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White-Tailed Deer (*Odocoileus virginianus*) on the Department of Energy's Oak Ridge Reservation: 1979 Status Report

J. Thomas Kitchings
Jay D. Story

ENVIRONMENTAL SCIENCES DIVISION
Publication No. 1583

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WHITE-TAILED DEER (*Odocoileus virginianus*) ON THE DEPARTMENT OF ENERGY'S OAK RIDGE RESERVATION: 1979 STATUS REPORT

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ABSTRACT

KITCHINGS, J. T., and J. D. STORY. 1980. White-tailed deer (*Odocoileus virginianus*) on the Department of Energy's Oak Ridge Reservation: 1979 Status Report. ORNL/TM-6803/S2. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 42 pp.

Seventy-three white-tailed deer (*Odocoileus virginianus*) were killed by vehicles on the Department of Energy's Oak Ridge Reservation during 1979, an increase of twenty-eight over 1978. Patterns of mortality were similar to those reported in previous documents. During the year, the highest number of deer was killed in October, November, and December. Throughout the year almost twice as many males as females were killed. Reproductive data collected from 19 does revealed that breeding during 1979 probably occurred from early December through early January.

Night-lighting showed the same general trends in population increase that were apparent in the road-kill sample. The number of deer night-lighted in 1976 was 11/100 km, while in 1979 the number rose to 40/100 km.

The habitat evaluation which began in 1978 was continued in 1979, with a survey of the number of deer trails from a given habitat-type supplementing the radiotelemetry work. Results indicated a preference for cutover areas where immature pine, eastern red cedar, and grasses dominated and for pine plantations where shelter was provided. Upland hardwoods areas were the least preferred.

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INTRODUCTION

Collisions between white-tailed deer and automobiles continued to increase on the Department of Energy's Oak Ridge Reservation during 1979 (Story and Kitchings 1979, Kitchings and Story 1979). This report is the third in a continuing series designed to document information on road-killed white-tailed deer on the Reservation and to summarize year-by-year data from group research efforts. During the 1979 reporting period we continued collecting data on habitat usage, population density, and other physical parameters of the deer. Night-lighting data are presented for the period 1976-1979 as an index of population increase which complements the trend data collected on road-killed deer. Our attempt at determining habitat usage via radiotelemetric methods was supplemented during 1979 by a system of white-tailed deer trail censusing designed to establish habitat use.

The study area and general methods of data collection for the road-kill monitoring portion of this report dealing with road-killed animals were discussed in detail by Story and Kitchings (1979); methods for night-lighting and trail censusing are discussed in those sections.

RESULTS OF 1979 ROAD-KILLED WHITE-TAILED DEER MONITORING

During the calendar year 1979, 73 deer were recorded killed by vehicles on the Reservation. Forty-two (57%) of these were males, 26 (36%) females, and 5 (7%) were recorded as unknowns. As noted in our previous documents, unknowns resulted from collisions in which the deer were not killed outright and escaped. Fifty-four of the 68 deer

recovered were weighed and aged, 12 animals were too badly damaged to obtain usable data, and two carcasses were removed by unknown individuals before ESD personnel could get to the accident scene.

Figure 1 compares the number of white-tailed deer killed by vehicles annually from 1969-1979. The 73 animals killed during 1979 are fewer than predicted in our first report (Story and Kitchings 1979). Using the method described in the 1969-1977 report, we calculated a linear regression equation: $y = 1.03x^{0.4018}$, $r^2 = 0.966$, where y = number of deer killed and x = the number of years since the study began (1969 = 1). The rate of increase (0.4018) represents a decrease in the annual road-kill rate from the value of 0.4379 determined using the 1969-1977 data. As last year, the reduction in the rate of road-kills could reflect some success with the Tennessee Wildlife Resources Agency's (TWRA) trap-removal program on the Reservation. TWRA removed 25 deer (14 males, 11 females) from the Reservation during 1979 - an increase of eight from 1978. A greater degree of driver awareness and caution in areas where deer have been killed frequently in the past could be a contributing factor even though traffic usage and patterns did not change significantly from those reported earlier (Story and Kitchings 1979).

Traffic records indicate an 8.2% annual increase for the Reservation (Story and Kitchings 1979), and, while records were not available for 1979, the Tennessee Department of Transportation (Wayne Lockett, personal communication) estimates a 4% annual increase in traffic statewide. The traffic increase during 1979 on the Reservation

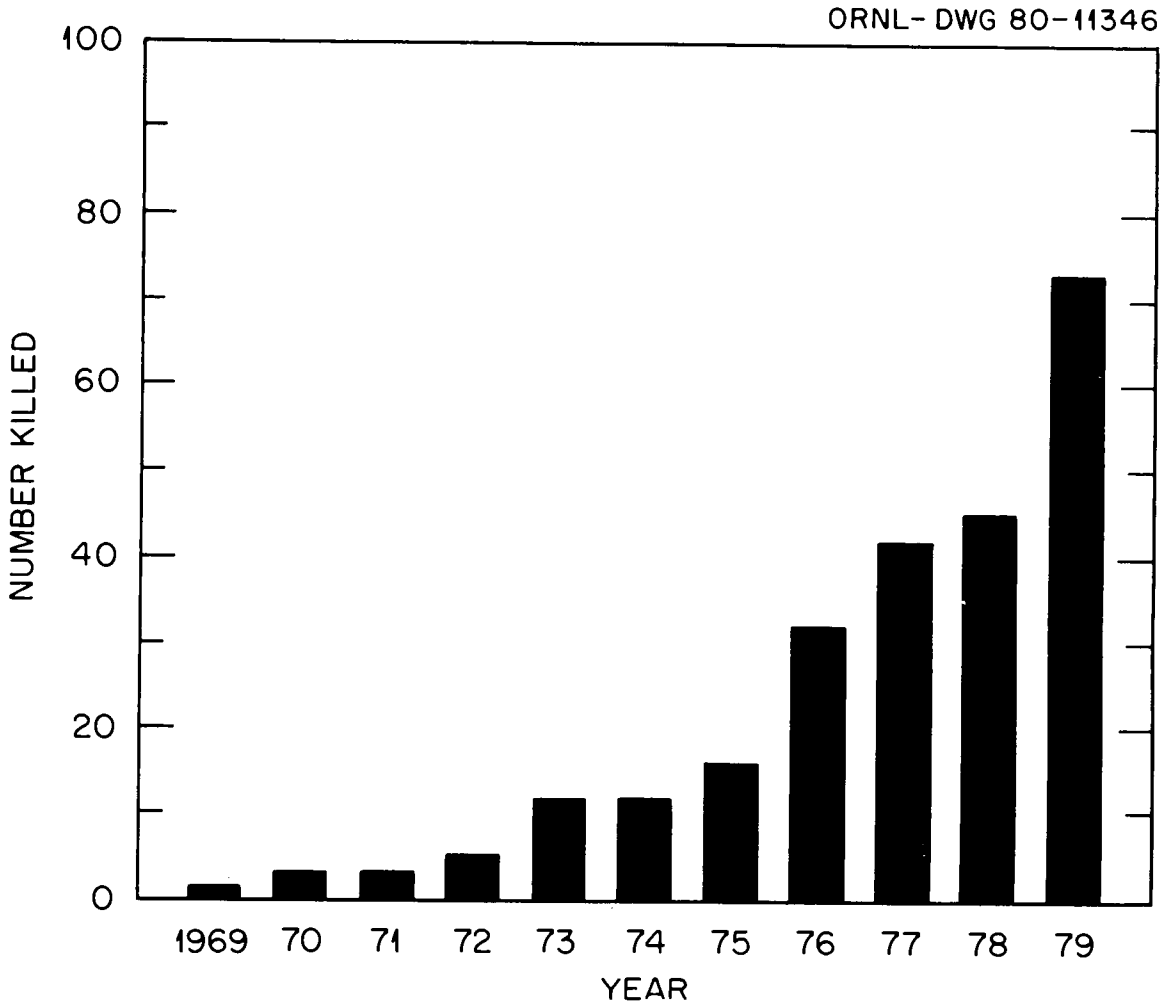

Fig. 1. Number of white-tailed deer killed by vehicles annually from 1969-1979.

