measured in millimeters only 62 x 45--smaller than any of the four eggs from the first nest. Bent (1932, see p. 341) gives 61 x 46.3 millimeters are the average of 56 eggs from turkeys in Florida.

Late nests often have more infertile eggs than earlier nests (Mosby and Handley, 1943, see p. 129). It is interesting to note, in this connection, that all 11 eggs in our latest nest hatched on 1 July.

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A TELEMETRIC STUDY OF DEER HOME RANGES AND BEHAVIOR OF DEER DURING MANAGED HUNTS[1]

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ABSTRACT

The home ranges of five white-tailed deer *(Odocoileus virginianus)* were determined on the Clark Hill Wildlife Management Area using telemetric equipment. The population density of deer on the 800 acres study area was estimated to be 50-55 deer per square mile (1 deer/12 acres) prior to the managed hunts in 1967. A six year old doe, radio-tracked from April 4, to May 9, 1967, had a home range of 121 acres. The same animal was tracked from October 12, to October 25, 1967, and had a home range area of 87 acres. A three year old doe with a fawn was radio-located from May 18, to July 8, 1967, and ranged on a 40 acre area during this period. The doe and fawn were instrumented from November 16, to December 31, 1967, and had a home range of 78 acres. These animals were never separated while both were instrumented. A 1½ year old buck was radio-instrumented from October 12, to November 1, 1967, and from November 13, to November 18, 1967. During this period, the animal had a home range of about 360 acres. A 1½ year old doe was

1 This is a contribution of Georgia Pittman-Robertson Project W-37-R-7.

radio-tracked from December 27, 1967, to January 1, 1968. The deer was trapped two times prior to being radio-instrumented in April, 1967, and tagged with a yellow collar. The home range of this deer, based on three trapping locations, one hunter observation, and six days of radio-tracking, was about 92 acres. These home range data provide further evidence of a possible inverse relationship between population density and home range size of deer. The home ranges of all deer studied exhibited considerable overlapping. No seasonal shift in home range location was noted. Radio-tagged deer remained within their telemetrically determined home range when subjected to heavy hunting pressure. Movement data obtained on radio-tagged deer during managed hunts revealed that the daytime movement patterns were different from daytime movements prior to and following the hunts. Generally, deer movement increased as hunting pressure increased. An absence of understory vegetation on the study area was believed to be a contributing factor in forcing deer to "move" as hunting pressure increased. These data indicate that a hunter density of five hunters per 100 acres is sufficient to "move" deer on areas containing sparce understory. A hunter density of 10 hunters per 100 acres should produce a "heavy kill".

INTRODUCTION

A good knowledge of deer movements is essential in developing and maintaining a good deer management program on any area. Until recently, techniques for studying deer movements were often inadequate. Information obtained by conventional methods (trapping and tagging) is often inconclusive due to a limited number of observations of tagged animals. With the advent and utilization of radio-telemetry equipment and techniques, more precise information about deer movements and behavior is being obtained.

In April, 1967, a study was begun to determine the home ranges of deer on the Clark Hill Wildlife Management Area during different seasons of the year. The extent to which food plots are utilized also was studied. Deer were radio-located during managed hunts to study their response to different types of hunting (archery and firearms) and their behavior during periods of heavy hunting pressure.

LOCATION AND DESCRIPTION OF STUDY AREA

This study was conducted on the Clark Hill Wildlife Management Area which is located in the Piedmont section of Georgia near Thomson, Georgia. The area consists of approximately 12,000 acres and is located in portions of McDuffie, Wilkes, and Lincoln Counties. The major portion of the area, about 9,000 acres, is located in McDuffie County and the entire area borders the Clark Hill Reservoir.

The study area was located on an 800 acre portion of a 2400 acre pennisula of the management area. The terrain varies from slightly rolling to very hilly and the elevation varies from 330 feet (normal pool level of reservoir) to about 560 feet above sea level. The major timber type is pine-hardwood *(Pinus taeda, P. echinada, Quercus alba, Q. falcata).* The area is intersperced with oak ridges and near mature pine stands.

The predominant understory is dogwood *(Cornus floridus),* red maple *(Acer rubrum),* sweetgum *(Liquidambar styraciflua),* red bud *(Cercis canadensis),* grape *(Vitis sp.),* and immature hardwood *(Quercus sp.).* Understory in the pine stands consists mainly of broomsage *(Andropogon spp.),* sumac *(Rhus copallina),* and sweetgum. A noticeable browse line is present on scattered honeysuckle *(Lonicera japonica)* thickets during the summer months which becomes prominent during the winter.

Food plots ranging in size from one to twelve acres are intersperced throughout the study area. Most plots are about one acre in size. Some food plots are planted annually to rye and rye grass while others containing native grasses and fescue are permanent. About 98% of the study area is in forest and the remaining 2% is in food plots.

During the 1967 managed hunts (Archery, Buck only, and Antlerless deer hunts), a total of 27 deer were harvested on the study area for a harvest rate of about 22 deer

per square mile. It was believed that about 40% of the deer were harvested on the study area. The population density, based on this assumption, was estimated to be 50-55 deer per square mile (1 deer/12 acres) prior to the hunts.

MATERIALS AND METHODS

Capturing and Handling

The deer studied during this investigation were captured in box type traps using cracked corn as bait. Four traps were set at different locations in a ten acre food plot and prebaited for two weeks.

Captured animals were treated in the following manner: Each animal was ear tagged, age determined by the method described by Severinghaus (1949), weight estimated, instrumented with a collar type transmitter and released at the point of capture.

Radio Equipment and Tracking Procedure

Collar-type transmitters were purchased commercially from Electronic Specialities, Cloquet, Minnesota, and Differential Electronics, Doraville, Georgia. All transmitters operated on 150 megacycles. The receiving unit, purchased from Electronic Specialities, was designed to be used as a portable unit. It was converted into a mobile unit by mounting a three element directional antenna to the roof of a four-wheel drive pickup truck and preparing the proper connections. The tracking procedure was the same as described by Marshall and Jenkins (1965), except the maximum signal was used to obtain directional readings. Tests indicated the directional readings to be within 200-250 feet of the animal's actual location.

