HOME RANGE AND ACTIVITY OF THE GRAY SQUIRREL IN A SOUTHWEST VIRGINIA WOODLOT

by

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INTRODUCTION

The gray squirrel (Sciurus carolinensis), one of the most important small game species in eastern United States, has remained relatively abundant despite man's exploitation of its natural range. The adaptability and availability of this small mammal make it an excellent subject for ecological investigations.

In an effort to better understand the ecology of the gray squirrel the present study attempts to: (1) determine the intensity of use, shape, and size of the gray squirrel's home range; and (2) analyze the effects of various environmental factors on the activity of the gray squirrel.

Home range and activity can be classified under the broader heading of "movements," which also includes migration, immigration, emigration, and movements associated with territory and behavior (Sanderson, 1966). Understanding animal movements is important for the purposes of predator and disease control, censusing, food and cover production and manipulation, studies of stocked animals, and movements beyond management areas.

Home range may be defined as the area about its established home which is transversed by the animal in its normal activities of food gathering, mating, and caring for young (Burt, 1940). Territory is distinguished from home range by the fact that a territory is defended against intruders of same species; a home range is not (Noble, 1939).

The added condition of defining home range through a given time might also be helpful from the standpoint of preciseness when making comparative analyses.

The area, or space, which an animal's home range represents is limited by the animal's ability to travel. As is the case with the gray squirrel, this space may have a three-dimensional aspect because of vertical movements. This space must provide the food, protection, and other necessities needed to sustain an animal. Thus, within limits, the condition and suitability of the habitat dictates the home range size. The area occupied by an animal affects intra and interspecific relationships, population densities, utilization of food and cover, social organization, breeding success, and other features of community dynamics.

Home range determinations provide greater information when attempts are made to describe intensity of use within the area. Intensity and type of use is directly related to the interaction of a species with its environment. If these can be ascertained, many relationships, such as food and cover dispersion, may become apparent which previously have not been accounted for in determining the distribution and abundance of animals. Activity is most directly affected by weather and behavioral considerations. The present study examines the effect of time of day, air and soil temperature, relative humidity, barometric pressure, sun exposure, precipitation, day length, wind velocity, and amount of snow on the ground on gray squirrel activity. Centers of activity (Hayne, 1949) within the home range will also be calculated.

The major problem confronting the investigator concerns accurately describing home range and activity. First, techniques for obtaining movement data have been for the most part inadequate. Although this problem has not been completely resolved, the future looks promising because of our advancing technology. Secondly, interpretation of data has not been standardized to the point where an investigator can readily make comparisons between various studies. This problem is becoming increasingly critical with the advent of new techniques for determining movement data. The wealth of data which the new techniques afford makes it imperative that some uniform methods for analyzing data be advanced. It must be remembered, however, that any technique for data assimilation must fulfill the objectives for which the study was intended.

Just what implications do animal behavior studies have for man? This is an area of current controversy, but it may be well to keep in mind the words of Robert Ardrey (1966:40-41): "It is the turn now of biology, I believe to extend our calculation of man by the addition of that...fourth dimension, time. It will be a leap of incomparable consequence. There will be a terror of sort in losing, once and for all, this comfortable pupa-like, three-dimensional chamber of human uniqueness, the only world we have ever known. And there will be a hazard...in the chance that we may discover ourselves the pale prisoners of a determinate past, whereas before we were at worst the nervous victims of an indeterminate future. But it is a chance I believe worth taking: in part, because I have reason to suspect that this will not be biology's answer; in part, because I believe that the winning of self-knowledge is worth every risk; and in part, because I have no choice, for truth is peering in my window and I cannot ask him to go away."

LITERATURE REVIEW

In reviewing the literature it becomes apparent that there are three broad areas of concern: (1) data acquisition; (2) data interpretation; and (3) specific information concerning gray squirrel movements and activity. Because the present study may have broader implications than the title suggests, each of the three areas will be considered.

Data Acquisition

The various techniques which have been used for acquiring movement data include the use of direct observation, natural signs, trapping, radioactive materials, dyes for urine and feces, photographic devices, and radio telemetry. Trapping and direct observation have been the most widely employed methods; however, recently radio telemetry has assumed an important role in movement studies. Because most of the past data concerning gray squirrels have been collected by trapping and observation, and since little work has been done with squirrels utilizing radio telemetry, these three methods were used in the present study.

Trapping

Trapping has been the most popular method of determining animal movements. This is probably the result of being able to collect other data simultaneously. Trapping is also less time consuming and expensive than the other methods. Chitty (1937), Mohr (1947), and Hayne (1949,

(1950) have discussed trapping techniques and the effect these techniques have on trap-revealed home ranges. Howard (1949) questioned the checkerboard or grid technique of trapping, and Blair (1951) disagreed with him on some points. Hayne (1950) states, "All in all it seems reasonable to conclude that a determination of apparent home range in this manner does not reveal a biological characteristic of the normal life history, but rather represents the working out of a complex relationship between an animal and a set of traps." Burt (1943) also concluded that a calculated home range based on trapping records is no more than a convenient index to size. Dice and Clark (1953) shared the view that traps bring about modification in the movements of an animal. On the other hand, Chitty (1937) and Layne (1954) both felt that the home range for red squirrels (*Tamiasciurus spp.*) was not perceptibly altered by traps if they were set in an irregular pattern. Shorten and Courtier (1955) found it impractical to use grid or random distribution of traps for gray squirrels because of the discontinuous nature of the habitat. Tanaka (1963) has stated that "the disturbance of activities by traps is not so important as imagined." If traps do modify activity, it may be partially due to the fact that some animals become accustomed to being trapped, or trap prone (Shorten and Courtier, 1955: Harrison, 1958). It has also been noted (Kaye, 1961) that harvest mice (*Reithrodontomys fulvescens*) display abnormal behavior upon release from traps.

Burt (1940) believed trapping to be an inadequate technique because of the amount of time necessary for recaptures. During long trapping periods shifts in the animal's home range may occur. From an analytical point of view, the observation period (trapping duration) should be short relative to the life span of the animal (Calhoun and Casby, 1958).

Direct Observation

Direct observation studies have been conducted using several methods. Some studies (Schaller, 1963) have utilized the normal physical characteristics of an individual as a means of identification. Natural deformities are also used as a means of identifying individuals. When the above methods cannot be applied, the animals may be live-trapped and marked in an individual manner. Uhlig (1955) and Pack (1966) utilized this technique when working with gray squirrels. Hicks (1949) also used direct observation in determining fox squirrel activity.

Little has been done concerning a critical assessment of direct observations. Sanderson (1966) points out some of the pros and cons of this technique. The most important consideration seems to be the effect the presence of an observer has upon the behavior of an animal.

Radiotracking

Radiotracking was defined by Southern (1965) as "an electronic technique for obtaining qualitative and quantitative data about an organism and its environment by remote means through space." This technique seems to offer the most promise for the future. To date, the effect of the transmitter package on the animal has not been evaluated. Heezen and Tester (1967), in evaluating radiotracking by triangulation, found four parameters which they felt were useful in studying deer movements. These were total area, greatest linear dimension, mean activity radius and distribution of activity radii, and appearance of the map. As this technique becomes more sophisticated, greater effort needs to be placed on objectively evaluating the data from an ecological point of view (Sanderson, 1966).

Data Interpretation

Numerous methods have been advanced for analyzing movement and activity data. A review of the most important methods will be presented here, followed by a discussion of the suitability of each.

The "minimum area method" (Dalke, 1942, as cited by Sanderson, 1966) is determined by connecting the outer-most points so as to enclose the remainder of the points. The enclosed area is then calculated. The "boundary strip method" has been used by Burt (1940) and others. This method includes a strip around the minimum area which is half as wide as the distance between traps. The area may be enclosed in two ways using this method. The "inclusive boundary strip method" (Blair, 1940: Stickel, 1954) encloses more area than the "exclusive boundary strip method" (Stickel, 1954).

Hayne (1949) described the technique for determining "center of activity." This is accomplished by finding the geometric center of all locations. The locations are weighted by the number of times an animal was located at a given point. Dice and Clark (1953), using Hayne's (1949) concepts, extended on them by using a statistical analysis. In their analysis the following were defined: "activity loci," the infinite number of positions an animal occupies as it travels over its home area; "activity radius," the distance between an activity and the center of activity; "recapture radius," the distance between a given recapture locus and the geometric center of all recapture loci recorded for a particular grid of traps for an individual; and "recapture center," the geometric center of the recapture loci.

The "observed range length" (Stickel, 1954) is the distance between the most widely separated locations. The "adjusted range length" (Stickel, 1954) is obtained by adding half the distance to the next trap to each end of the observed range length.

Harrison (1958) also used the statistical approach in defining movements. He defined "standard diameter" as the square root of the mean squares of all diameters about the center of activity. One standard diameter will include an area about the center of activity in which the probability of capture of a given animal is 68.28%.

Recently, Mohr and Stumpf (1964a, 1964b, 1966) and Mohr (1965) have described the method of "composite home range." This method attempts to obtain a statistical average for a large number of individuals, each of which was caught four or more times, for a particular sex, age, and seasonal, physiologic, or habitat condition. In the process of determining a composite home range, "median centers and axes" (Mohr and Stumpf, 1964a) are described. This determination is similar in some respects to center of activity; however, it is calculated in a different manner.

In choosing a method of analysis for a specific set of data several things should be considered. First, how were the data collected? Secondly, what are the objectives of the study? It should be remembered, however, that the matter of individual range is far from simple and that any "cut and dried" approach to it is likely to be more misleading than helpful (Allen, 1943).

There are three assumptions concerning the analysis of home range data (Calhoun and Casby, 1958): (1) home ranges are fixed (or time independent); (2) there is a center of activity although the true center may deviate from it; (3) the probability of an animal being in a unit area decreases with increasing distances from the true center of activity.

Mohr (1947) at one time concluded that the minimum area method gives the most consistent results. Layne (1954) also felt that this method gave the "most comparable and conservative results." Later Mohr and Stumpf (1964a, 1964b) found that median centers and axes were more convenient for studying the relationship of parasitism to areas of activity. Recently, however, these investigators (Mohr and Stumpf, 1966) in comparing minimum home range, circular, mean linear, and median composite, based on points where individual members were seen, reported that it seems best to report only observed areas along with distances between traps, duration of trapping, and number of points observed. Howard (1949) felt that to express home range in terms of area greatly magnifies any errors made in determining the distance of movements. Stickel (1954) in comparing minimum area, inclusive and exclusive boundary strip, and observed and adjusted range length using artificial populations concluded that the exclusive boundary strip method was the most accurate. Sanderson (1966) states that the inclusive boundary strip method "has a built-in deficiency for non-circular home ranges." Tester and Siniff (1965) in examining telemetry data felt that the center of activity and activity radius may be useful for intra and interspecific comparisons, and also for evaluating changes in an animal's behavior through time.

In analyzing home range data, care should be exercised not to include occasional "sallies" which are outside the animal's normal range (Burt, 1940). This is particularly important for ecological studies (Stickel, 1954). In an effort to systematically exclude such locations, Harvey and Barbour (1965) have presented a modified form of the minimum area method.

Gray Squirrel Movements

Home Range

Few systematic studies of the gray squirrel's home range have been conducted. Many of the data concerning this phase of the animal's life history have been collected incidental to larger studies (Seton, 1928; Goodrum, 1940; Brown and Yeager, 1945; Allen, 1952; Moran, 1953;

Uhlig, 1955). Even though observations were sometimes made during different seasons and for varying periods of time, the data point up the degree of variation which is brought about by diverse habitats.

Unlike the red squirrel (Gordon, 1936; Robinson and Cowan, 1954), the gray squirrel does not display territoriality (Bakken, 1952; Robinson and Cowan, 1954; Sharp, 1959). Intraspecific relationships are based upon establishment of a dominance order (Bakken, 1952; Robinson and Cowan, 1954; Pack, 1966) rather than on territoriality and the exclusion of other individuals from the area that it implies. The only reported exception concerns the defense of the immediate area around the den tree after parturition by the female (Bakken, 1952; Robinson and Cowan, 1954).

On the present study area, Pack (1966) found an average home range of 1.24 acres or 1.45 acres depending on the sample for which the calculations was made. Flyger (1960), working in comparable woodlots in Maryland, determined an average home range of 1.4 acres. In British Columbia, Robinson and Cowan (1954) found that the females moved over 5 to 15 acres; the males, from 50 to 55 acres (in this case, the entire study area). Table 1 presents the home range determinations secured by Bakken (1952) in Wisconsin. He also noted that pregnant females or females with a litter displayed a restricted activity, usually within 40 feet of the den. Odum and Kuenzler (1955) have also noted this type of behavior in birds with nestlings. In Britain, Shorten and Courtier (1955) found the general shape of the gray squirrel's home range to be long and narrow.

Table 1. Home range area by sex and age of gray squirrels in Wisconsin (Bakken, 1952)

Age	Home Range in Acres	
	Males	Females
Juveniles	5.0	3.8
Yearlings	10.7	7.1
Adults	24.7	9.9

As in the case with other small mammals (Burt, 1943), variation relative to age, sex, and season in the home range of gray squirrels has been reported. A drift in the home range may occur in summer and winter (Baker, 1944). Bakken (1952) believed that variation in size or shape of home ranges between sex and age groups might be correlated with individual dominance. Pack (1966) investigated this and found there to be no statistically significant difference. Flyger (1960) found no significant difference between adult males, adult females, or immatures, irrespective of social dominance.

Activity

Activity, measured as number of squirrels recorded per unit time, is the usual method for determining activity peaks. Seasonally, high points in activity have been noted in late summer and fall, and early spring in Texas (Baker, 1944), in September in Indiana (Allen, 1952), in October in Wisconsin (Bakken, 1952), and in autumn in Illinois (Moran, 1953). Activity peaks throughout the year may be associated with food availability (Baker, 1944).

Peaks in daily activity according to season have been reported by Bakken (1959). Baker (1944) felt that generally squirrels become less active as the day advances. Reports of nocturnal movements have been reported but not verified (Baker, 1944).

Little can be found in the literature concerning the consistent response of gray squirrels to various weather conditions. Hicks (1949) reports on fox squirrel activity, but no statistical analysis is presented. Most of the information on gray squirrels has been obtained by casual observation. The most consistent factors affecting activity which have been reported are low temperatures when accompanied by high winds (Shipley, 1941; Cross, 1942; Bakken, 1959; Sharp, 1959; Pack, 1966). Pack (1966) found that cloud cover had no significant effect on feeding activity.

TECHNIQUES AND PROCEDURES

The Study Area

The present study was conducted in North Crumpacker Woods, located on the Virginia Polytechnic Institute College Farm. This mature to overmature oak-hickory stand comprises seven and one-half acres. Approximately ten dairy cattle graze the area; the ground cover is grasses. The entire woodlot can be observed from a single location. Two small woodlots of similar composition are located within one-quarter mile of the study area. Occasional squirrel movements between these woodlots occur. Close proximity to campus, a population of between five and eight squirrels per acre, and availability of data from previous squirrel studies on this woodlot make it an excellent area for study.

Data Acquisition

Observation-Trapping

Pack (1966) obtained background data for the present study by the combined methods of visual observation and live-trapping. Squirrels were individually marked using three methods. Observations were made in conjunction with a study of the social hierarchy of the gray squirrel. Trapping was confined to one week of each month in order to gather "shock" loss data, obtain over-winter mortality information, mark new individuals, and mark again individuals that had lost tags and/or dye. The original data were used to plot locations of each individual from the period November 16, 1965, to March 5, 1966.

Trapping

Traps as described by Mosby (1955) were used in all trapping operations. Traps were placed at previously established stations. These 35 stations were distributed as evenly as possible in areas considered most suitable for capture throughout the woodlot (Fig. 1). Prebaiting of traps started in June, 1966; and on July 1, 1966, trapping operations began. Traps were visited twice daily in order to insure a maximum number of captures, and also to reduce "shock" losses. All squirrels captured were sexed and aged by the method described by Sharp (1958). All new individuals were ear marked with No. 1 monel tags (National Band and Tag Company, Newport, Kentucky). Most of the animals captured had been marked previously. Date, station number, tag number, sex, and age were recorded for each capture. Trapping was continued on a six-day-a-week basis until August 31, 1966. During the remainder of the study, trapping was continued during periods when animals were needed for placement or removal of the radiotracking package. New individuals were also marked and old squirrels that had lost tags had them replaced.