could reasonably be estimated at between 4 and 8%, because car- and van-pooling, which was being encouraged, probably reduced traffic somewhat from the 8.2% increase.

Illegal killing of deer on Reservation lands also is known to occur. Several instances were observed during the past two to three years, and in 1973 three individuals removing a carcass of a freshly killed deer from the Reservation were apprehended by TWRA officers. Gun shots have frequently been heard on the Reservation by both ESD personnel and other Union Carbide employees. Unsubstantiated reports of the illegal removal of from 25 to 100 white-tailed deer per year have been reported to us. Obviously, verifying these figures is impossible; thus, the impact of poaching on the deer population cannot be estimated.

Distribution of Road-Killed Deer by Season, Sex, and Age

Data collected in 1979 again show a bimodal seasonal distribution for road-kills (Fig. 2). October, November, and December were the months when the greatest number of deer was killed, with twice as many bucks as does being killed. During the whole year, the sex ratio of animals killed was 1.6:1 (males to females), slightly less than the 2:1 ratio reported for 1978. As discussed in earlier reports, the higher male to female ratio of road-killed deer on the Reservation may be the result of not having a differential harvesting program.

The age distribution of road-killed animals is shown in Table 1. In 1978, more male than female fawns were killed by vehicles. In 1979 approximately equal numbers of fawns of both sexes were killed (11 males

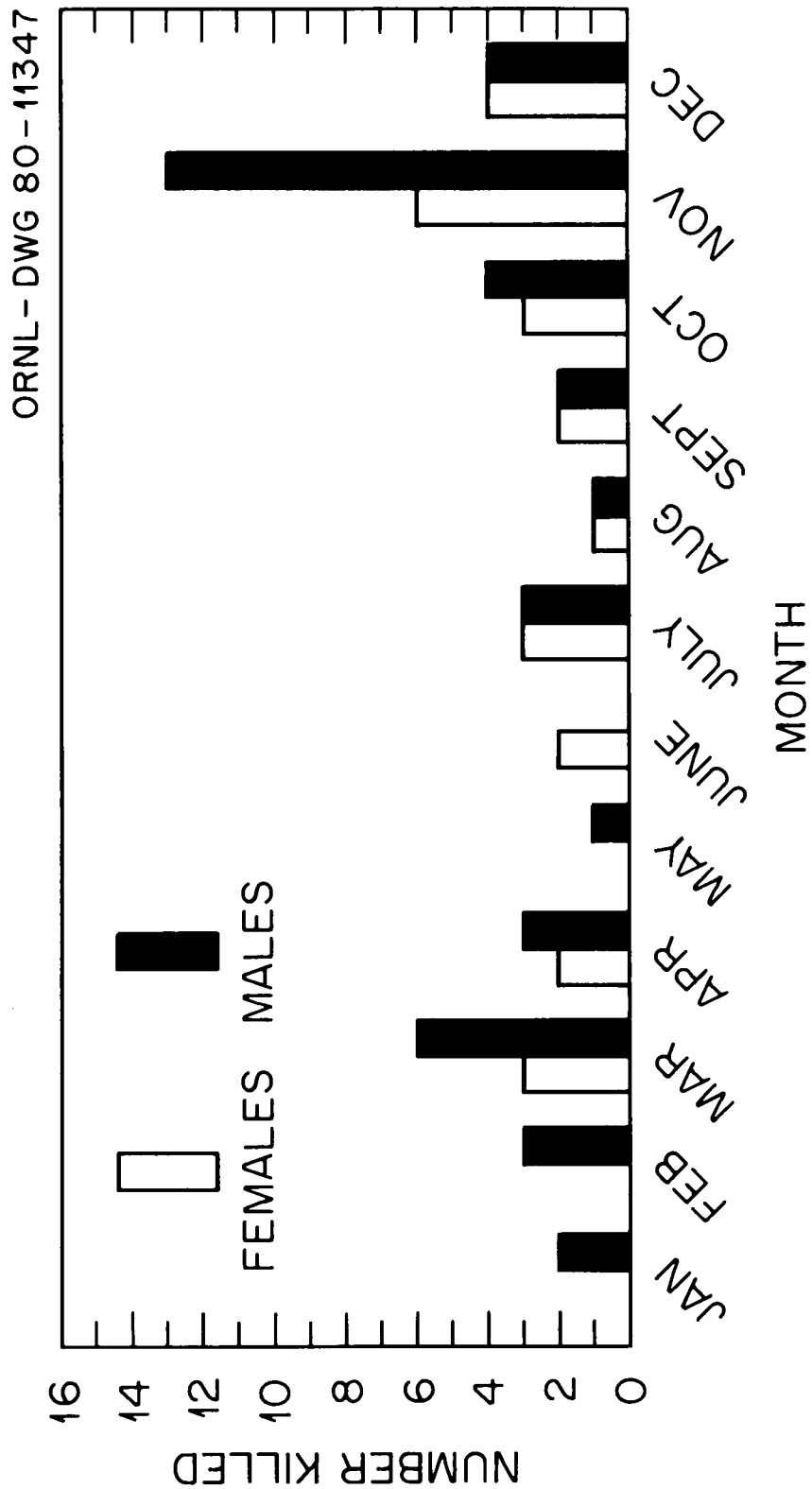

Fig. 2. Distribution of road-killed white-tailed deer during 1979 by month and sex.

and 10 females). There were, however, three times as many males as females in the 1.5-year age group. (The 1.5-year age group refers to animals between the ages of 1 and 2; the same applies to the other groups).

Table 1. Distribution of road-killed deer during 1979 by age. These deer include the 55 animals for which both sex and age information could be determined.

	Age group (years)					
	Fawns	1.5	2.5	3.5	4.5	5.5+
Male	11	13	2	5	4	0
Female	10	4	4	1	1	0
Total:	21	17	6	6	5	0

Table 2 shows data on the age distribution (% of total sample) from 1975 through 1979. Because the deer population on the Reservation appears to be increasing, no attempt to compute stable age distribution has been made. Also, because the sample sizes are still relatively small, especially for males during 1975 and 1976 and females during all years, tests of homogeneity on changes in the structure of age groups over time were not computed. For males, there seems to be a trend of increasing road-kill deaths in the 1.5-year age group and a decrease in the deaths in the 2.5-year age group, which might be attributable to changes in the populations of these two groups. Detection of changes of this nature must wait for a few more years of data accumulation.