Data Analysis

The home range size of animals was determined by connecting the outermost peripheral locations with straight lines and measuring the enclosed area with a planimeter. (In instances where a straight line intersected a lake, the lake boundary was considered the home range boundary.) This method was used since it appeared to be the most consistent method for determining home range areas.

Movement and behavioral information was determined by measuring the area enclosed by consective locations obtained for a particular period of time, monitoring radio-tagged animals and by sight observations. Deer were usually tracked during daylight hours, sometimes only during nighttime hours, and occasionally over 24 hour periods.

Hunting pressure was determined by records kept at the checking station as to the number of hunters utilizing the study area each day of a particular hunt.

RESULTS

Home Ranges

Estimates of maximum home ranges are given for radio-instrumented deer in table 1. Figures 1 and 2 show the home range area and the distribution of locations obtained on deer number 1 during the spring and fall of 1967. Figures 3 and 4 show the home range area and distribution of locations obtained on deer number 2 with fawn during the spring-summer and fall of 1967. Figure 5 shows the home range area and distribution of locations obtained on deer number 3 during the fall of 1967.

Daily Movements and Food Plot Utilization

The daily movements of deer number 1 were almost stereo-typed during the spring tracking period. Periods of maximum movement activity occurred during mid-morning as the animal moved to a daytime resting area in the northern portion of her range and in late afternoon as she moved from the daytime resting area to the food plot in the southern part of her range. The deer usually remained in or near the food plot for the entire night. She usually traveled about one mile over a 24-hour period. The same general movement pattern was exhibited during the fall tracking period. Some variations occurred and were attributed to a shift in feeding activity since a good mast crop was present on the study area at that time.

TABLE I
Summary of Home Range data obtained on deer radio-tracked at the Clark Hill Wildlife Management Area - 1967

Deer Number	Sex	Age	Estimated Weight	Tracking Interval	Approximate Home Range
1	F	6	70	4-4- to 5-9-67	121 acres
				10-12 to 10-25-67	87 acres
2 2*	F	3	70	5-18 to 7-8-67	40 acres
				11-16 to 12-31-67	78 acres
3	M	1½	60	10-12-to 11-1-67	
				11-13-67 to 11-18-67	360 acres
4**	F	1½	60	12-27-67 to 1-1-68	92 acres

* With fawn.
**Home range estimate includes two trapping locations (May 20 and 29, 1967) and one hunter observation (October 25, 1967).

Radio-locations obtained on deer number 2 during the spring were consistently within a 200-250 yard area adjacent to the same food plot used by deer number 1. The doe often remained at the same location for three to four hours, presumably with her fawn. During the fall tracking period, the doe and fawn moved about one mile over a 24-hour period.

Deer number 3, the only radio-instrumented buck, moved more than the other deer studied. This animal usually traveled from one to one and one-half miles over a 24-hour period. A typical movement pattern is shown in figure 6. The buck was seldom located in a food plot. He was observed on one occasion consuming acorns.

The movements of deer number 4 were similar to those of the other does studied during the one week period of radio-contact.

Movements During Hunts

Movement data was obtained on three deer during managed hunts. Figure 7 shows a typical daytime movement pattern exhibited by deer number 1 prior to the archery hunt and movements during the hunt until the animal was shot by a hunter. The deer moved about 400 yards outside of its telemetrically determined home range and died at least eight hours after being shot. Figure 8 shows three typical daytime movement patterns and movement patterns exhibited by deer number 2 and fawn during the "Buck only" hunt with firearms. Figure 9 shows two normal daytime movement patterns of deer number 3 and two daytime movement patterns during the archery hunt.

The hunter density on the study area during the archery hunt was 6.3 hunters per 100 acres (1 hunter/16 acres) on the first day of the hunt, 4.2 hunters per 100 acres (1 hunter/24 acres) on the second, and 3.7 hunters per 100 acres (1 hunter/27 acres) on the third day. During the six day "Buck only" hunt, the hunter density was as follows: 4.3, 2.9, 2.3, 5.0, 5.1, and 4.3 hunters per 100 acres (1 hunter/23, 35, 44, 20, 18, and 23 acres, respectively). There were 10 hunters per 100 acres (1 hunter/10 acres) on the "antlerless deer hunt".

DISCUSSION

Home Range Size

There have been many studies conducted to determine the home range size of deer. In these studies most home ranges were determined by capturing, tagging, and observing marked animals. Rather crude estimates are given in many cases.

Since few telemetric studies of deer have been reported, comparisons of data are somewhat limited. A rather extensive report by Marchinton (1968) revealed the manimum home ranges of nine deer studied in four southeastern habitats containing relatively high deer populations, 1 deer/12 acres to 1 deer/30 acres (53 deer/sq. mile

