per cent males). Sex ratio deviation was not statistically significant

($P > 0.01$).

Juveniles were present during every trapping period, but during July they made up 62.5 per cent of the population. Hatt (1929) found gestation was about six weeks and young squirrels were weaned after about five weeks (Palmer, 1954). Thus, the breeding season apparently took place in late March and early April with a small percentage of individuals breeding during February.

Species of Minor Importance

One Microtus pennsylvanicus, a juvenile female was captured on June 28 in the small oak area. Assuming an 0.25 acre home range (Manville, 1949:69) (marginal strips of 96 feet) density was 0.35 animals per acre.

Blarina brevicauda was captured a total of five times. Manville (1949:64) gives an average home range of 0.21 acres. With marginal strips of 109 feet, density in the small oak in July and August was 0.37 animals per acre (both adult females) and 1.12 per acre in the green brier (two adult males and one adult female) for August.

Sorex cinereus was captured in August in the large oak area (adult female) and green brier area (adult male). Assuming an 0.50 acre home range (Manville, 1949:61) (marginal strips of 148 feet) densities were 0.25 per acre.

One adult female Mus musculus was captured May 27 in the green brier area.

Three Mustela frenata (all adult females) were captured during the season, two in the large oak area (July 13) and one in the green brier area (July 18).

Average weights of those shrews (Blarina and Sorex) captured in August are presented in Table XIII.

Six additional species of mammals (listed in Table XVIII) were observed but not captured during the course of the study. Of these, the most common was Sciurus niger which appeared on all areas.

Total Populations

The calculated populations per acre of six species on each of the five plots are summarized in Table XIX. In general, there was an increase in the populations on all plots during the trapping season. Populations were relatively small on all areas in May, ranging from 3.01 per acre (small oak) to 4.37 per acre (green brier). Populations approximately doubled in June and in July maximal populations of 15.16 per acre (large oak) and 16.30 per acre (small pine) were obtained. Of this, Peromyscus in the large oak reached a density of 12.97 per acre, Tamias 2.02 per acre, and Glaucomys 0.17 per acre. In the small pine, totals were distributed

Table XVIII

Mammals observed but not captured. Observations made from March through September, 1967.

Species	Study Areas				
	sm. oak	lg. oak	sm. pine	lg. pine	gr. brier
Sciurus niger	X	X	X	X	X
Vulpes fulva				X	
Mephitis mephitis			X		
Mustela vison					X
Marmota monax*.		X		X	X
Scalopus aquaticus			X		X
Odocoileus virginianus			X	X	X

* Marmota was captured on the large oak and pine areas.

Table XIX

Populations of six species of small mammals live-captured on all study areas from May through July. Densities are based on home ranges by the writer, Burt (1946 and 1957), Doutt, Heppenstall, and Guilday (1966), and Manville (1949). Populations are based on both trapping plots. Mammals included are Peromyscus, Tamias, Glaucomys, Tamiasciurus, Blarina, and Microtus.

	Percentage of total captures			Total population per acre		
Study area	May	June	July	May	June	July
small oak	16.3	29.9	22.9	3.01	12.16	14.31
large oak	16.3	12.4	26.0	3.40	9.43	15.16
small pine	13.5	16.1	24.6	3.14	8.68	16.30
large pine	17.7	13.6	13.5	3.11	5.08	9.75
green brier	36.2	28.0	13.0	4.37	8.70	9.00
total of all plots	100.0	100.0	100.0	17.03	44.05	64.52
average of all plots	20.0	20.0	20.0	3.41	8.81	12.90
% monthly density	----	----	----	13.56	35.07	51.37

more, and of these Peromyscus reached a density of 9.54 per acre, Tamias 0.75 per acre, Glaucomys 2.59 per acre, and Tamiasciurus 3.42 per acre. Considering total species densities, the large pine area supported relatively low numbers throughout each trapping period, whereas the small pine area ranked toward the top.

Large Mammals

Because of limited data, large mammals are discussed together and in brief. Those live-trapped included Procyon lotor (sixteen individuals), Didlephis marsupialis (five individuals), and Marmota monax (three individuals). Table XX lists the numbers and sex ratio of those captured.

The size of the study areas (9.6-18.4 acres), the grid arrangement of traps (inclosing 3.7 acres), the short trapping periods (two weeks, except the large oak which was one week), and the irregularity in which these mammals enter traps (Llewellyn and Dale, 1964) made true population densities impossible to determine. Procyon appeared to be the most abundant large mammal on all study areas except the small oak. The largest number of raccoons, six, were captured in the large pine area. Didelphis was captured in three areas (oak and green brier areas) with three individuals occupying the small oak. Marmota was the least common species appearing in the large oak and pine areas.

Table XX

Composition of large mammals captured on all study areas.