Table 2. Age distribution of white-tailed deer road-killed on the Oak Ridge Reservation

Year	n	Age groups (years)					
		Fawn (%)	1.5 (%)	2.5 (%)	3.5 (%)	4.5 (%)	5.5+ (%)
				Males			
1975	9	33.3	44.4	0.0	11.1	11.1	0.0
1976	15	13.3	26.7	20.0	26.7	13.3	0.0
1977	26	23.1	7.7	26.9	15.4	19.2	7.7
1978	21	47.6	23.8	4.8	9.5	14.3	0.0
1979	35	31.4	37.1	5.7	14.3	11.4	0.0
Total males killed	106						
				Females			
1975	2	50.0	50.0	0.0	0.0	0.0	0.0
1976	5	40.0	20.0	40.0	0.0	0.0	0.0
1977	8	37.5	25.0	37.5	0.0	0.0	0.0
1978	16	25.0	37.5	18.8	12.5	6.3	0.0
1979	20	50.0	20.0	20.0	5.0	5.0	0.0
Total females killed	51						

Geographical Distribution of Road-Killed Deer

The geographical distribution of road-killed deer was similar to that reported for 1978. Areas of notable increase were in the vicinity of the intersection of State Highways 58 and 95, Highway 58 from Highway 95 to Gallaher Bridge, and Bethel Valley Road from Highway 95 to Walker Branch Embayment (Fig. 3). Road-kills at the Highways 58/95 intersection area numbered two in 1978 and twelve in 1979. Along Highway 58 in front of ORDGP ten were killed in 1978 and sixteen in 1979, and along Bethel Valley Road six in 1978, compared to eleven in 1979. Five deer were killed on secondary roads on the Reservation in 1979 compared to one in 1978 and none during the 1969-1977 period. Discussion of habitat types in these areas and their influence on deer-vehicle collisions is presented in the "habitat evaluation" section of this report.

Accidents by Time of Day

Two 2-h time periods - 0600 to 0800 hours and 2200 to 2400 hours - accounted for 45% of all deer-vehicle collisions (Fig. 4). Twenty-five percent (16) of the deer were killed during the heavy traffic 0600 to 0800 hours period and 20% (13) were killed during the 2200 to 2400 hours period when deer activity is probably at its maximum.

Summary Statistical Data

Table 3 gives a summary of data for the 55 deer killed on the Reservation during 1979 for which both weight and age could be determined. Bucks had significantly higher weights than did the does in both the 1 to 2- and the 2-year-old age groups. Weight and age data for both sexes were about the same as reported for 1978.

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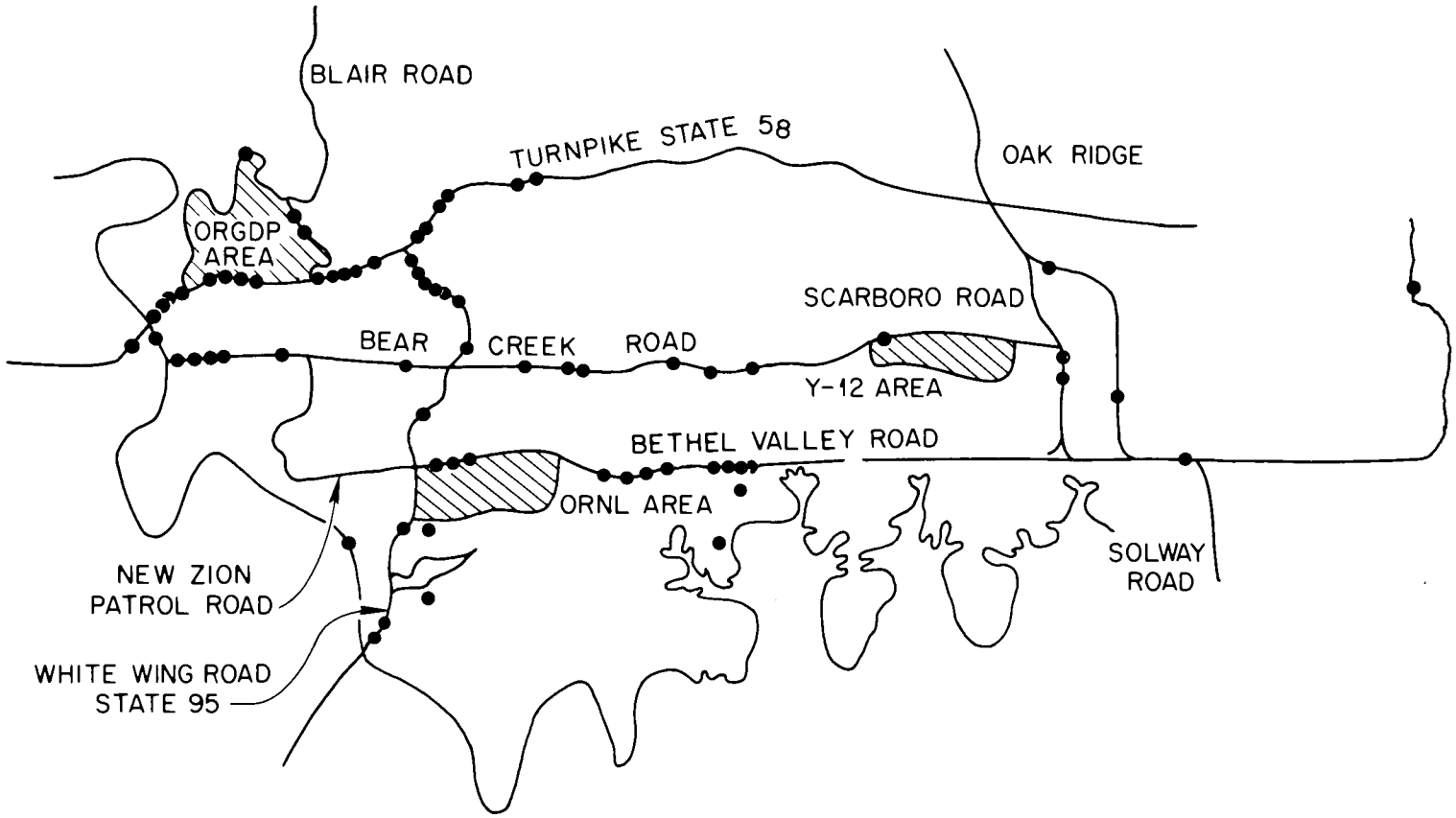

● DENOTES SPOT WHERE A WHITE-TAILED DEER WAS KILLED BY A VEHICLE

Fig. 3. Locations of road-killed white-tailed deer on the Oak Ridge Reservation in 1979.