Radiotracking

Custom equipment for radiotracking was designed and built by Mr. Lee Wilkins of Deerfield, Virginia. The receiver is a modified form of the D-11 receiver as described by Cochran and Nelson (1963). The receiver, loop antenna, power supply, and azimuth scale are a single unit designed for convenient use in the field. The receiver

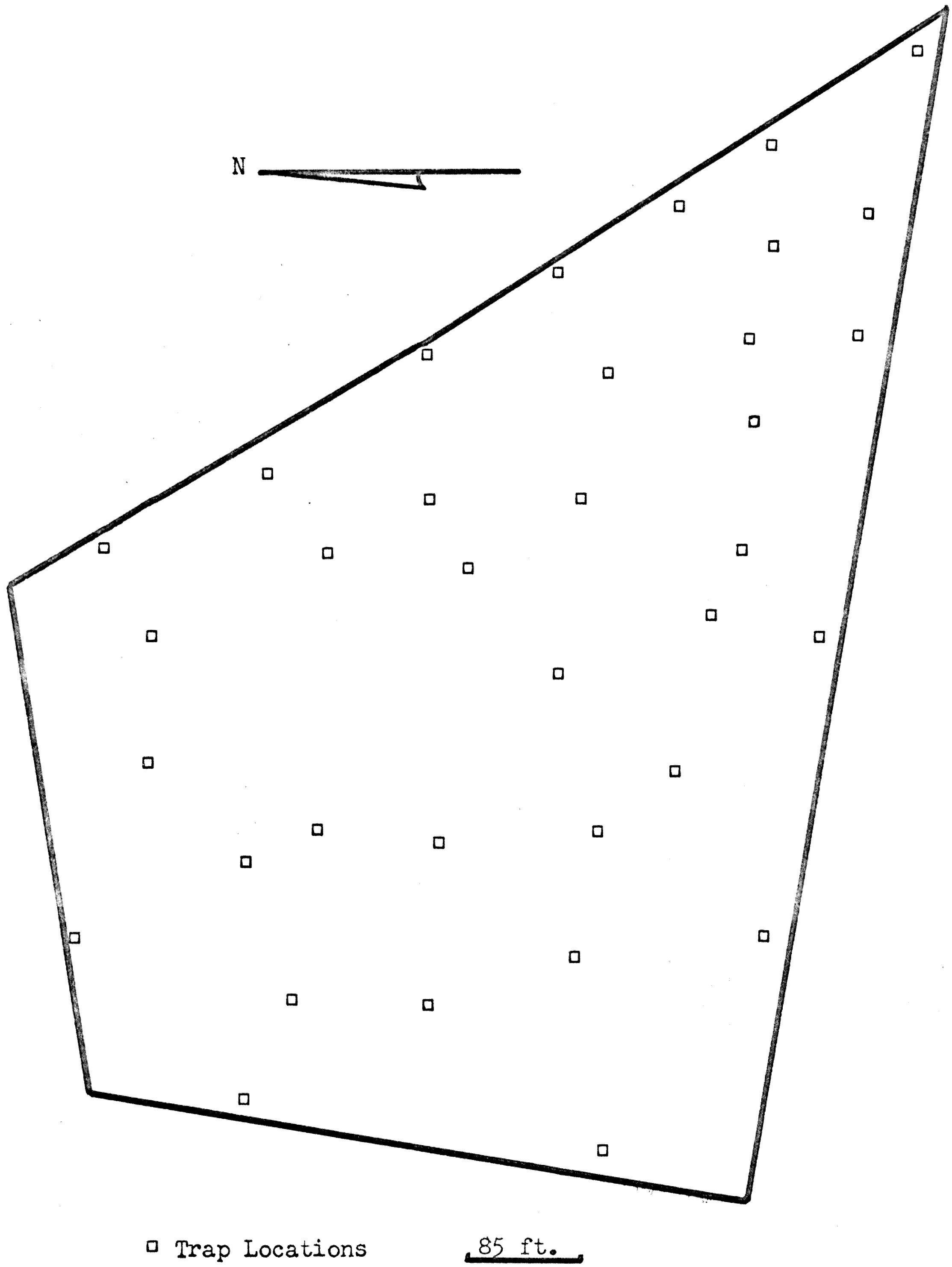


Fig. 1. Map of the 7-1/2 acre study area, North Crumpacker Woods, V. P. I. College Farm, indicating permanent trapping stations.

is a cubical structure six inches on a side and weighs seven and one-half pounds. The unit is powered with two six-volt lantern batteries which are expected to last a year under normal use.

The transmitters were similar in design to those used by Verts (1963). They weighed between 40 and 45 gms., depending on the amount of encapsulating material used. This approaches one-tenth of the weight of an average sized squirrel. The electrical circuits were secured with epoxy cement to a thin fiberglass sheet. The entire circuit was encapsulated with silicone rubber. As an added precaution, plastic electrical tape was wrapped around the encapsulated circuit and mounting board. Two banjo strings, approximately seven inches long, served as whip antennae. Mercury cells were used as a power source, and battery life was calculated at six weeks. Each transmitter operated on one of five set frequencies, allowing a total of five squirrels to be harnessed with transmitters and monitored during the same period.

The transmitters were harnessed to the squirrels with thin nylon belts (Figs. 2 and 3). The harness was designed to fit an average sized squirrel, and this single size was used for all animals harnessed. Binding was sewn to the nylon along edges which were cut. The harness and fiberglass board of the transmitter were attached using small bolts and nuts. Small grommets were affixed where bolts passed through the belts. Belt A was attached to belt B (Fig. 3) using epoxy cement.

The night previous to a planned harnessing, the transmitter was readied by connecting the power supply, encapsulating and taping the

Fig. 2. Gray squirrel with attached transmitter and harness.

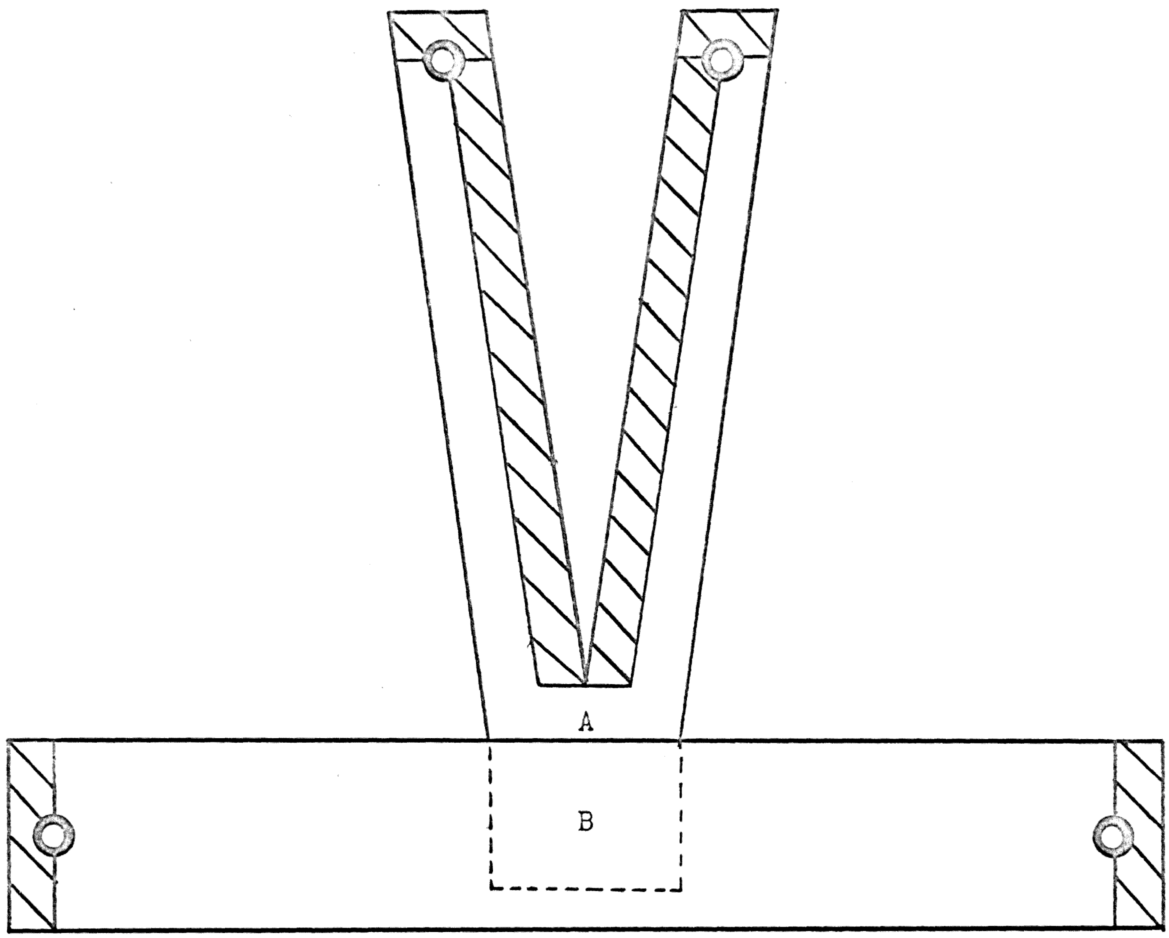


Fig. 3. Harness (actual size) used to attach radiotransmitter to squirrel. Cross hatched area represents binding sewn to cut edges of nylon belts. Grommets are affixed where bolts pass through belts. Belt A is attached to belt B with epoxy cement.

unit. The squirrels were live-trapped and brought to the laboratory for transmitter attachment. The animal was anesthetized with ether. After transmitter attachment, the animal was returned and released at the point of capture. This process required approximately one hour. By locating the animal once every daylight hour, it was felt that any modification of the animal's behavior caused by the presence of the receiver operator would be minimal. Tester and Siniff (1965) found that with an automated system, the proportion of error decreased as the sampling interval increased; however, the optimum interval was not determined. In order to determine whether any nocturnal movements occur, the squirrel was monitored once every two hours during night periods of the first two days following release.

Before determining the exact location of an animal in the field, it was noted whether the squirrel was moving. This could be determined by a modulation in the signal frequency brought about by movement of the whip antennae. In locating an animal, the general direction of the signal from a point outside the woodlot was first noted. The woodlot was entered in such a way as to reach the den tree of the animal in the shortest possible time. Then, walking from the den tree, the animal was located. Working in this manner prevented the squirrel from returning to its den tree upon approach. After familiarity with an animal's home range had been attained, the animal could many times be located without entering the woodlot.

The location of each animal at a given time was plotted on maps, noting time, day, and activity. A different map was used for each 12-hour period. Radiotracking was initiated on November 16, 1966, and terminated March 5, 1967.

Data Interpretation

Criteria for Selection of Animals

Based on previous investigations (Pack, 1966; Flyger, 1960) it was estimated that the average home range of the animals under consideration would be between 1 and 1-1/2 acres. Since there is an average of somewhat less than five traps per acre, an animal was required to be captured in a minimum of five different traps before it was considered in home range determinations. Bakken (1952) and Flyger (1960) used a minimum of five total captures as criteria in making home range measurements.

Pack (1966), in evaluating his observation-trapping data, used five points (plots) as the minimum for making his home range determinations. Because many of Pack's observations were made in close proximity to two feeding stations, the present investigator chose a minimum of seven points as a criteria for evaluating these data.

The percentage of immatures (less than 12 months old), adults, males, and females in the populations of the winter of 1965-66 and the summer of 1966 were determined by trapping. These same calculations were then made for that portion of the population for which home range determinations had been made. This was to insure that these animals represented a true sample of the population, and also to aid in the selection of individuals to be used in the radiotracking study. An effort was made to choose individuals for radiotracking such that the percentage of immatures and females in the sample closely approximated the composition of the winter population of 1965-66. This approach aided in making a realistic comparison of the two techniques.

Minimum Home Range

Minimum home range (the area included by a line connecting the outermost points of observation) (Dalke, 1942, as cited by Sanderson, 1966) determinations were made using a planimeter. Since most of the home ranges were irregular in shape, connecting the outermost points in an objective way sometimes posed a problem. Using a tracing table, a cover map of the area was laid under the home range map, and the home area was closed in a way which took into consideration the cover as well as the investigator's knowledge of the habitat. The average home range size for each sex, age, and technique was calculated. Differences between males and females, immatures and adults, and observation-trapping and radiotracking techniques were then tested for significance using the t-test. No tests for significance between the technique of trapping and the other techniques were attempted since any difference resulting could be attributed to a difference in the season of the year.

Greatest Linear Dimension

The greatest linear dimension (Burt, 1940) of each squirrel's home range was determined by measuring the distance between the two most distant points on the home range map. Again, differences between sexes, ages, and techniques were tested for significance using the t-test.

Standard Diameter

Standard diameter (Harrison, 1958; White, 1964) may be expressed algebraically as: $(D^2/N)^{1/2}$ (the square root of the sum of the diameters, D, squared, divided by the number of observations, N). When a circle with a radius of one standard deviation of the mean radius (center of activity) is circumscribed around the mean radius, it inscribes a zone which will contain 68.28% of all locations. This zone has been defined as a "standard diameter" (Harrison, 1958). This does not mean to imply that all of the area is used, only that 68.28% of the calculated activity takes place within this zone. A standard diameter for each sex, age, and technique was determined and included as part of the composite home range. No tests for significance between groups were applied to these data since home range data for individuals are not well disposed to this analysis.

Composite Home Range

Composite home ranges (the plotting of all individual ranges so as to form a composite) were plotted for each sex, age, and technique. The method used was a modification of the procedure described by Mohr and Stumpf (1962, 1964, 1966) and Mohr (1965). Composite home ranges as determined by the author were calculated as follows: (1) the center of activity (Hayne, 1949) for each home range was determined (only plots for which the squirrel was noted as active were used in determining centers of activity for radiotracked individuals); (2) a line was drawn from the center of activity to the point lying most distant from it; this is termed the major axis and is extended for the length of the home range; (3) the point most distant from the major axis was then located. A line, originating at the center of activity and perpendicular to the major axis, was drawn on the same side as the point and of a length equal to the distance of the point from the major axis; this is the minor axis (Fig. 4); (4) the centers of activity, major, and minor axes of each animal's range were aligned to form the composite. The position of each of these was indicated on the composite.

One set of axes may prove to be the mirror image of another. In this case all dextral ranges were converted to sinistral ranges (Fig. 4) using the method described by Mohr (1965).

<u>Increased Area with Time</u>

Starting from the time of release of instrumented squirrel, the increase in home range with each additional one-half day of radiotracking was determined. These points were enclosed using the minimum home area concept, and areas were calculated with a planimeter.

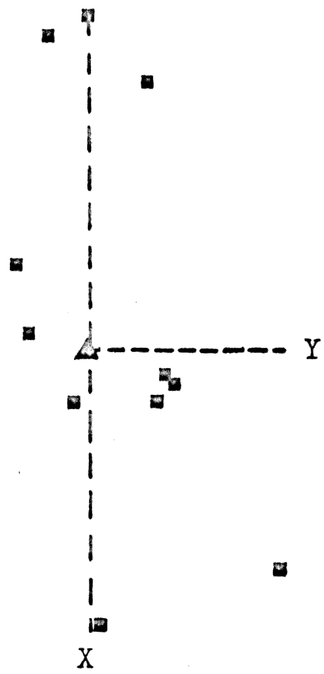


Fig. 4A

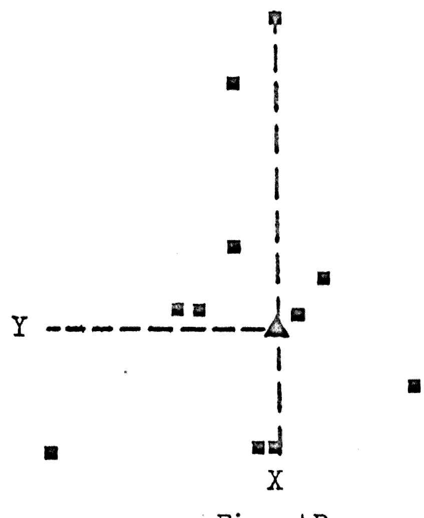


Fig. 4B

■ Points of Capture — X = Major Axis

▲ Center of Activity — Y = Minor Axis

Fig. 4. Major and minor axes, and centers of activity for two gray squirrels. Fig. 4A is a sinistral range; Fig. 4B is a dextral range.

Distance between Extreme Diel Locations

Distance between extreme diel locations (DBE) is defined (Marchinton, 1966) as the greatest distance between any two radio locations of an animal during a given 24-hour period. DBE's were calculated for each animal which was successfully radiotracked. The average and standard deviation for the entire sample were calculated. A correlation coefficient was calculated in order to ascertain if any relationship existed between home range area and its corresponding mean DBE.

Denning Habits

The denning habits of the gray squirrel were noted while collecting radiotracking data. The relation of den placement in the home area, number of den sites, and species preference were noted.

Activity

Each time a squirrel was located by radiotracking it was recorded as active or inactive. For the purpose of the present study, a squirrel was defined as active anytime it was out of its den. Eleven variables were tested for their effect on activity:

X_1 = air temperature

X_2 = soil temperature

X_3 = precipitation (in inches) for the day

X_4 = relative humidity

X_5 = sun exposure

X_6 = percent sun exposure for the day

X_7 = barometric pressure

X_8 = average wind speed for the day

X_9 = inches of snow on the ground

X_{10} = time of day

X_{11} = length of day

Data for variables 1 through 4 were collected three miles from the study area; data for variables 5 and 6, two miles from the study area; and data for variable 7, one mile from the study area. These data were collected by the V. P. I. Department of Agricultural Engineering. Data for variables 8 and 9 were collected one-quarter mile from the study area by the Department of Horticulture at V. P. I.

A regression analysis of the preceding variables was performed in order to ascertain the amount of variation each contributed. A discriminant function analysis (Fisher, 1958) was then conducted using the most significant variables.

RESULTS AND DISCUSSION

Data Acquisition

Data for the present study were collected from November 16, 1965, to March 5, 1967. During this period 1707 locations were obtained, and home range determinations were made for 55 gray squirrels. The squirrel population varied on the 7.5 acre woodlot from 40 to 65 individuals through this time interval.

