THE EFFECT OF FLOODING ON A MARKED POPULATION OF WHITE-FOOTED MICE *PEROMYSCUS LEUCOPUS NOVEBORACENSIS* (FISCHER))

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CHAPTER I

INTRODUCTION

Flooding is especially disruptive to the activities of fossorial and essentially terrestrial animals by destroying, temporarily at least, the usefulness of the habitat. This study is concerned with the effects of spring flooding on the movements of white-footed mice (Peromyscus leucopus noveboracensis (Fischer)) living in forested bottom lands.

Relatively few studies have dealt with the effects of habitat disturbance on small mammals. LoBue and Darnell found harvesting alfalfa resulted in the movement of meadow vole (Microtus pennsylvanicus) populations from the field into dense cover, while prairie deer mouse (Peromyscus maniculatus bairdii) populations remained in the less dense cover of the post-harvest field.[1] Several studies have followed the seeming reluctance of small mammals to leave an area damaged by fire and the immediate repopulation of the area afterwards.[2] Barbehenn and Strecker found that a light grassland burn had little immediate effect on rat

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[1]Joseph LoBue and Rezneat M. Darnell, "The Effect of Habitat Disturbance on a Small Mammal Population," Journal of Mammalogy, 40:425-37, August, 1959.

[2]Daniel L. Leedy, "Woodchucks Survive Brush Fire and Remain in Area," Journal of Mammalogy, 30:73, February, 1949; Lloyd Tevis, "Effect of a Slash Burn on Forest Mice," Journal of Wildlife Management, 20:405-409, October, 1956; and Sherburne F. Cook, "The Effect of Fire on a Population of Small Rodents," Ecology, 40:102-108, January, 1959.

populations while a subsequent burn the same season eliminated nearly all cover and greatly reduced the population.[3]

Yeager found that massive, permanent flooding of a river-bottom timber area limited the area suitable for ground dwellers, resulting in their eviction and that muskrats, raccoons, and minks remained common.[4] Yeager and Anderson found that flooding resulted in heavy mortality in woodchucks but had little effect on partially arboreal forms.[5] Blair observed that stream-valley flooding resulted in a reduction in numbers of terrestrial mice in the area,[6] and Grinnell observed that flash flooding was pernicious to ground dwellers.[7] McCarley observed that, although stream-valley flooding reduced the numbers of white-footed mice

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[3]Kyle R. Barbehenn, and Robert L. Strecker, "Studies of Natural Populations by Modification of Environment," (Manuscript).

[4]Lee E. Yeager, "Effect of Permanent Flooding in a River-Bottom Timber area," <u>Bulletin of the Illinois Natural History Survey</u>, 25:33-65, August, 1949.

[5]Lee E. Yeager, and H. G. Anderson, "Some Effects of Flooding and Waterfowl Concentrations on Mammals of a Refuge Area in Central Illinois," <u>American Midland Naturalist</u>, 31:159-178, January, 1944.

[6]W. Frank Blair, "Some Observed Effects of Stream-Valley Flooding on Mammalian Populations in Eastern Oklahoma," <u>Journal of Mammalogy</u>, 20:304-306, August, 1939.

[7]Joseph Grinnell, "Effects of a Wet Year on Mammalian Populations," <u>Journal of Mammalogy</u>, 20:62-64, February, 1939.

(Peromyscus leucopus), there was a definite tendency for survivors to remain within their home ranges.[8] In contrast, Stickel found that a flash flood had little effect on populations of white-footed mice.[9] Davis, Brown, and Jackson indicated that induced flooding and its influence on a woodland habitat did not alter the population of white-footed mice during the initial years of observation.[10]

These studies, with the exception of the last one, were derived from massive flooding, either temporary or permanent in nature. Such floods destroy rather than merely disrupt the habitat, and the animal residents are generally affected adversely. However, the effects of annual, small-scale flooding which often occurs in scattered bottom-land habitats seems not to have been examined. The present study involves the affect of annual, small-scale flooding on a population of white-footed mice living in a bottom-land woods in northern Ohio.

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[8]Howard McCarley, "The Effect of Flooding on a Marked Population of Peromyscus," Journal of Mammalogy, 40:57-63, February, 1959.

[9]Lucille F. Stickel, "Observations on the Effect of Flood on Animals," Ecology, 29:505-507, October, 1948.

[10]David E. Davis, Robert Z. Brown, and William B. Jackson, "The Effect on Mouse Populations of Sprinkling Industrial Effluent in an Oak Woods," Transactions of the Sixteenth North American Wildlife Conference, 16:283-289, March, 1951.

The study area was in Bowling Green State University's Steidtmann Wildlife Refuge, located in Liberty township, Wood County, Ohio (Range 10, Section 13). This general locale lies in a glacial lake bed and has often been termed the Black Swamp.[11]

The study area is located in the Beech-Maple Forest Region,[12] and is characterized by a mixed oak association. The arboreal vegetation was studied by a quarter-method survey,[13] and data are summarized graphically in Figure 1 and discussed in detail in Appendix A. The overstory was dominated by red oak (*Quercus rubra*), swamp white oak (*Q. bicolor*), and red maple (*Acer rubrum*). Herbaceous vegetation, sampled by meter-square quadrats, was sparse, and made up of a wild rose (*Rosa* sp.), several sedges (*Carex* sp.), and annuals (including *Pteridium* sp., *Aster* sp., and others). The more depressed areas of the woods are filled by surface drainage to a maximum depth of about two feet each spring for several months, or less, depending on climatic conditions.

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[11] Martin R. Kaatz, "The Black Swamp: A Study in Historical Geography," *Annals of the Association of American Geographers*, 45:1-35, February, 1955.

[12] E. Lucy Braun, *Deciduous Forests of Eastern North America* (Philadelphia: The Blakiston Company, 1950), p.305.

[13] Edwin A. Phillips, *Methods of Vegetation Study* (New York: Henry Holt and Company, Inc., 1959, p. 41.