Study area	Species								
	Procyon lotor			Marmota monax			Didelphis marsupialis		
	m.	f.	total	m.	f.	total	m.	f.	total
Sm. oak	--	--	--	--	--	--	1	2	3
Lg. oak*	3	2	5	1	1	2	1	--	3
Sm. pine	2	2	4	--	--	--	--	--	--
Lg. pine	5	1	6	--	1	1	--	1	1
Gr. brier	--	1	1	--	--	--	--	--	--

* trapping period of only one week.

The number of large mammals captured was insufficient for determining the true sex ratio. The ratios, based on all individuals captured were as follows: Procyon 62.5 per cent males, Didelphis 30.0 per cent males, and Marmota 33.3 per cent males.

Adult animals in all cases outnumbered the juveniles. For Procyon 56.2 per cent were adults; for Didelphis, 100 per cent; and for Marmota, 66.6 per cent adults.

Evidence of reproductive activity was observed in only one animal, a female Didelphis, captured June 26 and recaptured June 30 and July 3 in the small oak area. The marsupium contained young at each capture.

DISCUSSION

Relative Densities

Peromyscus leucopus was the most abundant small mammal appearing on all study areas during each trapping period. Populations increased from apparent lows in May to highs in July and August. Peromyscus density was estimated to have reached a peak of 13.80 animals per acre in the large oak during August.

Burt (1940), who worked with live-traps in an oak forest in southern Michigan, reported an August density of 7.07 P. leucopus per acre in 1936. A mid-summer peak density of 11.04 P. maniculatus per acre was reported by Manville (1949), who used live-traps in a northern Michigan study in white birch, maple, and oak forest in 1942.

Their methods differ from those of this study because they assumed they had marked nearly all of the resident population and omitted from the estimates those individuals captured only once which they considered as transients. In this study an average of 14.5 per cent of the Peromyscus captured were of transient classification (this included all study areas and all trapping periods). If population estimates were made assuming that nearly all animals were captured and omitting those animals captured once or twice as done by Burt (1940) and Manville (1949), the estimates for the

Allegan areas would average 12 per cent lower. With a 12 per cent reduction in the densities of the Allegan areas, data would parallel the density figures obtained by Manville (1949) and more closely approximate those found by Burt (1940). Once captured individuals were considered in this study and their presence was considered significant even if it is assumed that they represent only unestablished, temporary members.

There may be various factors that could play a significant role in the resident animal being captured only once or the non-resident being captured more than once. For example, the activity of an adult female may be drastically reduced shortly before and for the first few days after parturition (Ellis, 1964), or a nonresident animal may be captured more than once during a given trapping period. There is no means of detecting if an animal is "trap shy", but the writer suspects that there are resident animals that do not readily enter traps just as there are animals that readily enter them (Peromyscus 1 in the green brier area was captured twenty-nine times out of a possible thirty-three trap nights). Thus it is the belief of the writer that a classification to the degree of residency is a more valid means of arriving at a population estimate.

Trapping data for Tamias do not cover an area sufficiently large enough to present relative density conditions accurately. Relatively few population figures are available for this species.

Over a four-year period (1932-1935) Williams (1936) estimated autumn densities of four to fifteen individuals per acre in a beech-maple woodland in Ohio. Bole (1939) reported a density of 8.7 per acre in Ohio in 1935. Burt (1940) found populations in 1935-1937 of 0.8 to 3.6 per acre following appearance of the first litters in May and June. Manville (1949) reports densities range from 0.12 to 0.72 animals per acre between 1940 and 1942 in a northern Michigan study. The population estimates from this study are closest to those reported by Burt (1940).

Certain writers (Sollberger, 1940, and Howell, 1918) feel that Glaucomys seldom descends to the ground, and that population densities are biased by using ground-positioned traps. Other workers (Burt, 1940 and Jordon, 1948) and the writer have found that flying squirrels frequently travel on the ground and thus relatively good population data can be obtained from ground - positioned traps.

In his studies on the George Reserve, Burt (1940) found Glaucomys populations to have ranged from 1.6 to 1.34 animals per acre. Jordon (1948) in a Michigan study reports a density of one animal per acre. Bole (1939) found densities ranging from about three to six animals per acre and Sollberger (1940) reports five per acre in Pennsylvania to 2.2 animals per acre in New York. Populations in this study ranged from 0.17 to 2.93 animals per acre.

Observers of the red squirrel agree that the numbers of these animals vary widely with seasons, years and habitats. Klugh (1927) reported about one animal per twenty acres in both pine forests of Ontario and beech-maple forests. Hatt (1929) estimates summer populations ranging from two per acre to one per three acres in various coniferous forests. Hamilton (1939) counted forty-four individuals in about thirty acres of hardwood forests and Bole (1939) reports a peak density of 1.7 animals per acre in beech-maple forests in Ohio. Layne (1954) reported populations of 1.85, 0.96, and 0.72 squirrels per acre obtained in three woodlots of mixed hardwoods, hemlock, and white pine in upper New York state.