Observation-Trapping

Visual observations and trapping were conducted on the study area by Pack (1966) during the fall and winter of 1965-66. Data collected from November 16, 1965, to March 5, 1966, were used in the present study. A total of 485 observations and captures was made on 40 gray squirrels. Sufficient data were collected on 24 animals to provide the sample. Sample animals were each located an average of 18.2 times. The sample was of the same approximate sex and age composition as the total population (Table 2).

Trapping

Trapping was conducted by the writer from July 1, 1966, to August 31, 1966. During this time 47 individual animals were captured a total of 310 times. Sufficient recaptures were made to calculate the home range for 21 animals, each having a mean number of 12.1 captures. Again, the sampled portion of the population approximated the sex and age structure of the total population (Table 2).

Table 2. Sex and age composition of gray squirrel population as determined by sample and total counts during two winters (1965-66, 1966-67) and one summer (1966), North Crumpacker Woods, V. P. I. College Farm

	Winter population 1965-66		Summer population 1966		Winter population 1966-67
Classification	Sample (%)	Total (%)	Sample (%)	Total (%)	Sample (%)
AGE:					
Immatures	20.8	19.4	38.0	33.3	20.0
Adults	79.2	80.6	62.0	66.7	80.0
SEX:					
Males	58.4	55.6	72.1	62.8	70.0
Females	41.6	44.4	27.9	37.2	30.0

Radiotracking

The radiotracking phase of the study began on November 16, 1966, and terminated on March 5, 1967. Ten squirrels were tracked a total of 87 days while 912 locations were made. One animal was tracked during November and once again in January; no shift in the animal's home range or change in denning habits occurred during this time. The composition of this sample (Table 2) closely approximated the composition of the population sampled the preceding winter (1965-66).

Three attempts at tracking were unsuccessful. One squirrel appeared to be in "shock" when the transmitter was attached. This animal was placed in a den of a fallen tree after transmitter attachment. An hour later it was found dead outside the woodlot, approximately 100 feet from the point of original placement. Its skull had been crushed by what was thought to be a dog since no attempt was made to eat the kill. A second animal presumably removed the harness and transmitter after a day of tracking. It was thought that the package was removed in a den, and no attempt at recovery was made. The third squirrel received a transmitter which had been used previously. Since the antennae wires weaken with use, it was presumed that the antennae broke soon after harnessing. This was evidenced by the fact that a weak signal could be read, but the direction could not be ascertained. This commonly occurs when antennae break.

Use of ether as an anesthetic proved quite satisfactory once experience in its use had been gained. One squirrel was lost by what was believed to be an overdose. All other animals recovered quickly with no apparent side effects. However, field use of this anesthetic is not recommended. At an optimum dosage level, the animal is still able to move about and must be handled with some care. For this reason it is well to work in a confined area. Generally, by the time the harness was attached and the animal was transported back to the point of capture, the effect of the anesthetic had worn off. Movements were not perceptibly altered after initial release, indicating that the after effects of the ether were minimal.

Reaction of the squirrel to the transmitter and harness varied. Most of the squirrels made no attempt to remove the harness while under observation. When coming out of the anesthetic, three squirrels attempted to remove the harness. Even though they were capable of fleeing, they did not do so unless prodded. Instead, they attempted to pull the harness over their head by using their hind feet. This resulted in the claws becoming "hooked" in the nylon webbing; they were then virtually helpless. After the author had released the claws once or twice, they sought refuge in a nearby tree. Two of these animals eventually removed the transmitter package.

Physical irritation of the harness and transmitter to the squirrel appeared to be slight. Four animals were recovered while still wearing the package. None of these displayed any ill effects; one animal had worn the harness for 13 days. One animal was captured after losing the package; this squirrel had lost some of its fur, but the underlying skin was unaffected.

The amount of interference in activity brought about by the added bulk of the transmitter is somewhat open to question. The only behavior aberration noted was the inability of one animal to enter a small den hole because of the transmitter. It later occupied another den within three feet of this entrance for the remainder of the tracking period (20 days). One squirrel initially had difficulty entering its den; however, it was later noted that it had gnawed back the edges of the entrance. Because of the size of the trees in the study area (up to 50 inches DBH), most den holes were large enough that the transmitter offered little resistance to entrance.

It is the author's opinion that, other than for the exceptions noted above, the effect of the transmitter package on the animals' behavior was slight. This is substantiated by numerous observations of squirrels engaging in all types of activity. One harnessed female was observed in the act of copulation; the antennae extending over the female's back in no way affected the male's successful effort.

Ten transmitters were initially available for use. Five of these were recovered after use in one tracking period; two were retrieved by trapping; two, by shooting; and one was found on the ground, presumably removed by clawing. Four of the retrieved transmitters were reused; none of these was recovered a second time.

Technical problems associated with the radiotelemetry equipment were minimal. Electrical interference from the surrounding area caused the greatest problem. The exact causes of this interference were not determined. Because of this problem the investigator had to enter the woodlot in order to locate the squirrel. This procedure led to a concentration of locations at various trees within the home range. An animal feeding on the ground generally sought refuge in a nearby tree on approach by the receiver operator. Therefore, unless the squirrel was observed on the ground, all radiotracking locations were in trees. Since points of location within the home range are not as well distributed as they might be under normal conditions, this resulted in the calculated center of activity deviating from the true center.

Antennae breakage at the solder point also posed a problem. Normally, after about a week, the "wear and tear" on the antennae caused them to break. Since a tracking period ordinarily lasted a week, this caused little concern; however, a greater number of transmitters would have been recovered if this had not occurred. (Battery life was tested in the field for 45 days.)

Variation in the signal brought about by denning also caused some problems. The signal from a squirrel in a deep den often was altered such that the signal could not be read through a portion of the 360° about the tree. The degree to which this occurred depended on the size of the tree and the position of the den in the tree. Once this problem was recognized, it caused little difficulty.

Data Interpretation

Minimum Home Range

The mean minimum home range for 55 determinations was 1.20 acres. Thirty-four of these were for winter residents; 21, for summer residents. Males (Fig. 5) had a significantly larger (t=1.96 w/53 d.f.) mean home range (1.32 acres) than did females (0.99 acres). Adults had a larger mean home range (1.23 acres) than did immatures (1.11 acres), but the difference was not significant (t=0.63 w/53 d.f.). This information agrees in part with Bakken (1952) who believed that home ranges increase with age and is always larger for males; and in part with Flyger (1960) who found no significant difference between the size of home ranges of adult males, adult females, and immatures. Individuals for which home range information was obtained by radio-tracking had a smaller mean home range (0.96 acres) than their counterparts (1.31 acres) who had their home ranges determined by observation-trapping. This difference was significant at the 0.80 confidence level (t=1.49 w/32 d.f.). Trapping data for the summer of 1966 revealed a mean home range of 1.17 acres.

Greatest Linear Dimension

The greatest linear dimension (distance between the two most distant points on the home range) averaged 448.6 feet for the entire sample. This measurement (Fig. 6) was larger for males (466.0 ft) than females (422.1 ft), and also larger for adults (459.7 ft) than

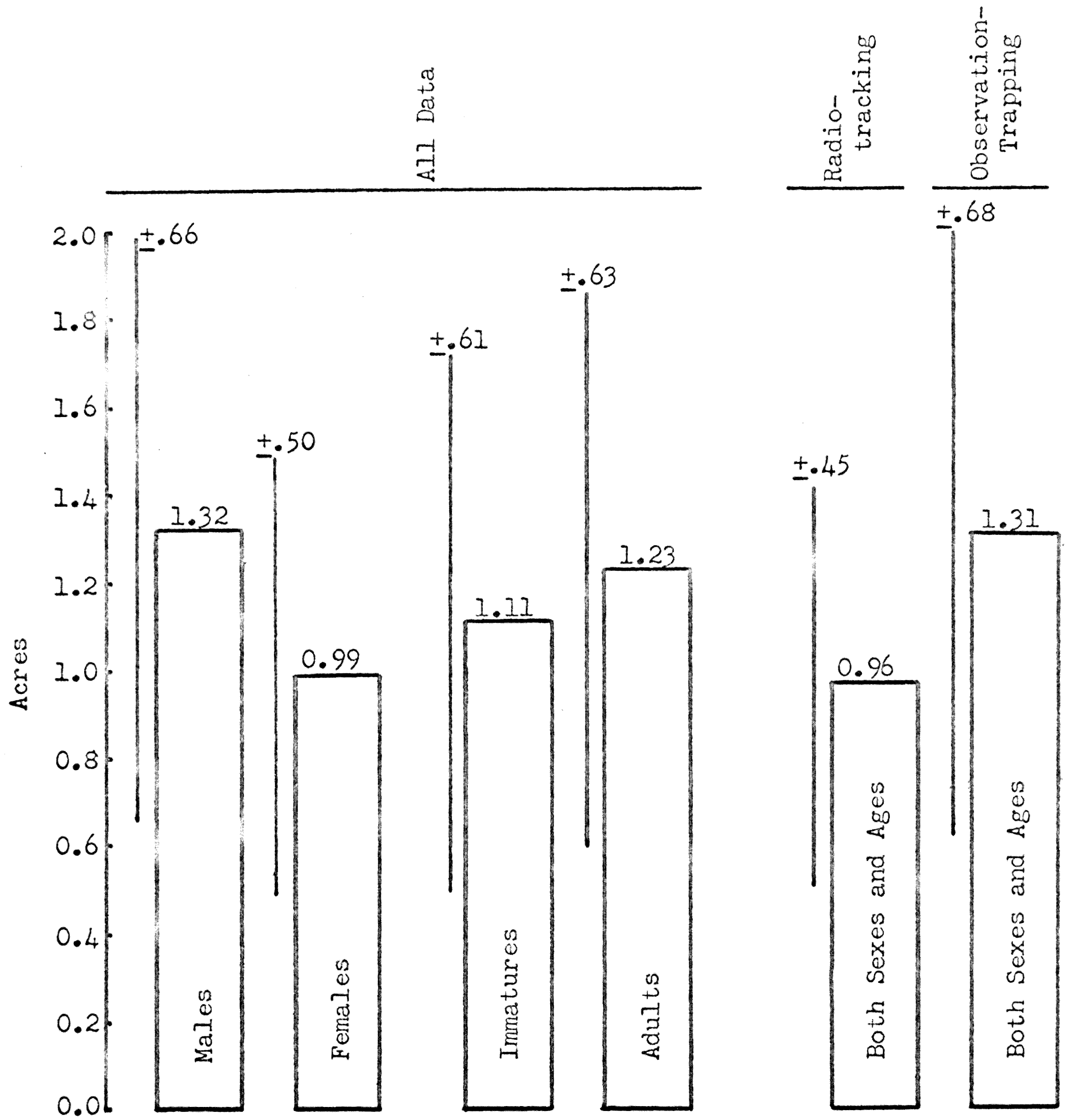


Fig. 5. Minimum home range (in acres) for each classification, North Crumpacker Woods, V. P. I. College Farm, November, 1965, to March, 1967. Difference between sexes significant at 0.95 confidence level, and difference between techniques significant at 0.80 confidence level. Difference between ages non-significant.

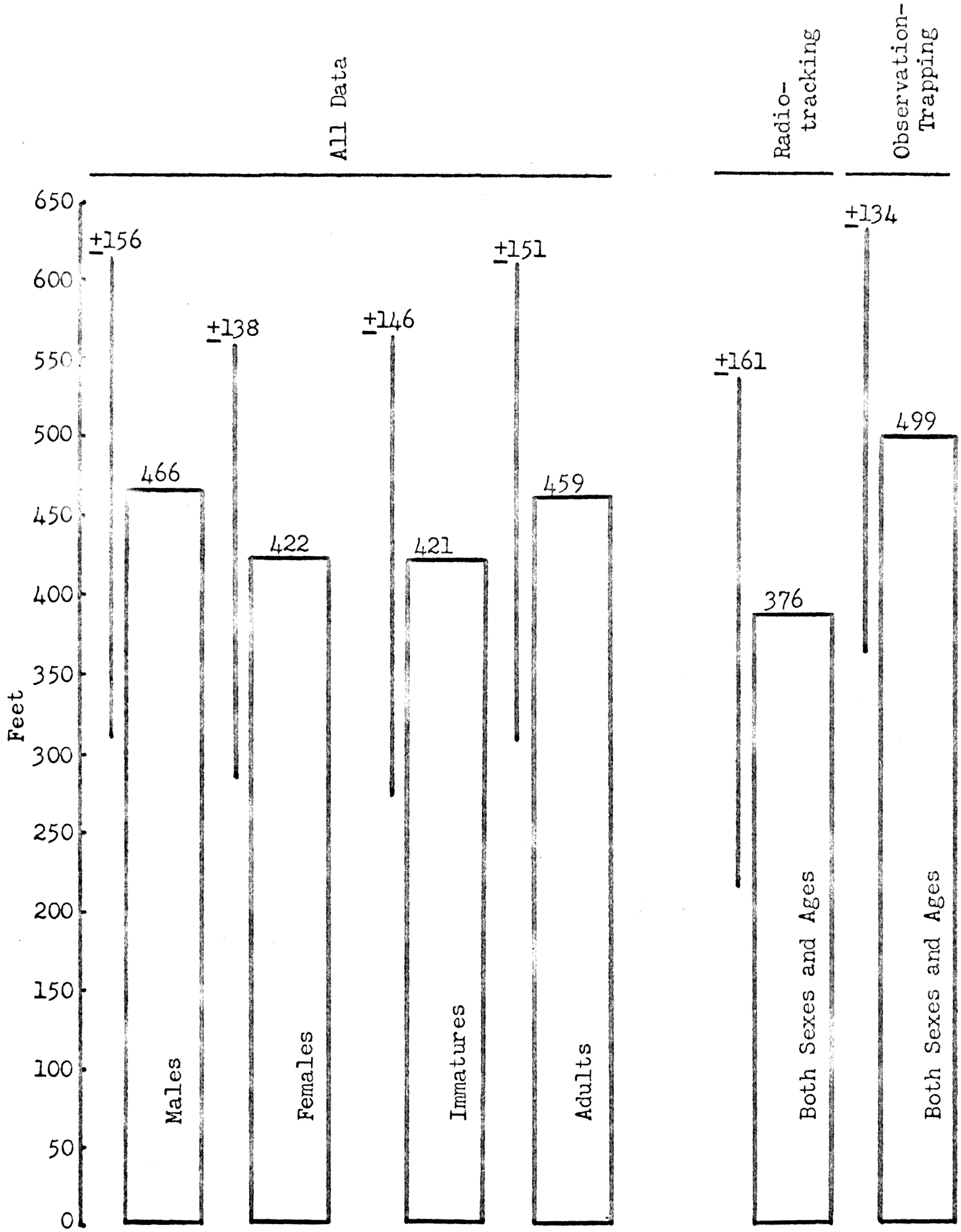
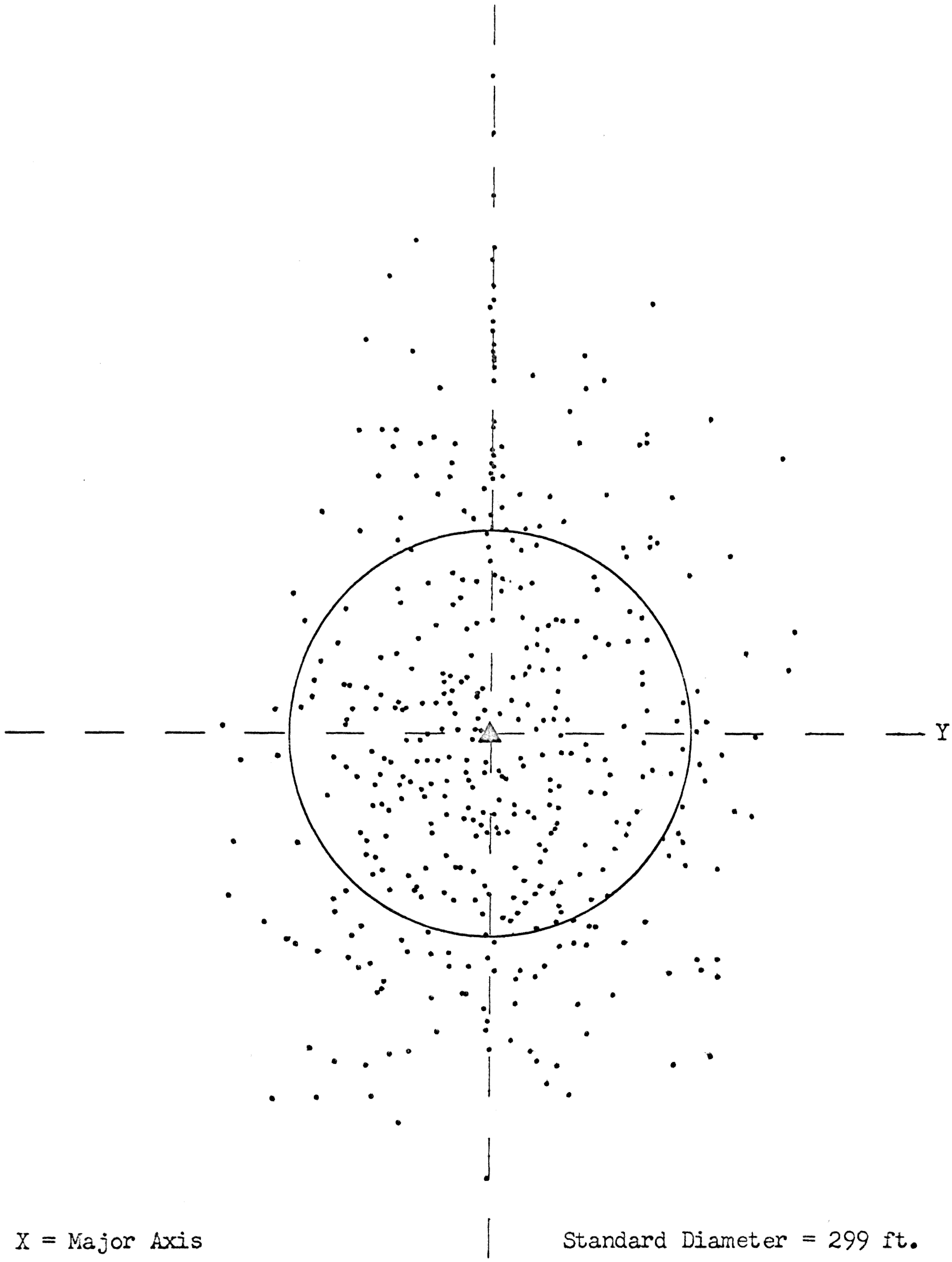


Fig. 6. Greatest linear dimension (in feet) for each classification, North Crumpacker Woods, V. P. I. College Farm, November, 1965, to March, 1967. Difference between techniques significant at 0.95 confidence level. Difference between sexes and ages non-significant.

immatures (421.4 ft) (t=0.84 w/53 d.f.). The difference in each case was not statistically significant. Data obtained by radiotracking produced significantly smaller mean measurements (375.9 ft) than data obtained by observation-trapping (499.1 ft) (t=2.31 w/32 d.f.). Data obtained by trapping alone produced a mean of 427.3 feet.

