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THE DYNAMIC ASPECTS OF DEER POPULATIONS UTILIZING A REFUGE[1]

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ABSTRACT

The impact of refuges on white-tailed deer (*Odocoileus virginianus*) movements and population dynamics, although often discussed, has never been clearly documented in the Southeast. This study used radio telemetry, modified Lincoln Index censusing, sex ratio counts, kill data and observations of 40 marked deer from March 1973 through November 1974 to analyze movements between Berry College Refuge and contiguous hunted areas in northwestern Georgia. Three major patterns of movement seemed apparent: (1) relatively sedentary movement patterns of resident refuge deer, (2) dispersal of 1.5 and 2.5-year-old bucks from the refuge coincident with the onset of rut, and (3) migration of a large contingent of deer (mainly does) onto the refuge concident with the opening of hunting season. Bucks dispersing from the refuge sustained considerable mortality from hunting. The concurrent influx of deer onto the refuge, however, nearly doubled the population ($P < 0.05$). These migrants remained on the refuge (where an abundant food supply was available) until late winter when they gradually returned to their summer ranges. Implications of our results are discussed regarding the concept of refuges in deer management, both as useful tools in the case of over-harvested herds and as difficult problems in situations where overpopulation exists.

Leopold (1947:195) defines a refuge as, "An area closed to hunting in order that its excess population may flow out and restock surrounding areas." The refuge concept as a deer management tool generally fell into disrepute in the 1950's as a result of studies showing deer to be very sedentary. More recent evidence has indicated that deer are more mobile than was previously believed. Hawkins et al. (1971) found heavy dispersal of bucks from Crab Orchard National Wildlife Refuge in Illinois. Migrations or large seasonal shifts of home range are not commonly reported for southern deer (Hahn and Taylor 1950, Thomas et al. 1964, Michael 1965, Siglin 1965, Marchinton and Jeter 1966). Several years ago, however, wildlife biologists at Berry College began to suspect that hunted deer were moving into a refuge in the fall, resulting in low hunter success and inadequate harvests on surrounding land open to deer hunting. Our study attempts to evaluate the interrelationships of refuges and hunted areas in the ecology of a deer herd. Up to the present time, migratory movements of large numbers of white-tailed deer have not been documented in the Southeast, and the effects of a refuge on deer movement have not been analyzed in a southeastern habitat.

The Georgia Department of Natural Resources, Game and Fish Division, provided assistance throughout the study. Several individuals from this organization deserve special thanks. These include regional supervisor W. C. Collins, biologists M. S. Reeves, E. S. Painter, R. H. Little and J. W. Bearden, and refuge manager V. F. Early. We are grateful to the Berry Schools for use of their land and to B. W. Steen, a Berry College student, who devoted long hours to the field work. We also acknowledge the assistance given by the faculty and students of the School of Forest Resources at the University of Georgia. G. H. Brister was especially helpful in statistical analyses and A. S. Johnson offered advice and assistance on the manuscript.

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STUDY AREA

Berry College properties include approximately 25,000 acres (10,125 ha) in Floyd County on the northern edge of Rome, Georgia. The area is typical of the Ridge and Valley Province. Two major ridges occur on the northern half of the study area, and the southern portion consists of relatively flat terrain.

Approximately 21,000 acres (8,505 ha) of Berry properties are forested with the remaining 4,000 acres (1,620 ha) developed for agricultural purposes. The forested acreage is 70 percent pine, 16 percent pine-hardwood, 10 percent upland hardwood, and 4 percent bottomland hardwood. Major agricultural operations included 1,300 acres (527 ha) of pasture and 150 acres (61 ha) of annual cropland.

In 1948, the Floyd County Wildlife Club released 20 deer from Texas on Berry College land. No native deer were known to be present, and it is assumed that the Berry deer herd descended from those animals. There was a gradual increase in this deer population until the early 1960's when a dramatic upsurge was noted. In 1970, Berry College, faced with large numbers of deer and increasing poaching problems, agreed to let the Georgia Game and Fish Division protect and manage their wildlife resources. The college properties were then divided into a 12,000-acre (4,860 ha) refuge and a 13,000-acre (5,265 ha) managed hunting area (Fig. 1). A deer capture program was immediately begun in the refuge to obtain stock for release in other parts of the state, and hunts were conducted annually in the managed hunting area. Over 300 deer were captured and removed, and an additional 175 were harvested on the hunts. However, hunter harvest was considerably lower than expected with 7.8, 5.9 and 9.4 percent hunter success, respectively, on buck-only hunts from 1971 through 1973. Despite removal of these deer, overpopulation continues to be the major management problem, especially on the refuge area.