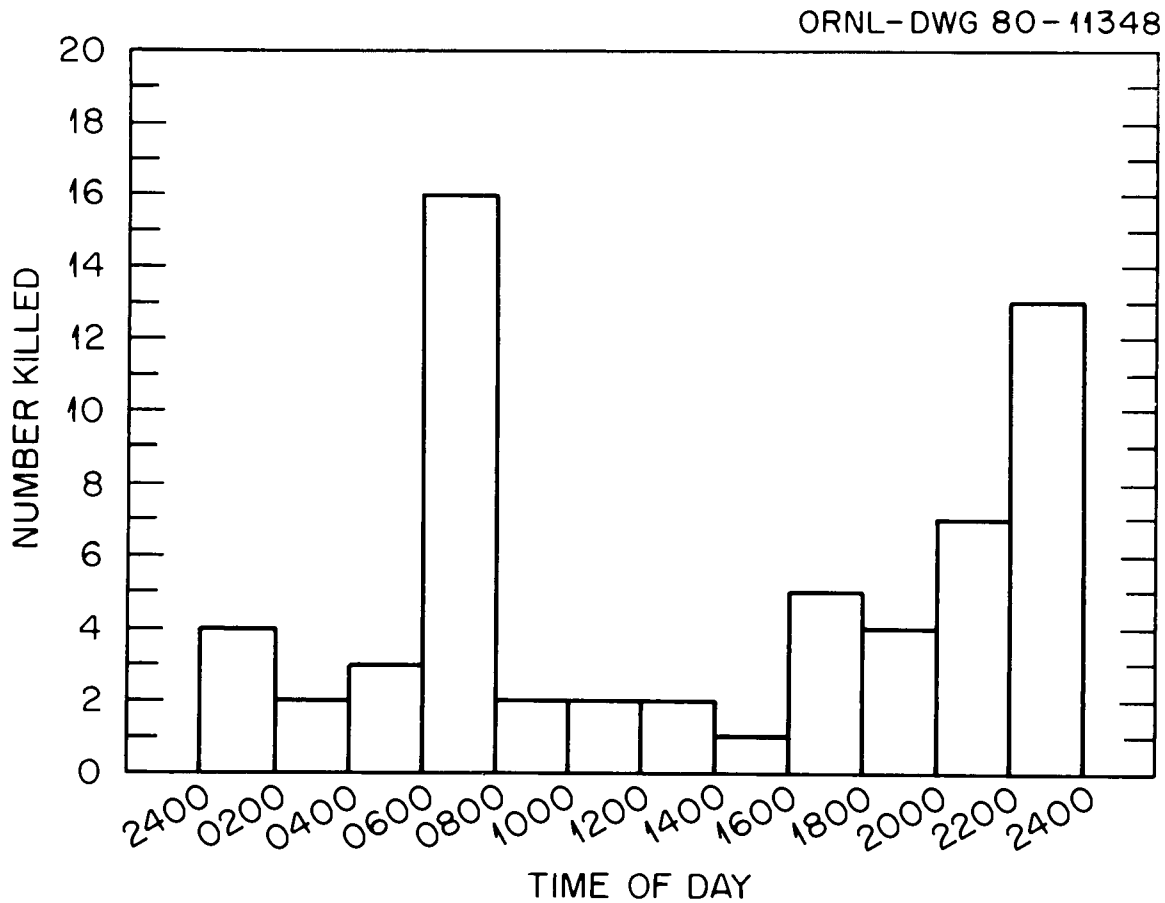

Fig. 4. Road-killed white-tailed deer by time of day during 1979.

Table 3. Summary data for white-tailed deer killed on the Oak Ridge Reservation during 1979. Animals included are ones where both weight and age were known. Percent of total is based on the total number of does and bucks (55) killed during this period.

	Does				Bucks			
Age	Number killed	% of total	Av weight[a] (kg)	Av age[a] (months)	Number killed	% of total	Av weight[a] (kg)	Av age[a] (months)
Less than 6 months	3	15	27.4 ± 1.4	4.7 ± 0.3	5	14	28.2 ± 4.7	4.1 ± 0.5
More than 6 months, less than 1 year	6	30	34.7 ± 1.3	9.0 ± 0.7	6	17	39.6 ± 1.7	9.3 ± 0.7
More than 1 year, less than 2 (1.5-years)	4	20	46.0 ± 4.5	13.6 ± 1.6	13	37	60.0 ± 2.3	18.5 ± 0.8
Two years and older	7	35	56.1 ± 2.5	33.9 ± 3.6	11	32	79.4 ± 3.5	45.6 ± 2.6
Total number killed	20				35			

[a]Means ± 1 standard error.

Reproduction

Reproductive tracts from 19 (not all road-killed) does were examined during 1979. Between March and July, seven of the 11 does that were examined were found to be pregnant. Information on six of the pregnant animals is shown in Table 4.

Based on these data, breeding appears to have occurred between early December and early January. From August through December, eight does were examined with four lactating, one adult not lactating and not visibly pregnant, two fawns not visibly pregnant, and one fawn possibly pregnant. One of the four lactating does was an adult (killed November 7) that was possibly pregnant. Three does were trapped and tagged in 1979; one on April 12 was pregnant, one on September 11 (fawn) was not visibly pregnant, and one on September 11 was lactating (adult).

Table 4. Age and sex of fetuses found in six pregnant does during 1979

	Age of fetuses (days)	Number and sex of fetuses	Age of doe (months)
March 19	96-105	1 male	30-36
March 26	106-110	1 male	9-11
March 30	96-105	2 (1 male, 1 female)	9-11
March 30	106-110	1 female	9-11
June 5	151-180	1 female	11-13
July 4	151-180	1 female	9-11

USE OF NIGHT-LIGHTING TO ESTABLISH POPULATION TRENDS

Deer have been censused, historically, by a number of methods: direct counting via herd drives, aerial counts, pellet count, capture-tag reobservation, radioisotope analysis of fecal groups, and night-lighting animals along transects. All the censusing methods, with the exception of direct counting which is impractical on the Reservation because of terrain and manpower requirements, have limitations which make their value questionable. Fecal pellet group counting in the Southeast is unreliable because of the rapid disintegration of the pellets (Downing et al. 1965) and capture-tag and radioisotope analyses require tagging of significantly large portions of the population which is logistically impractical (Standguard 1967). As an estimator of absolute density, night-lighting is hindered by variations in monthly climatic conditions and observor error, and is biased toward counting animals only in areas where they are easily observed, thus causing an underestimation of population size (Flynn 1976). However, night-lighting results can be used to discern changes in population trends, and in this case it provides a data set complementary to that obtained by road-kill monitoring.

Methods

Night-lighting routes were established in 1976 to cover the Reservation main roads and many of the secondary roads as well. This route covers approximately 112 km. In 1978, the route was reduced to one-half (56 km) that covered in 1976 and 1977. Night-lighting on a monthly basis was terminated in June 1979 when shortages of gasoline limited field work.

Sources of light were two hand-held 200,000 candle-power aircraft landing lights. The area immediately adjacent to the road was swept by the light; whenever deer were spotted, the vehicle was stopped so that animals could be counted and sexed when possible (Flynn 1976).

Results and Discussion

The total number of deer night-lighted over the 3.5 years was 676 on 5276.8 road km (Table 5). The index value (deer/100 km) increased from 11 in 1976 to 40 during the five months in 1979 that the survey was conducted (Fig. 5). When the June-December counts for 1976-1978 are eliminated to match the months counted in 1979, the emerging pattern is still very much the same (Fig. 6), i.e., a decline in 1977 from 1976 and a continuing increase in 1978 and 1979.

Table 5. Number of white-tailed deer observed while night-lighting on the Oak Ridge Reservation, 1976-1979. Data collected in 1979 are for January-May; all other years are for January-December.