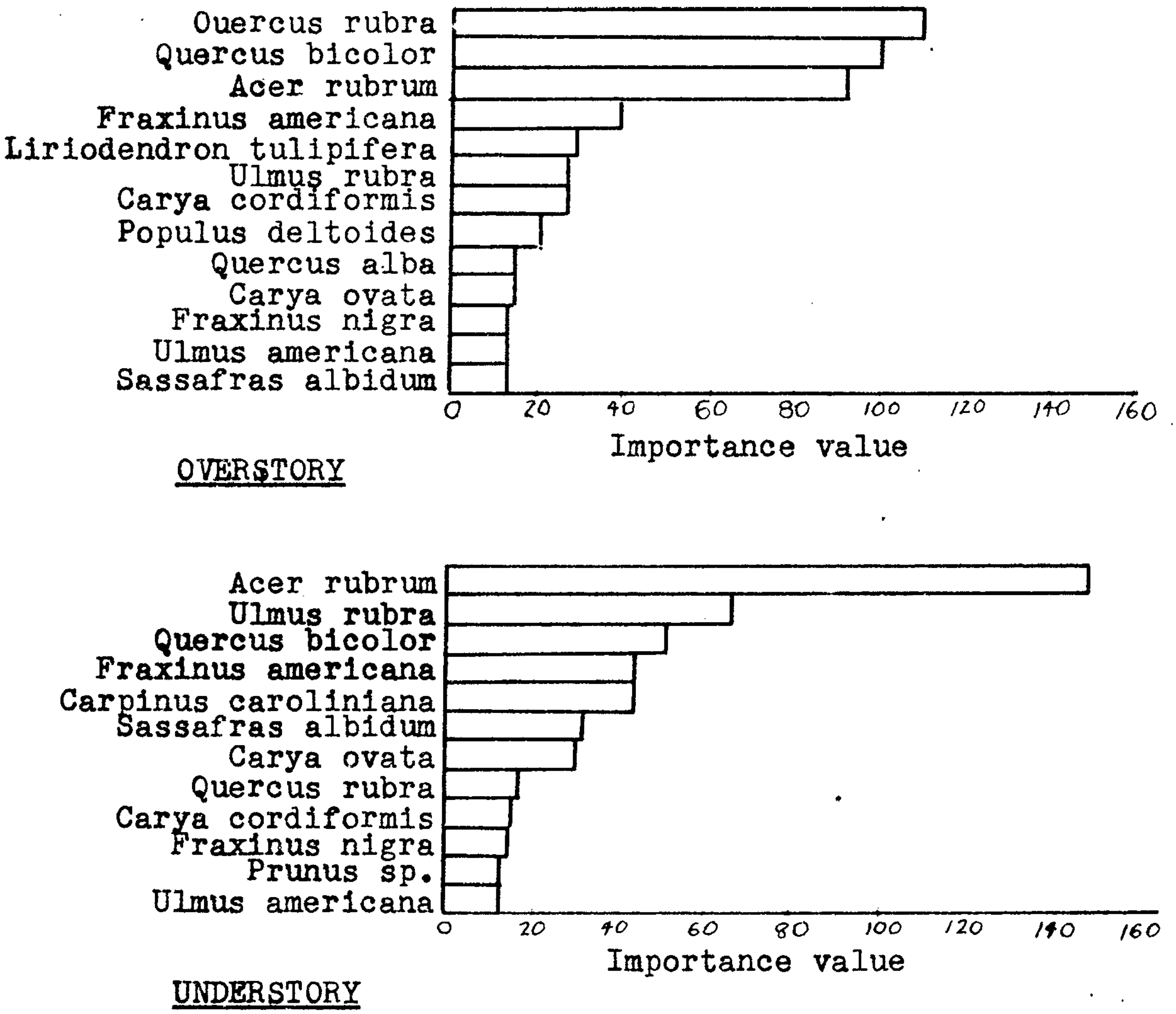


FIGURE 1

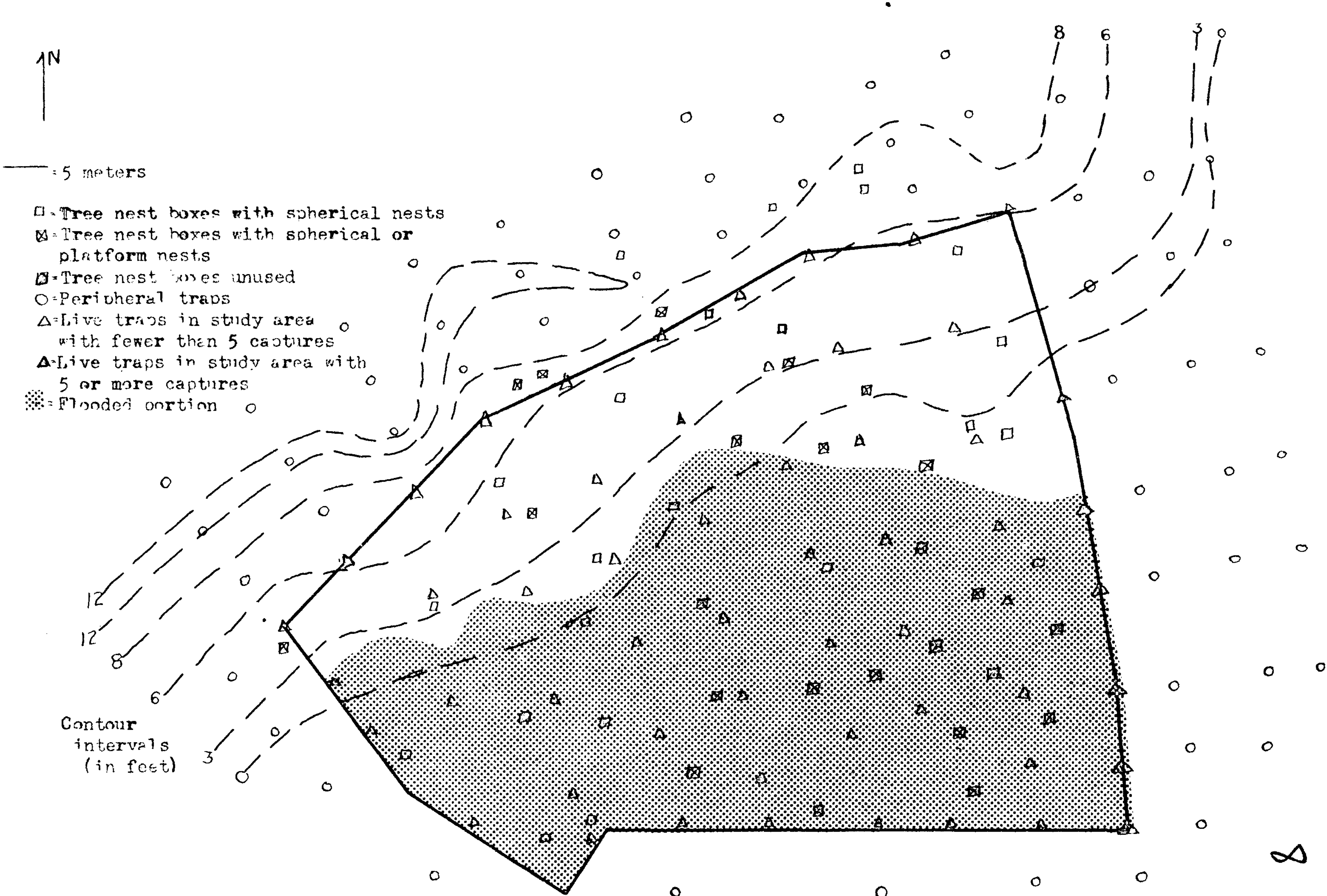
IMPORTANCE VALUES OF OVERSTORY AND
UNDERSTORY SPECIES IN THE STUDY AREA
OBTAINED FROM A QUARTER METHOD SURVEY

The study area included 0.71 acres of woodland bordered on the south by a winter wheat field and on other sides by contiguous woodland, the north being on a sandy, glacial lake ridge from three to six feet high (Figure 2).

The author wishes to acknowledge the assistance of Dr. William Jackson for advise and counsel and for valuable criticism of the manuscript. Dr. Ernest Hamilton and Mr. Gerald Acker offered many helpful suggestions and criticisms of the manuscript.

FIGURE 2

STUDY AREA MAP SHOWING CONTOURS
AND TRAP AND NEST BOX STATIONS
WITH INDICATIONS OF THE USE OF EACH



N
= 5 meters
= Tree nest boxes with spherical nests
= Tree nest boxes with spherical or platform nests
= Tree nest boxes unused
= Peripheral traps
= Live traps in study area with fewer than 5 captures
= Live traps in study area with 5 or more captures
= Flooded portion
Contour intervals (in feet)
12
12
8
6
3
8
6
3
8

CHAPTER II

METHODS

Movement patterns of the mice living in the study area were determined by trapping the mice alive, toe clipping each for individual identification, and releasing them. Subsequent captures indicated the extent of individual home ranges. The live traps, modified slightly from Davis,[14] were constructed by bolting one-quart oil cans to museum special traps and wiring one-quarter inch hardware cloth to the trigger bar. Cotton was placed in the cans to reduce mortality from sub-freezing temperatures; and no deaths from freezing were recorded from traps so provided, even though night temperatures reached 3° F.

A grid was established over the study area with permanently marked trapping stations at approximately thirty foot intervals (Figure 2, page 7). At the onset of the study in October 1959, and during the final week in June 1960, the entire area was trapped at one three-day period. However, during most of the study, one-third of the grid was trapped at a time, thus requiring three trapping periods to survey the area. Three complete trappings of the area were completed before the February thaw and subsequent flooding

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[14]David E. Davis (Comp.), *Manual for Analysis of Rodent Populations* (Privately Published), pp. 3-6.

(Table I). Traps were set in the morning, checked on each of three subsequent mornings, and then closed for at least the rest of the week.

With the onset of flooding, the interval between trapping periods was reduced to a minimum. Traps were placed at all stations not submerged and at regular intervals along a wooded perimeter strip sixty feet wide on the north and south edges. The latter traps were set to determine if movements in or out of the inundated area were occurring. The sequence of trapping periods is summarized in Table I.

After the water had receded, in June, the study was terminated with a seven day period of intense kill trapping to determine the total number of mice living in the area. Traps were set both in the study area and in perimeter strips (Figure 2, page 7).