Standard Diameter and Composite Home Range

Composite home ranges and standard diameters were calculated for each group (Fig. 7 through Fig. 14). Standard diameters for each group can be found in Table 3. No tests of significance were run between groups since each group was treated as a population entity. By calculating the standard diameters in this manner, rather than by obtaining a mean standard diameter for all individuals within the group, it was felt that a more accurate value was obtained. The general trend, as demonstrated by the two preceding home range characteristics was followed in the relative size of the standard diameters between groups. All composite ranges had the general configuration of a skewed elipse. The skewedness occurred along the major axis, which is approximately twice as long as the minor axis. Individual home range shapes were usually linear, although they were sometimes constricted or flexed along the major axis (Appendix Fig. I through Fig. X). It was probably this flexing or "dog legging" characteristic which caused the composite range to be skewed along the major axis and not along the minor axis. This would also account to some degree for its "tear drop" shape. It should be emphasized



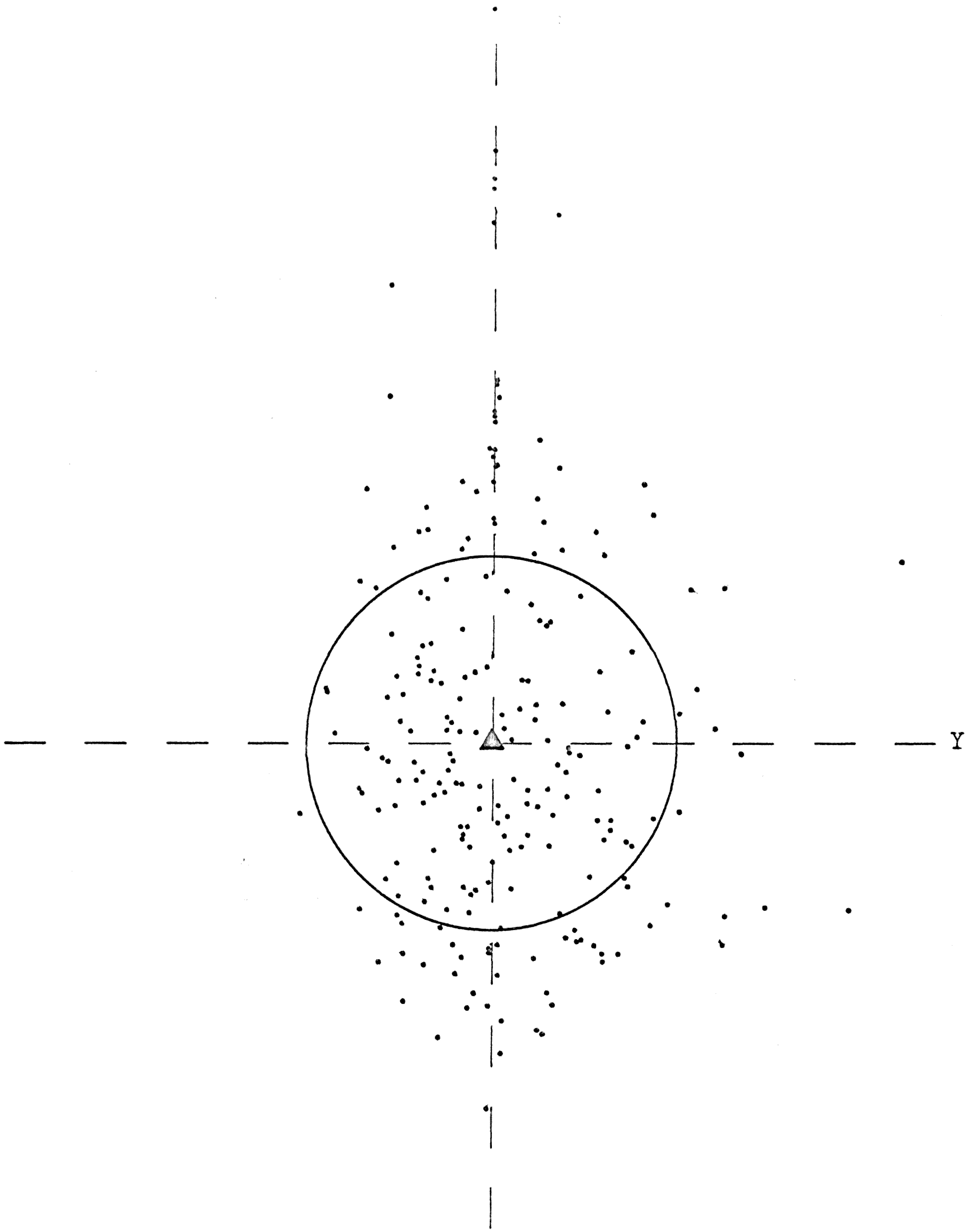
X = Major Axis

Y = Minor Axis

Standard Diameter = 299 ft.

▲ = Common Center of Activity

Fig. 7. Composite home range for 34 male gray squirrels based on 608 observations, North Crumpacker Woods, V. P. I. College Farm, November, 1965, to March, 1967.



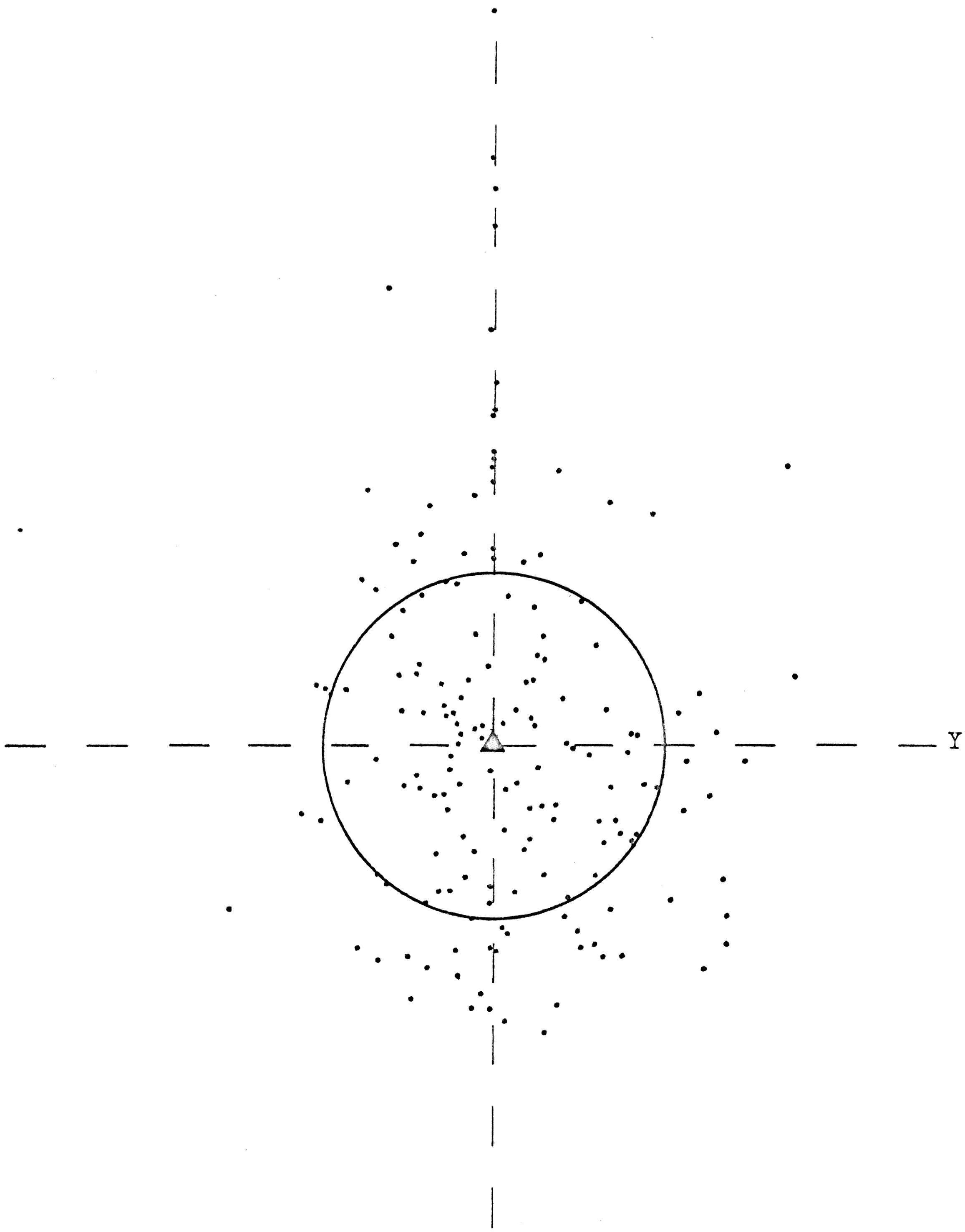
X = Major Axis

Y = Minor Axis

Standard Diameter = 273 ft.

△ = Common Center of Activity

Fig. 8. Composite home range for 21 female gray squirrels based on 397 observations, North Crumpacker Woods, V. P. I. College Farm, November, 1965, to March, 1967.



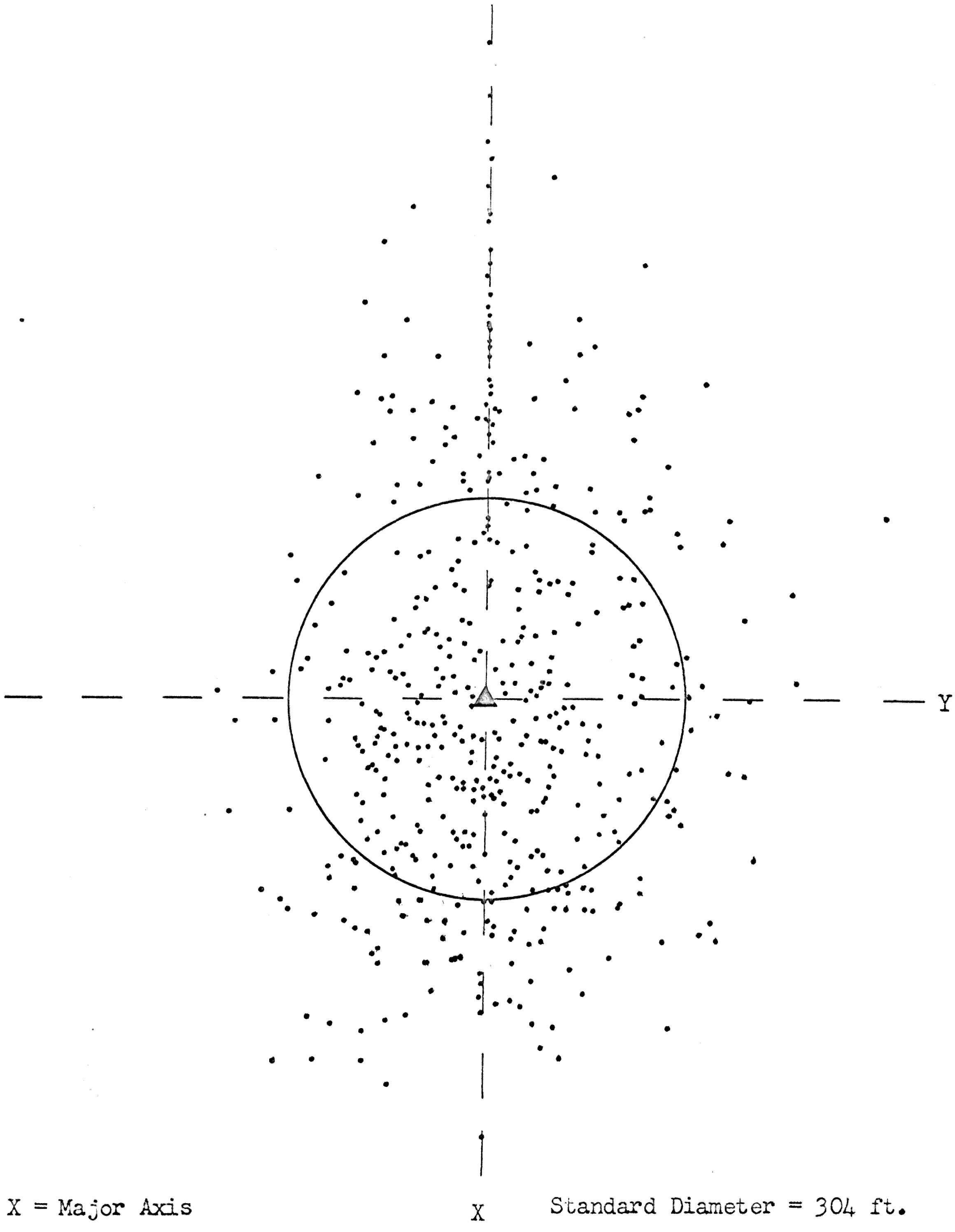
X = Major Axis

Y = Minor Axis

Standard Diameter = 258 ft.

△ = Common Center of Activity

Fig. 9. Composite home range for 15 immature gray squirrels based on 323 observations, North Crumpacker Woods, V. P. I. College Farm, November, 1965, to March, 1967.



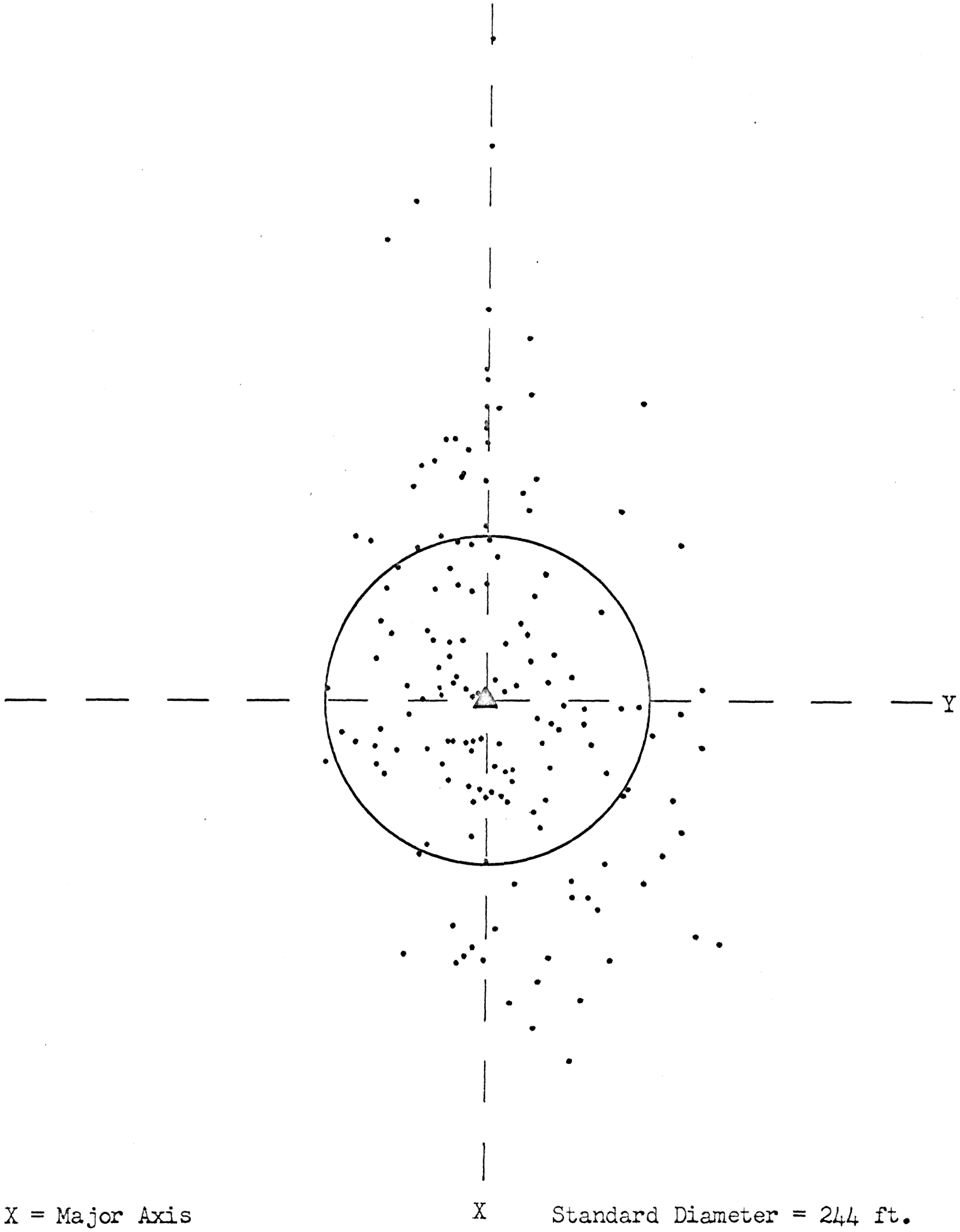
X = Major Axis

Y = Minor Axis

Standard Diameter = 304 ft.