Year	Number of deer	Total distance driven (km)	Deer/100 km
1976	206	1860.8	11
1977	223	2408.0	9
1978	135	728.0	19
1979	112	280.0	40

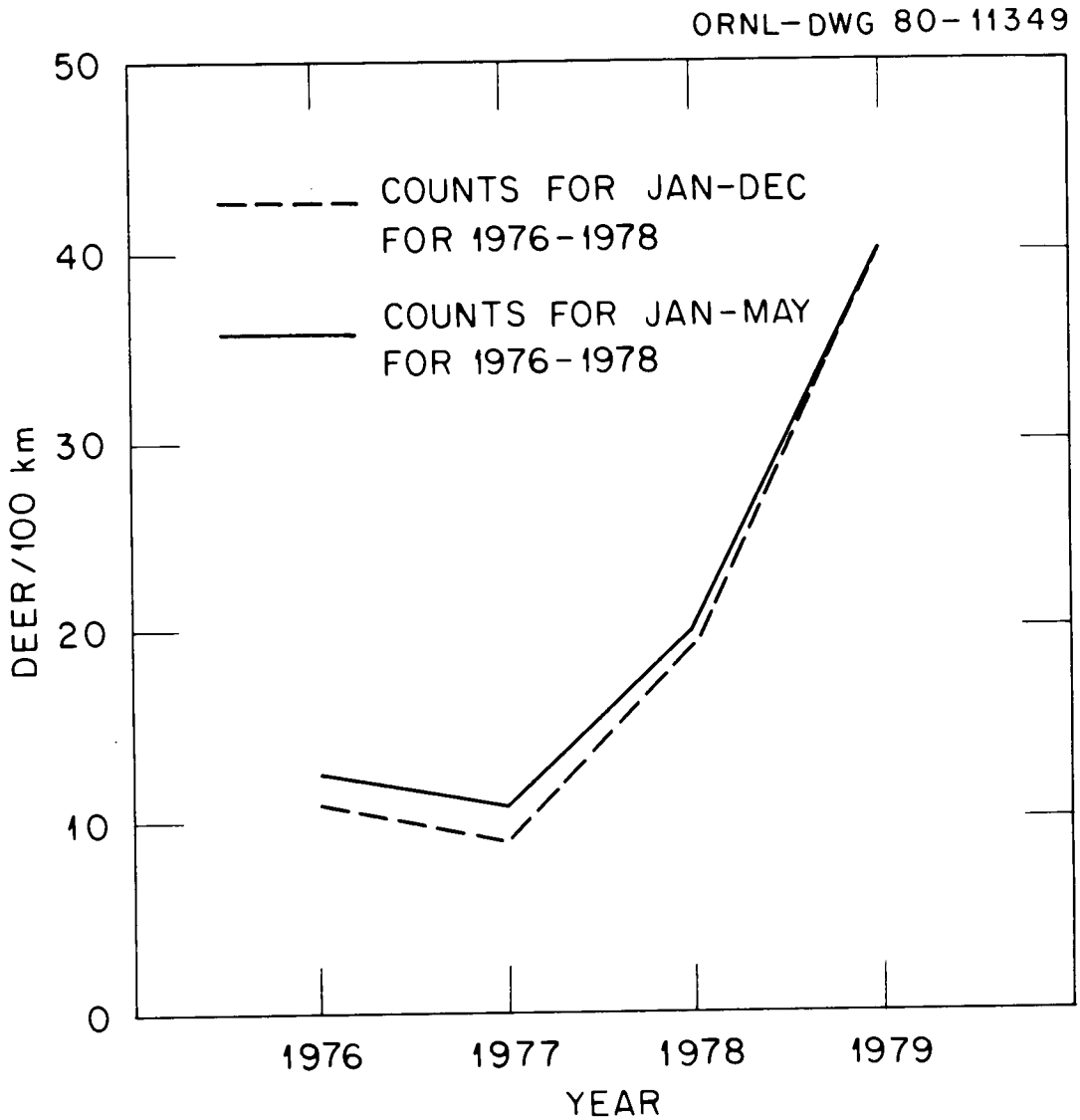

Fig. 5. Number of white-tailed deer observed (deer/100 km) by night-lighting from 1976-1979. The solid line represents the number counted during the entire calendar year for 1976, 1977, and 1978. The dashed line denotes elimination of the June-December data for 1976-1978 to match the months when animals were counted in 1979.

