POPULATION DYNAMICS OF PEROMYSCUS LEUCOPUS

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POPULATION DYNAMICS OF PEROMYSCUS LEUCOPUS

ABSTRACT

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This is the beginning of a long range study to determine lasting effects of permanent flooding on peripheral populations. Estimates were made of population density and home range sizes of a population of white-footed mice, *Peromyscus leucopus* in Rowan County, Kentucky during the spring of 1968. The Lincoln Index method using an inverse sampling technique was used to estimate population density. The boundary-strip method was used to estimate home range sizes of 2 adult male, 4 adult female, and 2 juvenile mice. Fifty mouse-sized Sherman live-traps were laid out on a grid in 10 rows of 5 traps per row, with the traps 25 feet apart. Population density was estimated to be 13 mice in the 22,500 ft^2 study plot. Home range sizes averaged 4738 ft^2 for adult males, 3125 ft^2 for adult females, and 2188 ft^2 for juveniles.

Accepted by: ______________________ Chairman

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ACKNOWLEDGMENTS

I wish to express my appreciation for guidance and assistance rendered by the members of my graduate committee; Dr. M.E. Pryor, Mr. Woodrow W. Barber, and Mr. Allen Lake. I would also like to thank Mrs. Rolene Cain for assistance in designing the method for statistical analysis of the data, and Mr. Warren Utterback, for the use of his farm as a study area.

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CHAPTER I

INTRODUCTION

At the close of the Korean War, the U.S. Army Corps of Engineers began a program of reservoir construction in the continental United States. Many of these reservoirs are at this time complete, and many others are either in the process of being constructed, or are on the drawing boards.

The reservoirs are classified into two main groups, according to their intended purpose. The first of these is flood control and the second is multi-purpose use. It is apparent that much careful study and planning goes into the construction of the reservoirs, yet it is also apparent that some important areas to consider are overlooked and cast off as minor in value.

A large dam is presently under construction across the Licking River in Rowan County, Kentucky. This dam, when complete, will form a sizeable impoundment of water to be known as Cave Run Reservoir. The creation of this reservoir will provide an outstanding natural laboratory for the study of the permanent effects of flooding on established ecosystems. The area to be flooded is rich in wildlife, as is the immediate area which will be above flood level. The entire area has, in the past, provided much game to be harvested by sportsmen from both near and far.

The lowlands will be covered by water, and obviously devoid of any game except waterfowl. The question then arises what effect will this flooding have on the wildlife of the higher surrounding areas? This question needs to be answered.

All of the lowland animals that escape the flooding will be forced to move to higher ground as the rising waters cover their home ranges. This movement in itself is no cause for concern, until one considers that there are already animals living in the higher areas to which the displaced individuals will move. It can be assumed that the highland populations maintain their numbers at the full carrying capacity of the area. This being the case, an influx of large numbers of animals from outside will result in a serious imbalance of the stable ecosystem. Will there be any lasting effects from this imbalance? If so, what will they be? These questions need to be answered so that when plans for new reservoirs are drawn up, consideration for the wildlife will be better represented.

It is the intended purpose of this study to lay the ground work for a complete and comprehensive consideration of the permanent effects of lowland flooding on peripheral highland ecosystems. A thorough study of the population dynamics of a peripheral animal species both before and after flooding would yield valuable information as to the lasting nature of the resulting ecosystem imbalance.

CHAPTER II

REVIEW OF THE LITERATURE

The capture, mark, release and recapture method for use in studying small mammal populations was first applied by W.F. Blair in 1940. Since that time, it has been used extensively in this respect and has proved to be a very reliable technique. The first applications of this method were in the study of home range size. It was not until about 1946 that this technique was applied to the study of population density.

W.F. Blair studied the home range of the woodland deer mouse _Peromyscus maniculatus_ in northern Michigan in the fall of 1940. The study group was very large, consisting of 151 mice. The size of the home ranges of the adult males was significantly larger than those of the females. Blair noted that there was an overlapping of home ranges in several cases, and that where this was the case, individual mice were very tolerant of each other (Blair 1942). Blair continued the trapping to make long range observations on the mice, and over a three year period, he found that the number of mice was greater in the fall than in the spring or summer. This would indicate that the wood mouse reaches its seasonal peak of abundance in the fall. A five year record gave evidence that the mice had no cyclic alternation of years of extreme abundance with years of extreme scarcity. There was noted, however, a degree of variation from year to year in population size. (Blair 1948).

There has been much discussion concerning the various methods used to infer home range from grid trapping data. Stickel (1954) made a comparison of the various methods, using artificial study populations. The results showed that a boundary strip method of measuring and an adjusted range length give sizes closer to the true range than do minimum area or observed range length methods. Stickel also showed that the traps on the grid layout must be close enough together to include two or more traps in the range of each animal.

In most area-trapping, all traps on the grid are operated at the same time. Sometimes, however, traps are set in different parts of the plot at different times, or alternate rows of traps are operated on successive nights. The idea here is that the mice will not travel to the limits of their range if food can be found close by. Stickel (1954) tested this hypothesis and found that the resulting range estimates were essentially the same as those made by standardized trapping in the same area. In some studies, multiple catch instead of single catch traps are used, or more than one trap is set at a site. Stickel (1954) tested this out on a population of feral house mice, and found that the same results were obtained in both cases.

One problem which arises in designing a study dealing with the home range of a species, is the question of how many recaptures are necessary to compute the home range area of an individual. Davis (1953) states that a minimum of 15 to 20 recaptures is necessary, while Davenport (1964), in estimating the home range size of Peromyscus polionotus, calculated the minimum number of recaptures per given mouse to be five. Davenport was dealing with a species quite similar to the species used in this study, and for this reason, it would seem that a minimum of 5 recaptures per given mouse would seem adequate.

Radioisotope tagging has been explored as a means for studying home range. The method has been used both in England (Godfrey 1954) and in this country (Harvey and Barbour 1965). Harvey and Barbour used the vole Microtus ochrogaster as the study species. It was learned that by placing a small radioactive wire under the skin of an animal, its movements could be followed closely by using a sensitive receiver.