A corrected trap success ratio was used as an index to population abundance and was calculated with the following formula:

$$\text{Trap Success (T.S.)} = \frac{\text{Number of Captures}}{\text{Total number of traps} - \frac{1}{2}\text{ sprung traps}}$$

As discussed by Jackson,[15] this method corrects for randomly sprung traps and assumes that these were sprung at an

[15]William B. Jackson, "Populations of the Wood Mouse (<u>Peromyscus leucopus</u>) Subjected to the Applications of DDT and Parathion," <u>Ecological Monographs</u>, 22:259-281, October, 1952.

TABLE I

PERIODS OF INUNDATION AND SATURATION
WITHIN THE STUDY AREA AND TRAPPING DATES

Trapping dates 1959-1960		Flooding dates 1960	Portion of grid trapped*
October	28-30		A,B,C
November	2-5		B,C
	15-18		B
	23-25		C
December	15-17		B
January	1-3		C
February	2-22	February 5-21	A,B,A,C,B
March	16-18	March 28	A
	25-31		A
		TO	
April	1-2		A,C
	6-8	April 7	A,B,C
	13-14		A,B,C
	19-21		A
	24-26	April 24	A,B,C
		TO	
May	11-20		A,B
	25-28	May 24	A,C
June	2-4		A,B,C
	6-8		A,B,C
	17-18		A,B,C

*Refer to Figure 2, page 7

arithmetic rate during the trapping period. One-half the number of traps sprung thus approximates the number of traps not available to catch the essentially nocturnal mice during the trapping period. Only during the last few weeks of the study was trap disturbance appreciable because of slugs (Deroceras sp. and Philomycus sp.) and land snails (Mesodon sp.).

Home range of an animal is defined as that area around its established home which is traversed by the animal in its normal activities of food gathering, mating, and caring for young.[16] Many techniques of estimating home range have been devised, but the boundry strip method[17] seemed most adaptable for the present data. A peripheral strip, equal in width to one-half the distance between traps, is laid around the minimum area revealed by capture points; and the total area inclosed is calculated. While Hayne criticised this method because it adds to an area of certain movement an area in which the mouse is not definitely known to travel he pointed out that an arbitrary system of trap settings

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[16]William H. Burt, "Territorial Behavior and Populations of some Small Mammals in Southern Michigan," Miscellaneous Publications of the Museum of Zoology, University of Michigan, 45:1-58, May, 1940.

[17]Lucille F. Stickel, "A comparison of Certain Methods of Measuring Ranges of Small Mammals," Journal of Mammalogy, 35:1-15, February, 1954.

does not necessarily correspond to the actual home range either.[18]

Nest boxes were installed to provide a less time consuming method of making observations of mice and to provide dry nesting sites during the spring flooding. The boxes were constructed of one-half inch plywood with roofs which could easily be lifted for examination.[19] Fifty such boxes with inside dimensions of 4 x 4 x 4½ inches were fastened to trees four feet above the ground, and an additional twenty-three boxes (inside dimensions of 4 x 4 x 9 inches) were placed on the ground. The boxes had a one-inch square entrance hole, and cotton was provided for nesting material. The boxes were checked at weekly or biweekly intervals.

Mice captured either in traps or nest boxes were examined for pelage development,[20] sexual condition (enlargement of mammae and perforation of vaginal orifice or position of testes), and were individually marked by clipping a combination of toes.[21] Animals accidentally killed

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[18]Don W. Hayne, "Calculation of Size of Home Range," Journal of Mammalogy, 30:1-18, February, 1949.

[19]William B. Jackson, "Use of Nest Boxes in Wood Mouse Population Studies," Journal of Mammalogy, 34:505-507, November, 1953.

[20]Jack L. Gotteschang, "Juvinile Molt in *Peromyscus leucopus noveboracensis*," Journal of Mammalogy, 37:516-520, November, 1956.

[21]David E. Davis, Manual for Analysis of Rodent Populations, pp. 7-8.

during the course of the study and during the final kill trapping period in June were autopsied. Standard physical measurements (weight, length of body, tail, ear, hind foot, and pelage type) were taken; reproductive tracts were examined for testis size and presence of sperm in epididymis or condition of uterus and length of embryos. Autopsy data are discussed in Appendix B.

CHAPTER III

RESULTS

Trapping results. The small mammal population consisted of virtually all white-footed mice. During the seven and one-half months of the study, 62 white-footed mice and two short-tailed shrews (*Blarina brevicauda*) were trapped in both live and snap traps. Of the 62 mice, 31 were males.

Trap success ranged from a low of three per cent during the final days of the first flooding period (19-22 February) to 31 per cent prior to the second flooding period (25-27 March) (Figure 3). Several factors influenced trap success. The number of traps available was not always the same because of trap disturbance and differing numbers of traps initially set. By computing a corrected trap success ratio, an attempt was made to correct for such variations.

Certain trapping periods were comparable in that essentially the same number of traps were available and all three portions of the study area were represented; but such climatological conditions as snow cover and temperature varied during periods of highest and lowest trap success.

Snow might be expected to make traps less available, but no attempt was made to place them in under-snow runways; and trap success was not consistantly lowered by snow cover (Figure 3).

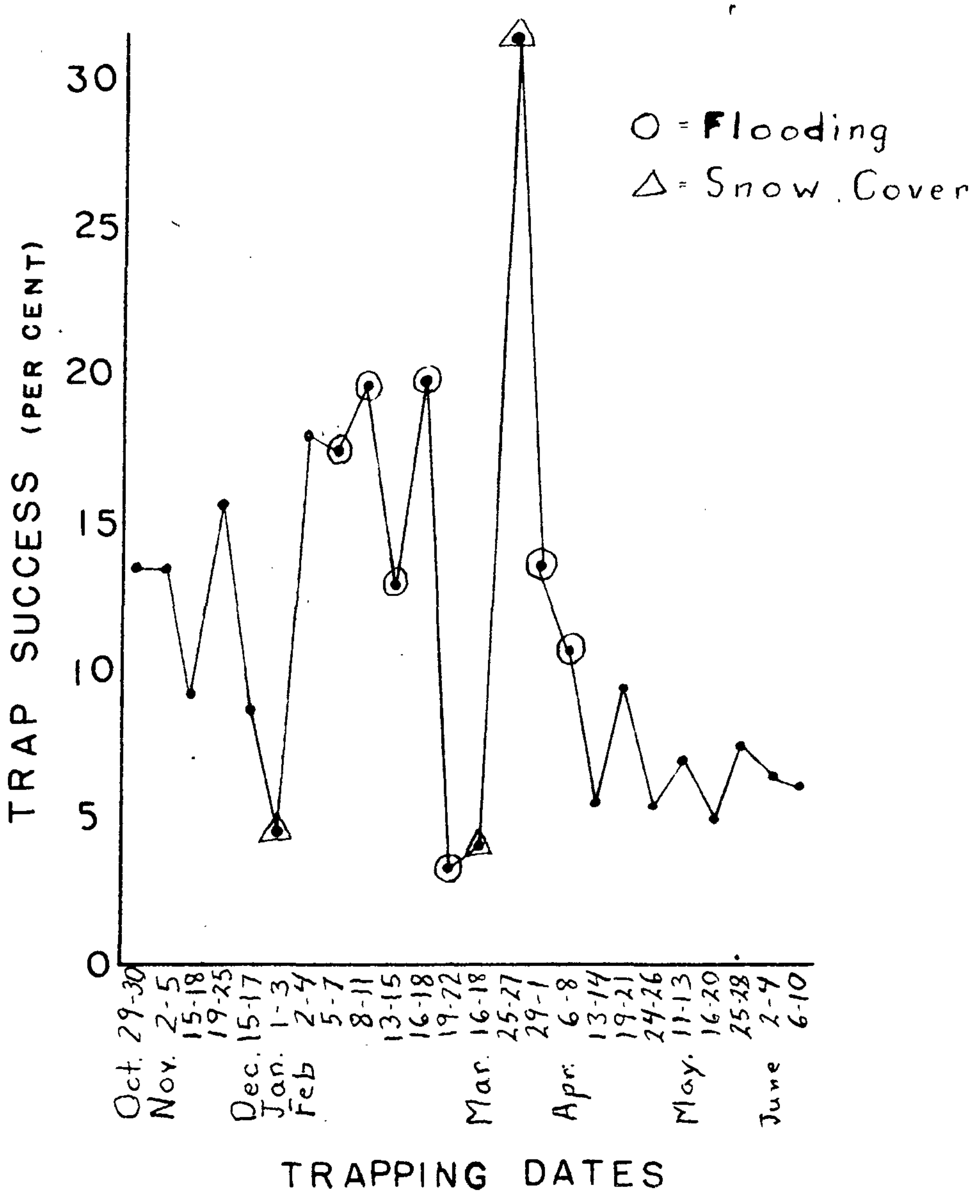

FIGURE 3

A COMPARISON OF TRAP SUCCESS
AND TRAPPING DATES (1959-1960)

No relationship was found between trap success and moon phase and cloud cover by Jackson,[22] and a similar lack of correlation with moon phase was found in this study (Figure 4). Ground level temperatures, taken between 0630 and 0700 hours prior to checking the traps, were not those temperatures at the time of maximum mouse activity but were considered indicative of the night temperatures. Trap success for each trapping period compared to mean morning temperatures for that period (Figure 5) indicated an apparent inverse relationship.