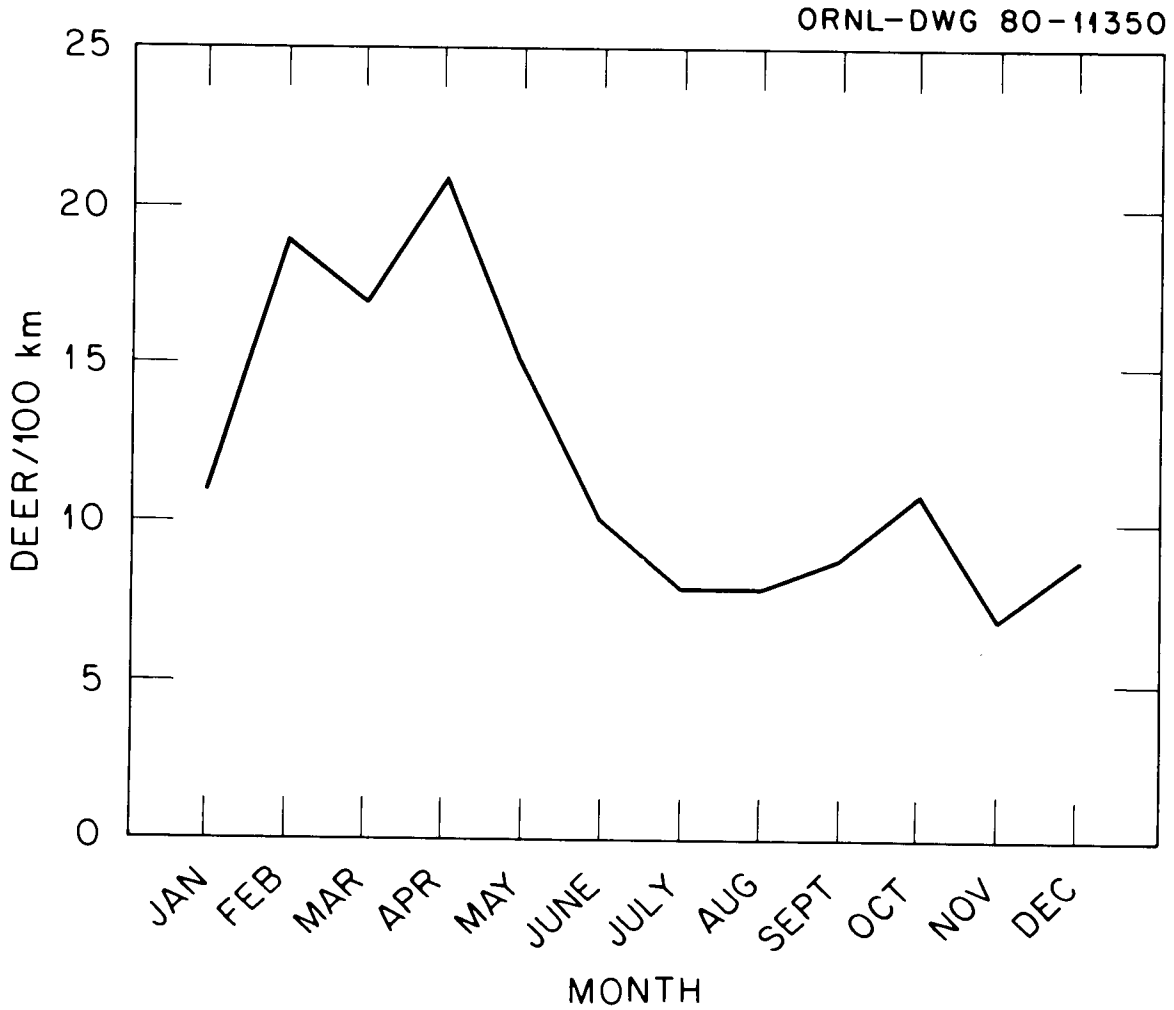

Fig. 6. Number of white-tailed deer observed (deer/100 km) by night-lighting on a monthly basis.

There is some seasonal influence on the number of animals seen while night-lighting (Fig. 6). Lumping the data from all years on a monthly basis, we see a peak in the number of animals observed during the spring of the year. The events during this time of year match the road-kill data reasonably well . Spring is a time of dispersion movements and increased food availability.

Our night-lighting data tend to support the conclusions reached from the road-kill data, i.e., the number of deer on the Reservation is still increasing dramatically.

HABITAT EVALUATION

Radiotelemetry Monitoring

In the 1978 status report, we described trapping and radio-tracking equipment and procedures (Kitchings and Story 1979). During the past year we continued to collect data on those deer outfitted with radio transmitters (2 does and 1 buck). One additional doe was captured September 11, 1979, and fitted with a radio-collar. However, the male which we had been radio-tracking was killed by a vehicle on Bear Creek Road on February 28, 1979.

Does #1 and #2 were located a total of 84 times each during the period January through September, while Doe #3 was located 19 times from September 11 through November 19.

The does which had been radio-tracked during 1978, #1 and #2, stayed within the same general area (Fig. 7) as reported previously (Kitchings and Story 1979). However, extensive timber harvesting and clearing activities appear to have caused an increase in their range.

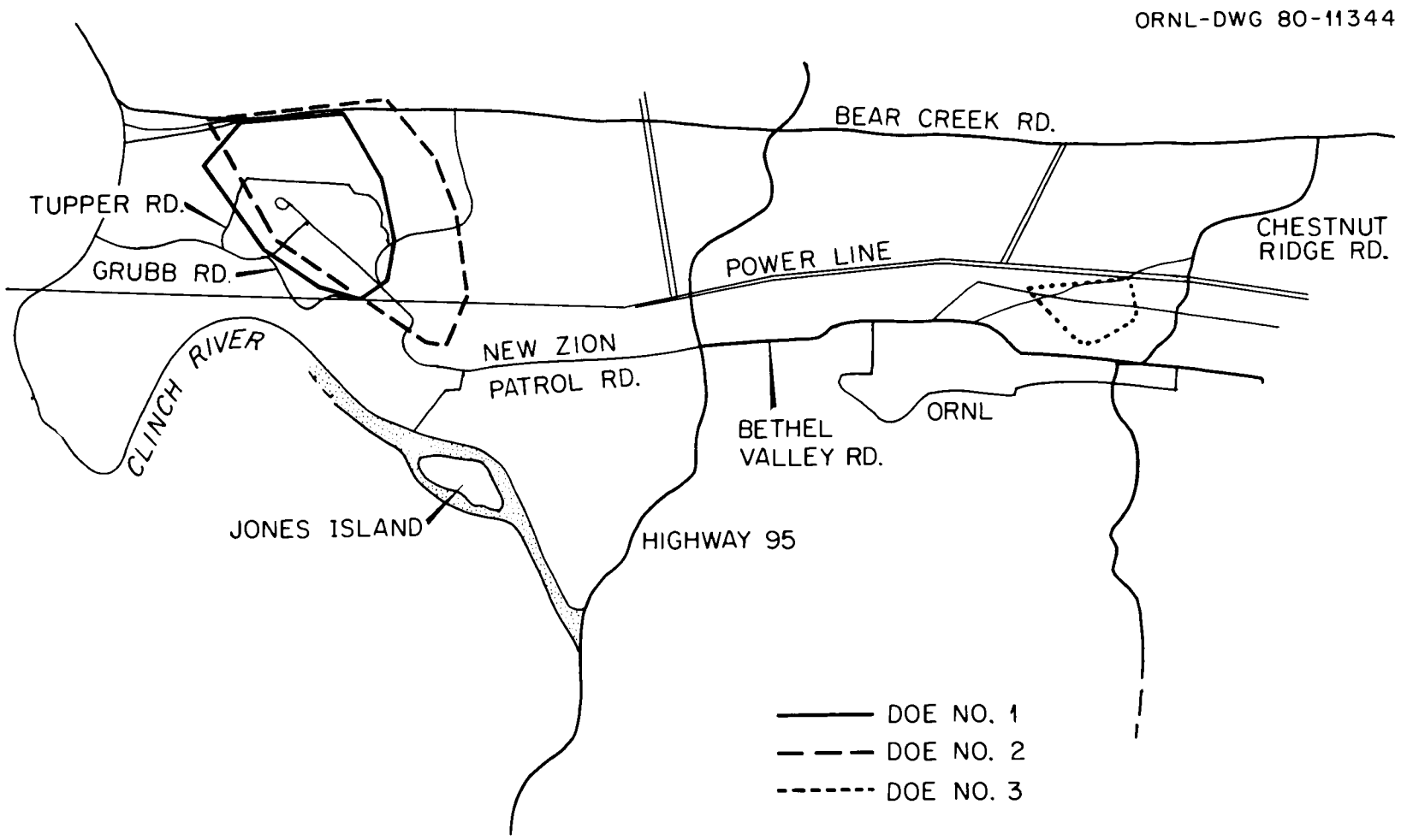

Fig. 7. Home range locations for three radio-collared female white-tailed deer tracked during 1979.

In 1978, Does #1 and #2 had a calculated range of 67 and 103 ha, respectively. In 1979 those areas more than doubled to 148 and 238 ha, respectively. Doe #3 was found where extensive maintained areas (predominately fescue grass which is cut on a regular basis) occur (Fig. 7), which provide ample grazing. In contrast to the other two does, #3 ranged over only 34 ha. Because data from these three animals did not provide a large enough sample base to assess habitat usage adequately, we began collecting habitat data using the method discussed in the following section.

Deer Trails as Indices to Habitat Use

Deer are year-round trail makers, and McCaffery (1976) demonstrated the utility of using the number of these trails in Wisconsin as an index to populations and habitat use. He found that the number of deer trails was closely correlated with the abundance of deer and that trail abundance was greatest in areas dominated by aspen, jackpine, pin oak, upland brush, and grasses. Learning the various habitats used by the white-tailed deer on the Reservation is an important element in attempting to develop a management plan to control numbers. Because the rugged and broken terrain precludes a comprehensive ground survey of population size, the ability to use deer trails to reflect abundance within various habitat types seemed appropriate. In 1977, we conducted a preliminary trail survey to determine if we could correlate trail numbers and various habitat and land-use parameters to supplement data collected by radiotelemetry. This effort was successful enough to prompt further investigation in 1979.