In this study, the long range plan is to learn the effects of an ecosystem imbalance which occurs as the result of permanent flooding. Such a study has not been made in the past. However, the effects of temporary flooding on mammal populations has been studied by McCarley (1959), Blair (1939), and Stickel (1948). McCarley learned that short-term flooding produced no detrimental effects on a population of white-footed mice studied before and after flooding. Flooding of a three week period in a similar habitat produced a 70 percent decrease in the population.

The behavior of translocated mice was studied by H.D. Orr (1966) but unfortunately, the area to which the mice were translocated, was snap-trapped beforehand, and had no competition to offer the new mice. Had he left the earlier residents in the area, it would have made an interesting study on competition and would have been very useful in deriving expected results from the present study. Orr showed that translocated mice in competition-free areas, established home ranges which very closely approximated the size of their previously established ranges.

In making the literature review for the present study, it soon became apparent that each experimenter was convinced that his method was the best method, and that each was reluctant to accept the findings of another. After carefully reviewing and considering each method, the author arrived at those methods which were felt to be best suited to the purposes of this study.

CHAPTER III

MATERIALS AND METHODS

The experimental plot used in this study is located on the Warren Utterback farm in Rowan County, Kentucky at the approximate map coordinates $83^{\circ}23'$ longitude, $38^{\circ}03'$ latitude. The plot is on a southwest facing bench of a ridge which runs south of Popping Rock Tunnel on Kentucky highway 519. The bench is approximately one half mile long, 200 feet wide, and 950 feet above sea level. Following completion of the dam, the rising water will ultimately reach a depth of about 30 feet around the ridge, forming a narrow necked peninsula of the area. The foliage of the ridge is predominantly oak-hickory, with moderate amounts of undergrowth. Several outcroppings of rock occur within the plot, providing excellent cover for the resident animals.

Preliminary studies led to the selection of the white-footed mouse, *Peromyscus leucopus*, as the study population. *P. leucopus* is found throughout the area of the proposed reservoir, both in the highlands and in the lowlands. The mouse occurs in abundance and is readily trapped in small, lightweight traps. The actual physical ordeal of being trapped seems to have very little effect on the normal activities of this species. The small home range of this species allows many to occur in a half-acre study plot.

Peromyscus leucopus is a medium sized deer mouse, the adults measuring about 170 mm in total length, and 16 to 28 grams in weight. In summer, the upperparts are grayish-brown to a pronounced orange cinnamon shade, the underparts white. These mice feed largely upon the seeds and mast of the forest floor and on the ripe heads of the grasses found in the clearings. They are especially fond of berries which they eat throughout the summer. At times they will eat insects, nestling birds, and other mice. They do not hibernate, so they must cache a sizeable store of nuts to last through the winter months. Breeding commences during the early spring and lasts well into fall, although there is a slight let-up during the middle of the summer months. The litter size ranges from 2 to 7, and these young mice grow rapidly, being weaned before they are three weeks old. They are sexually mature at the age of six weeks (Hamilton 1943).

There are three basic methods used in the study of small mammal populations; radioisotope tagging and subsequent tracking, direct observation, and trapping. The first method is perhaps the most reliable, in that it gives a truer picture of an animal's movements. A thin radioactive wire is placed under the skin of the animal, and the investigator is able to maintain contact with the subject at all times by means of a sensitive scintillator. The receiver for the scintillator must be placed on the end of a long pole, so that the investigator, when tracking the subject, will not upset the normal activities of the subject by approaching too near. This method is ideally the one to use in such a study as the one undertaken here, but because of the large amounts of foliage found in the study plot, it was felt that the trees would interfere with the swinging pole and result in a very impractical situation.

Direct observation of the subjects is a very suitable method, but the fact that the study species is nocturnal in habits ruled out the use of this method. This left trapping as the most practical method which could be used to study the population dynamics of this species. Although this method is not the most suitable of methods, the results are reliable.

The use of live-trapping to study populations has been in use for 25 years or more, and over the years, many improvements have been made in experimental and analytical methods.

The traps used in this problem were obtained from the H.B. Sherman Company of DeLand, Florida. The construction material is sheet aluminum which makes them very lightweight and resistant to deterioration. The trap size was 10 inches by 3 inches by 3 inches, and they were constructed in such a manner as to allow them to be folded over and made very compact for carrying purposes. The principle by which the trap operates is that of a treadle located in the rear of the housing which, when depressed, releases the door to spring up, thereby trapping the animal within, unharmed. The bait used to lure the mice into the traps was a mixture of peanut butter and rolled oats. Commercial rabbit food in pellet form was tested because it was easier to handle, but it was found to be less attractive to the mice than the peanut butter and oats.

The captured mice which were chosen for the study were marked for identification by excising one or more toes on either hind foot. It was felt that the traumatic experience of capture and excision of the toe would effect the activities of a mouse, but preliminary experimentation found this to be not the case. In so far as was possible an effort was made to have male and female, and adult and juvenile mice represented in this study. This was the only conscious bias on the part of the experimenter. No effort was made to select subjects on the basis of health and condition.

The traps were laid out in the form of a grid, which was measured off by means of a metal 100 foot tape. The grid consisted of ten rows of traps, with five traps in each row. Each trap was 25 feet from the nearest trap, forming a total grid size of 225 feet by 100 feet, or 22,500 square feet. In the actual placing of traps, no effort was made to move traps away from their assigned point on the grid in order that they be placed in a site which appeared better suited to mouse travel. It was felt that such a step would place an intolerable bias on the part of the experimenter and would result in untrue conclusions.

The traps were visited once each day during the trapping period, the time of day varying from early morning to early afternoon. Due to the irregularity of the experimenter's schedule, no routine could be established which would allow the visits to be made at the same time every day. Captured mice were examined and marked or released at the time of the visit, none of the subjects was ever retained and brought back to the laboratory. Each mouse was observed at the time of release and notes were taken as to the actions which followed.

There are several methods used to estimate the relative density of populations. Most of these methods were either designed for large populations, lacked precision in analysis, or for some other reason were not acceptable for the purposes of this study. After careful consideration, a modified Lincoln Index method which makes use of an inverse sampling technique was chosen as the most suitable method for this problem.