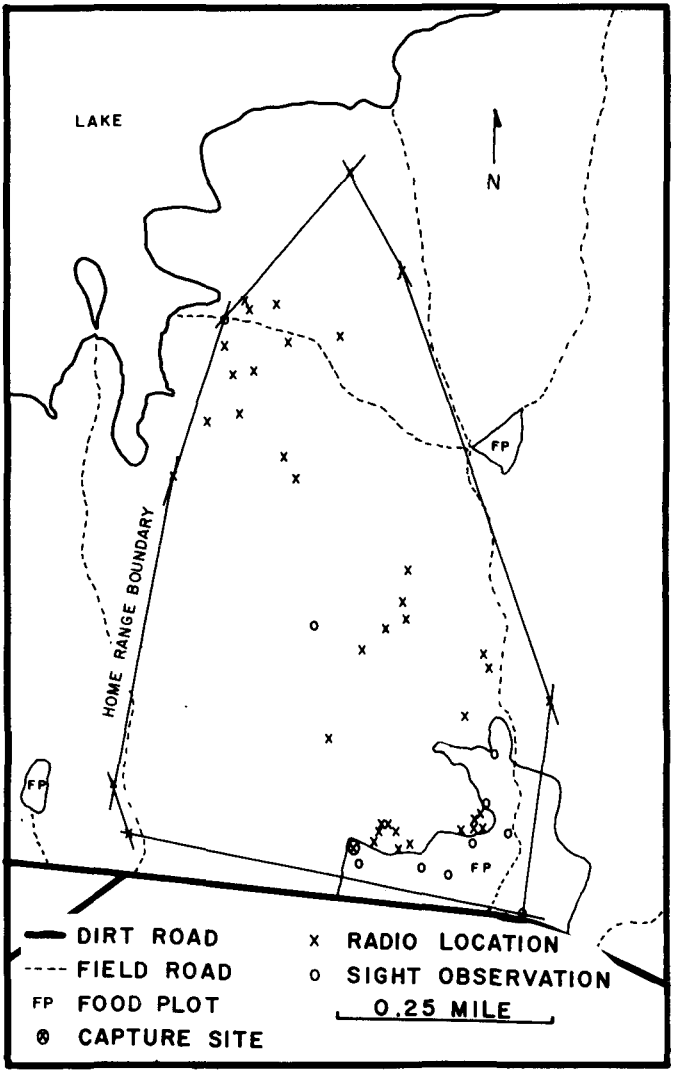

Fig. 1. Home range of adult doe (Deer No. 1) from April 4, to May 9, 1967.

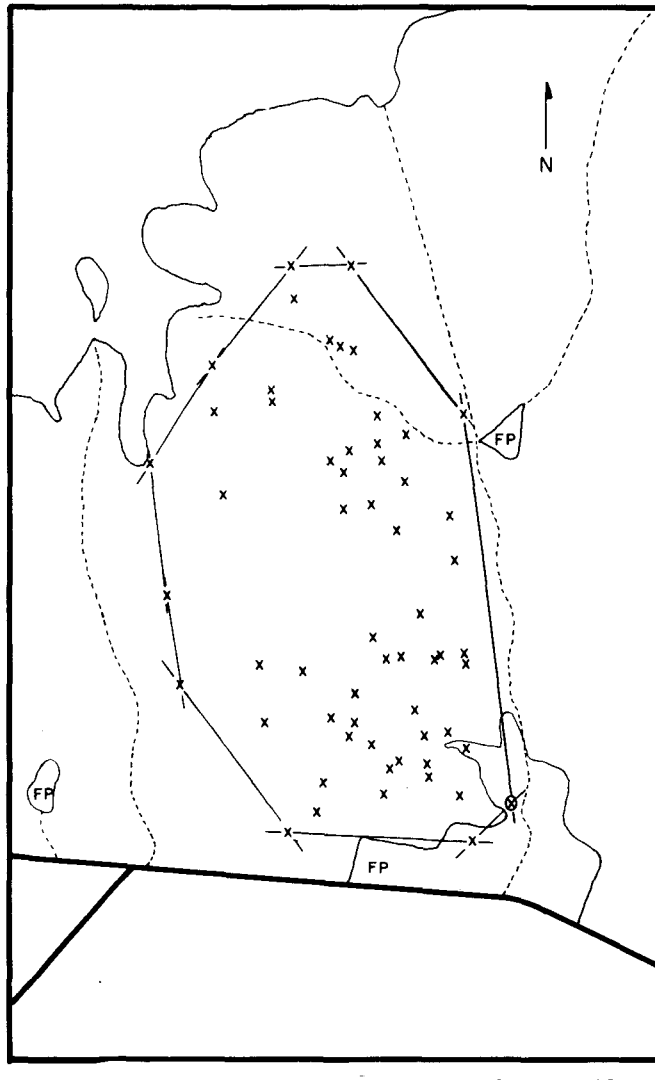

Fig. 2. Home range of deer No. 1 from October 12, to October 25, 1967.

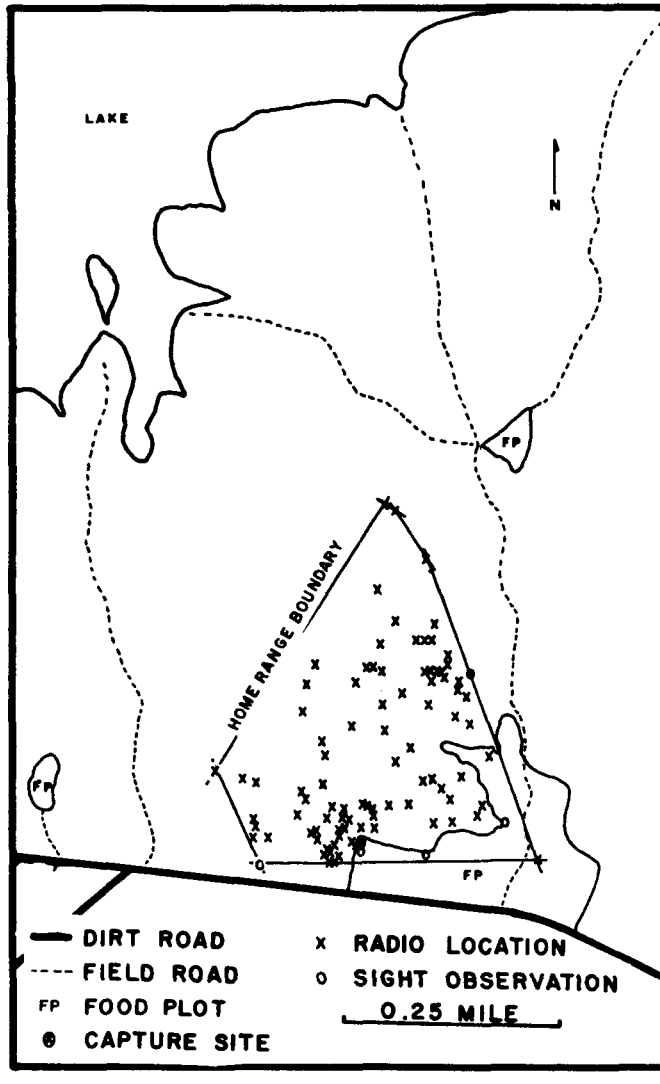

Fig. 3. Home Range of adult doe with fawn (Deer No. 2) from May 18, to July 8, 1967.