Only one Microtus pennsylvanicus was captured during the course of the study. Burt (1957) reports that the meadow vole is an inhabitant of moist, low areas with rank growths of grasses. The nearest grassland from the study area was about a thousand yards away and it was relatively dry. Various authors (Blair, 1940; Harper, 1929; Townsend, 1935) report strong migratory tendencies in Microtus. The lack of favorable habitat in an oak forest would account for the absent Microtus populations and the migratory behavior of this species may explain the single capture in the small oak area.

Only one Blarina brevicauda was live-captured, but three additional individuals were snap-trapped. Population estimates in

this study ranged from 0.37 to 1.12 animals per acre. In southern Michigan Burt (1940) found Blarina less common on high, dry areas with a scant cover of vegetation and more common in the woods and moist lowlands. Linduska (1950) reported more shrews in areas where the layer of duff and litter was heaviest. All the study areas were relatively dry and sandy with duff and litter minimal. Thus, it is not surprising to find small populations of Blarina in this study.

No Sorex cinereus were captured in the live traps, but a population density of about 0.25 per acre was estimated with snap traps. Manville (1949) feels that moisture is undoubtedly an important factor in the distribution of this species. The xeric nature of the Allegan study areas would account for the small Sorex densities observed.

One Mus musculus was taken during the study (green brier area). Burt (1957) states that the house mouse is a usual inhabitant of places of human habitation although it often inhabits fields especially if there is grain. Linduska (1950) reported that when he captured house mice he did not capture deer mice and when deer mice were common house mice were not. This would seem to indicate some measure of intolerance between the two species. In view of these above statements the low population of Mus reported here is not unusual.

The only predatory species captured was the long-tailed weasel (Mustela frenata). Live-trapping data of the type used here has limitations in indicating actual densities of a wide-ranging predatory animal. Linduska (1950) indicates fall concentrations in Michigan to be about six to eight animals per hundred acres. The prey of this animal is known to include considerable numbers of small mammals (Hamilton, 1933; Errington, 1936; Allen, D., 1938; Polderboer et al., 1941).

The relative abundance of different species of small mammals is constantly changing (Manville, 1949). Peromyscus is probably always present in relatively large numbers, while the species of shrews are always relatively few in xeric oak and oak-pine forests.

Of the nine species of small mammals captured, four comprised at least ninty-eight per cent of the total capture during any one period. Of the five other species, none ever comprised more than one per cent of the total catch. Specimens of Mus, Blarina, Microtus, and Sorex were largely restricted to habitats not included in the plots trapped. Tamiasciurus and Glaucomys population estimates are subject to question because the size of the traps used were not designed for capture of animals of their size. Captures of Mustela may be considered completely accidental.

Animal species interact chiefly by being associated in the same habitats and by being active at the same time (Allen, D.,

1938). The xeric conditions of the study areas could have been limiting to shrews and other species that would require more moist conditions. Reduced inter-specific competition because of the limited numbers between these species and Peromyscus may have been important in the relatively high population estimates of Peromyscus. Food relationships also would favor Peromyscus because of the dryness and sparseness of the litter; soil invertebrate fauna would probably be minimal and consequently few insectivores would be able to occur.

The Sciurid mammals were found sympatrically but to what extent their habitat requirements overlap is not definitely known. Linduska (1950) maintains that fundamental food requirements of red squirrels, flying squirrels, and chipmunks are similar. Tamiasciurus, was present only on the small pine area, where Tamias populations were the lowest. The Glaucomys population numbers, however, were relatively high, thus indicating that there may be intolerance between red squirrels and chipmunks, but not between red squirrels and flying squirrels. In the other areas with no red squirrels and substantial flying squirrel populations, chipmunk numbers seemingly were not affected, again suggesting the more tolerant relationship between these two species.

Studying populations by trapping involves the addition to the environment of considerable amounts of energy in the form of food used as bait. Presumably there is some relationship between

the size of population an area can support and the energy available to the population. Estimates of the additional caloric input for the small mammal populations are necessarily crude because the amount of bait used per trap was not carefully standardized and the amount eaten varied greatly. An approximate average of 1.5 pounds of bait was added to each plot during each trapping period. If we assume that the bait was made up of about two-thirds peanut butter and one-third rolled oats (by weight), then the potential addition of energy to the environment (not all of it utilized) would be about 5.7 Kcal per square meter. (This assumes a caloric content of about 2600 Kcal per pound for peanut butter and about 1800 Kcal per pound for oats.) This amount is small relative to the total annual net primary production of such forests, which is probably on the order of 4800 Kcal per square meter (based on figures from Westlake, 1963, and Golley, 1961). It is more substantial, considering the short time period and relative to the percentage of net primary production available as food for small mammals. Even so, it seems unlikely that the addition of bait increased the energy base of the small mammal populations by even five per cent for the three months of live-trapping. This does not seem an important alteration (although equivalent amounts of bait in very unproductive ecosystems might be). It is possible, and even likely, that other factors associated with baiting and trapping (see Home Ranges, beyond) may influence estimates of population size.