The basic idea of the Lincoln Index method is: to capture, mark and release (A) animals out of a total population of size (X). After a short period of time, traps are re-set and a random sample of size (N) is taken. The sample (N) will contain both new individuals and (R) previously marked individuals. Using this information then, the population size is estimated as $P = \frac{A\,N}{R}$. This method was used for quite some time, and in some cases, still is. The problem which presents itself here is that the relative bias of the estimate is too large, and the estimate of sample variance lacks precision.

When an inverse sampling technique is used, a much more precise population estimate can be obtained. The idea here is quite similar to that of the previously mentioned method, with one basic difference. In direct sampling, the total size of the samples drawn can be regarded as fixed whereas in indirect sampling, random sampling is continued until a certain predetermined number of individuals (M) that were previously marked has been obtained. The use of the inverse sampling technique with simple recapture results in simplification, and an unbiased estimate of population size, along with an exact value of sample variance can be obtained (Bailey 1951). Because statistical analyses of the data are to be made, it is essential that the sample variance be calculated.

In the inverse sampling technique as described by N.T.J. Bailey, the population size is estimated as........

$P = \frac{N(A+1)}{M} - 1$ where N is the random variable under consideration. The exact sample variance is calculated as .....

$$\text{Var } P = \frac{(A-M+1)\ (P+1)\ (A-P)}{M(A+2)}$$

By setting up a confidence interval about the population estimate before flooding, and another confidence interval after flooding, any significant difference in the two populations can be statistically determined, according to whether or not the two confidence intervals overlap. After the population size and sample variance have been determined, the standard deviation of the population (P) is found to be the square root of the variance. With this information, the confidence interval is found to be .....

95% CI: $P \pm Z$ (std dev P) or $P \pm 1.96$ (std dev P)

(Bailey states that the distribution of P is asymptotically normal)

A second major facet of population dynamics to be measured in this study is that of home range size. Home range, as it applies to mammals, has been defined by W.H. Burt, 1943, as "That area traversed by the individual in its normal activities of food gathering, mating, and caring for young". Occasionally, the animal may wander outside this area, but according to Burt, these jaunts are specifically excluded from the home range, since they are not considered to be ecologically significant.

Within the home range, certain areas are used more extensively than others, and these use patterns are subject to change with changing conditions. It is because of this that boundaries must be considered diffuse and general rather than sharply defined (Stickel 1954). These factors work against any accurate measurement of range size, and too great a precision cannot be expected. At best the measurement can only be an approximation.

The question then arises, why try to measure anything as indefinite and variable as home range? The home range can be considered to represent the living area of an animal, and it is felt that changes in population density can be better interpreted by knowing the approximate size of the home range (Stickel 1954).

In calculating the home range of mice selected for this aspect of the study, the same grid was used as that used in the estimation of population density. Mice were once again marked individually by means of toe clipping. Trapping was continued until it was felt by the experimenter that each marked individual was staying within a given area and not wandering beyond the calculated borders of the range. All recaptures were plotted on a map of the grid layout.

There are three major methods of inferring home range size from trapping data:

#1--- The minimum range method - In this method, a line connecting all peripheral points of recapture is said to encompass the home range. It is felt that animals range at least part way to the next adjacent trap, and since this method does not allow for this detail, it is unacceptable.

#2--- The maximum distance method - In this method, the two points of recapture most distant from each other are considered to be the diameter of a circle which encompasses the home range. Although this circle may in fact contain the home range, it will usually include more area than the individual would in fact traverse, because it assumes that the home range is circular when this is rarely the case. Estimates inferred by this method are frequently greater than the true range.

#3--- The boundary strip method - This method is based on the logical assumption that animals range on the average, half way to the next trap beyond their peripheral boundary limits. Although this may not always be true, for the most part, this is so This method is no doubt the most accurate of the three, hence it was used to infer home range size from the trapping data gathered.

CHAPTER IV

EXPERIMENTAL RESULTS

The trapping procedure for this study was begun during November of 1967. There were certain misgivings about trapping mice during this time of the year, for it was known that mice would die from exposure to low temperatures for any length of time. With this in mind, the traps were laid out on the grid on 11 November 1967. The traps were baited and the spring mechanism of each trap deactivated, to allow free movement in and out of the trap. This pre-baiting period was continued until 15 November when it was felt that ample time had been allowed for exposure of all resident mice to the traps. Trapping continued with satisfactory results until the evening of 19 November. At this date a cold spell moved through the area, dropping the temperature to below 20°F, and resulting in the death of eight captured mice. The population of this study plot was decimated by the loss of eight individuals, so it became necessary to abandon this plot.

After several unsuccessful attempts to insulate the traps satisfactorily, it was decided that the project would have to be postponed until the warmer months of spring.

On 16 March,1968, the traps were once again laid out on a grid, this second plot being about 150 yards from the first. Once again all was progressing quite satisfactorily when on 22 March, low temperatures once again took a heavy toll of mice in the traps. This forced another postponement and another move.

On 2 April, the traps were laid out on a third plot, and the pre-baiting process continued until 7 April, when traps were activated for capture of the resident mice. Upon visiting the traps on 8 April, they were found to contain 7 mice; 2 males and 5 females. It was decided that these 7 mice would all be marked to serve as the basis for the population estimate. Trapping continued until 25 recaptures of marked individuals was accomplished. This was the number chosen prior to the start of experimentation. The following chart shows the results of this period of trapping.

Date	total captures	marked recaptures
9 April 68	6	4
10 April 68	7	3
11 April 68	8	5
12 April 68	7	6
13 April 68	8	4
14 April 68	8	3
Totals	44	25

Using the information obtained through this phase of trapping, and the formula as outlined by N.T.J. Bailey, the population is estimated as.....

$P = \frac{N(A+1)}{M} - 1$ where N = total sample taken = 44

A = number originally marked = 7

M = marked recaptures = 25

$P = \frac{44(7+1)}{25} - 1$, or P = 13 mice

After estimating the population (P) to be 13 mice in the 22,500 ft^2 plot, the variance of the population can then be calculated as.....

$$\text{Var } P = \frac{(A-M+1)\ (P+1)\ (A-P)}{M(A+2)}$$

$$\text{Var } P = \frac{(7-25+1)\ (13+1)\ (7-13)}{25(7+2)} \qquad \text{Var } P = 8.3$$

If the Var P = 8.3, std. dev. P = square root of Var, = 2.87

With this information, a confidence interval can now be set up about the population.