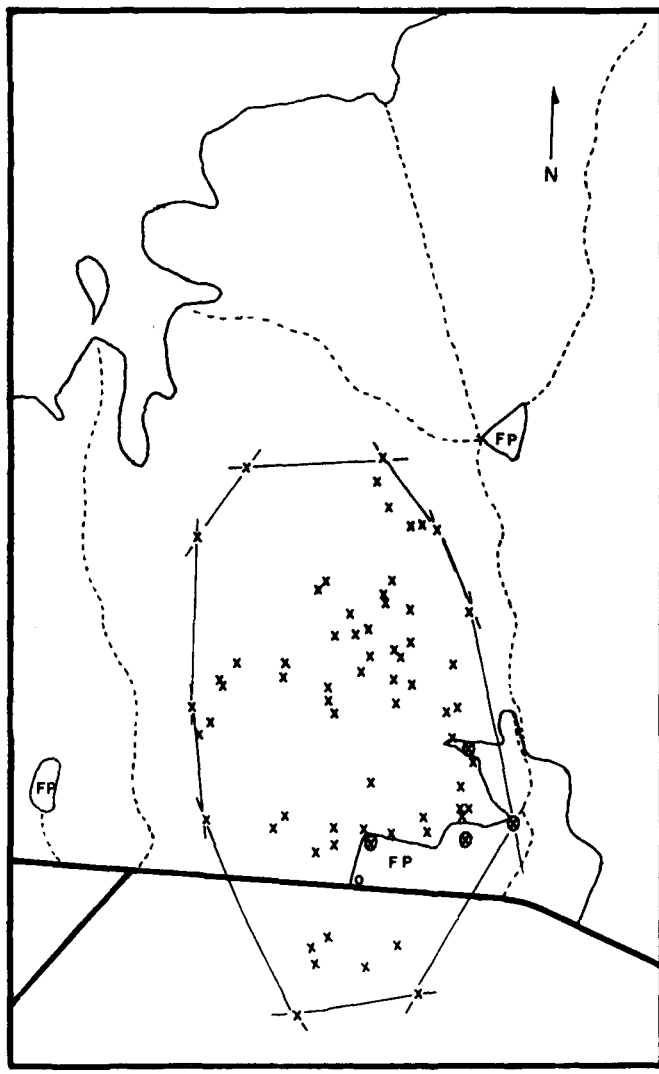

Fig. 4. Home Range of Deer No. 2 with fawn from November 16, to December 31, 1967.