△ = Common Center of Activity

Fig. 10. Composite home range for 40 adult gray squirrels based on 682 observations, North Crumpacker Woods, V. P. I. College Farm, November, 1965, to March, 1967.



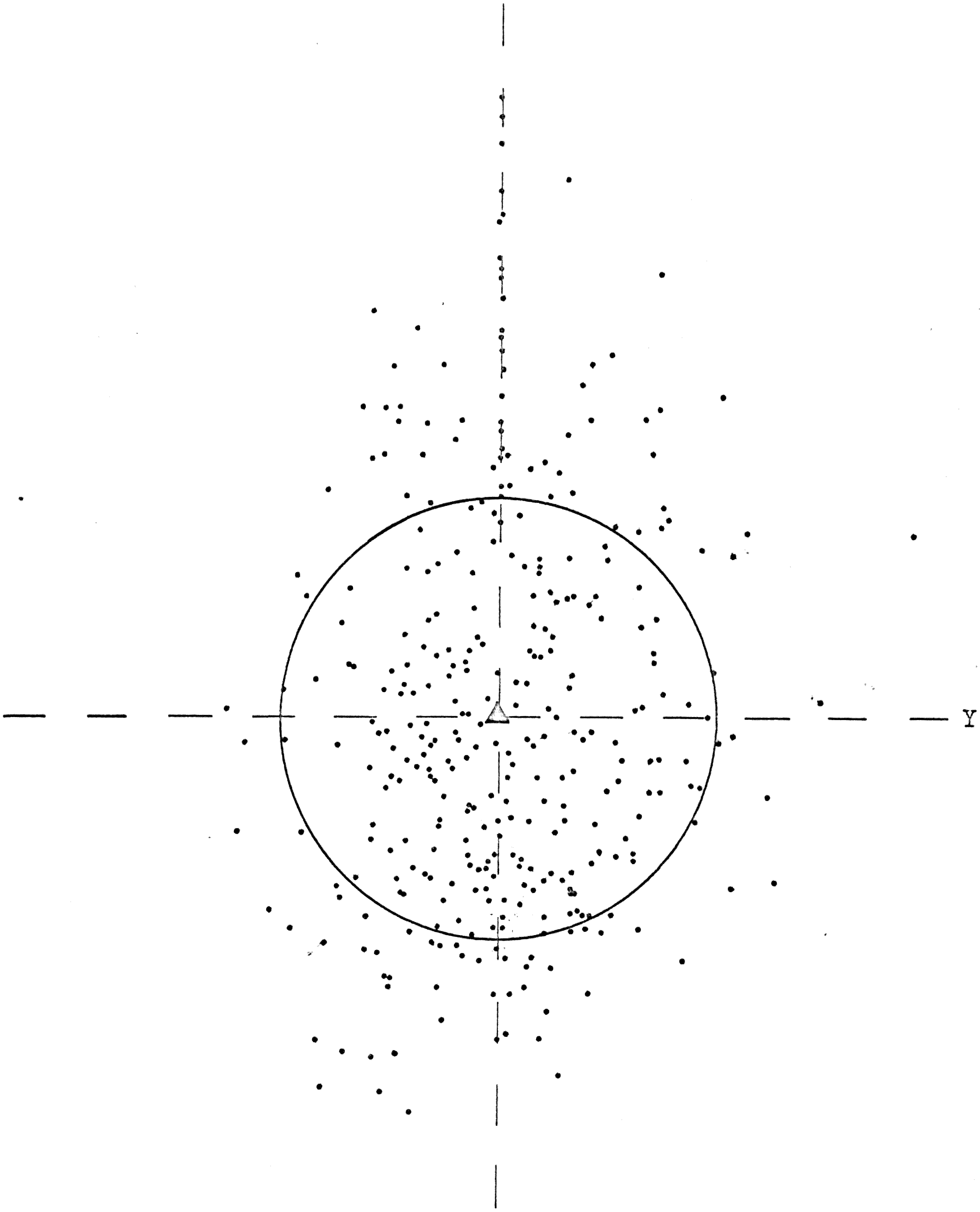
X = Major Axis

Standard Diameter = 244 ft.

Y = Minor Axis

△ = Common Center of Activity

Fig. 11. Composite home range of 10 gray squirrels based on 313 radio-tracking observations, North Crumpacker Woods, V. P. I. College Farm, November, 1966, to March, 1967.



X = Major Axis X Standard Diameter = 317 ft.

Y = Minor Axis △ = Common Center of Activity

Fig. 12. Composite home range of 24 gray squirrels based on 437 observation-trapping observations, North Crumpacker Woods, V. P. I. College Farm, November, 1965, to March, 1966.

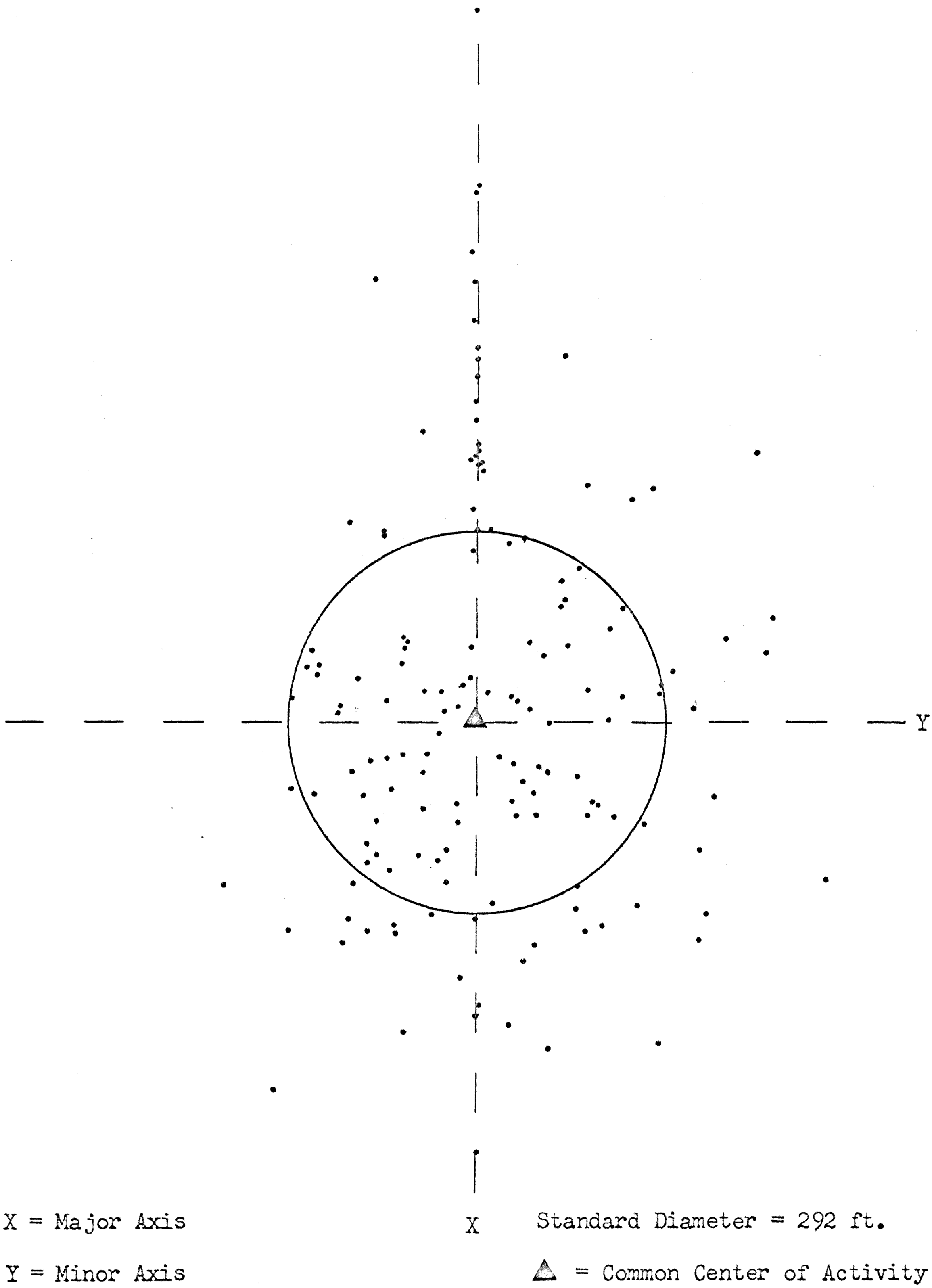
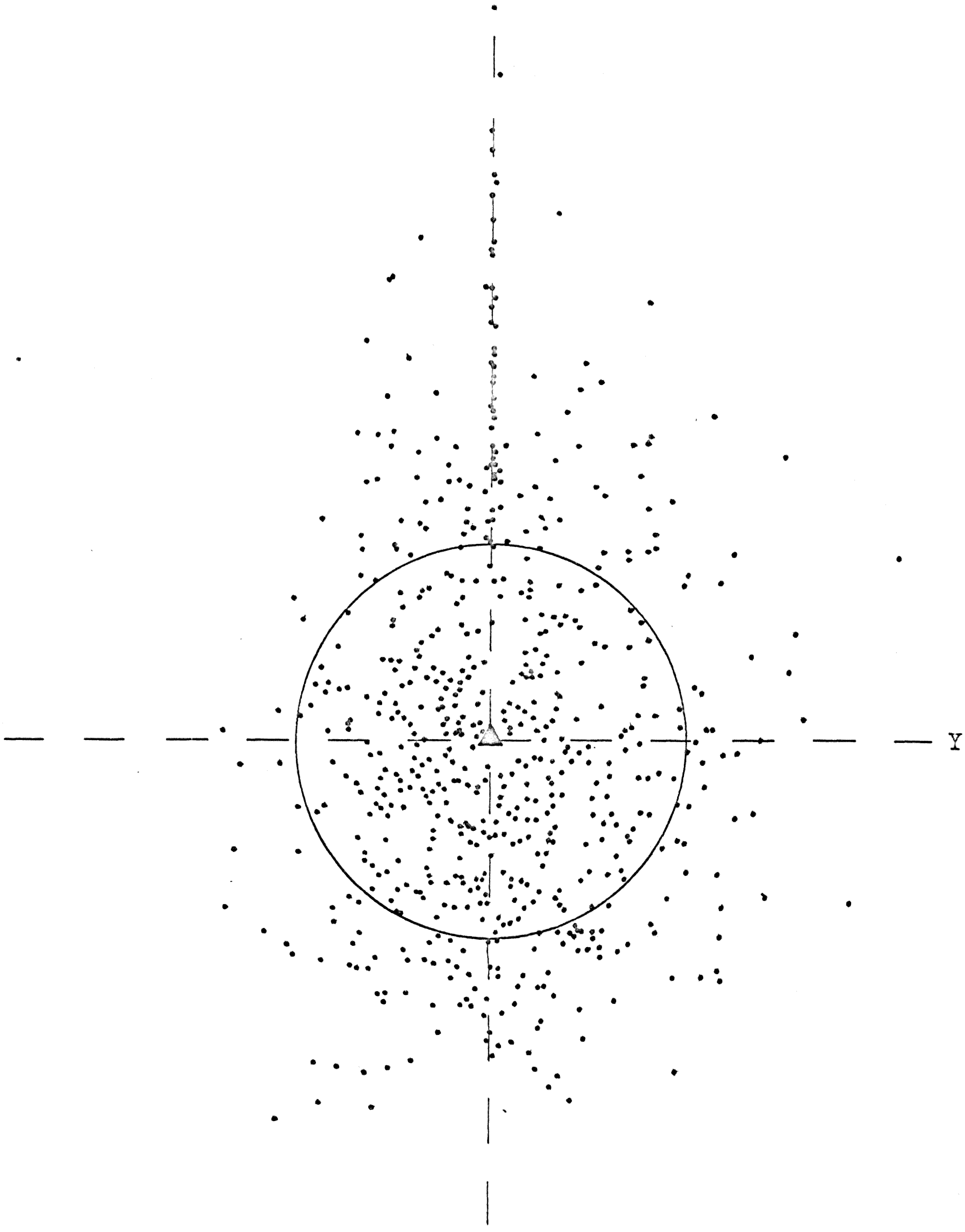


Fig. 13. Composite home range of 21 gray squirrels based on 255 trapping observations, North Crumpacker Woods, V. P. I. College Farm, July, 1966, to August, 1966.



X = Major Axis

Y = Minor Axis

Standard Diameter = 289 ft.

△ = Common Center of Activity

Fig. 14. Composite home range for 55 gray squirrels based on 1005 observations obtained by observation-trapping, trapping, and radiotracking, North Crumpacker Woods, V. P. I. College Farm, November, 1965, to March, 1966.

Table 3. Standard diameters by sex, age, and technique, for gray squirrel home ranges, North Crumpacker Woods, V. P. I. College Farm

Classification	Standard diameter (feet)
BY SEX AND AGE:	
Males	299
Females	273
Immatures	258
Adults	304
BY TECHNIQUE:	
Observation-trapping	317
Trapping	292
Radiotracking	244
All data	289

that each point on the composite range may represent more than a single location of an animal.

Distance Between Extreme Diel Locations

DBE's were obtained for all animals which were radiotracked (Table 4). The average DBE for all animals was 181.7 feet. There appeared to be quite a variation among individuals. This may have been caused by the weather conditions accompanying the tracking period of an individual since no statistical correlation existed between the average DBE of an individual and its minimum home range size.

Increased Area with Time

There was no steady increase in home range size with each additional one-half day of radiotracking (Table 5). Rather, these increases seemed to take place erratically during a tracking period, and many increases took place near the end of the tracking period. Therefore, it may be wise to extend the tracking period for several days (e.g., 10 days). The desired length of the tracking period depends on the weather conditions accompanying it and on the objective of the study.

Denning Habits

Ten radiotracked squirrels used 17 den sights in 15 trees. Nine of these 15 trees were white oak (*Quercus alba*); the remaining five species represented were black oak (*Quercus velutina*), red oak (*Quercus rubra*), black cherry (*Prunus serotina*), tame cherry (*Prunus cerasus*),

Table 4. Results of DBE measurements (in feet) for radiotracked squirrels, North Crumpacker Woods, V. P. I. College Farm, November, 1966, to March, 1967

Squirrel tag number	Days 1	2	3	4	5	6	7	Average (feet)
569	47.1	0.0	47.1	146.0	47.1	174.3	—	76.9
628	334.4	386.2	362.7	—	—	—	—	361.1
136	89.5	89.5	221.4	117.8	113.0	65.9	—	116.2
594	395.6	235.5	367.4	362.7	357.9	423.9	—	357.2
389	160.1	180.0	180.0	113.0	202.5	180.0	0.0	119.4
631	103.6	197.8	98.9	127.2	188.4	84.8	—	133.4
579	197.8	164.8	155.4	94.2	117.8	240.2	—	161.7
462	372.1	310.9	—	—	—	—	—	341.5
713	117.8	47.1	268.5	47.1	296.8	70.6	—	141.3
379	80.1	70.6	0.0	141.3	0.0	—	—	58.4
					Average = 181.7 ±138.2			

Table 5. Home range area (in <u>acres</u>) for each one-half day interval for radiotracked squirrels, North Crumpacker Woods, V. P. I. College Farm, November, 1966, to March, 1967

Squirrel tag number	Days															
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
594	0.21	0.72	0.74	0.74	0.74	0.74	0.74	1.07	1.07	1.07	1.07	1.07	1.07	1.28	—	—
389	0.02	0.14	0.18	0.18	0.38	0.38	0.42	0.42	0.42	0.49	0.49	0.49	0.49	0.49	0.60	0.77
631	0.00	0.00	0.00	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.45	0.45	0.55	0.55	0.55	—
462	1.17	1.40	1.23	1.42	1.42	1.66	—	—	—	—	—	—	—	—	—	—
628	0.16	0.16	0.40	0.57	0.57	0.86	0.86	0.86	0.86	1.33	1.33	1.52	—	—	—	—
379	0.02	0.02	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.19	0.19	0.29	0.29	0.32	—	—
569	0.04	0.04	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.22	0.22	0.22	0.22	0.22	0.36	0.45
579	0.12	0.68	0.68	0.68	0.68	0.76	0.76	0.91	0.91	0.91	0.91	0.91	1.05	1.05	1.05	—
713	0.03	0.22	0.22	0.22	0.83	0.83	0.83	0.83	0.83	0.95	0.95	0.95	0.95	—	—	—
136	0.10	0.19	0.19	0.38	0.38	0.38	0.59	0.73	0.73	0.73	0.73	0.82	1.07	—	—	—

and red hickory (<u>Carya ovalis</u>). The mean DBH of these trees was 35 inches. One squirrel used four dens; one used three dens; two used two dens; and the remaining six each used one den during the tracking period. Den sights were generally located on the peripheries of the home ranges (Appendix Fig. I through Fig. X).