95% CI : $P \pm Z$(std dev P), or $13 \pm 1.96(2.87)$, or 7.4 to 18.6

What this means then, is that when the population is estimated after flooding has occured, the second confidence interval must overlap with the first if the populations are to be considered the same. If the confidence intervals do not overlap, the two populations are considered significantly different.

Trapping for the home range study was begun on 17 April. The same grid was used in this study as that used in the population estimate. The boundary strip method of estimating home range size was used, so it is important to bear in mind that although the grid size is the same as that used previously, the total area of the study plot is increased from 22,500 square feet to 31,250 square feet. The reason for this increase is that the boundary strip method assumes that an animal ranges at least half-way to the trap or traps adjacent to the periphery of its home range. This would mean that the border of the plot must be extended by 12.5 feet on all sides.

All traps were set on the evening of 17 April, and a check on the following morning yielded 8 mice. The catch consisted of 2 adult males, 4 adult females, and 2 juveniles. Sexing of the juvenile mice was very difficult and at most could be only a guess, consequently they were considered simply as juveniles. After each mouse received an individual identifying mark, it was released, and the trap re-set.

Trapping was continued from 18 April until 27 May 1968, a total of 40 calendar nights and 2000 trap nights. At the end of this period, it was apparent that each study subject had displayed definite boundary limits. According to Davenport (1964), only 5 recaptures are necessary to establish the boundaries. This study included many more recaptures.

Although an apparent overlap of home ranges was exhibited in some cases, it was noted that no subject was ever captured in the trap nearest the center of activity of another mouse.

The number of recaptures ranged from 17 in the case of one juvenile to 31 in the case of one adult male and one adult female. Home range size varied from 1875 ft^2 for one of the juveniles, to 5000 ft^2 for one of the adult males. The following chart gives a complete listing of the eight study mice, and the number of recaptures and home range size of each.

Number	Sex	Recaptures	Home range size
1	F	28	3125 ft^2
2	J	17	2500 ft^2
3	F	19	3125 ft^2
4	F	23	3125 ft^2
5	F	31	3125 ft^2
6	M	31	5000 ft^2
7	J	23	1875 ft^2
8	M	26	4475 ft^2

The information gathered here indicates that adult male mice have a substantially larger home range than either the adult females or the juvenile mice, and the adult females in turn have a larger home range than the juveniles. The most curious fact is that every female studied had the same size home range, 3125 ft^2. The number of animals studied was too small to establish whether this fact is purely coincidental or the true state of nature in this study area. If all the females in the area do in fact have a home range size which closely approximates this figure, it would prove most valuable in the analysis of the population following flooding. The following pages show figures of the actual plot used in the study area, and of the home ranges of all eight mice.