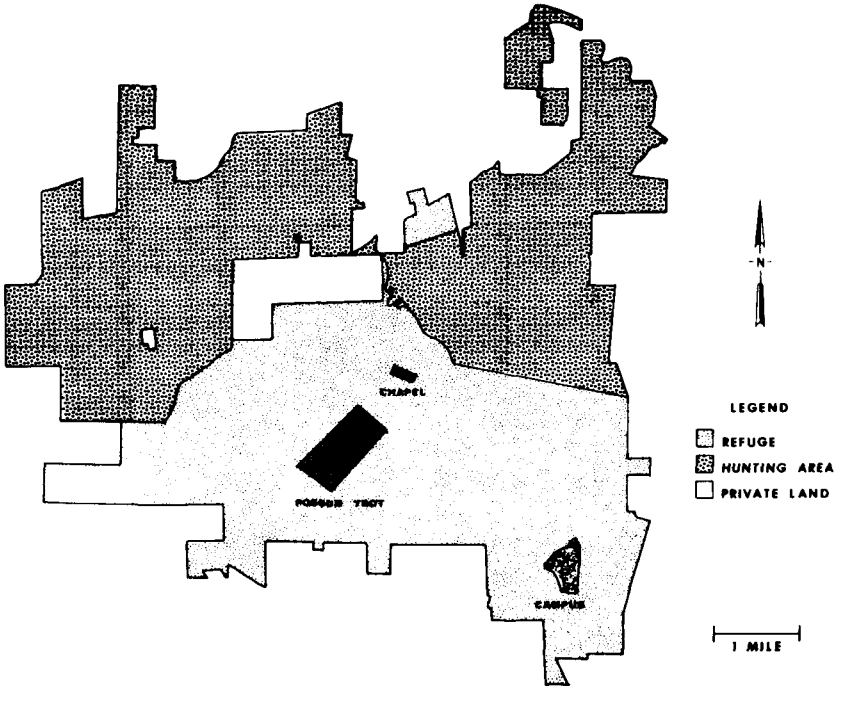

Figure 1. Map of Berry College study area showing the three census locations—Possum Trot, Chapel and Campus—used in 1973 and 1974.

METHODS AND MATERIALS

Capture and Telemetry Techniques

The Cap-chur Gun (Palmer Chemical Co., Douglasville, Georgia) was used with various immobilizing agents to capture 40 study animals. Nineteen of these deer were bucks and 21 were does. Succinylcholine chloride, available in Pneu-darts (Pneu-Dart Inc., Williamsport, Pennsylvania), was the most effective drug for capturing deer. Numbered metal ear tags and color-coded plastic ear streamers were placed on all captured deer. Fourteen animals were also fitted with reflective collars (Wildlife Materials, Carbondale, Illinois) and 13 with radio transmitters (Davidson Co., Minneapolis, Minnesota), depending upon the capture location. Both collars and transmitters carried a reflective number or letter, and were easily identified at night with a spotlight and binoculars at distances up to 300 meters.

Radio equipment operated at 0.015 mHz intervals along a receiving range from 150.815 to 151.085 mHz. Radio monitoring and data analysis techniques were similar to those described by Kurz and Marchinton (1972) with a 24-hour period used as the basic data gathering unit. A Cessna Skyhawk airplane was used to search for deer when normal procedures failed to achieve radio contact.

Census Techniques

Deer were captured and marked at three locations on the refuge (Fig. 1). These, identified as Possum Trot, Chapel and Campus, were selected because of the intensive deer utilization of open fields at these locations. Particular attention was focused on the Possum Trot location as it offered a 1-mile (1.6 km) stretch of road with open pastures on both sides. Lateral visibility was unobstructed for a 0.25-mile (0.4 km) radius. Six to 12 (usually 10) deer were equipped with reflective collars during any census at this location. The Chapel location was a 50-acre (20 ha) pasture approximately 0.75 mile (1.2 km) northeast of Possum Trot. At least two deer were equipped with ear streamers here at any time. The Campus, approximately 3 miles (4.8 km) southeast of the other locations, contained about 150 acres (61 ha) of cropland. Four to seven deer were tagged with ear streamers at all times on this area.