Nocturnal Movements

Nocturnal movements have been noted (Baker, 1944) but not documented. Radiotracked squirrels were monitored for 24 nights. During this time two movements were noted. The first such movement occurred on November 18, 1966, between 6 p.m. and 8:30 p.m. This squirrel moved approximately 60 feet from a den in a black cherry to a den in a red oak. A second squirrel was noted as being active in the den tree at 7:15 p.m. on February 22, 1967.

Movements Outside the Woodlot

Two squirrels were recorded as being outside the woodlot during radiotracking periods. The first squirrel was located and observed on an unpaved road running along the edge of the woodlot. The second animal moved from North Crumpacker Woods to Turkey Pen Woods, a distance of one-quarter mile over grazed land. This squirrel stayed in Turkey Pen Woods for 24 hours, then returned to North Crumpacker Woods. This movement was not considered as part of the animal's home range.

Activity

The results of the step wise regression and discriminant function analysis on the environmental data were negative. The 11 variables considered together only contributed about 10% (Table 6) to describing the variance in activity. Air temperature alone (standard error = 0.4730) contributed almost as much toward predicting activity as the combined effect of all 11 variables (standard error = 0.4642). As was to be expected, no discrimination between active and inactive groups was attained.

There are three reasons which may help to explain these results. First, the variables measured may not be reliable indicators of activity. Second, the variable measurements may not have been accurate. Third, the sampling technique may have been inadequate. The first two are probably the sources of error. Many of the weather data were transposed from polygraphs not collected on the study area. Even so, one would expect a greater ability in prediction than was attained. This seems to indicate that other important variables were overlooked; the most important variable not measured was probably the individual behavior of the animal.

Table 6. Simple correlation coefficients obtained for the 11 variables tested for their correlation to gray squirrel activity

Variable	Simple correlation coefficient
Air temperature	-0.211600
Average wind speed for the day	0.150447
Sun exposure	0.098278
Barometric pressure	-0.082040
Length of day	0.081594
Percent sun exposure for the day	0.067532
Soil temperature	-0.066312
Time of day	0.048372
Inches of snow on the ground	-0.040223
Precipitation (in inches) for the day	0.034631
Relative humidity	0.004413

GENERAL DISCUSSION

Data Acquisition

As noted previously, three techniques were employed to determine the movements and activity of the gray squirrel. From an ecological point of view, the technique which interferes least with the squirrel's behavior and produces the most accurate information is the most desirable. An objective appraisal of this aspect of the problem was not undertaken; however, a subjective look at this question may be beneficial to future investigators.

Even though the author did not collect the observation-trapping data, it can be reasoned from techniques used (Pack, 1966), that the two feeding stations in the woodlot influenced feeding behavior. Further evidence of this lies in the fact that the observation data for all animals was most heavily concentrated in the areas of the feeding stations. Feeding behavior is probably also affected by trapping since the bait serves as enticement for entering the traps. It is doubtful whether either feeding stations or trapping seriously change the size or shape of the squirrel's home range. The extent to which home range modification might occur depends partially on food availability during a given season. Only one behavior aberration was noted for radiotracked squirrels; this concerned the difficulty or impossibility of some squirrels in entering dens with small entrances. As noted previously, this was not considered to bring about any serious behavioral changes. An objective analysis of the problems in this area would be helpful to further investigators.

In the final analysis, the choice of a technique for determining gray squirrel movements depends in large part on the specific objectives of the study. Assuming that the money and personnel are available, radiotracking offers the greatest quantity of reliable information. After initial costs have been met, the cost of radiotracking is less than the other two methods when required man hours are considered. Radiotracking offers the greatest promise for future ecological investigations; however, when home area is desired for general land management purposes or as part of a population study, the other two methods will probably suffice.

Data Interpretation

The home range characteristics measured in the present study appear to be reliable indicators of movements. The relationship between groups (i.e., males, females, immatures, adults, radiotracking, and observation-trapping) is approximately the same for all characteristics measured. An investigator is limited to degree in the characteristics which can be measured by the data acquisition techniques employed. The characteristics measured in the present study lend themselves well to all techniques being used to obtain movement data. In an effort to present movement data in a standardized form, so that comparisons can be made between studies, more emphasis should be placed on the characteristics which can be utilized when using any or all techniques.

The experimental design and data acquisition techniques need further refinement if the combined method of multiple regression and discriminant function analysis are to be useful in determining the environmental effects on activity. In order to do this, a greater effort must be made in accurately determining environmental factors which affect activity. Management of the gray squirrel could be enhanced considerably if a meaningful discriminant function equation could be ascertained. This would be manifested most importantly in an increased hunter harvest. This could be realized by providing the hunter with a means of accurately determining optimum conditions under which to hunt. The discriminant function equation might also prove an important research tool.

The use of the composite home range-standard diameter complex, when used with other methods, may prove useful in comparing habitat conditions among seasons or areas. In the present study, standard diameters were not determined for each squirrel individually because of the sparsity of data for some individuals. Because of this there was no replication and, therefore, no tests of significance for differences between groups. Composite home ranges, as calculated in the present study, appear to provide an adequate means for comparing any two populations.

As noted earlier, a significant difference was found between home areas and greatest linear dimensions as determined by radiotracking and observation-trapping. The question arises as to whether these two techniques can be assumed to be comparable. The sex and age composition of the samples were similar, and each observation period took place during the same time of the year (indicating that food availability and other behavioral considerations were similar). The difference in the two populations concerns the time of observation of individual samples in the population. Each individual was observed for the entire sample period using observation-trapping, whereas each individual was observed for only a portion of the total sampling period using radiotracking. Since weather conditions varied considerably from one tracking period to another, the prospect of combining all data from individual squirrels in order to determine mean values may not be valid. The differences between the techniques may not be real since the sampling techniques were not entirely comparable.

It also may not be valid to compare results between radiotracked individuals unless they were sampled over the same period. This problem can be solved if a discriminant function equation can be determined. The average discriminant function value together with the number of days tracked could serve as a basis of comparison between individual radiotracked squirrels.

Formulation of true centers of activity for use in compiling composite home ranges also poses a problem. Centers of activity are probably most accurately determined by the methods of observation-trapping and radiotracking. Centers of activity determined by trapping probably represent a true center of feeding activity (since it is feeding that brings about capture of the animal), but not a true center of all activity. It is doubtful, however, that there is a significant deviation since the composite home ranges of the samples as determined by the three techniques approach the same general shape.

Males had a significantly larger home range than females, and the ratio of males to females in the population was quite high for a polygamous species. Strong breeding competition between males may contribute to this increased movement.

Pack (1966) investigated the size of the home range relative to the position of the individual in the social hierarchy; no strong statistical correlation was found. It was assumed by Pack that the larger the home range, the greater the food availability. This may hold true in an even-aged, homogenous stand of timber; but under most conditions food availability varies within an area. For this reason, it may be that the more dominant squirrels choose to feed in "prime" areas, thereby necessitating less movement. Increased movement, as noted previously, is probably more closely associated with breeding activity; far-ranging squirrels have a greater probability of interaction with sexually responsive females.

The three-dimensional aspect of the squirrel's home range was noted during periods of radiotracking. It appears as if the home range displayed by movement in the forest canopy may be larger than that as recorded on the ground. This difference was small, however, since movements were observed only in tree tops which had their bases located in home range as determined at ground level. The difference between the two home ranges depends largely on the size of the trees on the periphery of the home range.

It may be noted that the home range areas of the gray squirrels in the study area were smaller than those described in the literature (Bakken, 1952; Robinson and Cowan, 1954; Flyger, 1960). This is probably due to the abnormally high population level in the woodlot which is directly related to optimal environmental conditions of the area.

Recommendations

In order to determine true home ranges precisely, studies should be conducted employing various techniques for data acquisition side by side for the same population. These techniques could be modified in various ways in an attempt to best approximate the true home range of the animal. One modification, the time intervals between radio-tracking locations, should be conducted to determine optimum conditions. This may call for the use of an automated radiotracking system.

In attempting to describe a discriminant function equation, a weather station should be erected on the study area so that environmental data may be accurately recorded with each radiotracking location obtained. This could possibly be incorporated into an automated system.

A larger follow-up study might include the calculation of home ranges and composite home ranges for squirrels on a number of areas which vary in habitat and location. By measuring the environmental conditions accompanying each population's composite or average home range, a "site index" for the area may be calculated. This would indicate the squirrel density on a given area as reflected in a home range.

SUMMARY AND CONCLUSIONS

1. From November 16, 1965, to March 5, 1967, 1707 locations were obtained by utilizing the techniques of observation-trapping, trapping, and radiotracking. Home range determinations were made for 55 gray squirrels on the 7.5 acre study area.
2. The mean minimum home range for all data was 1.20 acres. Males had a statistically significant larger mean home range than females. Data collected by radiotracking produced significantly smaller mean home ranges than data collected by observation-tracking.
3. The greatest linear dimension averaged 448.6 feet for the entire sample. Data obtained by radiotracking produced significantly smaller mean measurements than data obtained by observation-trapping.
4. The mean standard diameter for the entire sample was 288.7 feet.
5. Composite home ranges assumed the shape of an elipse skewed along the major axis. The major axis was approximately twice as long as the minor axis.
6. No statistical correlation existed between the average DBE of an individual and its home range size.
7. The desired length of a tracking period depends on the weather conditions accompanying it and the objectives of the study.
8. Den sites were generally located on the peripheries of the home ranges.

9. Two nocturnal movements were noted in 24 nights of radiotracking.

10. Two squirrels were located outside the woodlot during radio-tracking periods.

11. The 11 variables tested for their effect on activity contributed 10% toward describing the variance in activity. No discrimination between active and inactive groups was attained.

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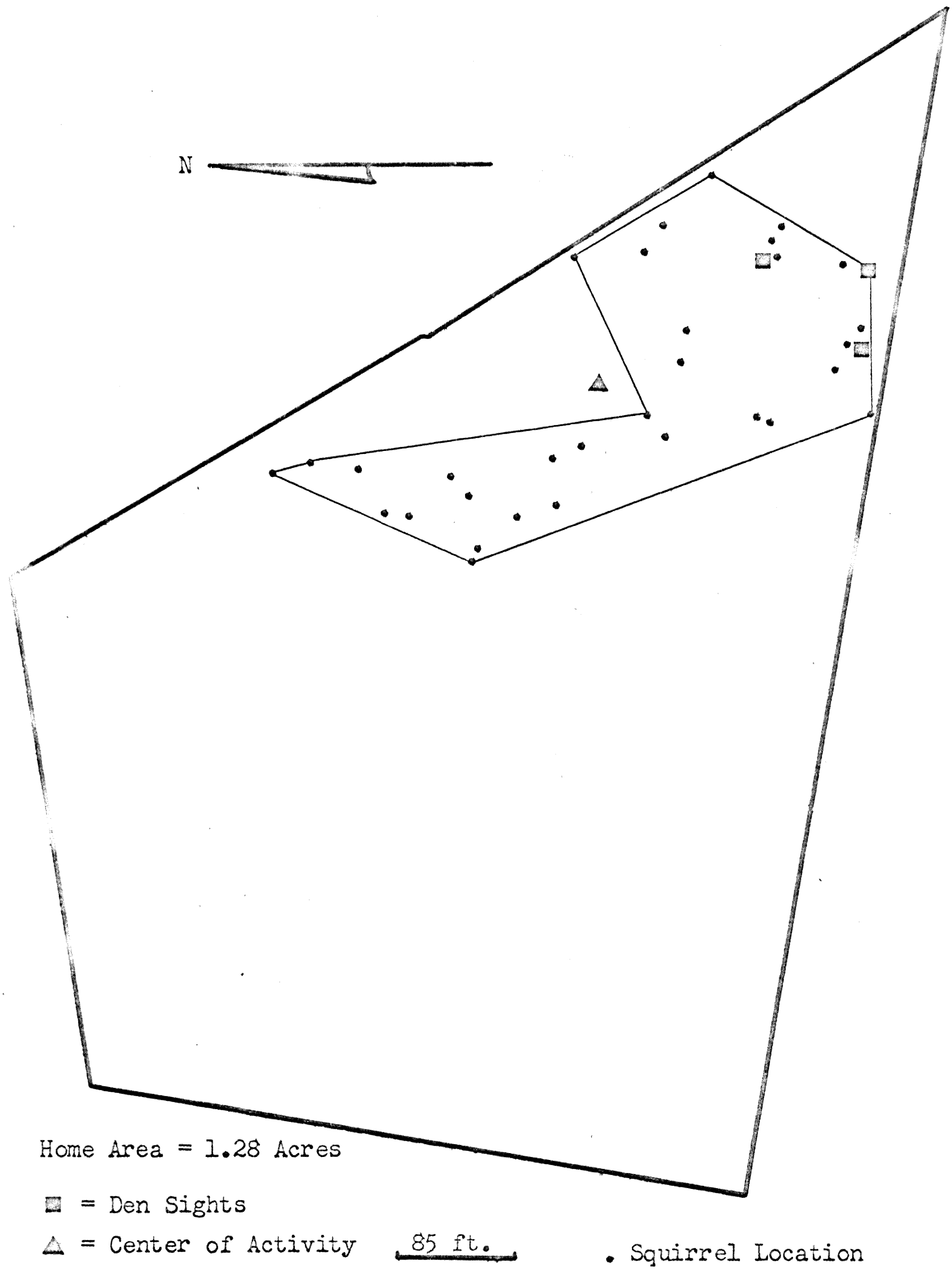
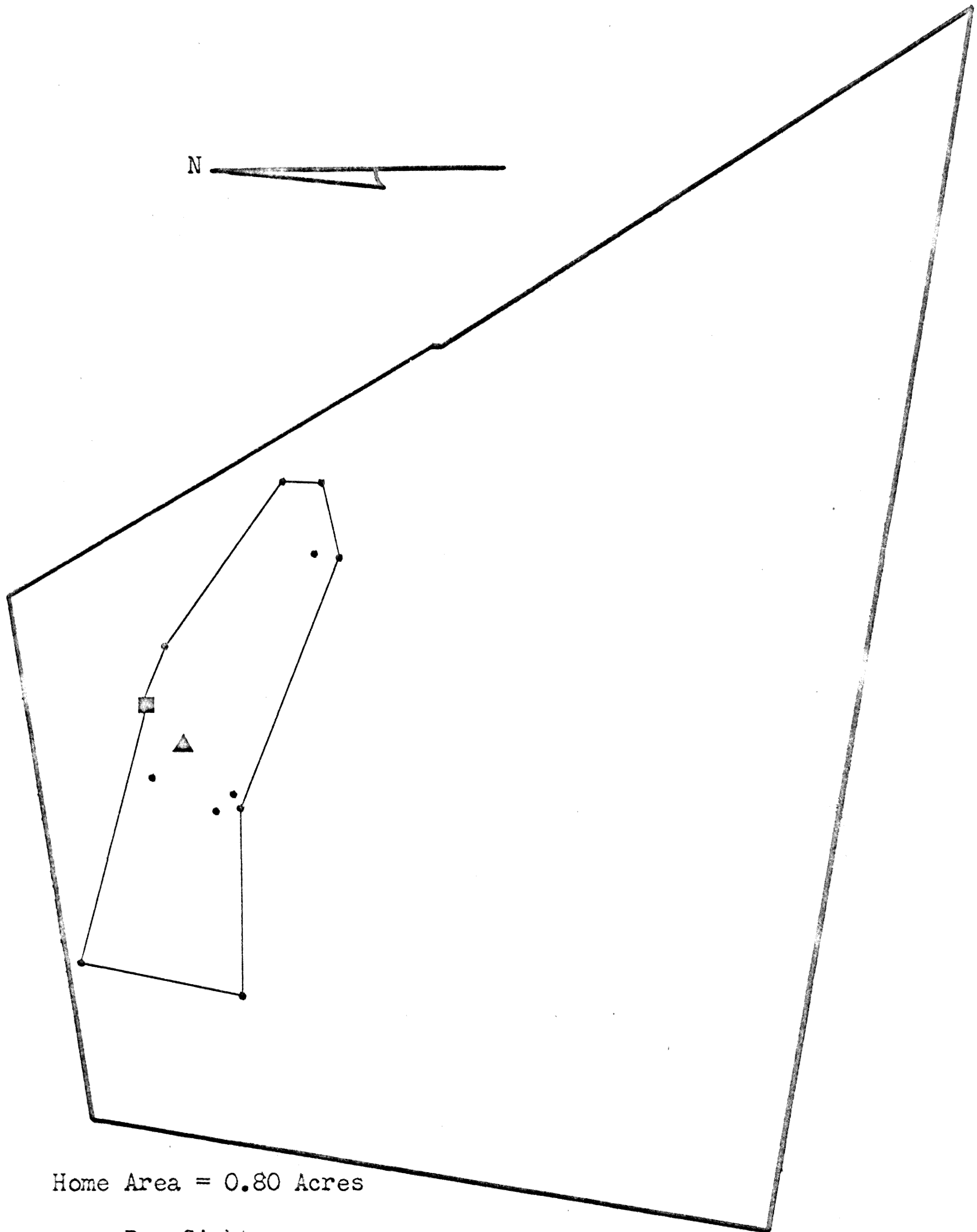


Appendix Fig. I. Home range of immature, female gray squirrel (tag number 594) based on 103 radiotracking observations over a 7-day period, North Crumpacker Woods, V. P. I. College Farm, November, 1966.