There was variation in population density within the study area since the number of captures was greatest in sections A and B (Figure 2, page 7) and very low in the south portion of section C. Home ranges supported this in that the major part of only one home range was within section C, but both high and low trap successes were recorded in that section of the area.

Movements of mice. Portions of the study area were flooded on two separate occasions; and, during an additional period, the area, although not inundated, was considered to be uninhabitable at the fossorial level as a result of extremely saturated leaf litter. The first flood (5-21 February), the extent of which is shown in Figure 2, resulted from melting of a heavy snow layer and covered the entire

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[22] William B. Jackson, Ecological Monographs, 1952, p. 261.

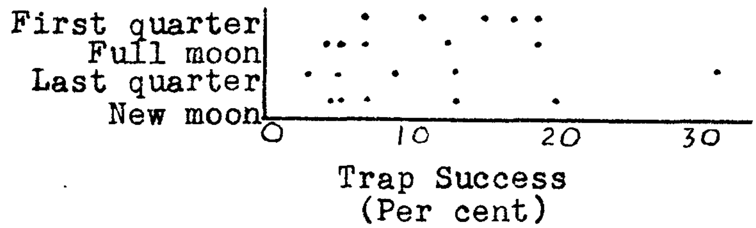

FIGURE 4

THE RELATIONSHIP BETWEEN
MOON PHASE AND TRAP SUCCESS
FROM 28 OCTOBER 1959 TO 10 JUNE 1960

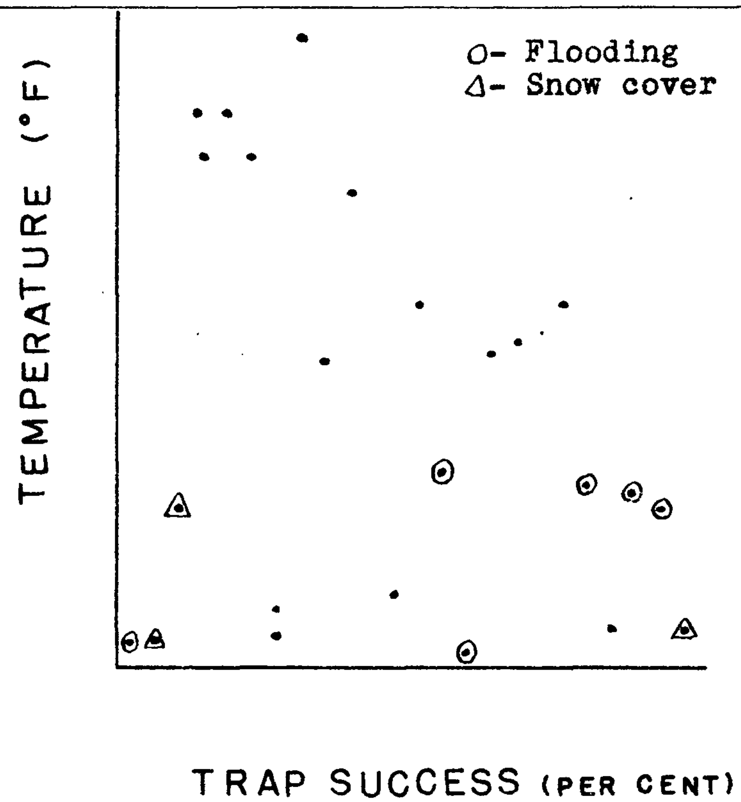

FIGURE 5

THE RELATIONSHIP BETWEEN
MORNING GROUND LEVEL TEMPERATURE
AND TRAP SUCCESS OF LIVE TRAPPING PERIODS

home ranges of one-half of the resident mice. Resident individuals were those mice captured four or more times during the course of the study. The second flooding period (28 March to 7 April), resulting from melting snow and rain, covered the same area; and the remainder of the area was too saturated for leaf litter habitation. During this period, the home ranges of 17 of the 19 resident mice were affected. Two mice had home ranges extending north of the study area, but their most frequent points of capture were on islands within the flooded area.

Heavy rains during April resulted in a month from 24 April to 24 May when the ground was too saturated to be habitable for the mice, though it was not inundated. Again ninety per cent of the resident individuals had home ranges corresponding entirely to the area of uninhabitable leaf litter.

Movement patterns of the mice relating to flooding are summarized in Table II. Resident mice captured during periods of flooding were captured at extremes of their home range (32 captures), at new sites (30 captures), or at sites of previous capture (15 captures). New sites of capture were within the pattern of an already established home range. Four individuals were not captured after a flooding period, and their death or dispersion beyond the study area was assumed. Since movement patterns in the three periods of flooding was essentially the same, the data have been combined.

TABLE II

SUMMARY OF HOME RANGE DATA OF
RESIDENT WHITE-FOOTED MICE
IN RELATION TO FLOODING

Mouse number	Number of captures	Area in home range (acres)	Time between first and last captures (days)	Flooding period
Males				
1300	5	0.19	145	1
2100*	4	0.10	15	none
5300	14	0.30	65	1
5400	10	0.25	144	1
0023	9	0.40	32	2
0044	5	0.07	43	1
0054	6	0.11	16	1
Females				
1100	6	0.18	164	1&2
2200	4	0.10	195	1&2
3100	11	0.20	134	1
3500*	4	0.18	84	none
4100*	5	0.36	74	1
5500*	4	0.07	9	none
0025	7	0.26	45	2
0043	9	0.24	117	1&2
0052	4	0.25	53	1
0053	5	0.05	53	1
1020	11	0.38	66	2
2030	5	0.12	42	none

* Individuals not captured after a flooding period.

The 19 resident individuals included 12 females (68 per cent). This differs significantly from the ratio of equality of total captures (P = 0.02). Home ranges for females averaged 0.20 acres (range 0.05 to 0.38 acres) and for males 0.19 acres (range 0.05 to 0.40 acres). Mice captured ten or more times showed an average home range of 0.28 acres, supporting the criticism that an individual must be captured 15 or more times to approximate the true home range.[23] These data differ from most in that male and female home ranges were essentially similar.

Burt found home ranges of adult female _Peromyscus leucopus_ to average 0.21 acres (range 0.06 to 0.37 acres) and adult males to average 0.27 acres (range 0.17 to 0.54 acres).[24] While these home range calculations involve the addition of a subjectively drawn rather than an arbitrary border strip to the minimum trap revealed area, the data obtained from either method should be essentially similar.

Maximum movement is the greatest distance between points of capture of a mouse. Stickel found the average maximum movement of _P. leucopus_ was 146 feet for males and

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[23] David E. Davis, "Analysis of Home Range From Recapture Data," _Journal of Mammalogy_, 34:352-358, August, 1953.

[24] William H. Burt, "Territorial Behavior and Populations of Some Small Mammals in Southern Michigan," p. 26.