Censuses were made on all three areas beginning in August 1973 and continuing through September 1974. During the period of intensive study (fall 1973 and winter 1974), three or four counts were made every week at each location. In spring and summer, five to eight counts were made in every month except May, when none were recorded. All counts were made in the evening 0.5 to 3.0 hours after dark when deer were feeding or bedding in the open fields in greatest numbers. The counting procedure required the use of a spotlight and binoculars from the back of a truck. The same route was driven every night. Attempts were made to move bedded or obscured deer so that any identifying marker was clearly visible. Collared deer were individually identified up to 300 meters, but deer marked only with streamers, in many cases, could not be seen farther than 100 meters. At Possum Trot, all deer used in calculations carried reflective collars. At Chapel and Campus, however, only deer with streamers could be used, thereby reducing efficiency and accuracy at these two areas.

Four items were recorded at each count and location: (1) total number of marked deer currently in the population, (2) marked deer seen, (3) identifiable deer seen, and (4) total deer seen (including those obscured from plain view). The population estimate for a given night was determined by the Lincoln Index (Seber 1973). At the Chapel and Campus locations, where small proportions of the population were tagged, the modification proposed by Bailey (1952) was used. Nightly estimates were averaged to indicate monthly mean numbers of deer in each of the three census locations.

Our census procedure relied on five assumptions which we believed were generally satisfied on the basis of our telemetric information and frequent observation of both marked and unmarked individuals. (1) Marked animals had the same average probability of being seen as unmarked animals. (2) Marked animals did not lose their marks. Some animals did lose collars but were identified by streamer codes and eliminated from the equation the next time seen. (3) Recruitment and loss were negligible (since counting time was only about one hour). The seasonal changes in populations were documented by successive counts as this was a major objective of the census procedure. (4) Marked animals were a representative sample of the population. This was apparently true for resident animals but could not be determined for non-residents and therefore constitutes a possible source of error. (5) The number of marked animals in the population was known at the time each count was made. Tagged animals were not included as "marked" in the population until the first time they were seen or 1 week after tagging (whichever occurred first) to allow for any behavioral changes resulting from the tagging operation. The number of marked animals in the equation was adjusted for each census to account for

known emigration, death, or loss of marks. Nine of the 24 animals specifically marked for use in censusing were eliminated during the study.

Four methods were used to determine approximate percentages of antlered bucks present at different seasons and locations. Before the 1973 hunts, estimates for the refuge were obtained from observations during monthly counts. Percentages on the managed hunting area were estimated from hunter questionnaires during the hunt. Percent bucks on the refuge after the hunts was estimated from capture records and daytime observations of all recognizable deer.

MOVEMENTS AND DISPERSAL OF REFUGE RESIDENTS

Home range and dispersal movements for radio-monitored deer were based on 915 radio and visual locations. Minimum ranges of six resident deer captured on the refuge during the summer and fall of 1973 ranged from 94 to 603 acres (38 to 244 ha), with a mean of 313 acres (127 ha). These deer proved to be relatively sedentary and their ranges generally conformed to those found in the literature for the Southeast (Marshall and Whittington 1968, Marchinton 1968, Byford 1969).

Marked changes in movement patterns and behavior of refuge bucks, however, occurred in late October and November during the rut. One buck, for example, enlarged his range from 228 to 603 acres (92 to 244 ha) in a 1.5-month period during the rut. This increased, unpredictable activity often led to dispersal of bucks from the refuge. Of 19 bucks tagged or radio-collared on the refuge at least 6 (32 percent) were known to have dispersed. These movements averaged 2.7 miles (4.3 km) and ranged from 1.5 to 4.75 miles (2.4 to 7.6 km). If only bucks 1.5 and 2.5 years old are considered, 5 of 10 (50 percent) made long-range movements (all during the rut). Only 1 of 21 does (5 percent) made a similar movement.