Figure 1

Schematic Drawing of Study Plot

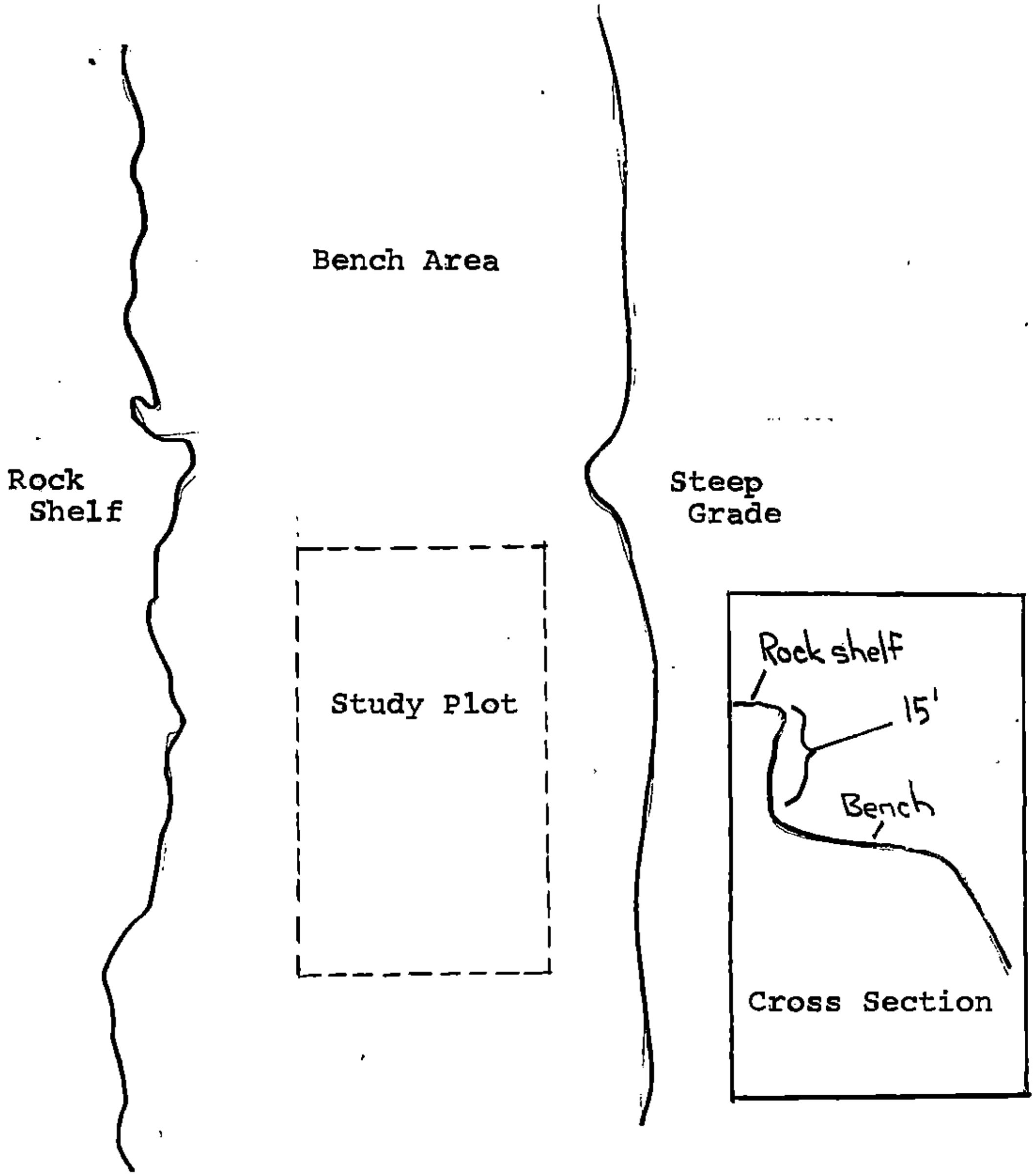
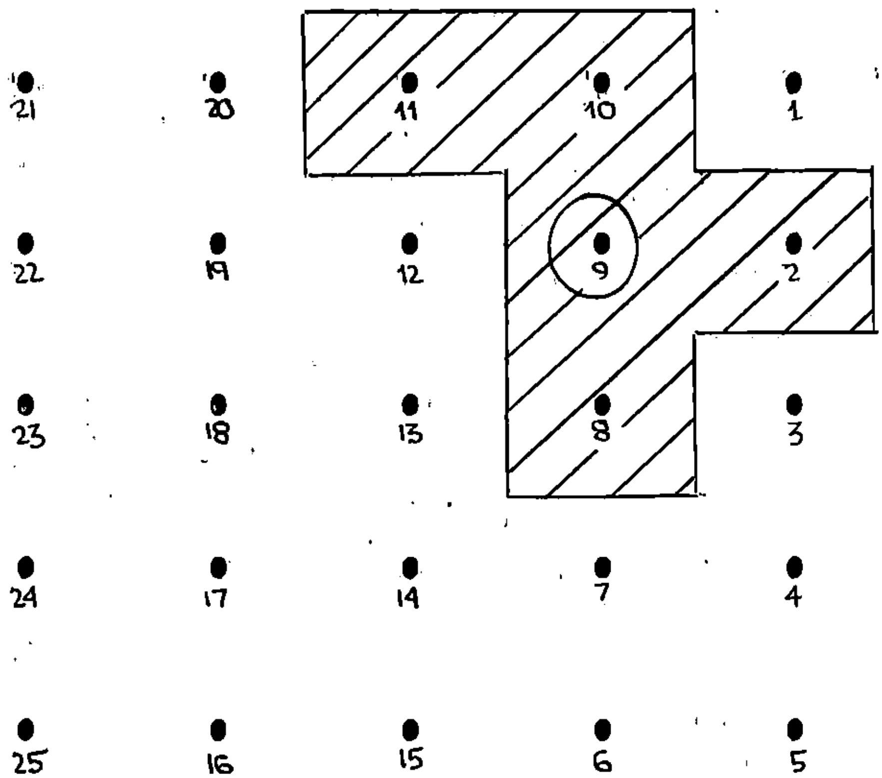
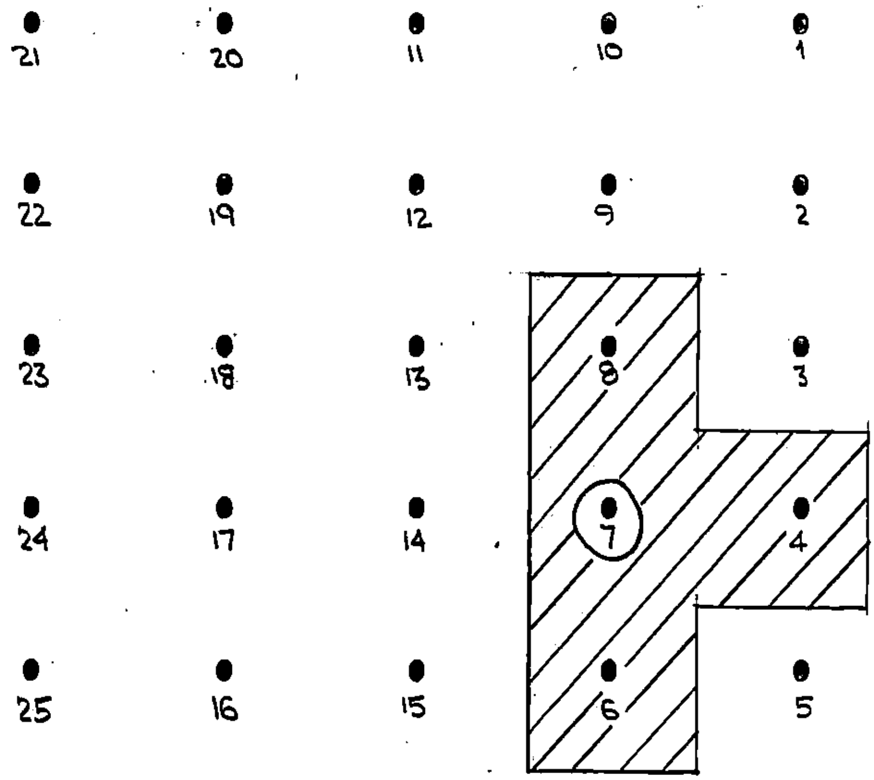


Figure 2



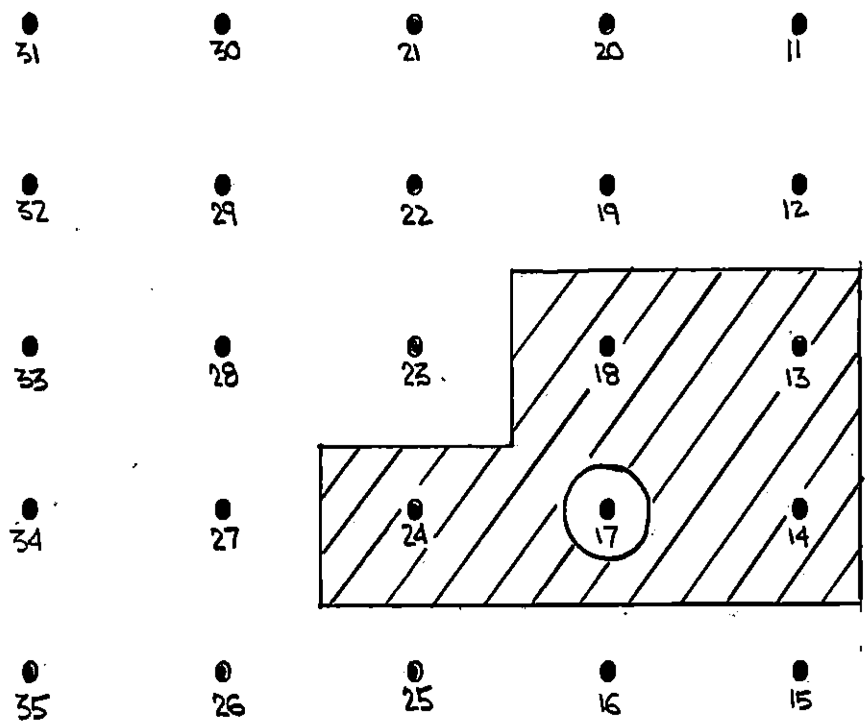
Home range of mouse number 1, an adult female. This mouse was recaptured 28 times. The area of the home range is 3125 ft^2. The circle around trap # 9 indicates that it is the center of activity of this mouse.