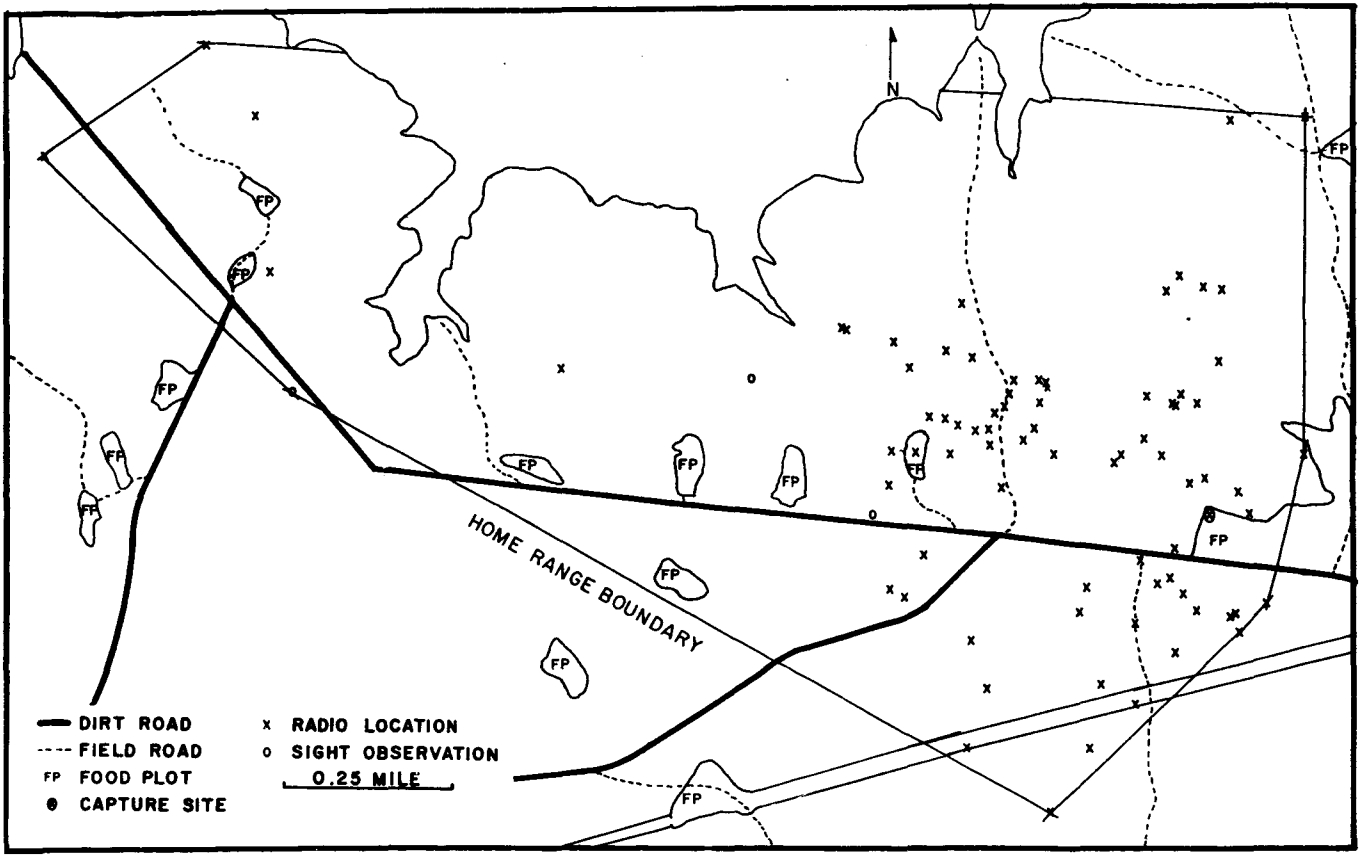

Fig. 5. Home range of 1½ year old buck, Deer No. 3, from October 12, to November 1, and November 13, to November 18, 1967.

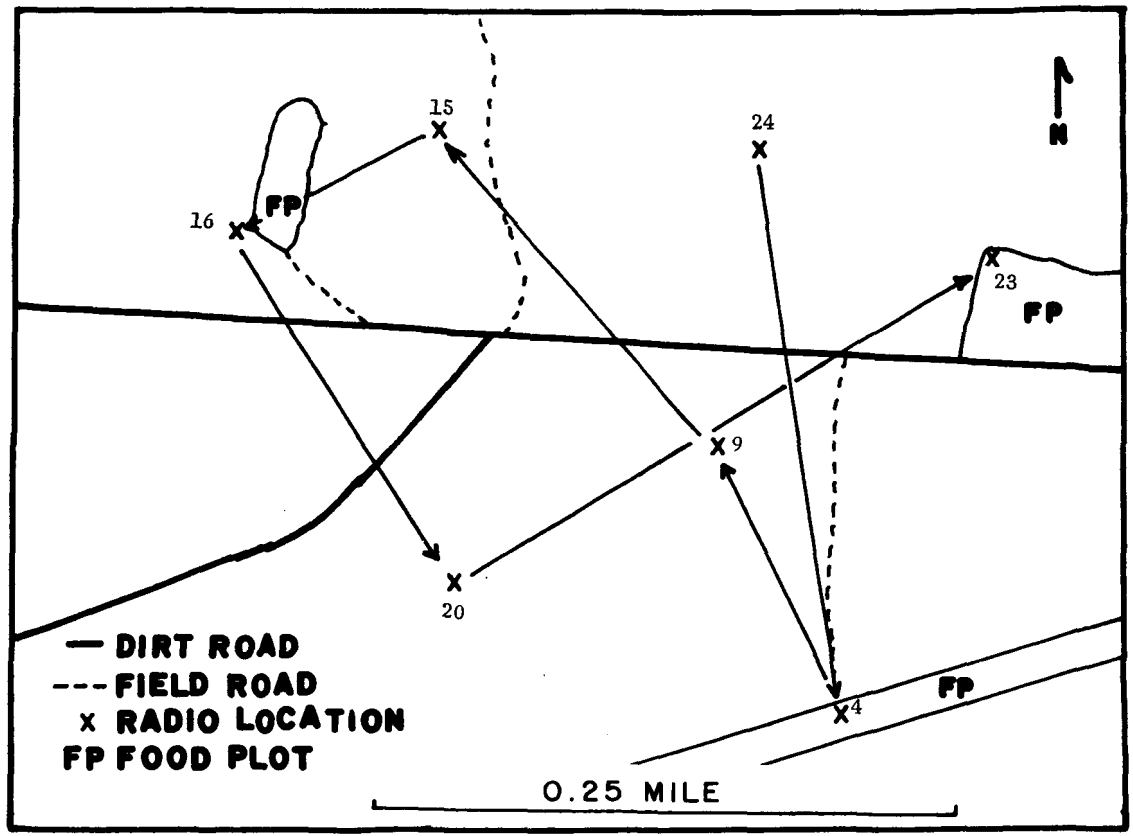

Fig. 6. Typical 24-hour movement pattern of Deer No. 3 (1½ year old buck) on November 16, 1967.