All recorded buck dispersals originated from dense concentrations of deer around refuge agricultural areas and terminated in wooded areas open to hunting and supporting fewer deer. Dispersals apparently added a considerable number of bucks to the legal kill outside of the refuge boundary since five of six known movements resulted in the animals being killed.

High dispersal rates have been reported in the literature for northern and western deer herds (Robinette 1966, Sparrowe and Springer 1970). Hawkins et al. (1971:217) found 80 percent dispersal in yearling bucks and 10 percent for adult bucks. They suggested that increased population and social pressures were possible causes of the high rate of dispersal. In the South, few studies have been conducted on this aspect of deer movement-ecology although Downing et al. (1969) observed apparent dispersal tendencies among bucks within the Radford Arsenal.

FALL MIGRATION ONTO THE REFUGE

Over a period of 14 months, 318 evening deer counts were made at the three census locations on Berry College Refuge. Efforts were concentrated at Possum Trot because of the greater number of tagged deer in that area. The Lincoln Index was applied to 138 separate counts at Possum Trot. Population estimates remained relatively stable from August through October 1973 (Fig. 2).

On the last 3 days of October, the annual gun hunt was held on the managed hunting area, followed by a 6-day archery hunt beginning less than 2 weeks later. The month-long county gun hunt began on 3 November on land surrounding Berry School properties. Hunters exerted intense pressure, especially near the refuge boundaries. The daily population estimates at Possum Trot increased abruptly, coincident with the initiation of hunting on the outside. The average estimate for November increased to 461 and was significantly greater ($P < 0.05$) than the 267 estimated for October (Fig. 2). Over 200 non-resident deer had apparently moved into the area within a month's time. The population remained stable at this high level through December, and estimates indicated that many of the non-resident deer remained on the refuge, near agricultural openings where pasture and winter crops provided high quality forage, until late winter.

Deer capture operations (for restocking purposes) began on 7 January and were terminated on 19 February. Sixty-seven deer were captured and removed from Possum Trot alone. Although daily population estimates closely reflected this removal, February estimates continued to drop, and the monthly average of 261 was significantly lower ($P < 0.05$) than December and January levels, indicating that most non-resident deer left during February (Fig. 2). From March through September the estimates fluctuated only slightly, except during June when a yearly low of 178 deer was recorded. Since the April, August and September estimates probably were the most accurate, the mean estimate of 257 deer for those 3 months was thought to closely approximate the 1974 year-round

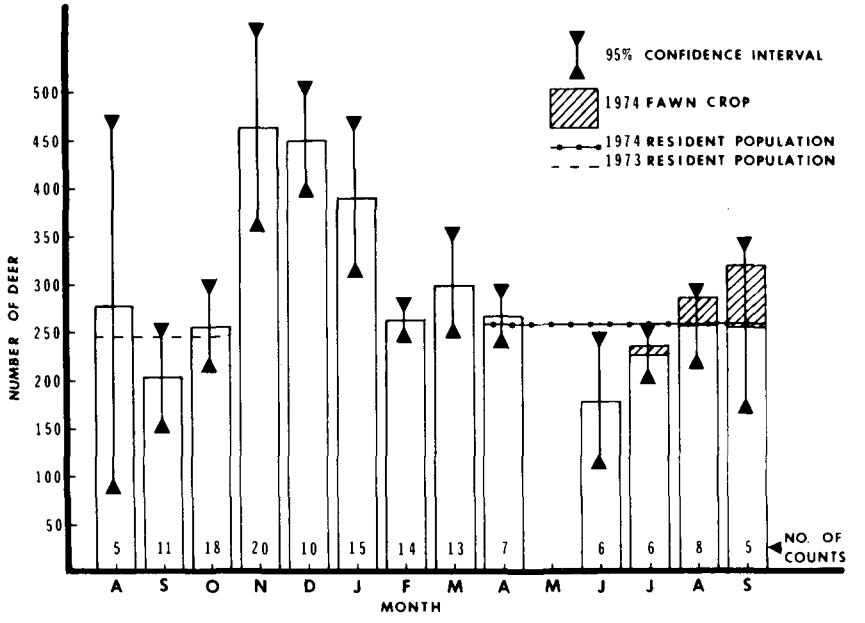

Figure 2. Monthly population estimates at the Possum Trot census location from August 1973 to September 1974.

resident population at Possum Trot. In comparison the three monthly estimates for 1973, when averaged, indicated a resident herd of 246 deer. The apparent gain of 11 deer from one summer to the next (not including the 1974 fawn crop) may have been due to normal sampling error. In any case, these estimates did not account for the 67 deer captured and removed from Possum Trot the previous winter. The possible cause of this discrepancy will be discussed later.