Trails were counted in late October-early November and were defined as distinct paths in ground vegetation caused by repeated deer use (Fig. 8). Seventeen survey transects, 1 km in length, were established along roads in the western portion of the Reservation. Trails which intersected the road were counted. By using roadways as the transect, the whole Reservation could be covered in a relatively short period of time. The transects were then divided into ten 0.1-km units and trails were placed within these units, resulting in a total of 170 units that were used in subsequent data analysis. Dividing the transect into 0.1-km units normally placed the unit within a single forest or land-use type. Transect segments were classified as having zero trails, one trail, or more than one trail.

Information on land use and habitat type was taken from ground surveys, forest inventory maps, and topographical maps (Table 6). Data were noted for the 0.1-km^2 (10-ha) area immediately surrounding the transect segment (Fig. 9).

Multiple stepwise discriminant function analysis (Cooley and Lohnes 1971) was used to evaluate the correlation between the measured habitat variables and the trail abundance categories.

In order to include only those variables in the multivariate analysis which would be most likely to contribute to differentiation between trail levels, univariate statistics were evaluated, and only those variables found to be significant ($P < 0.05$) were used. Of the original 14 variables measured, six were important in correlating habitat type and land use with the number of trails present (Table 7).

Fig. 8. An example of the distinct trail in ground vegetation caused by repeated deer use.

Table 6. Variables used to describe the habitat or land use within one of the 0.01-km^2 transect sampling units

Pnemonic code	Variable description
UPHD	Area, in hectares, covered by upland forest type within a 0.01-km^2 plot. Species typical of this type - red oaks, hickory, black oak, white oak.
BTHD	Same as UPHD except bottomland species (poplar, sycamore, ash, etc.) are dominant.
CUPN	Area which has either been cutover and now contains scrubby pine or cedar, or an area which was once shallow soil and has a park-like grazed appearance.
CUHD	Same as CUPN but current vegetation is hardwood scrub.
MXPH	Area of mixed pine-hardwoods; calculation of number of hectares present in transect segment.
CLCU	Bare ground, clear-cut areas; calculation of number of hectares present in loblolly, white, or Virginia pine.
RDWY	Old logging road with right-of-way; distance in meters through the transect segment.
ROWX	Right-of-way; number of hectares in segment.
DIHO	Distance to a stream, lake, or other body of water, in meters.
ELVA	Elevation of transect segment center, in meters.
SLPE	Slope across segment.
NONF	Calculation of number of hectares of maintained area within segment, i.e., coal yards, junk yards, etc.
NAPI	Calculation of number of hectares of naturally occurring pine stands within segment.

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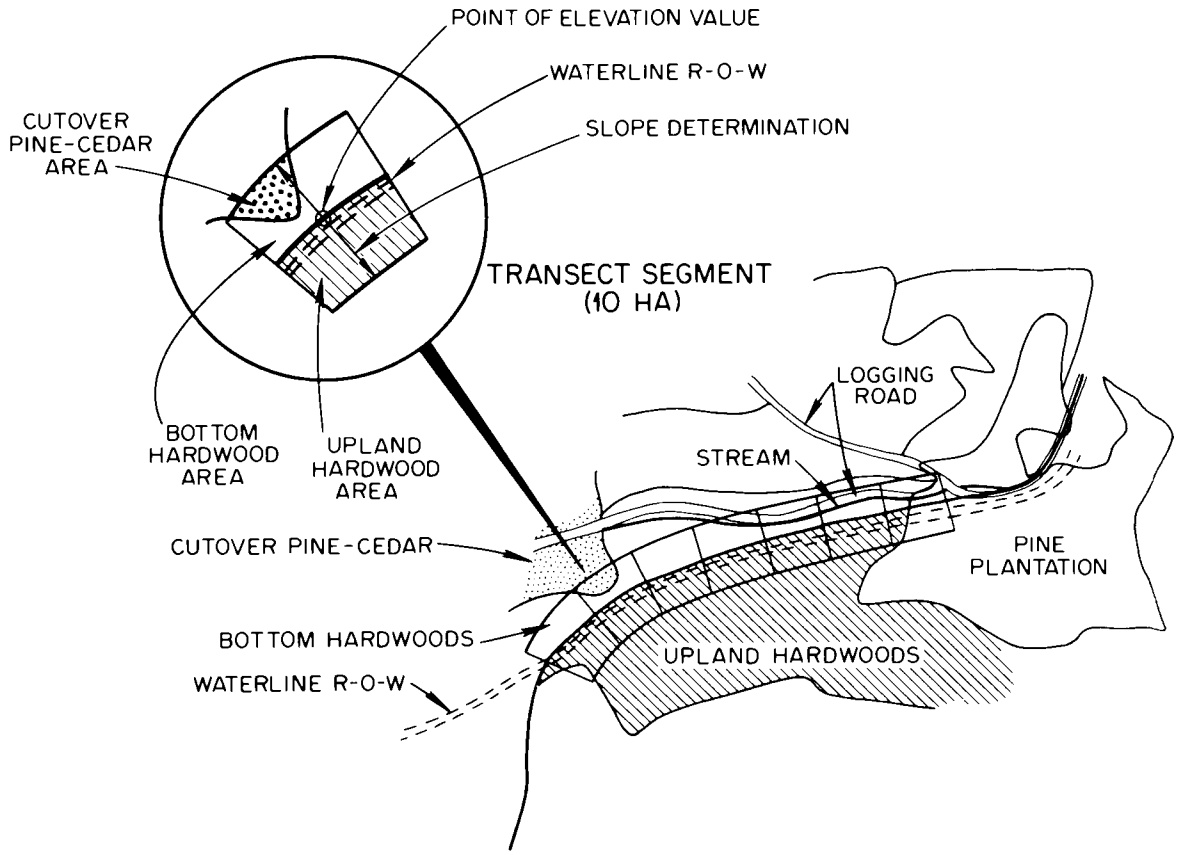

Fig. 9. Deer trail transect showing how variable information was taken from habitat map. Area of each type was calculated using a dot grid from the ten 0.1-km segments. (R-O-W = right of way).

The more upland hardwood forest within the plot, the less likely it becomes to find an abundance of deer trails. When the entire transect segment was virtually all upland hardwoods no trails were found (Table 7).

The number of trails was also significantly influenced by the amount of bottomland hardwoods, mixed pine hardwoods, and pine plantations present within the 10 ha. Additionally, the amount of area

Table 7. Means[a] for the six significant habitat variables used to classify transect segment into deer habitat potential. Numbers in parentheses indicate the number of sample segments in each group.

	Group[c]		
Variable[b]	1 (92)	2 (59)	3 (19)
UPHD	9.98 ± 0.98	5.97 ± 1.09	3.24 ± 1.20
BTHD	0.40 ± 0.20	1.77 ± 0.58	0.33 ± 0.33
CUPN	0.50 ± 0.29	1.02 ± 0.44	4.54 ± 1.57
MYPH	1.71 ± 0.47	0.42 ± 0.24	3.57 ± 1.65
PIPL	2.84 ± 0.60	5.95 ± 1.07	6.85 ± 1.97
SLPE	17.80 ± 1.3	16.60 ± 2.10	22.80 ± 1.90

[a]Mean ± 1 standard error.