93 feet for females.[25] The seven resident males in the present study had an average maximum movement of 119 feet (standard deviation (S.D.) = 75.7), and the twelve resident females averaged 140 feet (S.D. = 53.6). If captures during the flooding periods are disregarded, the average maximum movement for males is 110 feet (S.D. = 87.7) and 121 feet (S.D. = 42.01) for females. Because of the large amount of variation, none of these differences is statistically significant ($P > .10$).

Nest boxes. Nicholson found nest boxes a convenient means of studying small mammal populations,[26] and Jackson described two types of nests that were constructed by *P. leucopus* in nest boxes attached to trees.[27] The same nest types were observed in this study. One type, used for sleeping and raising young, was a hollow sphere of shredded cotton with an entrance near that of the box. Only one of 72 different nests of this type used additional materials; this one was augmented with pieces of metal screen taken from a trash pile 27 feet distant.

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[25]Lucille F. Stickel, "Experimental Analysis of Methods for Measuring Small Mammal Populations," *Journal of Wildlife Management*, 10:150-159, April, 1946.

[26]Arnold J. Nicholson, "The Homes and Social Habits of the Wood Mouse (*Peromyscus leucopus noveboracensis*) in Southern Michigan," *American Midland Naturalist*, 25:196-223, 1941.

[27]William B. Jackson, "Use of Nest Boxes in Wood Mouse Population Studies," pp. 505-506.

A second type of nest was constructed in the form of a cotton platform and was used as a feeding station. Food was not stored here, but there was ample evidence of feeding activity in the form of empty pupal cases and acorn shells. Platform nests were constructed in unused boxes or from spherical nests; and at times, spherical nests were formed from feeding platforms.

During the study period, six defecation stations were observed. These concentrations of feces and urine were found in two uninhabited boxes and in four boxes with feeding stations. In sleeping nests, urine concentrations were generally observed on one corner, but fecal accumulations were lacking.

Data obtained from nest boxes are summarized in Table III. A box was considered unused if no new activity were recorded in the box since the previous observation period. The data indicated a gradual increase in the use of the boxes during the study period, and a relatively greater utilization of spherical nests during 1960, following flooding was observed.

The larger boxes placed on the ground produced few data. Occasional pellets were found during the first month of observation, and on one occasion a mouse was captured in a box containing a spherical nest; but these were the only indications of use.

TABLE III

SUMMARY OF TREE NEST BOX USAGE

Observation dates 1959-1960	Habitable boxes	Spherical nests	Feeding nests	Defecation stations	Unused	Captures A'	B"
Oct. 26	50	0	0	0	50	0	0
Nov. 14	50	10	4	0	36	4	0
22	48	10	3	0	35	3	0
Dec. 14	48	12	15	2	19	3	0
31	48	15	17	0	16	4	0
Jan. 17	48	19	15	0	14	6	0
Feb. 1	48	20	15	0	13	9	0
12*	48	23	13	0	12	4	0
20*	48	25	7	0	16	3	0
Mar. 11	48	24	9	2	13	2	0
20	48	23	7	2	16	2	0
27*	48	21	8	2	17	0	0
Apr. 3*	48	23	12	2	11	3	0
13	48	26	11	0	11	5	3
23	48	25	14	1	8	6	8
May 1*	48	23	15	1	9	5	8
15*	48	24	17	0	7	4	11

*Indicate observations taken during flooding periods.

' Adult captures " Immature captures

The only verbebrates other than white-footed mice observed in the boxes were a pair of Southern flying squirrels (Glaucomys volans) who raised three young in one box. The female did not enlarge the one-inch-square entrance hole, as observed by Jackson,[28] even though she entered with considerable difficulty.

Various invertebrates were associated with the nest boxes during the latter stages of the study (after 13 April). Ants (Formicidae), spiders (Arachnida), wasps (Vespidae) which built nests on the underside of nest box lids, wood roaches (Blattidae), and Carabid beetles were very common. Fleas (Siphanoptera) were often found in cotton nesting material in nest boxes. The mice fed on the wasps, apparently when immobilized by cool temperatures.

Nesting activity. When the area was not flooded, mice, upon release, would go either to nest boxes or nests in the leaf litter. After flooding, the leaf litter in most of the area was uninhabitable, and different patterns of activity occurred. Nests were noted in small areas of land not flooded, and nest boxes were used with greater frequency; but nests occurred more often in other places. One white-footed mouse lived in a two-gallon oil can lying in an area of partial inundation. Other nests were observed between peeling bark and tree trunks (Quercus bicolor), and

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[28]William B. Jackson, "Use of Nest Boxes in Wood Mouse Population Studies," p. 506.

a small hollow log served as a nesting site for one mouse. Several trees in the area had died and broken off, leaving tall stumps; and two nests were noted on these. Observations of this type of nesting behavior were not noted during non-flooding periods.

Winter activity. During periods of heavy snow cover, tracks of the mice were observed. At seven places in the study area, paths with average lengths of 30 feet were established between holes under the snow and nest boxes. In five cases the paths went from holes to boxes with spherical nests, one to a defecation station, and one from a sleeping nest to a feeding platform. In all cases the paths were well worn and indicated considerable use. Although there was extensive movement within the study area and on top of the ridge of the north, no trace of movement up or down the ridge was noticed.

Occasional observation of traps during the afternoon indicated some activity during the day, since cotton was removed from traps. However, no observations of actual removal were made, and any small animal could have taken the cotton; but Behney found that caged white-footed mice diverged from the usual nocturnal pattern and made occasional movements during the day as a result of snow cover and/or hunger.[29]

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[29] W. H. Behney, "Nocturnal Explorations of the Forest Deer-Mouse," Journal of Mammalogy, 17:225-230, August, 1936.

Reproductive status. Burt states that breeding in white-footed mice normally occurs between late March and October.[30] Data from the present study support this in that from 28 October until 30 March all males had abdominal testes and females had imperforate or secondarily closed vaginal orifices. March 30 was the first date of recorded scrotal testes and perforate vaginal orifices, and first pregnancies were noted from external observation on 23 April with 1 May as the date for the first recorded litters. These data are discussed in detail in Appendix B.

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[30] W. H. Burt, The Mammals of Michigan (Ann Arbor: University of Michigan Press, 1948), p. 209.

CHAPTER IV

DISCUSSION

This study was designed to measure the affect of small scale flooding on a known population of white-footed mice living in a bottom-land woods with known spring flooding. The entire terrestrial portion of the home ranges of 17 resident mice and more than 75 per cent of the home ranges of two other residents were made uninhabitable in three periods of high water table.

Burt indicated that the territory (the protected portion of the home range) of *Peromyscus leucopus* was probably similar in size to the home range and that the home ranges of breeding females did not overlap.[31] This suggests that a breeding female actively protects her home range. Only three resident females in the present study were known to breed, and their home ranges did not overlap; but many other home ranges did overlap considerably. Since much of the study was done during a non-breeding period, Burt's premise could not be adequately tested.

During flooding periods, the average number of nest boxes with spherical nests (24) increased 50 per cent over the pre-flooding number, while the number of feeding

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[31]William H. Burt, "Territorial Behavior and Populations of some Small Mammals in Southern Michigan," pp. 25-26.

platforms remained essentially unchanged (Table II). These data and observations indicating an increase in above ground nests during flooding suggest that mice, at times of high water table, move from apparently preferred ground nesting sites. The lack of significant increase in numbers of mice actually captured in nest boxes (5 to 6) after flooding suggested that the mice may spend less time in these nests, and the unaltered status of feeding platform use indicated no observable flood effect on this aspect of feeding habits.

Mice were frequently observed moving about on wet ground, to swim short distances, and to move on fallen logs across flooded areas. Thus, bottom land flooding appeared not to have greatly inhibited their movements. Differences between maximum distances moved in flooding and pre-flooding periods were statistically insignificant, but the trapping data indicated a significant increase ($P \doteq 0.01$) in utilization of the peripheral portions of the home range, even though these areas were often partially flooded. This may be a result of forced use of more distant food supplies because of the inacessability of previously used areas.

The population was estimated by the recapture-ratio method.[32] In November, the study area population was estimated to be between 11.6 and 24.4 individuals (mean

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[32]David E. Davis, <u>Manual for Analysis of Rodent Populations</u>, pp. 17-21.

one standard error); and in May, 18 marked white-footed mice were caught in the terminal kill trapping. Thus, the estimate of resident mice within the area is in good agreement with the trap-out results. During the study, the population appeared to remain stationary, since each individual killed accidentally in trapping was replaced by an unmarked mouse.