Peromyscus Sex Ratios

The dominance of *Peromyscus leucopus* males in the population is in general agreement with estimates of others (see especially Terman and Sassaman, 1967). During the total trapping season males significantly outnumbered females. Only in the immature age class did females outnumber males, but this difference was not significant and the sample size was relatively small (sixty individuals). The explanation most often given for the preponderance of males in trapping records for natural populations is that males tend to "wander" more or travel over larger areas than females and thus have greater trap exposure and consequently greater probability of capture than females (Burt, 1940; Townsend, 1935; and Blair, 1940). Terman and Sassaman (1967) indicate, however, that there may actually be an unbalanced sex ratio at birth in the very similar *P. maniculatus*.

Breeding Seasons

The extent of the breeding season, as estimated by reproductively active *Peromyscus* females and the number of immatures captured was approximately six months (late March to August). Main breeding periods appeared to be in May and August. Burt (1940) reported a breeding season in southern Michigan for *P. leucopus* of about eight months (March through early November) with maximum activity in April, May, and September. Manville (1949) in

a northern Michigan study observed a five-month breeding season (May through September) for P. maniculatus with reproduction peaks being obtained in May, July, and August. There is little evidence in this study that breeding occurred before March. The reduction in reproductively active females captured in June and the few immatures captured in August indicated that few females bred in June. Both Burt (1940) and Manville (1949) reported a reduction in breeding in June.

Literature reports on the breeding behavior of the eastern chipmunk do not agree. Condrin (1936) and Allen, E. (1938) report that two broods are produced. Burt (1940) indicated that old females produce two litters, but young females of the spring may also produce in the fall of the same year. Schooley (1934) found that old females breed in the spring and the younger ones (those born the preceeding spring and summer) breed during July. Also, old females that did not breed during the spring mating may also breed during July. Observations from this study indicated two breeding periods but both of them were in the spring (April and May) and no mid-summer mating was observed. It is the belief of the writer that females in this study bred only once during the season and that the second breeding period was for those females that did not successfully mate during the first period.

There is little published data on flying squirrel breeding. Burt (1940 and 1957) reports two litters are born to a female each

year in southern Michigan in April, May, or early June and again in August. Hibbard (1935) found that in Kentucky the young are born in March and September. Data from this study indicate that young were born in April and March. Live-trapping was ended in late July and if litters were present in August or September, they would have gone undetected.

Most recorded observations on reproduction in the red squirrel indicate that the time of birth is April to June (Preble, 1908; Dice, 1921; Hatt, 1929; Layne, 1954). Klugh (1927) indicated that a second brood is possible but is an exception. Hamilton (1939) found in New York that females were producing both spring and fall litters. Lyon (1936) believed that two litters were produced in Indiana and Linduska (1950) in a Michigan study felt that two broods were also produced. Observations on marked animals in this study indicated that litters were produced in the middle of March and possibly early in April. Population estimates were low in August indicating that some of the females may have been delivering young at the time.

Home Ranges

Estimates of Peromyscus home ranges from this study are probably smaller than the actual home ranges of the individuals concerned. These home ranges are generally smaller than those that appear in the literature (see especially Blair, 1953 and Brown,

1962).

Many animals taken were captured at least once in the outside row of traps which indicated that their home ranges may have extended some distance beyond the area trapped. For those animals in which a home range was estimated, the range varied from 0.17 to 0.27 acres with no statistical difference in the sizes between sexes or age groups. Many writers (Blair, 1953 and Brown, 1962) report differences in home ranges between both sexes and age groups, but generally differences are not significant. Possibly if the trapping plots had been larger, differences might have been evident. Blair (1943) reported that P. leucopus ranged more widely in comparatively sparse cover than in dense cover. In this study each of the five areas was relatively different in ground cover composition; yet no differences in home range sizes were evident between areas. The largest home range recorded was in the area with the densest ground cover and possibly the best food supplies. The smallest home range was also reported from this area (large pine). High densities may have had an effect on the small home range of the animals in this study, but Southern and Laurie (1946), Calhoun (1948), and Young, Strecker and Emlen (1950) found that densities have no effect on the size of home ranges of various small mammals.

Although home range estimates of this study are somewhat smaller than those reported in the literature, the writer does not

believe they are subject to any more error. It is the belief of the writer that actual home range sizes cannot be determined by present trapping methods. "The greatest difficulties of the live-trapping method stem from the fact that both the environment and the activity patterns of the animals are altered considerably by the introduction of a large supply of exotic foods in the traps and by the fact that a considerable part of the normal activity time of the animal is spent in the confines of the trap" (Blair, 1953). Possibly the concentration of food sources is more important than their amount. Chitty (1937) also points out many difficulties encountered in the study of mammal populations with the use of traps in natural populations. Thus only arbitrary indices can be obtained by trapping methods.