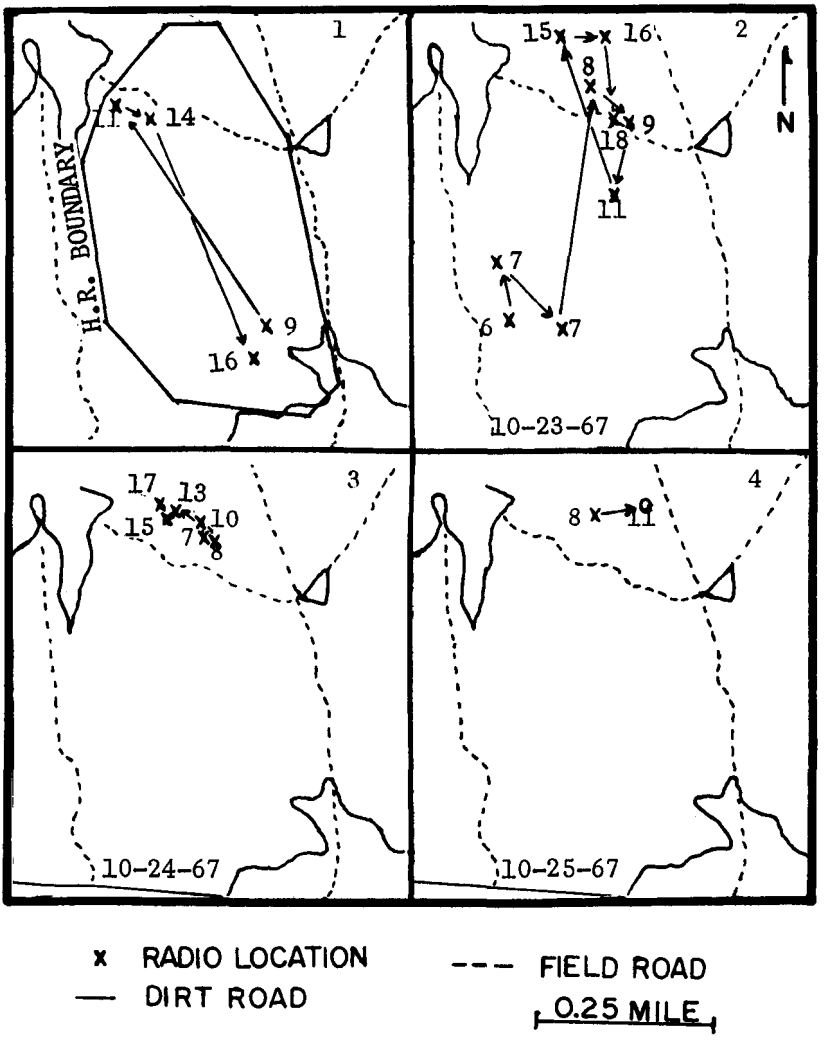

Fig. 7. Map No. 1 shows a normal daytime movement pattern of deer No. 1. Maps number 2-4 show daytime movements during the Archery Hunt. Deer was shot by an archer at 11:00 A.M. on the third day of the hunt. Numbers adjacent to radio locations are the hours (based on 24-hour clock) during which the animal was located.

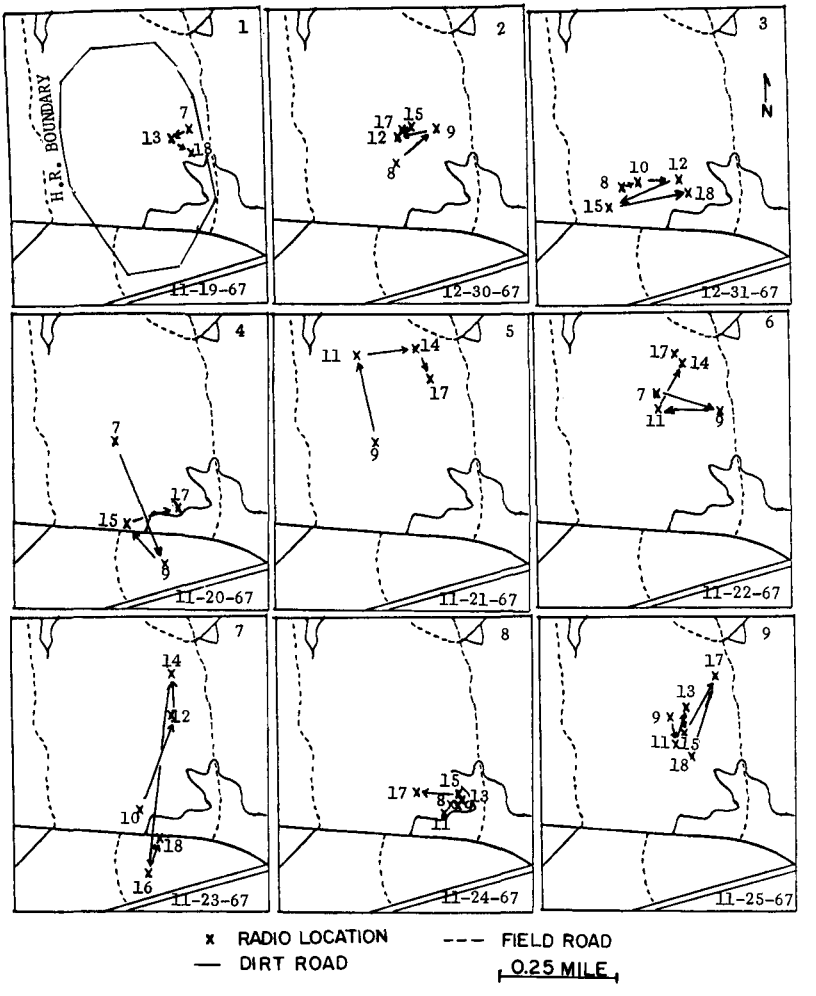

Fig. 8. Maps numbered 1-3 show normal daytime movement patterns of deer No. 2 and fawn. Maps numbered 4-9 show the daytime movements of the same deer during the "Buck Only" hunt. Numbers adjacent to radio locations are the hours (based on 24-hour clock) during which the animal was located.