[b]For explanation of pnemonic designation, see Table 6.

[c]Group denotes: 1 = no trails present, 2 = one trail present, and 3 = more than one trail present.

within a transect segment which had been cut and which had scrub pine as the principal cover was significant. Finally, the slope across the transect segment was significant at the $P < 0.05$ level with the greatest abundance of trails found on the less-steep slopes. This correlation is probably indicative of the deer's use of gap areas in traversing rough terrain.

While univariate analysis points to those individual variables which influence the abundance of deer trails, it does not describe how the variables interact. A multiple stepwise discriminant function was used to reduce the data to linear combinations which describe a two-dimensional space containing the abundance data. The F-ratio for overall discrimination was significant at the $P < 0.01$ level ($F_{12,324} = 2.27$). This indicates that the positions of the three trail classes within the two-dimensional space are different.

The first discrimination function (DF-I, Fig. 10) accounted for 58% of the discriminating information and the second (DF-II, Fig. 10) for 42%. The two axes are interpretable by observing the factor patterns (product moment linear correlation, r, Table 8) between the functions and the variables. The DF-I is composed of amount of upland hardwoods (UPHD, $r = -0.65$), the area of pine plantation present within the transect segment (PIPL, $r = 0.53$), and contour areas with scrubby pine-cedar (CUPN, $r = 0.69$). The position of the three classes on this scale (Fig. 10) indicates that transect segments with the greatest number of trails occur in areas of scrubby pine-cedar and pine plantations with very little upland hardwoods present. As upland hardwoods begin to dominate the segment, the usage by many deer tends to decrease.

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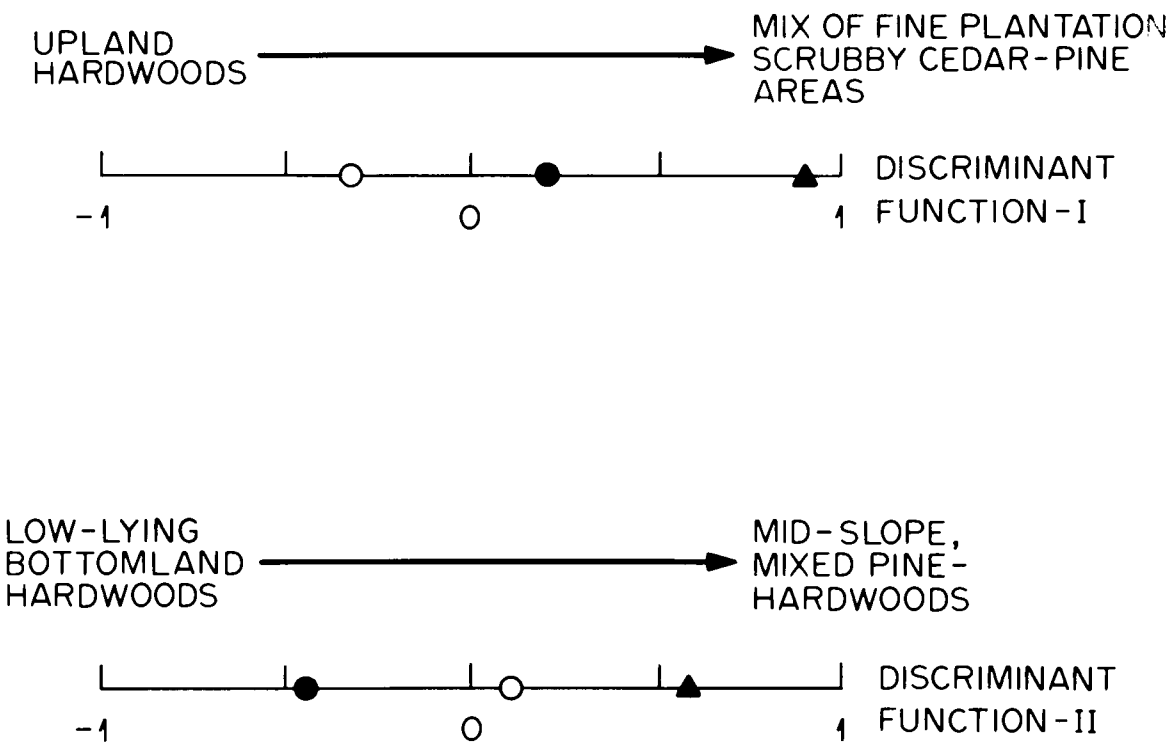

Fig. 10. Position of trail abundance groups on two discriminant-function axes: ○ = Group 1, ● = Group 2, and ▲ = Group 3. Discriminant function I describes a gradient from segments dominated by upland hardwoods to one of pine plantations mixed with scrubby pine-cedars. Discriminant function II moves upslope from low-lying bottomlands to mid-slope mixed pine-hardwoods.

Table 8. Factor patterns (r) for each variable and the discriminant functions.

Variable	Discriminant function I	Discriminant function II
UPHD	-0.65	0.14
BTHD	0.18	-0.56
CUPN	0.69	0.40
MXPH	0.13	0.60
PIPL	0.53	-0.23
SLPE	0.11	0.52

The second axis (DF-II) represents the combination of bottomland hardwoods (BTHD, r = -0.45), mixed pine-hardwoods (MXPH, r = 0.60), and the slope across the transect segment (SLPE, r = -0.52). The class positions can be interpreted to show that a few deer may use the low-lying bottomland hardwoods, but one would be more likely to find a greater number of deer using midslope, mixed pine-hardwood areas (Fig. 10).

Both food resource availability and shelter needs are reflected in the discriminant axes. The correlation of scrub pine-cedar areas and heavy usage by deer would be expected, because this type of area supplies browse and grazing material for food. Fescue and other grasses are available in these cutover- or old-field-type areas and are used heavily by the Reservation deer. The bottomland area usually offers a variety of browse species which are also used as food stuff, while the pine plantations and mixed pine-hardwoods provide shelter.

From the results of our radiotelemetry and habitat-usage analysis, it would seem that the clearing of blocks of hardwood forest near the major highways and the planting of pine plantations in their stead has contributed to attracting deer to the highways, increasing the chance of deer-vehicle collisions. Maintenance of wide strips of highway rights-of-way adjacent to power lines and gas lines has also apparently contributed to the increase in road-kills observed over the past years. How much of a contribution we cannot estimate, but, creating prime deer habitat along major roads can only help to increase the road-kill rate of the rapidly expanding Reservation deer population.

CONCLUSIONS

1. The population of white-tailed deer on the Oak Ridge Reservation is increasing, based on the continued increase in automobile/deer collisions. The rate of increase slowed during 1979 and may be attributable to the trap removal efforts of the Tennessee Wildlife Resources Agency.
2. Based on habitat preference data, land management practices appear to create habitat which attract deer. The positioning of these prime habitat areas along major Reservation roadways may contribute to the automobile/deer collisions by attracting deer to areas of heaviest traffic use.

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