Parasites

A large percentage of P. leucopus captured in July and August were parasitized by botflies (Cuterebra sp.) (66.6 per cent of those captured in August). Burt (1940) reported only minor infection of 0.7 and 3.4 per cent in a southern Michigan study and Manville (1949) observed no infections of P. maniculatus in northern Michigan. Wecker (1962) in a southern Michigan study found 48.0 per cent of the mice were parasitized by botfly. Observations indicate higher rate of infestation than those in the literature; in the small oak area 90.0 per cent of the captured immature males were infected in July and in August 87.5 per cent

of the adult females of the green brier area were parasitized. Various other writers in addition to Wecker (Scott and Snead, 1942 and Hirth, 1959) report high percentages of Cuterebra parasitism in Peromyscus in late summer. This study agrees with Wecker (1962) in that there was no correlation between parasitism and host sex or age. The author's observations agree with the consensus (Test and Test, 1943; Buckner, 1956; and Clough, 1965) that Cuterebrid parasitosis is tolerated by Peromyscus without causing increased mortality rates.

Habitat Preference

Although each of the five study areas differed in ground cover vegetation there was no statistically significant preference demonstrated by Peromyscus among these areas. Wecker (1964, 1963) stated that habitat preference of wild populations of Peromyscus is an expression of an innate pattern of behavior and that this pattern is elicited by certain key environmental stimuli. Williams (1955) believed that habitat preference is usually linked with the availability of suitable food and shelter. The writer and Harris (1952) believe that the availability of food, water, and cover alone do not give an adequate explanation of observed habitat distribution, whereas food may put only loose limits to the habitat in most species, as maintained by Hilden (1965).

According to the principle of stimulus summation (Hilden, 1965), each of the five study habitats had enough features or positive characteristics that the selection stimuli exceeded the threshold of the selection reaction. Hilden (1965) also maintained that one key stimulus may outweigh others. This key stimulus may be an ultimate factor (shelter or a structural characteristic of the habitat) that is being substituted for a sequence of proximate factors in the selection of habitat. Such a key factor might be the physiognomy of xeric oak forests and may account for the equal distributions of P. leucopus on all study areas.

The absence of other dominant species may also help explain the equal distributions observed here. Brown (1962) believed that a dominant species might prevent the spreading of others. Hatt (1928) and Werner (1956) described such a situation between Blarina and Microtus. In this study shrews, Microtine and Murine rodents were very uncommon and other species of Cricetine rodents were absent. In the absence of interspecific competition between related species, species once bound to a species-specific environment in a common area might have a wider ecological amplitude.

Although some of the areas appeared to be more suitable habitats for Tamias because of old rotted pine stumps and downed logs, Tamias showed no significant selection of any of the study areas. Howell (1923) and Quimby (1944) have reported that this species shows preference for upland woodlands; therefore, it is

not unusual to find chipmunks on all the areas. If habitat selection is innate, reinforced by a stimulus summation and the possible substitution of an ultimate factor for a sequence of proximal factors, each of the Allegan areas would support relatively similar population of T. striatus.

So few critical population studies on flying squirrels have been conducted that it is difficult to estimate what constitutes their optimal habitat. The flying squirrels in this study showed a statistical preference for two of the study areas (small oak and small pine areas). Sollberger (1940) reported flying squirrels most commonly in climax forests in which nesting cavaties were numerous and nuts were abundant. Observations made by Jordon (1948), with traps placed in trees, show that the squirrel preferred large trees (average dbh of 13 inches). Also he showed that the greatest number of captures were made where ground cover was sparse to medium density. Both Jordon (1948) and Hanson (1944) observed that overgrazed woodlands were avoided by flying squirrels. The preference demonstrated in this study is difficult to analyze because those habitats selected for do not agree with what is presented in the literature. In the small oak area the trees were relatively small, but the ground cover was sparse to medium. In the small pine area the majority of the trees were also small. Some large trees were present, but the ground cover was very dense. The most suitable habitat according to the literature

was the large oak area because of the large trees and sparse ground cover; yet only one flying squirrel was captured there during the entire study. The presence of nest cavities is probably an important factor in the occurrence of flying squirrels, but no information is available on the numbers of suitable cavities on the five areas. It is possible that the population estimates given here are invalid and the areas which seemingly have the highest populations are, instead, those in which flying squirrels tend to come to the ground. This possibility should be investigated by using both ground and tree traps in the areas.

The red squirrels in this study were captured on only one of the five study areas, the small pine, an area which has a dense understory of white pine and white oak and a relatively well-developed ground cover vegetation. Several authors report that red squirrels accept a great variety of foods (Klugh, 1927; Murie, 1927; Hatt, 1929; and Layne, 1954). Linduska (1950) showed that T. hudsonicus demonstrated a clear preference to areas with a variety of trees, shrubs, and dense ground cover. Contrary to previous statements, Layne (1954) maintains that sufficient food seems to be a primary habitat requirement of the red squirrel. He lists conifer plantations as a preferred habitat. This inclination has also been noted by Sherman (1936) and others and is probably an expression of an inherent predilection for coniferous cover or seeds or both. With an analysis of the small pine area it becomes

evident that the understory white pines offer cover but not food because the pines are not producing cones. In addition the canopy is predominantly white oak and the acorns of this species are probably more palatable than those of the black oak as found in most of the other areas. Either or both factors could be involved in the occurrence of the species in this area and its absence from the others.