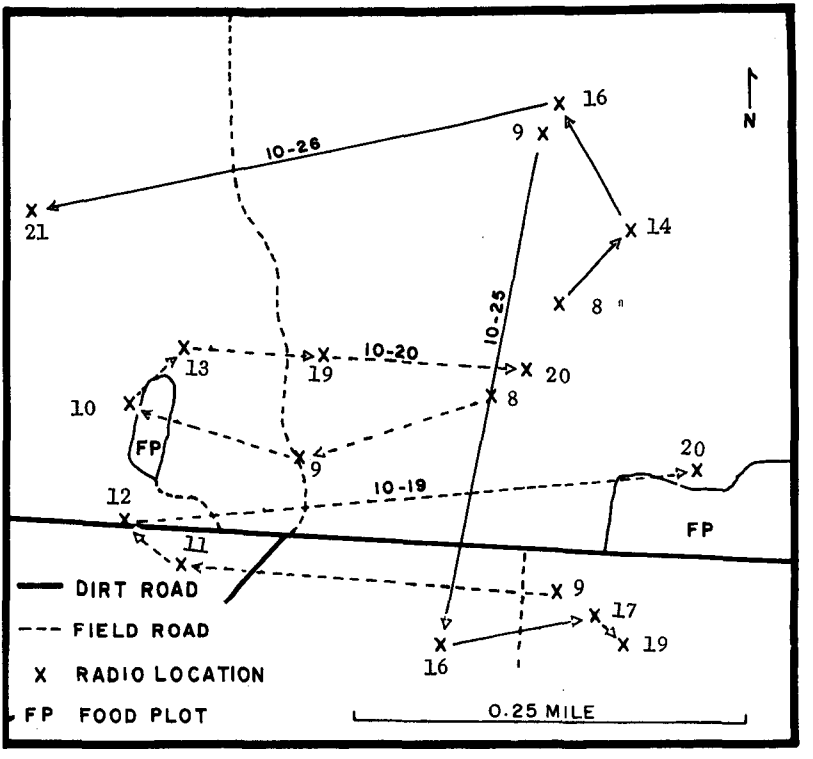

Fig. 9. Map shows normal daytime movement patterns, 10-19 and 10-20, exhibited by Deer Number 3 (1½ year old buck) and daytime movement patterns during archery hunt, 10-25 and 10-26-67. Numbers adjacent to radio locations are the hours (based on 24-hour clock) during which the animal was located.

to 21 deer/sq. mile), varied from 147 to 243 acres. The arithmetic mean was 211 acres, and the "modal average" was about 230 acres. Marchinton suggested the existence of an "ecological constant" for deer home ranges in the southeast since the similarity of home range size occurred despite habitat differences.

In the present study, the deer population was estimated to be one deer per 12 acres (53 deer/sq. mile). The maximum home ranges of two does studied during the fall season were 78 and 87 acres. The maximum home range of the yearling buck was about 360 acres, about four times larger than any of the does studied. Although the buck was radio-tracked during the rutting season, it was not definitely determined if the animal actually participated in rutting activities.

Michael (1965) stated that recent studies of deer movements showed that patterns and movements differ not only within geographic areas but also between them.

Marchinton (1968) suggested that home range size may be related to deer population density, i. e., deer in less dense populations having larger ranges. The present study provides further evidence of a possible inverse relationship between population density and home range size of deer. This relationship has been reported in small mammals by several investigators (Blair 1940, Buckner 1966, Frank 1957, Getz 1961, Van Vleck 1968). This concept can be verified only by future investigators and the development of an effective method for determining deer population densities.

Stumpf and Mohr (1962) reported that home ranges of birds and mammals generally are linear in shape. This was true for all deer studied in this investigation (Figure 10). The home range of all does (Deer numbers 1, 2 and fawn, and deer no. 4) were orientated in a north-south direction, and the home range of the buck (Deer No. 3) was orientated in an east-west direction.

Overlapping Home Ranges

All of the deer radio-instrumented had overlapping ranges (Figure 10). This was expected since all deer studied were captured in the same food plot. The home ranges of deer numbers 1 and 4 exhibited considerable overlapping. Although these two deer were not instrumented simultaneously, it was believed they belonged to the same social group. They were captured in the same trap on May 29, 1967, and observed with three other deer on October 25, 1967.

Deer numbers 1 and 2 were seldom located in the same area. Occasionally both animals were located at night near the food plot in the southern portion of their ranges, but were usually located considerable distances apart during the day. During the period both were instrumented, deer number 3 was never located with deer number 1.

Seasonal Shift in Home Range

Seasonal shifts in home ranges of white-tailed deer have been known to occur in the northern portions of their range, (Carlsen and Farmes 1957, Olson 1938), but not in the south unless forced to move from a certain location by flooding, etc. as pointed out by Marchinton (1968). Hahn and Taylor (1950) and Thomas *et al* (1964) reported sedentary habits of deer on the Edwards Plateau of Texas. In the present study, two adult does (deer numbers 1 and 2) were radio-located during the spring and fall seasons. There was no shift in home range location, but the size of the home range areas was different for both deer between seasons. Deer number 1 had a home range of 121 acres during the spring and ranged over an area of 87 acres during the fall. The reduction in home range size during the fall may have resulted from a shift in feeding activities since a heavy mast crop was present at that time or the animal may not have been radio-located for a sufficient period of time to determine its entire range during the fall period.

Deer number 2 had a home range of only 40 acres during the spring and ranged over an area of 78 acres during the fall-winter tracking period. The small home range during the spring was attributed to caring for a fawn. The major portion of the home range area was within 200 yards of a food plot. During the fall, both deer number 2 and her six month old fawn were radio-instrumented. The animals were never separated during the tracking period.

Movements During Hunts

The daytime movement patterns of the three deer tracked during the managed hunts were different than those prior to or following the hunts. During the archery hunt deer number 1 responded to heavy hunting pressure by remaining near the northern boundary of her home range area until she was shot (Figure 7). This portion of her home range area was believed to have the least amount of hunting pressure.

Prior to the archery hunt deer number 3 usually traveled in a circular manner during daytime hours, but traveled in a more linear pattern during the hunt (Figure 8). This deer was observed by two hunters on the archery hunt. One hunter shot at