Variations in trap success have often been linked to various environmental factors. Gentry and Odum[33] state that the catch on a given night of a three night trapping period was definitely related to weather but that total catch of the trapline for the three night period was not so greatly influenced by weather. They show a positive correlation between catch and warm, cloudy weather, as opposed to cool, clear weather when the catch was lower; but they state that the differences were not statistically significant ($P = 0.25$). Hatfield found a positive relationship between activity of caged meadow voles (Microtus p. pennsylvanicus) and temperatures between 0 and 30 degrees Centigrade but suggested that food consumption was negatively related to the same temperature range.[34]

In this study, population density, moon phase, or

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[33]John B. Gentry, and Eugene P. Odum, "The Effect of Weather on the Winter Activity of Old-Field Rodents," Journal of Mammalogy, 38:72-77, February, 1957.

[34]Donald M. Hatfield, "Activity and Food Consumption in Microtus and Peromyscus," Journal of Mammalogy, 21:29-36, February, 1940.

periods of flooding or snow cover had no consistant effect on trap success, but an inverse relationship between temperature and trap success was indicated in Figure 5. Perhaps the higher metabolic demands of winter required wider ranging food gathering and thus greater trap exposure.

The flooding thus forced the mice into utilizing more above ground nest sites and the peripheral parts of their home range but did not seem detrimental to the animals.

CHAPTER V

SUMMARY

1. A study of the affect of spring, bottom-land flooding on the movements of a marked population of white-footed mice (*Peromyscus leucopus noveboracensis* (Fischer)) was conducted in a mixed oak woods in Wood County, Ohio. The study area included 0.71 acres and was flooded on two separate occasions and on one occasion the leaf litter was so saturated as to be uninhabitable.

2. Live traps and nest boxes were used to obtain recapture data from which home ranges for the 19 resident mice were calculated. Home ranges averaged 0.19 acres for resident males and 0.20 acres for females. Although flooding did not cause the mice to enlarge their home ranges, it brought about an increased use of the peripheral portions of the established home range and above ground nesting sites. Flooding did not seem to inhibit movements of the mice within the area nor was it detrimental to their numbers.

3. Trap success ranged from a low of three per cent to a high of 31 per cent and was found to be negatively related to temperature but was not consistantly related to other environmental factors such as snow cover, flooding, moon phase, or population density.

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APPENDIXES

APPENDIX A

STUDY AREA VEGETATION

The study area (Figure 6) is in a region of Beech-Maple climax forest,[34] but is specifically characterized by a mixed oak association, and was studied by a quarter-method survey.[35] With the data obtained from this survey, importance values for the species within the area were calculated. Importance Value is a statistic indicating the ecological role of a single species within a given area. It is a summation of the values for relative density (the relationship between numbers of one species to numbers of all species), relative dominance (the total basal area of one species compared to the total basal area of all species), and relative frequency (the percentage of the total points taken at which a species was recorded).[36] The maximum value thus would be 300.

The overstory included those species over four inches in diameter at breast height (DBH) and was sampled by selecting four trees at each of ten points on two transects through the area. Species are listed in Table IV according to

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[34] E. Lucy Braun, Deciduous Forests of Eastern North America, p. 305.

[35] Edwin A. Phillips, Methods of Vegetation Study, p. 14.

[36] Ibid.

FIGURE 6

A VIEW OF THE STUDY AREA SHOWING PARTIAL INUNDATION AND THE NATURE OF THE VEGETATION

TABLE IV

IMPORTANCE VALUES OF OVERSTORY AND UNDERSTORY SPECIES IN THE STUDY AREA OBTAINED FROM A QUARTER METHOD SURVEY

Species	Importance value %	Relative density %	Relative dominance %	Relative frequency %
<u>Overstory</u>				
Quercus rubra	110.6	20.0	20.6	70
Quercus bicolor	100.8	25.0	15.8	60
Acer rubrum	90.9	17.5	33.4	40
Fraxinus americana	40.4	7.5	2.9	30
Liriodendron tulipifera	29.2	5.0	4.2	20
Ulmus rubra	27.9	5.0	2.9	20
Carya cordiformis	27.5	5.0	2.5	20
Populus deltoides	21.1	2.5	8.6	10
Quercus alba	14.5	2.5	2.0	10
Carya ovata	14.2	2.5	1.7	10
Fraxinus nigra	13.6	2.5	1.1	10
Ulmus americana	13.3	2.5	0.8	10
Sassafras albidum	13.0	2.5	0.5	10
<u>Understory</u>				
Acer rubrum	149.4	34.2	35.2	80
Ulmus rubra	67.4	15.8	11.6	40
Quercus bicolor	52.0	7.9	14.1	30
Fraxinus americana	45.6	10.7	5.1	30
Carpinus caroliniana	45.0	7.9	7.1	30
Sassafras albidum	34.4	5.3	9.1	20
Carya ovata	32.7	5.3	7.4	20
Quercus rubrum	17.3	2.6	4.6	10
Carya cordiformis	15.0	2.6	2.4	10
Fraxinus nigra	14.4	2.6	1.8	10
Prunus sp.	13.6	2.6	1.0	10
Ulmus americana	13.2	2.6	0.6	10

Seedlings	Number of individuals
Acer rubrum	2
Quercus bicolor	5
Carpinus caroliniana	8
Fraxinus americana	4
Carya ovata	1
Cornus florida	1

importance value and indicate that the most important species in the overstory are red oak (Quercus rubra), swamp white oak (Q. bicolor), and red maple (Acer rubrum).

The understory included those trees over five feet high with a DBH of four inches or less and was sampled in the same manner as the overstory. Data from the survey (Table IV) indicated that red maple (Acer rubrum) was the most important species in the understory, with the oaks of much less importance. The limited number of seedlings present (Table IV) obtained from two-meter-square quadrats placed at ten points on the two quarter method transects, indicated the limited reproductive success of this portion of the woods.

The Steidtmann Wildlife Refuge lies in the general locale often referred to as the Black Swamp.[37] The swamp was formed by the latter stages of glaciation which left many lakes which were filled in by erosion and eventually became swamps or bogs. In the late nineteenth century, the swamps were drained, and more mesic forests appeared. The data from this study indicate that the present mixed oak association is a remnent of the old swamp forest. The fact that the oaks assume a relatively unimportant role in the makeup of the understory and seedling composition indicate

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[37] Martin R. Kaatz, "The Black Swamp: A Study in Historical Geography," pp. 1-35.

that the oaks are being replaced by the red maple as the land assumes a more mesic moisture content.

The presence of the red maple in the overstory and its dominance of the understory indicate the succession of the maples into the area. This species is tolerable to shade and grows best in swamplands. If the present state of oak reproduction continues, the red maples may become the dominant overstory species; or, should the soil conditions become more xeric, they may become a stage leading to the establishment of the beech (Fagus grandifolia) and sugar maple (Acer saccharum) climax condition.

Data on herbaceous vegetation, obtained from ten one-meter-square quadrats placed at the points on the transects used in the arboreal vegetation survey, are given in Table V. Lack of flowers made possible the identification of most plants to family or genus only. The sparse herbaceous vegetation was dominated by a wild rose (Rosa sp.), a sedge (Carex sp.), and several annuals.

TABLE V

HERBACEOUS VEGETATION OF THE STUDY AREA
SAMPLED BY TEN, METER-SQUARE QUADRATS

Species	No. points of occurrence	Number of individuals
Rosaceae	4	117
Pteridium sp.	2	27
Aster sp.	3	19
Carex sp.	1	13
Ranunculus sp.	2	13
Osmunda regalis	1	8
Rhus radicans	2	6
Helianthus sp.	1	6
Ampelipsis sp.	2	4
Vitis sp.	1	4
Aralia nudicaulis	1	3
Euphorbia sp.	1	3
Agrimonia sp.	1	1
Podophyllum peliatum	1	1
Graminaceae	3	8 sq. ft.