Large Mammals

The scope of this study did not allow detailed information on the large species of mammals. Data show only relative numbers of those species present. Raccoons were the most abundant large species, appearing on all study areas except the small oak. Stuewer (1943) reports that raccoons inhabitat lowlands, but adjacent oak country is an important part of their range since it furnishes an attractive and substantial supply of food in the form of acorn mast. The absence of raccoons from the small oak might be due in part to its distance from a lowland association.

Woodchucks were captured in only two areas (large oak and pine), but dens were present in the green brier as well as the large oak. Burt (1957) reports that this species inhabits forests and areas of heavy brush. The green brier area has dense stands of green brier and in the large oak burrows were located near witch hazel stands. Brushy areas were present in the large

pine, but the captured Marmota was an immature and its residence is questionable.

Seven Didelphis were captured in three areas (large pine and both oak areas). Llewellyn and Dale (1964) report that dry upland woods are relatively poor habitats and that this animal primarily occupies low, dense woodland, favoring those areas near water. Two areas were near lowland woods, but the small oak was some distance from a moist area.

SUMMARY

During the spring and summer of 1967, intensive live-trapping was employed to measure comparative populations, home ranges, and habitat preference of twelve species of mammals in the Allegan State Game Area, Allegan County, Michigan. A total of 581 mammals were handled, of which 508 were taken in 13,500 trap nights of live-trapping, the remaining by snap traps in 1,800 trap nights.

Peromyscus leucopus was by far the most numerous animal; it appeared on all study areas and reached a late summer maximum density of 13.80 animals per acre. Calculated home ranges of this species were smaller than those that appear in the literature, probably because of the small trapping plots used in this study. There was no significant preference demonstrated by this species to any of the five study areas, possibly because each area offered a positive stimulus summation for selection.

Blarina, Sorex, Microtus, and Mus were few possibly because the xeric conditions of the study areas were unfavorable habitats, or, in the case of Mus because of the dominance of Peromyscus.

Sciurid mammals appeared on all study areas. Tamias was the most consistent resident of the areas. A preference was shown by Glaucomys and Tamiasciurus. The reasons for response of these two species to the preferred areas was not clearly evident, but

the presence of abundant foods and white pines may have been an important factor in the red squirrel selection for the small pine area. Data offer no additional evidence into the habitat preference of the flying squirrel. Possible competition between sciurids occurred only between red squirrels and chipmunks when they appeared together on the small pine area.

An analysis of total small mammal populations was made for May, June, and July. Total densities ranged from a May low of 3.01 animals per acre to a July maximum of 16.30 animals per acre. Of the nine species of small mammals captured, four comprised at least ninty-eight per cent of the total captures during any one period.

The large mammals captured included Procyon lotor, Marmota monax, and Didelphis marsupialis. The raccoon was the most numerous large mammal, appearing on all study areas excepting the small oak. The opossum and the woodchuck were present in lesser numbers on three areas.

APPENDIX

Table I

Dates of the three live trapping-periods in the five study areas.

Area	period I	period II	period III
small oak	May 19-30	June 20-30	July 14-24
large oak	May 9-19	June 9-19	July 3-12
small pine	May 7-17	May 30-June 10	July 1-11
large pine	April 28-May 9	May 29-June 8	June 22-July 2
green brier	May 18-28	June 11-21	July 12-22

Table II

Temperature ranges in degrees Fahrenheit from each trapping plot for each trapping period.

study areas	trapping period	mean daily min. temp.	mean daily max. temp.	low temp. range	high temp. range
Small oak	1	47.8	78.1	30-60	64-90
	2	55.7	77.3	48-63	72-80
	3	58.6	79.3	50-68	60-88
Large oak	1	42.2	69.5	21-54	57-82
	2	65.3	80.3	54-69	72-88
	3	57.8	77.2	48-70	68-87
Small pine	1	41.0	69.5	22-52	62-80
	2	58.0	85.4	50-72	80-91
	3	63.4	83.1	50-74	70-90
Large pine	1	37.5	63.0	24-60	44-84
	2	54.5	83.2	44-60	74-92
	3	56.1	80.4	49-64	72-90
Green brier	1	44.4	73.7	30-58	50-84
	2	58.2	75.3	48-66	64-84
	3	51.2	71.0	44-58	60-84
	means	52.78	76.42		

Table III

Soil pH ranges of the A_1 horizons from all study areas.