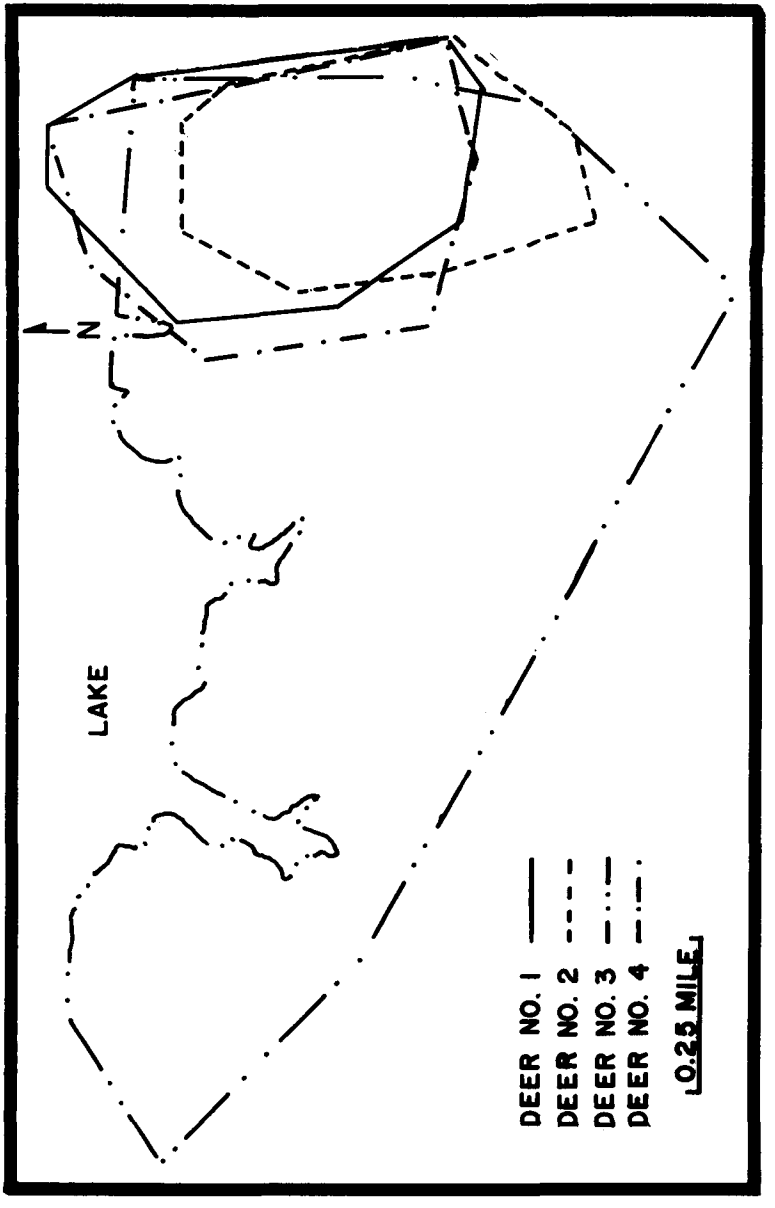

Fig. 10. Overlapping Fall ranges of deer radio-tracked on the Clark Hill Wildlife Management Area.

the deer, but missed. It was located 45 minutes later about 200 years away, where it remained until dark (about two hours) in an area containing moderately dense understory. No data were obtained on this animal during the "Buck only" hunt because the transmitter became inoperable one day prior to the hunt. The deer was killed during the fourth day of the hunt on the western boundary of his home range.

During the "Buck only" hunt, the hunting pressure was believed to be about evenly distributed throughout the home range of deer number 2. Usually, this animal spent the daytime hours near the center of the home range area. During the hunt, she traveled to the northern boundary or southern boundary of her home range each day, except on the fifth day. On this particular day, there was very little hunter activity because of rain, and deer number 2 remained in a small area near a food plot on the eastern boundary of her range (Figure 8 – map 8). It is believed that the animal moved continuously during daytime hours throughout the hunt because of an even distribution of hunters and a lack of understory vegetation where the animal could hide. Even under these conditions, the animal apparently was able to avoid hunters since it was reported sighted by only one hunter during the six days.

Deer number 4 and the six month old fawn of deer number 2 were radio-instrumented at the beginning of the "Antlerless deer hunt". The transmitter quit operating on the fawn after one location was determined at 0830 hours. The fawn was killed about 400 yards from that location at about 1500 hours.

Deer number 4 was located twice before being killed at 0830 hours. The animal was being monitored at 0808 hours when three shots were heard in the general area of the deer. The deer began moving immediately following the shots. It was killed about 300 yards from the last location. The animal apparently was wounded while being monitored at 0808 hours. The hunter killing the deer said it was "broken down" – dragging its rear legs when he shot it.

Deer number 2 apparently also was killed on this hunt. The transmitter was found just after the "Antlerless deer hunt" on the study area. The collar transmitter had been removed and discarded in the woods.

Both the fawn and deer number 4 were shot within their previously determined home ranges. The transmitter from deer number 2 was found within this animal's home range.

Heavy hunting pressure did not force the instrumented deer to leave their home range area. On one occasion during the hunt deer number 2 was radio-located about 100 yards north of her previously determined home range. This exception was not considered significant since the error in determining the location could account for this distance. Deer number 1 was located about 100 yards outside of her home range boundary after being shot by an archer. The investigators, attempting to observe the wounded deer, forced it to move about 300 yards further away from the home range area where it died.

Deer Response to Heavy Hunting Pressure

Generally, deer movement increased as hunting pressure increased. Deer number 1 moved a greater distance during the first day of the archery hunt when the hunter density was 6.3 hunters/100 acres than the following two days when the hunter density was 4.2 and 3.7 hunters/100 acres respectively. Deer number 2 moved a much greater distance during the "Buck only" hunt when the hunter density was 5.0 hunters/100 acres than when the hunter density varied from 2.9 to 4.3 hunters/100 acres.

Other than hunting pressure, it was believed that the deer studied were forced to move because of an absence of understory vegetation due to an overbrowsed condition. On several occasions during the hunts, instrumented deer spent considerable time in areas containing relatively dense understory.

Very little telemetry data were obtained on the "Antlerless deer hunt" since all three radio-instrumented deer were killed. The hunter density on the study area was 10 hunters per 100 acres during this hunt.

From these data, it appears that a hunter density of five hunters per 100 acres is sufficient to "move" deer on areas containing little understory vegetation. If a heavy kill is needed on such areas, 10 hunters per 100 acres should produce the desired results.

On areas containing very dense understories, deer movement would probably be less than on areas with sparce understory vegetation, assuming hunting pressure was comparable. Actually, such areas may require a considerably higher hunter density to "move" deer.

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