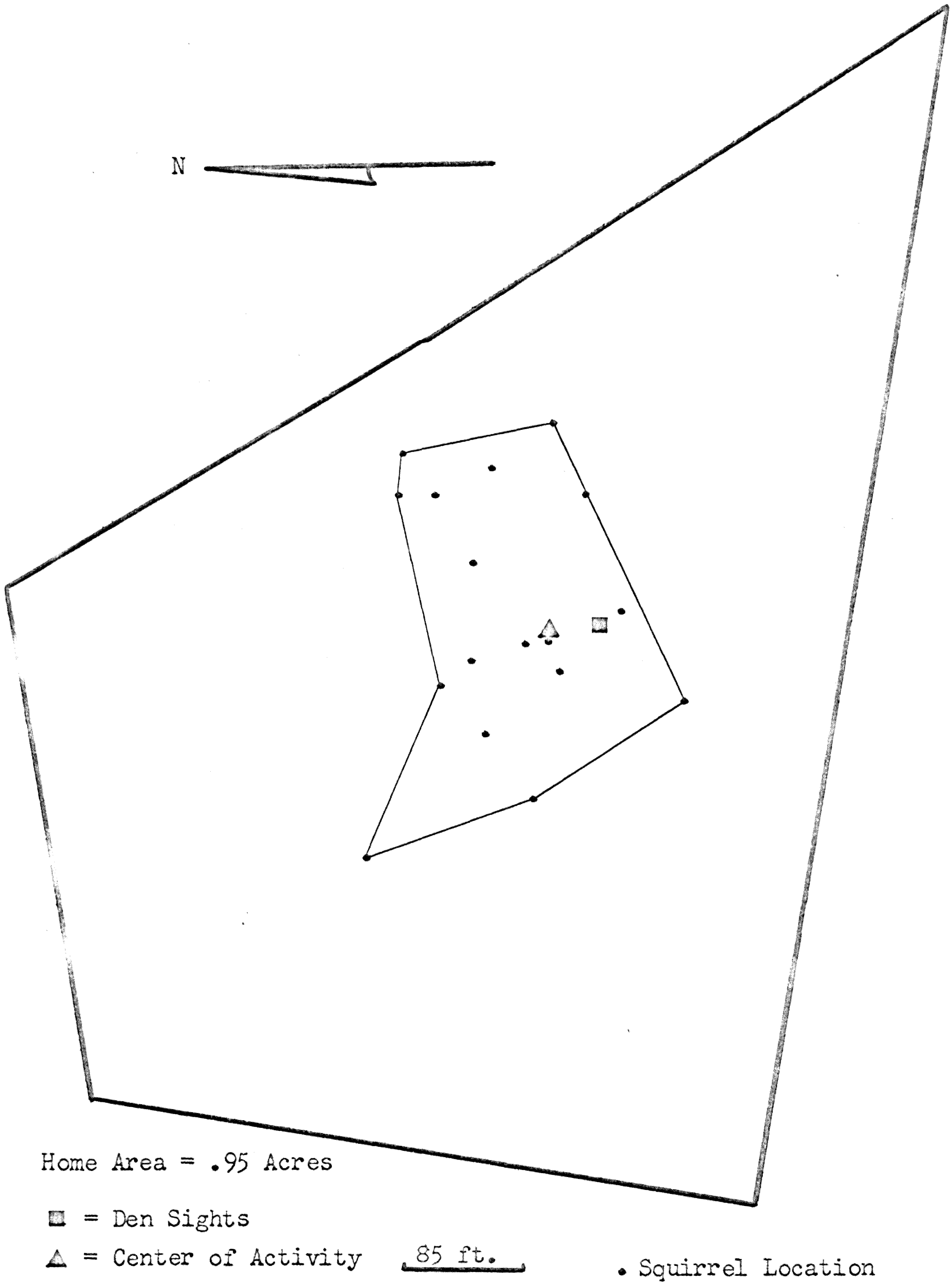
Home Area = 0.80 Acres

▪ = Den Sights

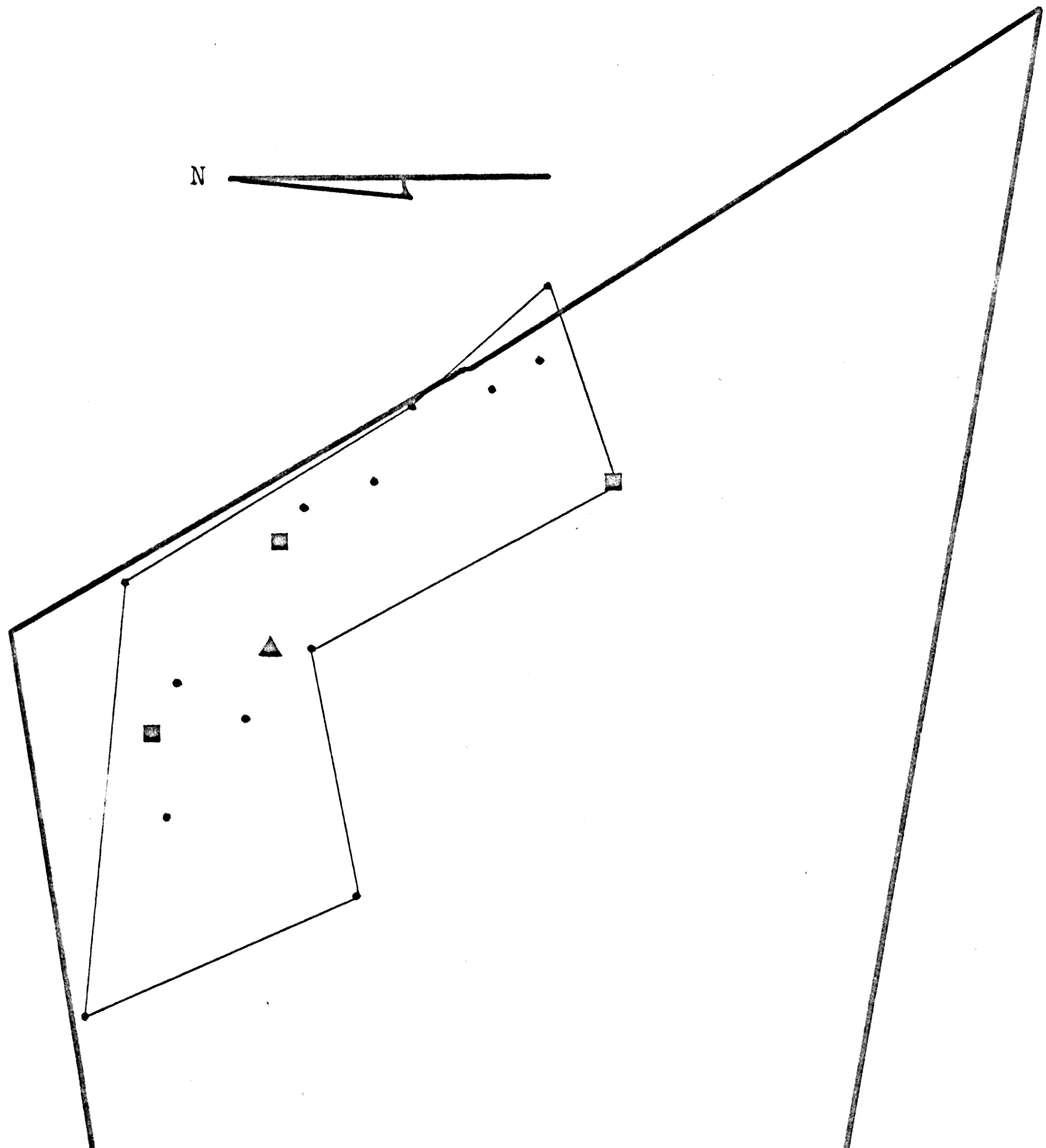
▲ = Center of Activity 85 ft.

• Squirrel Location

Appendix Fig. II. Home range of adult, female gray squirrel (tag number 389) based on 126 radiotracking observations over a 20-day period, North Crumpacker Woods, V. P. I. College Farm, November, 1966.



Appendix Fig. III. Home range of immature, male gray squirrel (tag number 713) based on 76 radiotracking observations over a 6-day period, North Crumpacker Woods, V. P. I. College Farm, December, 1966.

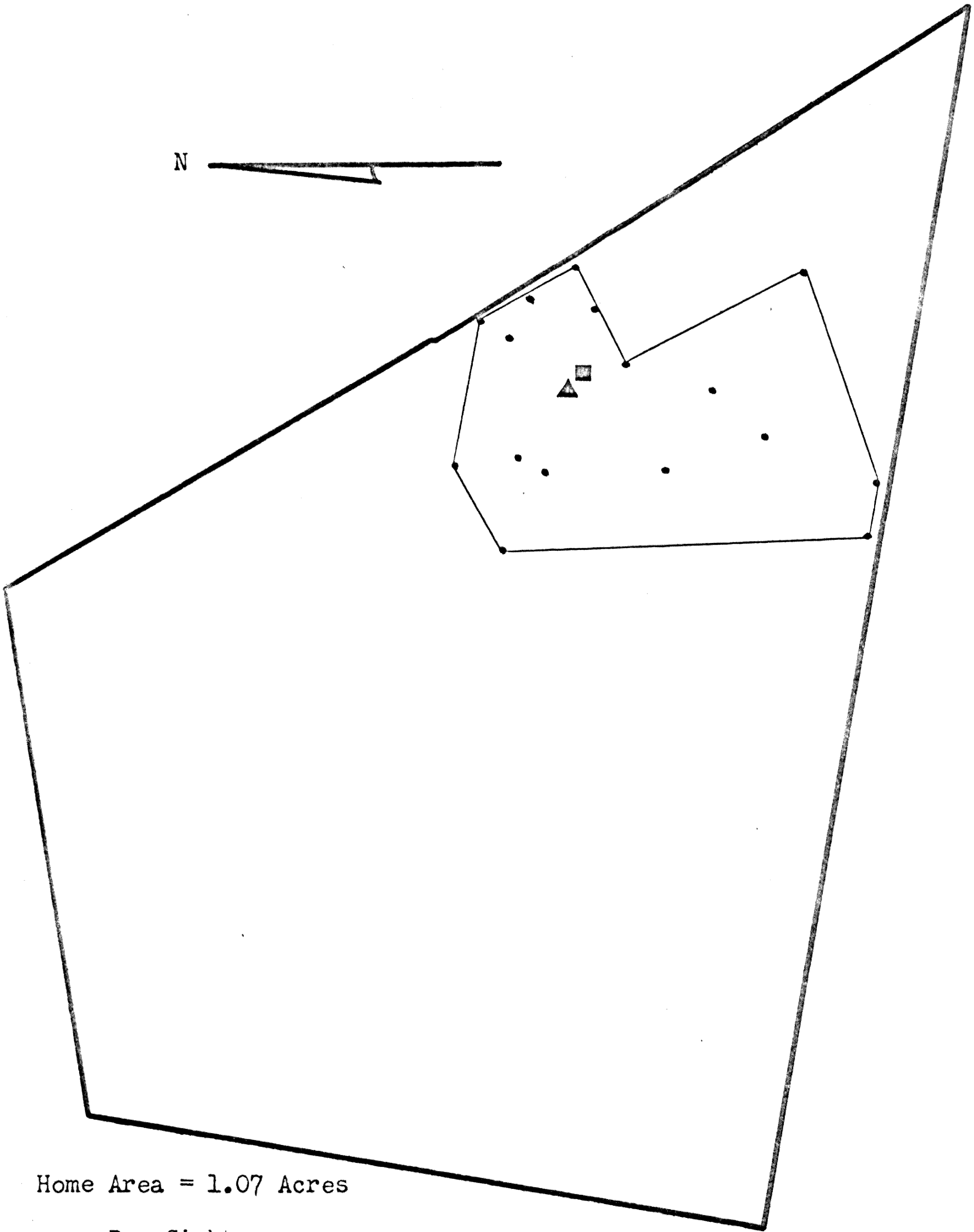


Home Area = 1.52 Acres

■ = Den Sights

▲ = Center of Activity   85 ft.   • Squirrel Location

Appendix Fig. IV. Home range of adult, male gray squirrel (tag number 628) based on 73 radiotracking observations over a 6-day period, North Crumpacker Woods, V. P. I. College Farm, January, 1967.

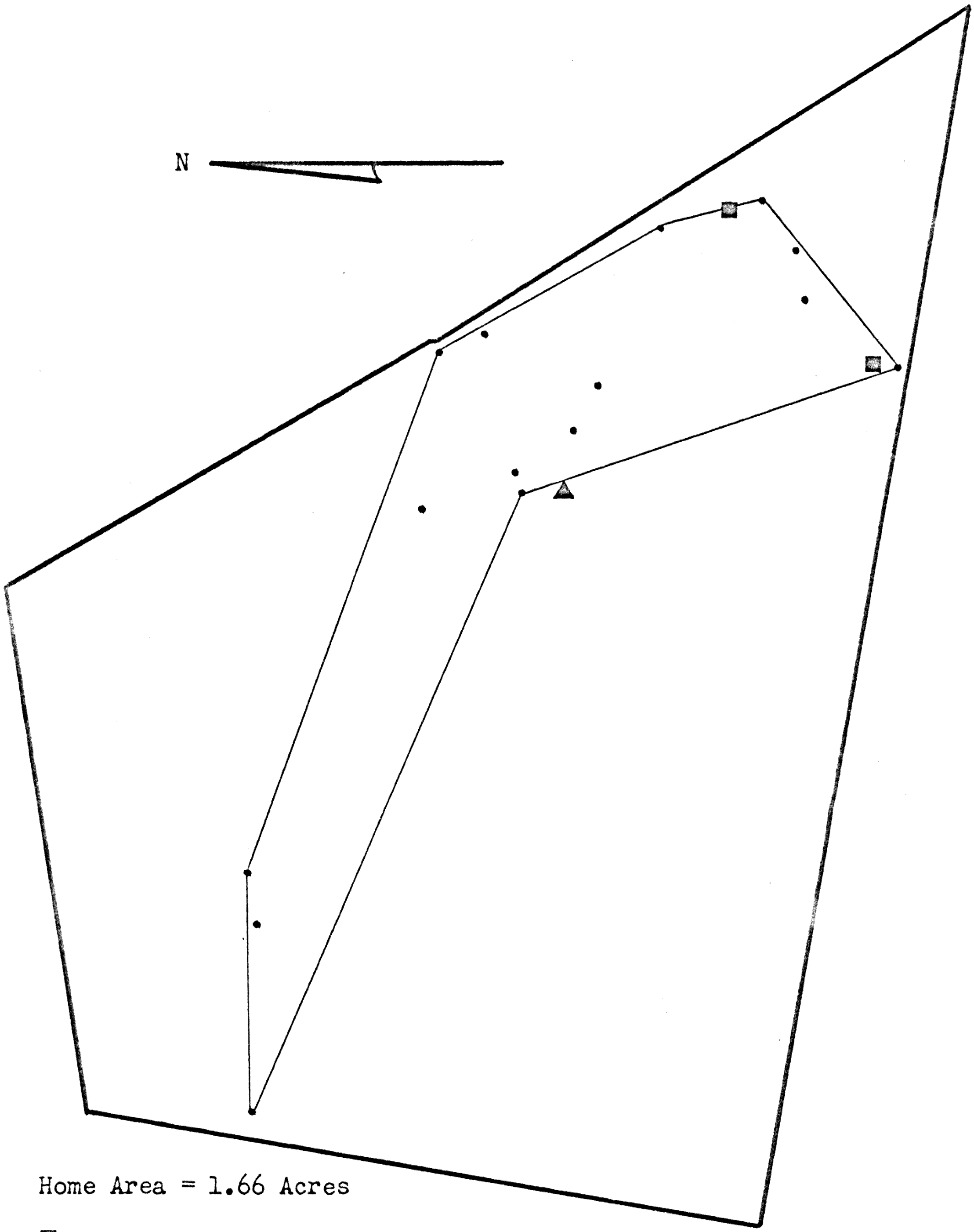


Home Area = 1.07 Acres

▪ = Den Sights

▲ = Center of Activity 85 ft. • Squirrel Location

Appendix Fig. V. Home range of adult, female gray squirrel (tag number 136) based on 90 radiotracking observations over a 7-day period, North Crumpacker Woods, V. P. I. College Farm, January, 1967.