Study area	lowest reading	highest reading
Small oak	5.0	5.8
Large oak	5.4	6.4
Small pine	5.0	6.2
Large pine	4.8	5.0
Green brier	4.4	5.0

LITERATURE CITED

Allen, D. L. 1938. Ecological studies of the vertebrate fauna of a 500-acre farm in Kalamazoo County, Michigan. Ecol. Monogr. 8: 347-436.

_____ 1943. Michigan fox squirrel management. Michigan Department of Conservation, Game Division publ. 100, pp. 1-404.

Allen, E. G. 1938. The habitats and life history of the eastern chipmunk, Tamias striatus lysteri. Bull. New York State Mus. No. 324, pp. 1-122.

Blair, W. F. 1940. Home ranges and populations of the meadow vole in southern Michigan. J. Wildl. Mgmt. 4: 149-161.

_____ 1941. Techniques for the study of small mammal populations. J. Mammal. 22: 148-157.

_____ 1943. Populations of the deermouse and associated small mammals in the mesquite association of southern New Mexico. Contr. Lab. Vert. Biol., Univ. Mich. 21: 1-40.

_____ 1953. Population dynamics of rodents and other small mammals. Advances in Genetics, Vol. 5: 1-41.

Bole, B. P. 1939. The quadrat method of studying small mammal populations. Sci. Pub. Cleveland Mus. Nat. Hist. 5: 15-77.

Brown, L. E. 1962. Home ranges in small mammal communities, p. 131-179. In B. Glass (Editor), Survey of biological progress, Vol. 4, Academic Press, New York.

Buckner, C. H. 1958. Cuterebrids (Cuterebra grisea, Cog.) attacking small mammals. Bi-Monthly Progress Report. Forest Biology Div. Can. Dept. Agr. 14: 2-3.

Burt, W. H. 1940. Territorial behavior and populations of some small mammals in southern Michigan. Univ. Michigan Press, Misc. Publ. Museum Zool. 45: 1-58.

_____ 1943. Territorality and home range concepts as applied to mammals. J. Mammal. 24: 346-352.

_____ 1946. Mammals of Michigan. Univ. Mich. Press, Ann Arbor. p. 288.

_____. 1957. Mammals of the Great Lakes region. Univ. Mich. Press, Ann Arbor. 246 p.

Calhoun, J. B. 1948. Mortality and movement of brown rats (Rattus norvegicus) in artificially supersaturated populations. J. Wildl. Mgmt. 12: 167-172.

Chitty, D. 1937. A ringing technique for small mammals. J. Anim. Ecol. 6: 36-53.

Clough, G. C. 1965. Physiological effect of botfly parasitism on meadow voles. Ecology 46: 344-346.

Condrin, J. M. 1936. Observations on the seasonal and reproductive activities of the eastern chipmunk. J. Mammal. 17: 231-234.

Cottam, G. and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecology 37: 451-460.

Curtis, J. T. 1959. Vegetation of Wisconsin. The Univ. of Wisc. Press, Madison, Wisconsin. 657 p.

Dice, L. R. 1921. Notes on the mammals of interior Alaska. J. Mammal. 2: 20-28.

Doutt, J. K., C. A. Heppenstall, and J. E. Guilday. 1966. Mammals of Pennsylvania. The Pennsylvanian Game Commission. Carnegie Museum, Carnegie Institute, Pittsburgh. 273 p.

Ellis, R. J. 1964. Tracking raccoons by radio. J. Wildl. Mgmt. 28(2): 363-368.

Errington, P. L. 1936. Foods of the weasel family. J. Mammal. 17: 406-407.

Golley, F. B. 1961. Energy values of ecological materials. Ecology 42: 581-584.

Hall, E. R. and K. R. Kelson. 1959. The mammals of North America. The Ronald Press Co., New York. 1083 p.

Hamilton, W. J., Jr. 1933. The weasels of New York. Their natural history and economic status. Amer. Midland Nat. 14: 289-344.

_____. 1939. Observations on the life history of the red squirrel in New York. Amer. Midland. Nat. 22: 732-745.

Hanson, H. C. 1944. Small mammal census near Prairie du Sac, Wisc. Acad. Sci., Arts and Letters 36: 105-129.

Harper, F. 1929. Notes on mammals of the Adirondacks. New York State Museum Handbook 8: 51-118.

Harris, V. T. 1952. An experimental study of habitat selection by prairie and forest races of the deermouse, Peromyscus maniculatus. Contrib. Lab. Vert. Biol., Univ. Mich. 56: 1-53.

Hatt, R. T. 1928. The relation of the meadow vole, Microtus pennsylvanicus pennsylvanicus to the biota of a Lake Champlain island. Ecology 9: 88-93.

_____. 1929. The red squirrel: its life history and habits, with special reference to the Adirondacks of New York and the Harvard Forest. Roosevelt Wild Life Annals 2: 1-146.

Hibbard, C. W. 1935. Breeding seasons of the gray squirrels and flying squirrels. J. Mammal. 16: 325-326.