Similar seasonal fluctuations (although less in magnitude) were recorded for the Chapel location where the population estimate rose from 82 in the summer to 117 in the winter and then in the spring dropped back to the summer 1973 level. Because of the small number of marked deer, statistical tests were not attempted. The Campus showed population fluctuations greater than either the Possum Trot or Chapel locations. The estimate increased from 70 in the summer to 240 during the fall and remained near that level (246 deer) through the winter. No counts were made in the spring, but observations suggested that the population declined to about the summer level.

Late winter population estimates reflected the combined removal of 112 deer from the three locations by mid-February. However, the decline continued after trapping ceased and by the end of February, population estimates had dropped substantially more than the number captured, indicating a gradual emigration of non-resident deer from the entire refuge. The 1974 summer estimates were nearly equal to those of the previous summer, suggesting that approximately the same number of non-resident deer remained on the area as was removed, or that most deer captured were non-residents.

Since deer tagged on the refuge during the summer proved to be permanent residents, the percentage of these tagged deer that were seen per count in fields was used to project resident deer usage of fields from August 1973 to September 1974 (Fig. 3). From a low point in October (corresponding to the period of peak mast availability), the percentage increased slowly through January but still remained only slightly above the August level. While total deer seen in fields (Fig. 4) and the population estimates showed dramatic increases in November, these increases were not reflected in

the percentage of tagged deer (residents) using fields and provided further evidence for the influx of non-resident deer. February was the month when the greatest numbers of deer were counted in the fields (Fig. 4) and was the winter peak of tagged deer usage (Fig. 3). The population estimate for this month, however, had dropped almost to the summer level (Fig. 2), indicating very heavy use of fields by resident deer after departure of most non-residents. In the spring, percent of tagged deer seen declined, with the sharpest decrease occurring in June probably as a result of restricted movements and secretive behavior of does during the fawning season. The greatest usage of the fields by tagged deer occurred in July but it declined sharply in August and September. These data, when combined with population estimates and total deer usage, indicate that deer seen in the fields during the spring and summer were almost entirely residents (Figs. 2-4).