APPENDIX B

A DISCUSSION OF THE SPECIES PEROMYSCUS LEUCOPUS NOVEBORACENSIS (FISCHER) AND PEROMYSCUS MANICULATUS BAIRDII (HOY AND KENNICOTT)

The Rodent genus Peromyscus includes a great variety of mice that vary greatly in size and often are the most abundant small mammals in an area. They are found in almost every part of North America and occupy diverse habitats from the arid desert to wet woodlands and swamps, from the Arctic Circle to southern Mexico.[38]

Early workers placed members of this genus in the genus Mus because of a superficial resemblance to the European wood mouse (Mus sylvaticus). Because of differences in dentation later discovered, these mice were removed from the genus Mus and placed in several different genera, including Herperomys, Verperimus, and Sitomys. In 1894 these names were discarded, and the mice were placed in the genus Peromyscus Gloger 1841 as a result of priority. This name has remained unchanged since that time.

The differentiating characters of the various species and subspecies of Peromyscus are so subtle that the production of synonyms in the genus is unusually large. Many

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[38]The following discussion is based upon: Wilfred H. Osgood, "Revision of the Mice of the American Genus Peromyscus," North American Fauna, 28:1-281, April, 1909.

supposed new forms are only color variations, for the genus us quite varied in size and coloration, even within a single subspecies.

Two closely related forms often found in closely related habitats in northern Ohio are the white-footed mouse (*P. leucopus noveboracensis* (Fischer)) and the deer mouse (*P. maniculatus bairdii* (Hoy and Kennicott)). Because of the difficulty involved in distinguishing between these subspecies and the possibility of confusing them, a discussion of the two species follows.

P. leucopus noveboracensis is characterized by white underparts, a less distinctly bicolor tail, cinnamon rufose upperparts, and a mid-dorsal dusky-cinnamon line. During the spring the worn pelage of the mouse shows a greater distinction between the sides and back. However, in the late summer, this pelage is replaced by the thicker and longer winter coat that is more brightly colored, and the tail is also covered by longer hairs.

P. maniculatus bairdii is characterized by a darker dorsal color, smaller ears and feet, and a decidedly shorter tail than in *noveboracensis*. The upper parts are dark brown mixed with black; and the underparts are white, often separated from the sides by a narrow russet line. The tail is sharply bicolor, black or blackish brown above and white below with shorter hairs. The worn pelage also shows a distinct contrast between sides and back.

Because of a lack of sufficient numbers of individuals, the use of dried specimens, and insufficient data, Osgood's measurements for the two subspecies are not comparable to more recent data and will not be used for reference.

Table VI gives the ranges of measurements for the two subspecies. As can be seen from these data, bairdii, by its smaller size, can generally be distinguished from noveboracensis. But, these measurements, because of overlapping ranges, may be insufficient for separating the two mice in all cases.

Average measurements for mice autopsied in the present study (Table VII) compare closely with the measurements given for noveboracensis. It will also be noted that the average measurements for total length, tail length, and ear length are greater than the extremes given by Burt[39] for these characteristics in bairdii but fit well into the ranges for noveboracensis.

Burt gives the habitat of noveboracensis as forested and brushy areas and occasionally grassy areas that border woods. On the other hand, open grasslands with a preference for dry uplands is given as the habitat for bairdii. P. l. noveboracensis may nest above ground while bairdii

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[39]William H. Burt, The Mammals of Michigan, p. 209.

TABLE VI

A COMPARISON OF THE EXTERNAL MEASUREMENTS FOR THE SUBSPECIES *P. L. NOVEBORACENSIS* AND *P. M. BAIRDII*.* ALL MEASUREMENTS IN MILLIMETERS.

	Total length	Tail	Hind Foot	Ear	Skull length	Skull width
P. l. noveboracensis	141-195	59-93	18-23	15-18	24.0-27.4	12.1-14.1
P. m. bairdii	119-156	47-69	16-20	12-16	22.2-24.8	11.1-12.9

*Taken from: W. H. Burt, *Mammals of Michigan*, pp. 204, 209.

TABLE VII

AVERAGE PHYSICAL MEASUREMENTS
OF AUTOPSIED WHITE-FOOTED MICE

Age & sex	Length (Millimeters)				Weight (grams)
	Total	Tail	Ear	Hind foot	
Immature females	145	68	15	19	16.7
Adult females	158	72	16	20	20.5
Immature males	150	67	15	19	15.1
Adult males	160	73	17	20	18.4
All Adults	159	72.5	16.5	20	19.1
All immatures	148	67.5	15	19	15.7

nests solely on the ground.[40]

On the basis of capture data and measurements taken, the subspecies was definitely identified as noveboracensis rather than bairdii. All resident mice were captured above ground at least once, and none was captured outside the woodland. Pelage of the mice followed Osgood's description of noveboracensis, and measurements more closely resembled measurements for noveboracensis.

Animals accidentally killed during the course of the study and during the final kill trapping period in June were autopsied. In addition to data recorded in the field, standard physical measurements (weight, length of body, tail, ear, hind foot, and pelage type) were taken; reproductive tracts were examined for testis size and presence of sperm in the epididymis, or condition of uterus and number and length of embryos, if present.

Two adult male short-tailed shrews (Blarina brevicauda) with measurements of 118 and 120 mm. total length, 19 mm. tail length, and 13 and 14 mm. hind foot length were captured.

Twenty-eight white-footed mice were killed including 15 adult and three immature males and eight adult and two immature females. An adult mouse was characterized by having full adult pelage or cinnamon with a grey stripe on the side,

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[40] William H. Burt, The Mammals of Michigan, p. 209.

while immatures were those mice with all grey pelage. Average measurements for the mice are given in Table VII, and measurements for individual adult mice are given in Table VIII. Four of the eight adult females were pregnant. Two had litters of six embryos (average length 14 mm. and 15 mm.); one of four embryos (average length 8 mm.); and one of three embryos (average length 6mm.).

Breeding in P. l. noveboracensis usually occurs from late March to October. Old females produce their first litters as early as late March. This is often followed by a second litter and than usually by a rest period of from four to six weeks. After this, two or more litters are born in the fall. Young females born in the spring may give birth to their first litters when they are about fourteen weeks old and raise one or two litters in the fall. Young females born after August 1 usually do not produce their first litters until the following spring.[41]

The number of young per litter range from 2 to 6 and average 4. Thus, an old female will give birth to at least eight young in the spring and fall. In addition, the spring born females which survive will also produce four or eight young in the fall.

Data from the present study support these observations in that from 28 October until 30 March, all males

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[41] William H. Burt, The Mammals of Michigan, p. 209.

TABLE VIII

INDIVIDUAL PHYSICAL MEASUREMENTS
OF AUTOPSIED WHITE-FOOTED MICE

Age & sex	Mouse number	Length (Millimeters) Total	Tail	Ear	Hind foot	Weight (grams)
Immature females	101	140	66	15	19	15.0
	114	150	69	15	19	18.3
Adult females	91	154	65	15	18	**
	93	151	66	16	20	**
	94	152	70	16	22	**
	98	128	69	16	20	12.5
	102	160	74	16	20	20.8*
	104	162	75	16	20	17.6*
	107	183	83	17	20	31.0*
	117	170	78	15	19	20.7
Immature males	101	140	66	15	19	15.0
	114	150	69	15	19	18.3
Adult males	92	162	70	17	20	**
	95	151	72	19	22	**
	96	162	74	19	19	**
	97	151	68	18	20	19.3
	99	156	76	15	21	17.4
	100	175	78	17	21	22.9
	103	150	70	17	20	14.5
	105	160	70	15	19	18.6
	108	174	79	16	20	20.8
	109	159	70	15	19	20.6
	110	179	84	19	19	21.2
	112	142	63	16	19	13.8
	113	174	79	16	19	20.2
	116	147	71	16	19	14.6
	118	**	**	15	19	19.9

*indicate pregnant females
**indicate data not available or not recorded.

had abdominal testes and females had imperforate or secondarily closed vaginal orifices. Scrotal testes and perforate vaginal orifices were first observed on 30 March; first pregnancies were noted from external observation on 23 April; and the first litters were recorded on 1 May. The two observed litters had four and five mice.