Hilden, O. 1965. Habitat selection in birds. A review. Annales Zoologici Fennici 2: 53-75.

Hirth, H. F. 1959. Small mammals of old field succession. Ecology 40: 417-425.

Howell, A. B. 1923. Periodic fluctuations in the numbers of small mammals. J. Mammal. 4: 149.

Howell, A. H. 1918. Revision of the American flying squirrel. U.S. Dept. Agr., Bur. Biol. Survey, No. Amer. Fauna 44: 1-64.

Jameson, E. W., Jr. 1950. Determining fecundity in male small mammals. J. Mammal. 31: 433-436.

Jordon, J. S. 1948. A midsummer study of the southern flying squirrel. J. Mammal. 29: 44-48.

Klugh, A. B. 1927. Ecology of the red squirrel. J. Mammal. 8: 1-32.

Layne, J. N. 1954. The biology of the red squirrel, Tamiasciurus hudsonicus loguax (Bangs), in central New York. Ecol. Monogr. 24: 227-267.

Linduska, J. P. 1950. Ecology and land-use relationships of small mammals on a Michigan farm. Michigan Dept. Conserv. Game Division Publ. pp. 1-144.

Llewellyn, L. M. and F. H. Dale. 1964. Notes on the ecology of the opossum in Maryland. J. Mammal. 1: 113-122.

Lyon, M. W. 1936. Mammals of Indiana. Amer. Midland Nat. 17: 1-384.

Manville, R. H. 1949. A study of small mammal populations in northern Michigan. Univ. Michigan Press. Misc. Publ. Museum Zool. 73: 1-83.

Murie, O. J. 1927. The Alaska red squirrel providing for winter. J. Mammal. 8: 37-40.

Palmer, R. S. 1954. The mammal guide: mammals of North America north of Mexico. Doubleday and Co., Garden City, New York. 384 p.

Polderboer, E. B., L. W. Kuhn, and G. O. Hendrickson. 1941. Winter and spring habits of the weasels in central Iowa. J. Wildl. Mgmt. 5: 115-119.

Preble, E. A. 1908. A biological investigation of the Athabaska-Mackenzie region. U.S. Dept. Agr., Bur. Bio. Survey, No. Amer. Fauna 27: 1-574.

Quimby, D. C. 1944. A comparison of overwintering populations of small mammals in a northern coniferous forest for two consecutive years. J. Mammal. 25: 86-87.

Sanderson, G. C. 1966. The study of small mammal movements -- a review. J. Wildl. Mgmt. 30: 215-235.

Schooley, J. P. 1934. A summer breeding season in the eastern chipmunk, Tamias striatus. J. Mammal. 15: 194-196.

Scott, T. G. and E. Snead. 1942. Warbles in Peromyscus leucopus noveboracensis. J. Mammal. 23: 94-95.

Sherman, F. 1936. Some mammals of western South Carolina. J. Mammal. 18: 512-513.

Sollberger, D. E. 1940. Notes on the life history of the small eastern flying squirrel. J. Mammal. 21: 282-293.

Southern, H. N. and E. M. O. Laurie. 1946. The house mouse (Mus musculus) in corn ricks. J. Anim. Ecol. 134-149.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co. Inc., New York. 481. p.

Steuwer, F. W. 1943. Raccoons: their habits and management in Michigan. Ecol. Monogr. 13: 203-258.

Stickel, L. F. 1954. A comparison of certain methods of measuring ranges of small mammals. J. Mammal. 35: 1-15.

Terman, C. R. and J. F. Sassaman. 1967. Sex ratio in deer mouse populations. J. Mammal. 48: 589-597.

Test, F. H. and A. R. Test. 1943. Incidence of diptern parasitosis in populations of small mammals. J. Mammal. 24: 506-508.

Townsend, M. T. 1935. Studies on the small mammals of central New York. Roosevelt Wild Life Annals 4(1): 1-120.

Wecker, S. C. 1962. The effects of botfly parasitism on a local population of the white-footed mouse. Ecology 43: 561-565.

_____. 1963. The role of early experience in the habitat selection by the prairie deer mouse, Peromyscus maniculatus bairdi. Ecol. Monogr. 33(4): 307-325.

_____. 1964. Habitat selection. Scient. Amer. 211(4): 109-116.

Werner, W. E., Jr. 1956. Mammals of the Thousand Island region, New York. J. Mammal. 37: 395-406.

Westlake, D. F. 1963. Comparisons of plant productivity. Biol. Rev. 38: 385-425.

Williams, A. B. 1936. Composition and dynamics of a beech-maple community. Ecol. Monogr. 6: 318-408.

Williams, O. 1955. Home range of Peromyscus maniculatus rufinus in a Colorado ponderosa pine community. J. Mammal. 36: 42-45.

Young, H., R. L. Strecker, and J. T. Emlen. 1950. Localization of activity in two indoor populations of house mice, Mus musculus. J. Mammal. 31: 403-410.