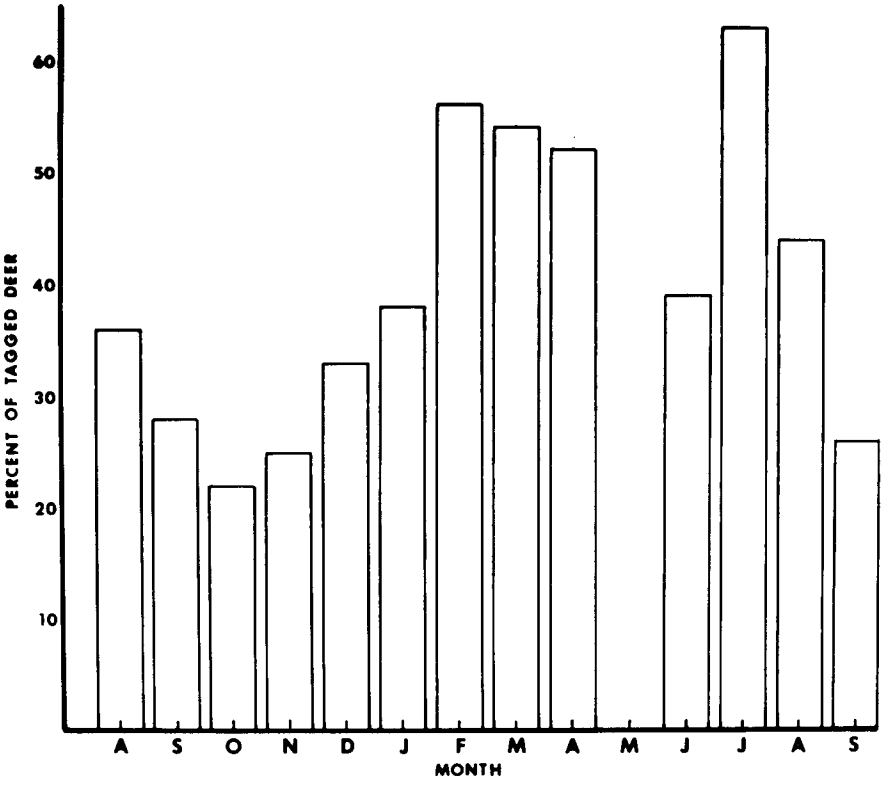

Figure 3. Percent of tagged deer seen in open fields at the Possum Trot census location. These monthly percentages were used to project resident deer usage of open fields.

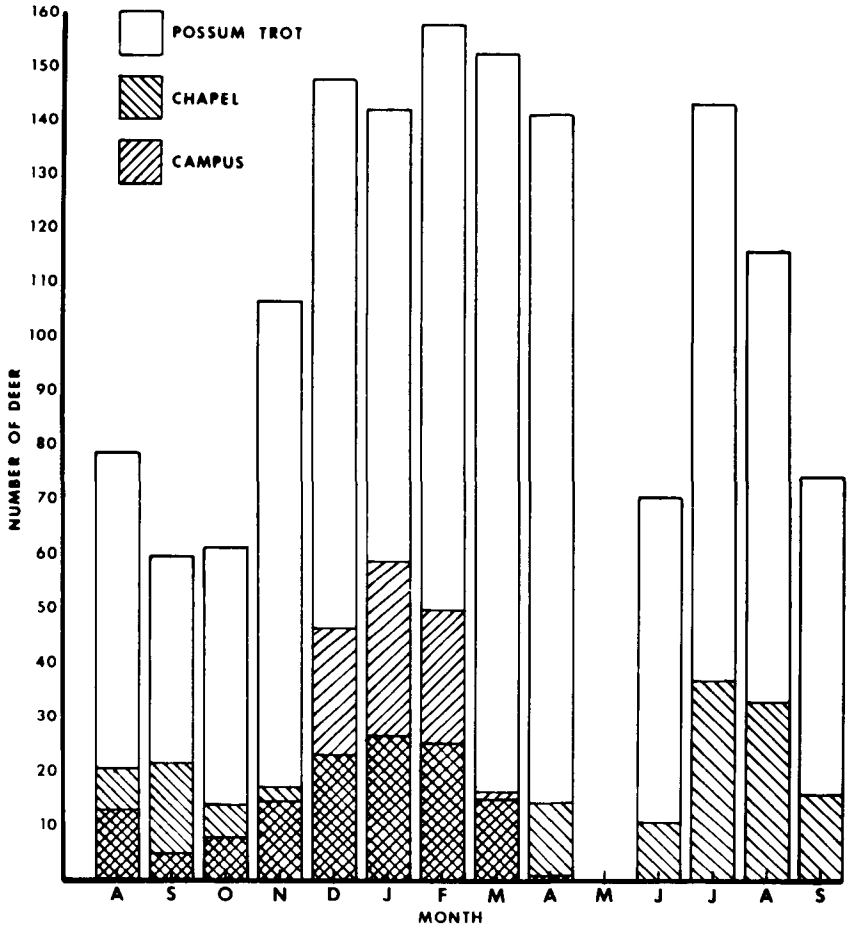

Figure 4. Average number of deer seen per count at three census locations on Berry College Refuge in 1973 and 1974.