Figure 3



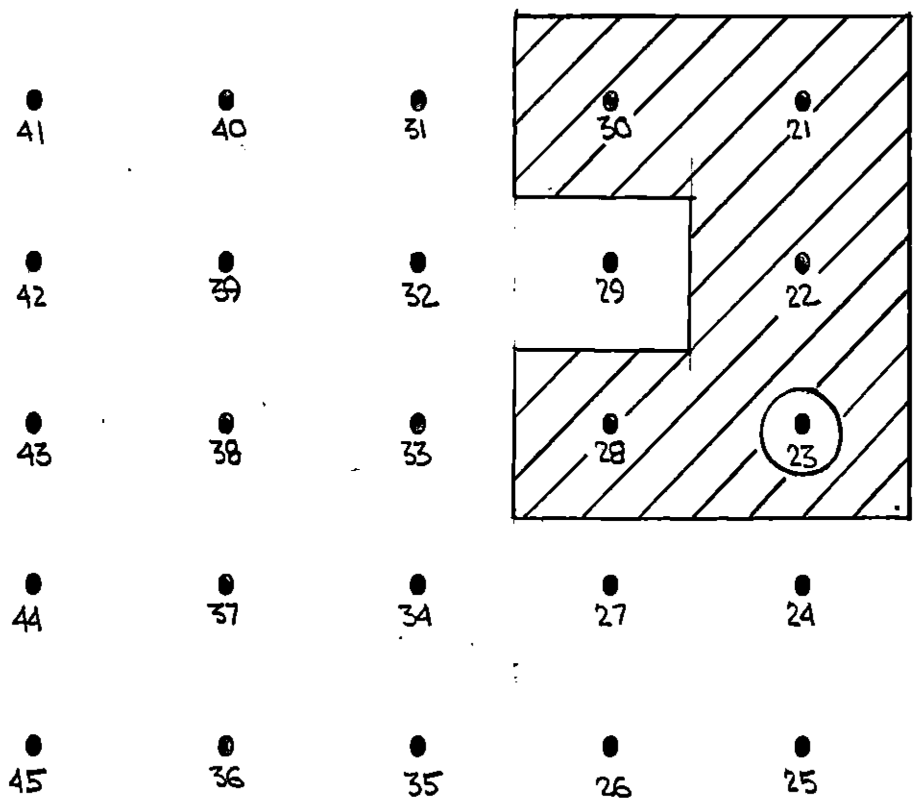
Home range of mouse number 2, a juvenile. This mouse was recaptured 17 times. The area of the home range is 2500 ft^2. The circle around trap # 7 indicates that it is the center of activity of this mouse.

Figure 4



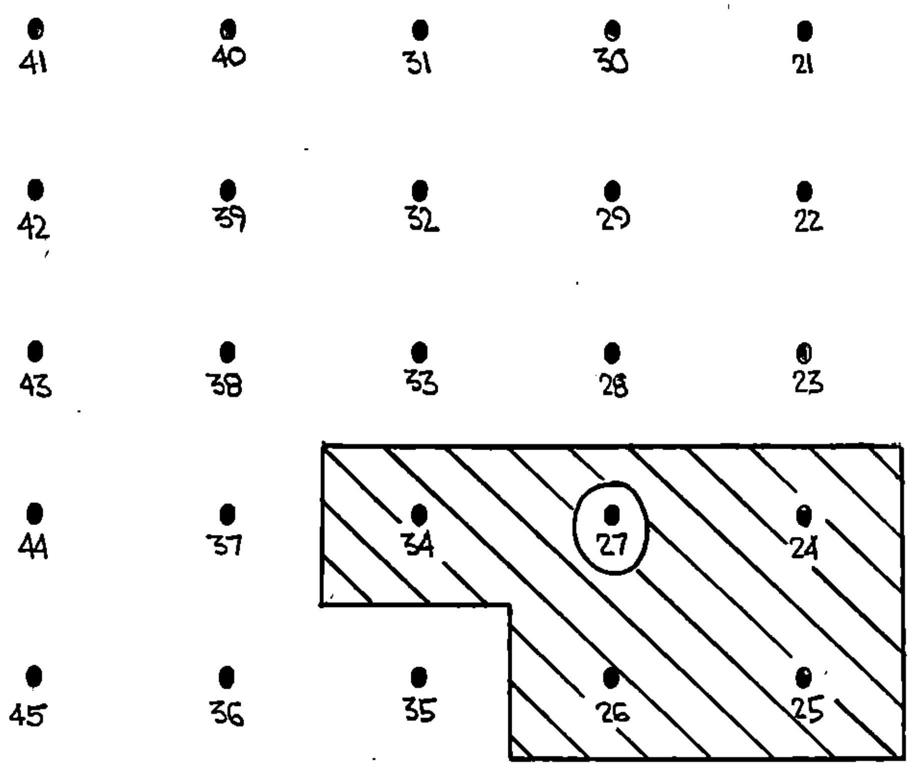
Home range of mouse number 3, an adult female. This mouse was recaptured 19 times. The area of the home range is 3125 ft^2. The circle around trap #17 indicates that it is the center of activity of this mouse.