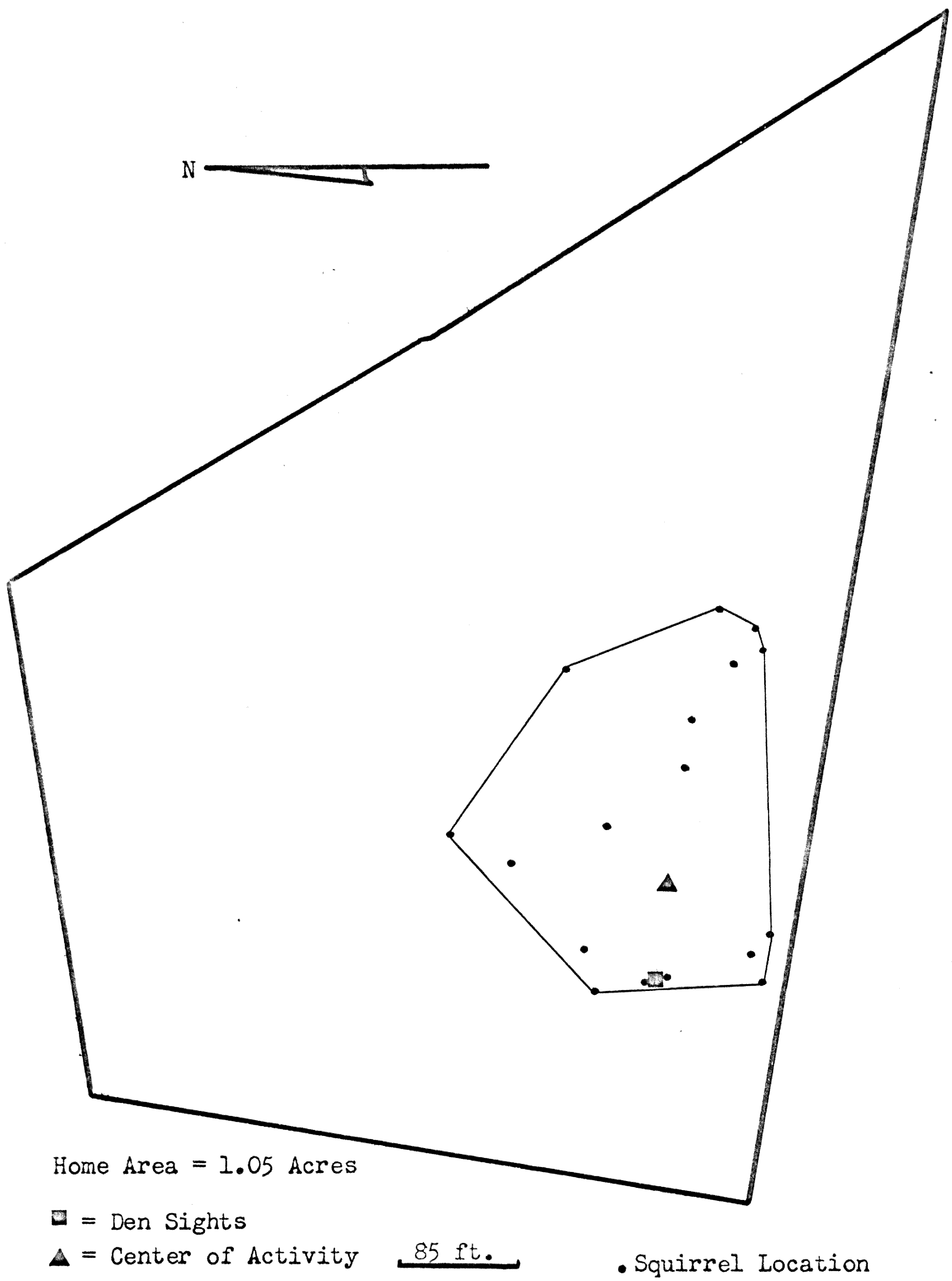


Home Area = 1.66 Acres

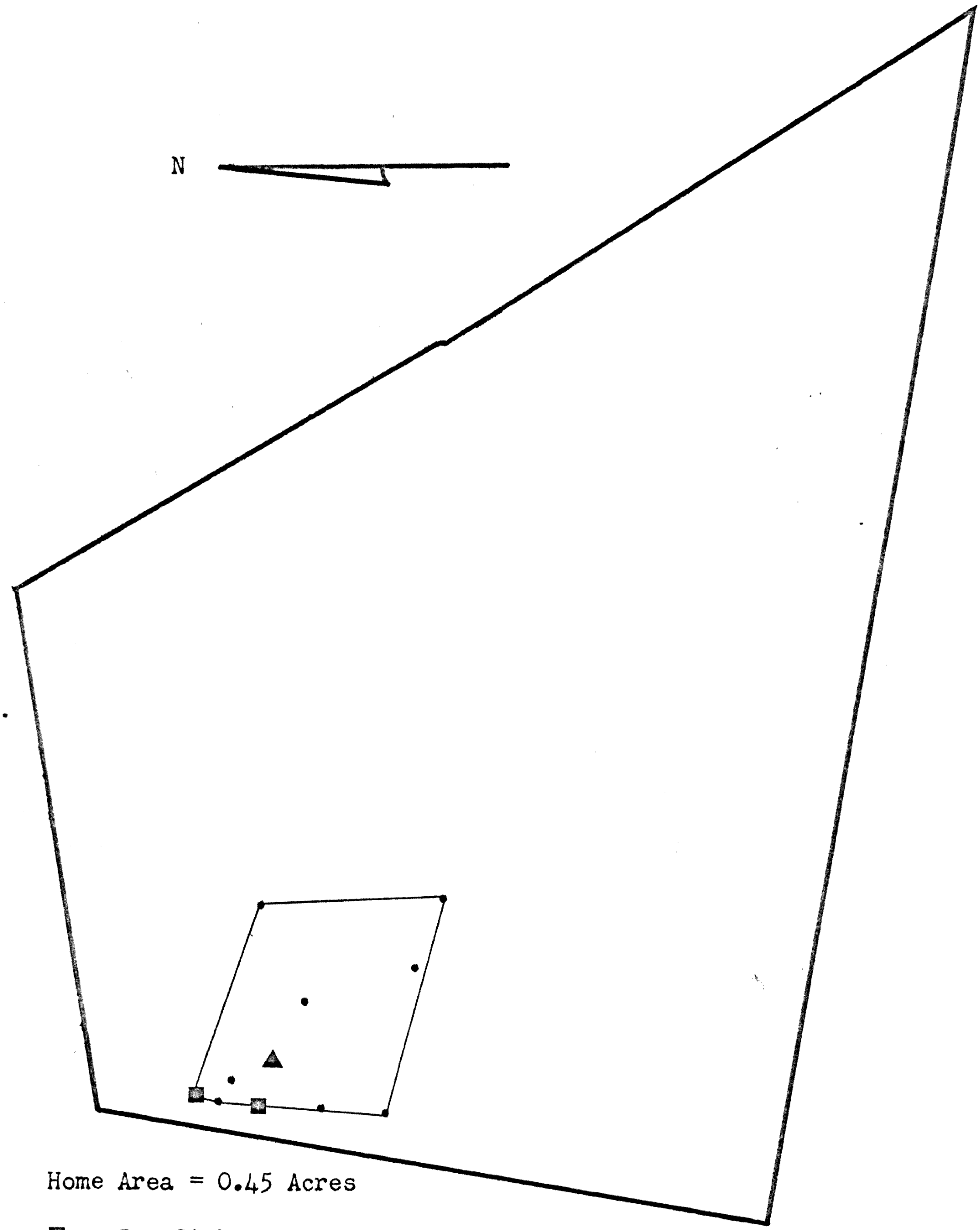
■ = Den Sights

▲ = Center of Activity   85 ft.   • Squirrel Location

Appendix Fig. VI. Home range of adult, male gray squirrel (tag number 462) based on 43 radiotracking observations over a 3-day period, North Crumpacker Woods, V. P. I. College Farm, January, 1967.



Appendix Fig. VII. Home range of adult, male gray squirrel (tag number 579) based on 83 radiotracking observations over an 8-day period, North Crumpacker Woods, V. P. I. College Farm, February, 1967.

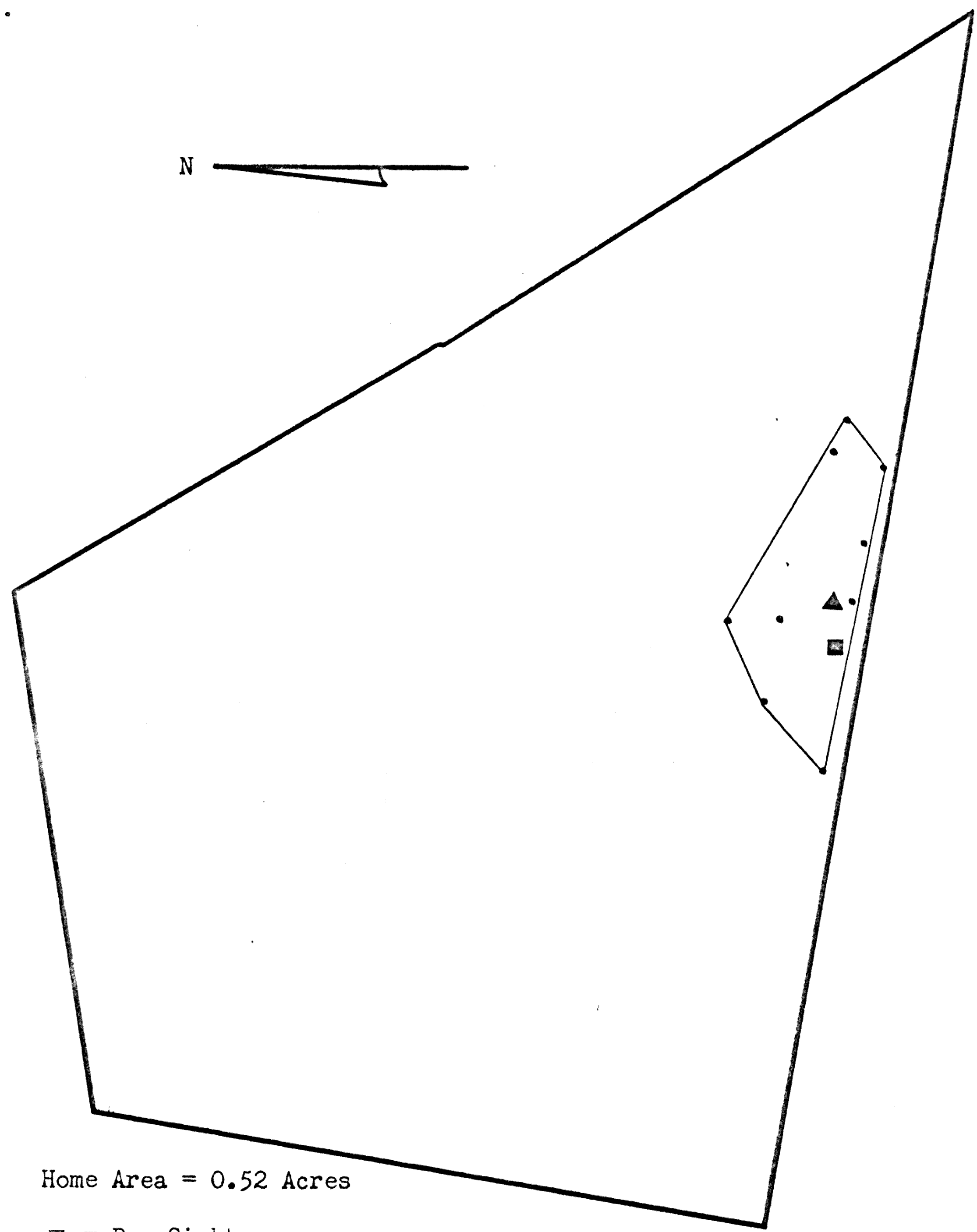


Home Area = 0.45 Acres

■ = Den Sights

▲ = Center of Activity   85 ft.   • Squirrel Location

Appendix Fig. VIII. Home range of adult, male gray squirrel (tag number 569) based on 77 radiotracking observations over an 8-day period, North Crumpacker Woods, V. P. I. College Farm, February, 1967.

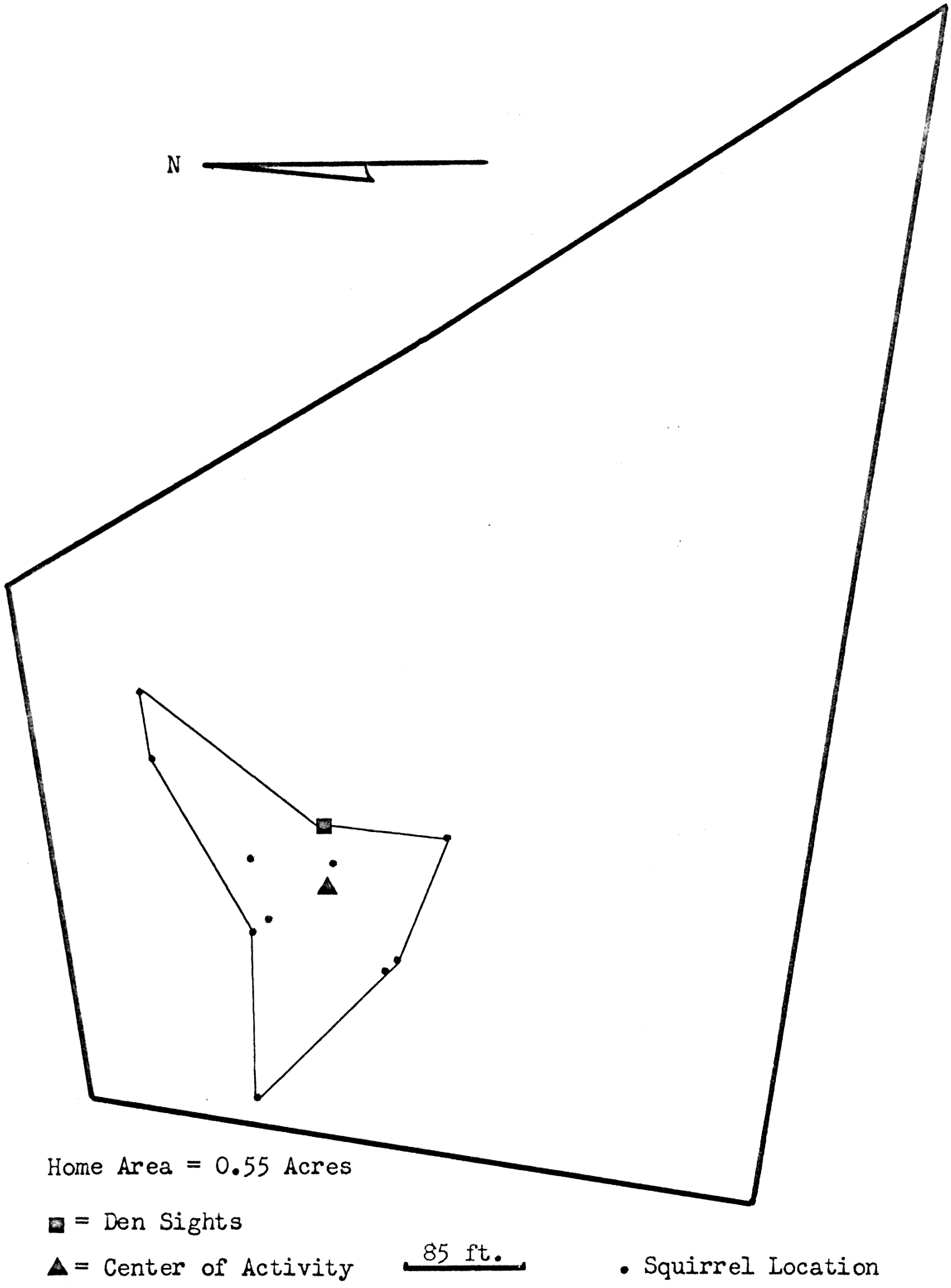


Home Area = 0.52 Acres

▪ = Den Sights

▲ = Center of Activity 85 ft. • Squirrel Location

Appendix Fig. IX. Home range of adult, male gray squirrel (tag number 584) based on 71 radiotracking observations over a 7-day period, North Crumpacker Woods, V. P. I. College Farm, February, 1967.



Appendix Fig. X. Home range of adult, male gray squirrel (tag number 631) based on 85 radiotracking observations over an 8-day period, North Crumpacker Woods, V. P. I. College Farm, February, 1967.

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HOME RANGE AND ACTIVITY OF THE GRAY SQUIRREL

IN A SOUTHWEST VIRGINIA WOODLOT

by

John H. Doebel

ABSTRACT

Home range determinations based on 1707 observation-trapping, trapping, and radiotracking locations were made for 55 gray squirrels (Sciurus carolinensis). The mean minimum home range for all data was 1.20 acres, and the greatest linear dimension was 448.6 feet. Males had a larger home range than females. Radiotracking data produced smaller mean home ranges and greater linear dimension measurements than did observation-trapping. The mean standard diameter was 228.7 feet. Composite home ranges assumed the shape of an elipse skewed along the major axis. Den sights were generally located on the home range periphery. The 11 variables tested contributed little to describing the variance in squirrel activity; no discrimination between active and inactive groups was attained using a discriminant function analysis.