On the other hand, it is apparent that many of the deer using the fields in fall and winter were non-residents from surrounding hunted areas when the following evidence is considered. (1) Several deer tagged on the refuge during the winter disappeared and one was later observed in his summer range on the hunted area 4.75 miles (7.6 km) away. Summer-tagged deer (except for dispersing bucks) were generally seen on the refuge throughout the year. (2) Based on the 1.5-mile (2.4 km) radius within which radio-monitored deer were known to frequent the agricultural fields, circles were drawn which encompassed 8,110 acres (3,285 ha) of the refuge habitat. The remaining area of 1,890 acres (765 ha) would have to contain 141 deer per square mile (54.4 per sq km) or one deer per 4.5 acres (1.8 ha) to account for an influx of 416 deer if all refuge deer vacated outlying areas and migrated to the fields. This is an absurd estimate because much of the outlying refuge is relatively low quality habitat probably supporting less than 30 deer per square mile (11.6 per sq km). (3) Although 40 tagged deer were radio monitored and observed on the refuge, there was no evidence of movement between or among the three refuge census locations. This is more significant since the Possum Trot and Chapel

locations are only 0.5 mile (0.8 km) apart. It is probable that a few deer from the managed hunting area made daily trips to one of the refuge fields; however, we believe that long daily movements of this kind were minimal.

Population Densities

Density estimates were computed at all three census locations using information obtained from radio-monitored deer to indicate how much area was being utilized by deer observed at each location. A circle was drawn to encompass a 1.5-mile (2.4km) radius around each location (which was the approximate length of the average major axis computed for radio-monitored deer). This yielded an estimate for 8,110 acres (3,285 ha) on which all deer were presumed to use one of these three field complexes. If this was not the case, then the resulting estimates are probably somewhat low. The assumption was then made that the same density occurred on the remaining 1,890-acre (765 ha) portion of the refuge, and total population estimates were computed for the entire area. The summer population was estimated at 469 deer or 30 deer per square mile (11.6 per sq km) while the peak estimate occurring in the fall was 922 or 59 deer per square mile (22.8 per sq km). Although these figures are considered reasonably accurate for the entire refuge, they do not reflect the concentrations of deer around the three census locations. A careful examination of data suggested that deer density on the four square miles of prime habitat surrounding the Possum Trot fields, approached 116 deer per square mile (44.8 per sq km) in the fall.

Changes in Sex Ratio

Doe immigrations and buck dispersals were further substantiated by sex ratio changes. (Estimates did not reflect true male-to-female percentages because buck fawns were counted as antlerless deer.) Percentages of antlered bucks observed on the hunted area were significantly lower during the gun hunt (14.1 percent) than on the archery hunt (19.3 percent) less than 2 weeks later ($X^2=9.16$, d.f. = 1, $P < 0.01$). Although one might assume that this resulted from closer observation by archers, an opposite trend occurred during the same time period on the refuge. The percentage of bucks observed before the hunt (11.8 percent) was significantly greater ($X^2=17.57$, d.f. = 1, $P < 0.01$) than after the hunt (6.5 percent) but not significantly different from capture ratios after the hunt (10.7 percent antlered bucks). Unbalanced ratios on the refuge were apparently due to the heavy dispersal of bucks during the rut and immigration of a doe-biased contingent of animals during and after the gun hunt. In all cases, percentages of bucks seen on the refuge were significantly lower ($P < 0.01$) than on the hunted area despite selective removal of bucks by hunting.

Tag returns also indicated that many bucks dispersed from the refuge and were either killed during the hunt or remained on the hunted area where social competition was less intense. In analyzing mortality of tagged deer by sex, we found that 47 percent of tagged bucks and only 14 percent of tagged does died during the study. The major cause of mortality was legal and illegal hunting. These percentages suggest that heavy differential mortality between the sexes may be another factor in unbalancing the refuge sex ratio.

Capture records indicated that the fawn sex ratio was very nearly balanced since 55 percent of the fawns captured in 1974 were males. Records of previous years (from 1968 through 1973) showed that 52 percent of fawns were bucks. While some bias toward buck fawns may be inherent in capture operations, we do not think it was significant.

Harvest Trends and Seasonal Movement

Berry College managed hunts began in 1971 and have continued on an annual basis through 1974. Some interesting trends can be seen upon analysis of the hunt data. In 1971 and 1972, 6-day, buck-only hunts held in early December resulted in low hunter success (7.8 and 5.9 percent, respectively). In 1973, with the managed hunt shortened to only 3 days and moved ahead to late October, hunter success rose to 9.4 percent, possibly due to the harvest of deer that (1) in previous years had already moved to the refuge, and (2) were at their peak of dispersal from the refuge. An early 4-day hunt in 1974, which also included a 3,000-acre (1,215 ha) portion of the refuge, showed a dramatic increase in total harvest and hunter success (19.2 percent).