The relationships between individual weights and external measurements are summarized in Figures 7, 8, and 9. A direct relationship is indicated between weight and total length and tail length (Figures 7 and 8) and between total length and tail length (Figure 9). These are for adult individuals for which all three measurements were available. No differences were noted between the sexes, and the data were combined.

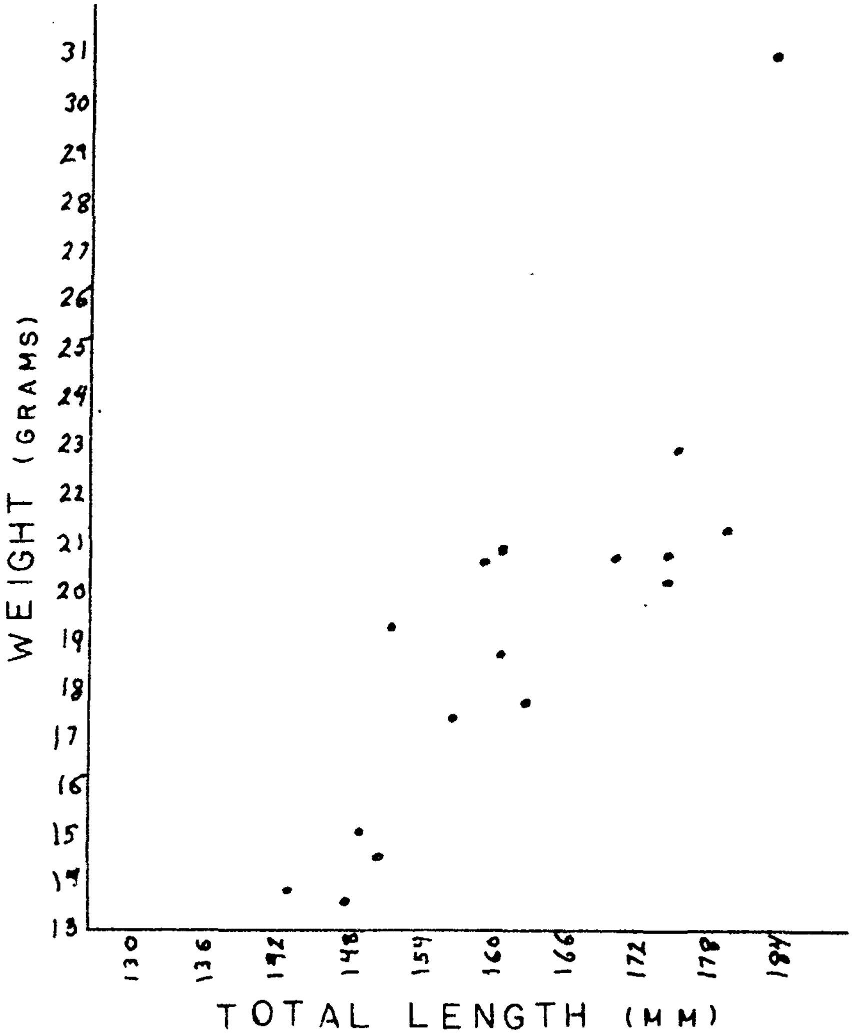

FIGURE 7

THE RELATIONSHIP BETWEEN WEIGHT
AND TOTAL LENGTH OF ADULT
WHITE-FOOTED MICE

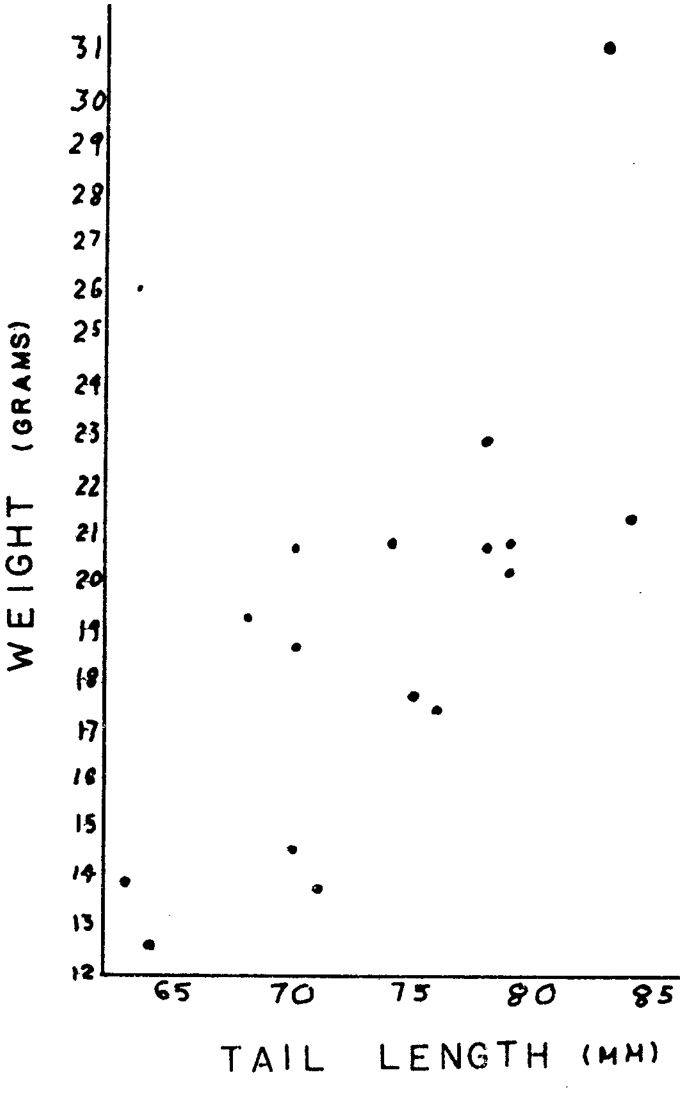

FIGURE 8

THE RELATIONSHIP BETWEEN
WEIGHT AND TAIL LENGTH OF
ADULT WHITE-FOOTED MICE

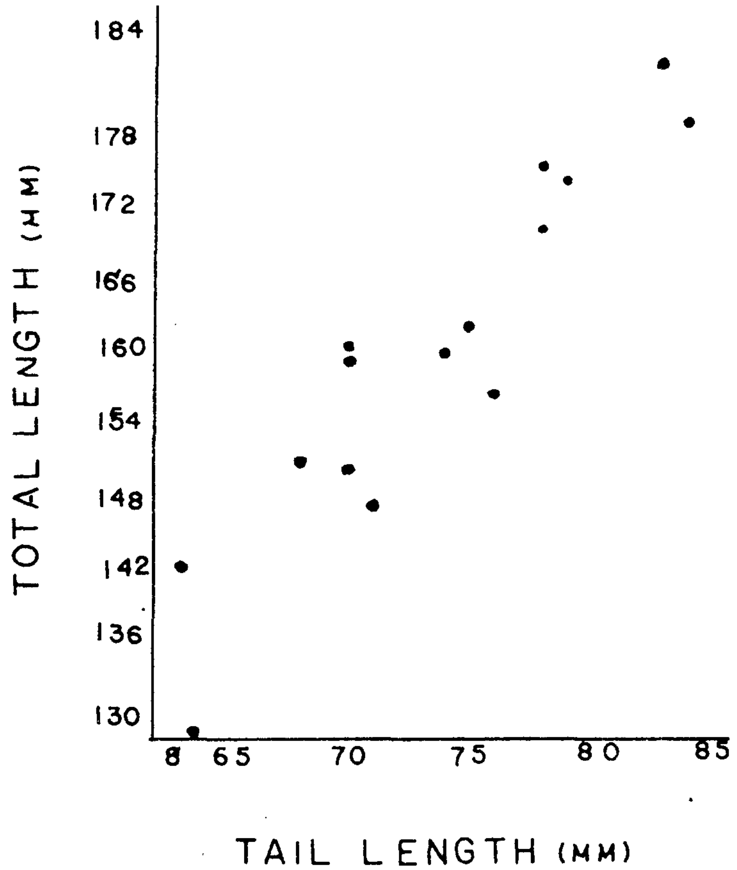

FIGURE 9

THE RELATIONSHIP BETWEEN
TOTAL LENGTH AND TAIL LENGTH
OF ADULT WHITE-FOOTED MICE