Figure 5



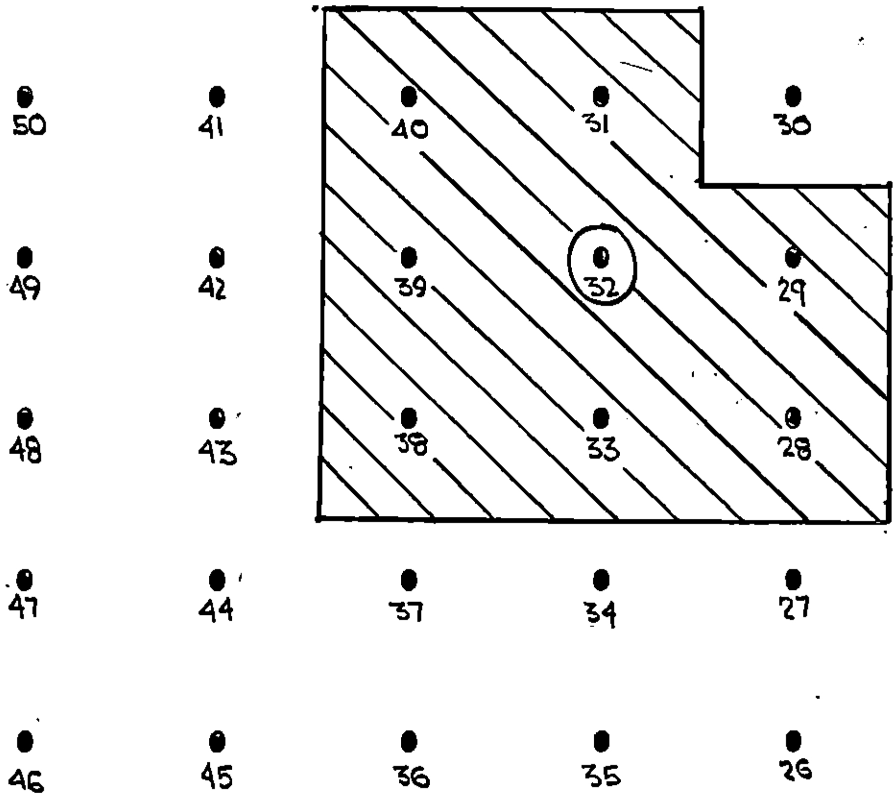
Home range of mouse number 4, an adult female. This mouse was recaptured 23 times. The area of the home range is 3125 ft^2. The circle around trap #23 indicates that it is the center of activity of this mouse.

Figure 6



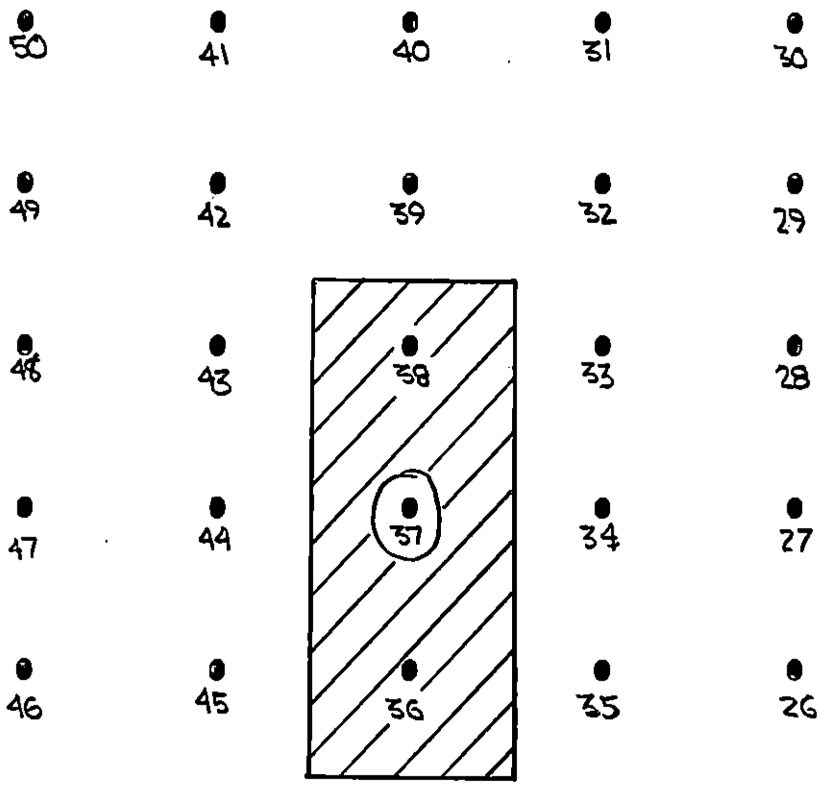
Home range of mouse number 5, an adult female. This mouse was recaptured 31 times. The area of the home range is 3125 ft^2. The circle around trap #27 indicates that it is the center of activity of this mouse.

Figure 7



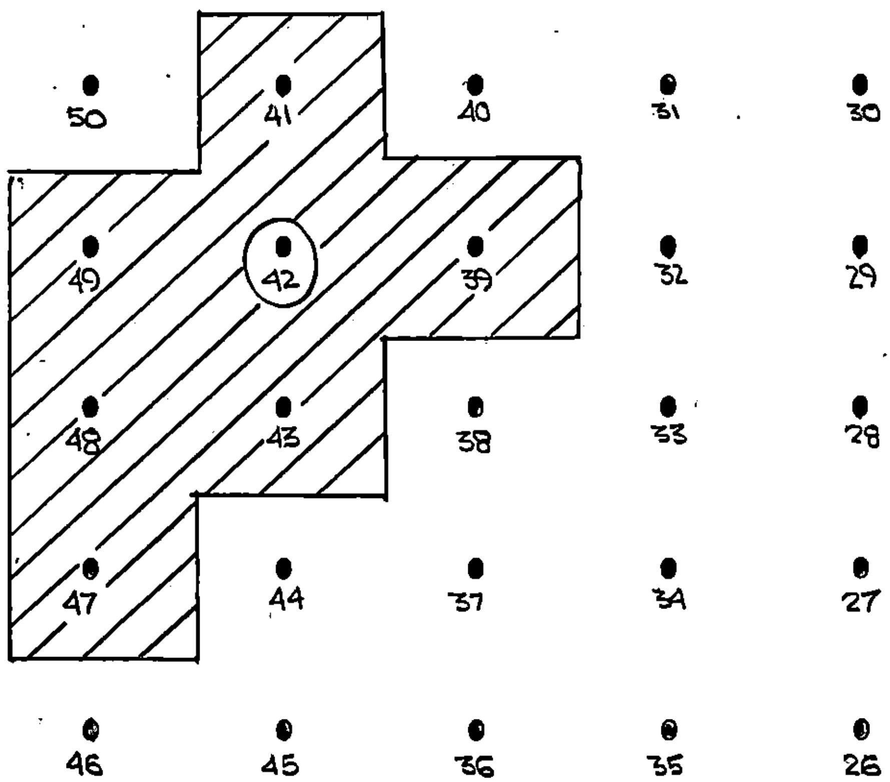
Home range of mouse number 6, an adult male. This mouse was recaptured 31 times. The area of the home range is 5000 ft^2. The circle around trap #32 indicates that it is the center of activity of this mouse.