From 1971 to 1972, the percentage of yearling bucks in the harvest rose from 44 to 72 and in 1973, yearlings comprised 87 percent of the harvest. An increase in percent yearlings was expected, but, since harvest rates were not high, the magnitude of change may reflect increasing numbers of 1.5-year-old-bucks dispersing from the refuge and thereby becoming available for harvest.

Factors Other Than Hunting Affecting Seasonal Movement

A poor acorn crop in fall 1973, combined with hunting pressure, most likely made the refuge attractive for both food and security. Fall and winter food was provided by a variety of grasses and crops not available on the areas open to hunting. The abundance of these foods may have prompted deer to remain on the refuge throughout the winter. However, migratory deer were apparently leaving the refuge in February when the agricultural fields were being most heavily used by resident deer. This indicates that food may not be the most important factor influencing the annual migration.

Availability of cover was probably not an influencing factor as it was abundant on both refuge and hunted areas.

THE MIGRATORY TRADITION

There is little evidence in the literature suggesting the type of seasonal short-range migration between a refuge and hunted area which apparently occurred at Berry College. However, hunting and related disturbances similar to those in our study have repeatedly been shown to stimulate unusual movements (Tester and Heezen 1965, Robinette 1966, Downing et al. 1969). Marshall and Whittington (1968:45) found that deer in Georgia increased movement as hunting pressure increased, yet remained within their home ranges. Their study area had a long history of intensive hunting, but study animals were located on a peninsula surrounded by a large lake with the only land exit also subjected to intensive hunting. There appeared to be no incentive for movement from this area. Autry (1967) monitored the effects of the first hunt ever conducted on the 18,000-acre (7,290 ha) inviolate portion of Crab Orchard Refuge. He found no movement into 4,000 acres (1,620 ha) of unhunted land, although hunting did cause increased movement by both bucks and does. The greater movement may have been an attempt at seeking refuge by the harassed deer, although none was found. The deer on Crab Orchard Refuge apparently had no previous experience with hunting or were living on the area they had known as refuge from surrounding hunts. Zagata and Haugen (1973:207) in Iowa presented an example of traditional movement into a refuge. They stated that deer were observed entering a state park after being jumped by hunters in outlying areas up to one mile away. In each year, more deer were in the park in late winter than in early winter (Zagata and Haugen 1973:212).

Variations in movement patterns indicate that habitat conditions, juxtaposition of refuge areas, and past history of hunting may all play roles in the deer's response to heavy hunting pressures. Berry College deer seemed to be initially stimulated to move onto the refuge by hunting and induced to remain there by an abundant food supply. Hunting has been conducted here for many years, and food-providing refuge habitat is available for hunted deer. It seems likely that many deer on the Berry College hunting area had "knowledge" of the refuge since the original stocking was made on the refuge with all surrounding areas being supplied from this nucleus. After substantial population expansions, some deer may have developed the tradition of returning annually to the refuge to escape hunting harassment and take advantage of the high quality winter food available.

MANAGEMENT IMPLICATIONS

Taken independently, the census and telemetry data, changing sex ratios, harvest trends, and tag returns may be subject to other interpretations. If all the evidence is considered together, however, it seems obvious to us that the migrations, dispersals, and population density changes were, in fact, occurring. It also seems reasonable to conclude that similar phenomena probably occur in many other areas where refuges and tempting food sources are available.

We suggest that deer refuges may be advantageous where overharvest of deer herds is a problem (a situation not uncommon in some areas of the coastal plain). Given such circumstances, refuge breeding stocks and non-resident deer (temporarily displaced by hunting) could annually move out to replenish surrounding populations. We also suggest that limited removal of deer by whatever means (e.g., capture or hunting) from a refuge may have the effect of reducing the flow of deer from the refuge rather than decreasing population density within it.

Deer moving freely between contiguous refuge and hunted areas, however, can result in inadequate harvests and overpopulations. This is the management problem at Berry College and probably many other areas throughout the United States. Hunting on the refuge and earlier harvests on the previously hunted areas appear to be the best practical methods to control high population levels and possibly reduce seasonal migration to the overburdened refuge area.

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