Figure 8



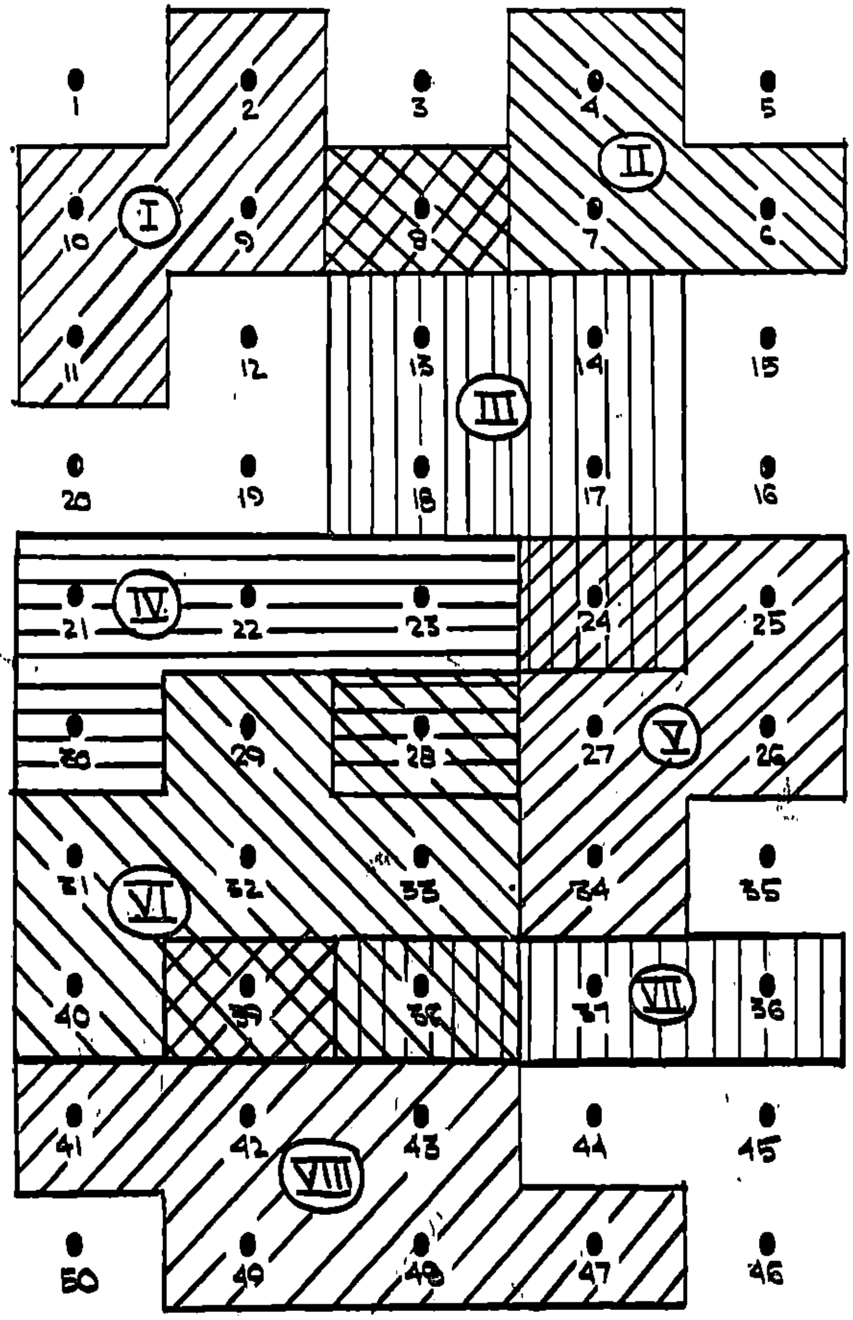
Home range of mouse number 7, a juvenile. This mouse was recaptured 23 times. The area of the home range is 1875 ft^2. The circle around trap #37 indicates that it is the center of activity of this mouse.

Figure 9



Home range of mouse number 8, an adult male. This mouse was recaptured 26 times. The area of the home range is 4475 ft^2. The circle around trap #42 indicates that it is the center of activity of this mouse.

Figure 10



A composite view of the home ranges of all eight mice, showing overlap.

CHAPTER V

DISCUSSION

The stated purpose for this population study was to pave the way for further, more extensive studies on the effects of permanent flooding on peripheral animal populations. It is felt that the response of a white-footed mouse population to flooding can, with reservation, be applied to other related species such as the sciurids and lagomorphs. Squirrels and rabbits are valuable game species in Kentucky. If a multi-purpose reservoir is to be constructed, it is necessary to consider fully the effects that permanent flooding will have on the game species of the area.

The results of this experimentation showed that the population of mice studied in the 22,500 ft^2 plot was thirteen. The estimated average home range sizes of eight study mice were: 4738 ft^2 for adult males, 3125 ft^2 for females, and 2188 ft^2 for juvenile mice.

The results obtained in the reported study represent only half of the desired information needed to interpret the effects of flooding on wildlife. Following completion of the Cave Run Reservoir, the study area must be sampled again by the author or some other interested experimenter. Estimations of the population density and home range sizes must be made, then a confidence interval for the second survey must be calculated. A comparison of the two confidence intervals would show any significant difference between the two populations. It is sincerely hoped that the information gathered in this study can be utilized in determining the advisability of reservoir construction in areas where the wildlife population is of great value.

CHAPTER VI

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