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Density and distribution of whitetailed deer (Odocoileus virginianus) on the Energy Research and Development Administrationś Oak Ridge, Tennessee Reservation

Dwight Charles Flynn

To the Graduate Council:

I am submitting herewith a thesis written by Dwight Charles Flynn entitled "Density and distribution of whitetailed deer (Odocoileus virginianus) on the Energy Research and Development Administrationś Oak Ridge, Tennessee Reservation." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Michael R. Pelton, Major Professor

We have read this thesis and recommend its acceptance:

Ralph W. Dimmick, Boyd L. Dearden, James L. Byford

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Ralph W. Dimmick

Accepted for the Council:

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DENSITY AND DISTRIBUTION OF WHITETAILED DEER (ODOCOILEUS VIRGINIANUS) ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

A Thesis

Presented for the

Master of Science

Degree

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Dwight Charles Flynn

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ABSTRACT

This study was conducted on 6,340 ha (15,666 acres) in the western section of the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation. The objectives were to determine the density and distribution of whitetailed deer. Techniques for determining density included: (1) pellet group surveys, (2) night-lighting counts, (3) roadside counts, (4) radioactive feces tagging, and (5) mark-reobservation. Distribution was determined by using (1) five years of road-kill data, (2) night observations, and (3) pellet group locations on transects. Concurrent studies testing the techniques of pellet group surveys and night-lighting counts along with a study of deterioration of pellet groups were conducted on the Chuck Swan Wildlife Management Area.

An average of 6.57 pellet groups per hectare (2.66/acre) was recorded on the Reservation. The pellet group count was too low for a valid estimate of deer density. An average of 289 pellet groups per hectare (113/acre) was recorded on the Chuck Swan Wildlife Management Area resulting in a density estimate of one deer per 4.05 ha (10 acres).

A mark-reobservation program was conducted from December 1974-September 1975 on Section A of the study area. Eighteen of 404 observations were of marked animals. Based upon the

Schnabel method, a density estimate of one deer per 51 ha (125 acres) resulted.

Night-lighting counts, with density estimates based upon the King method, were conducted on Section A of the study area from December 1974-September 1975. The average estimate was one deer per 114 ha (281 acres). Night-light counts conducted on the Chuck Swan Wildlife Management Area during July, August, and September 1975, yielded an average estimate of one deer per 7.83 ha (19.36 acres). This density estimate was 1.9 times lower than density estimates reported by the Tennessee Wildlife Resources Agency and previously mentioned pellet group surveys.

Seven deer were radioactively tagged with Zn-65 from December 1974-September 1975. Thirty-two pellet groups were collected from Section A of the Reservation, three of which were radioactively tagged. Using the Lincoln Index, the density estimate was one deer per 47 ha (115 acres).

Density estimates based upon radioactively tagged feces (Lincoln Index) and mark-reobservation (Schnabel's method) were believed to be more accurate than density estimates based upon night-light counts (King method).

Sections of higher deer density observed on the study area were: (1) the 0800 Area, (2) Burial Ground Number Three, (3) Chestnut Ridge Gap on White Wing Road, (4) the old construction camp site southeast of K-25, (5) Bethel

Valley from 7600 Area west to X-10, and (6) Bear Creek and White Wing Road intersection.

Deterioration and/or disappearance of pellet groups marked in July 1975 on the Chuck Swan Wildlife Management Area was 5 percent during a one month period from July through August and 20 percent during a two month period from July thru September 1975. In comparison, 24 percent of the pellet groups marked in August were not found one month later in September 1975. Further study is necessary for a better understanding of pellet group deterioration and/or disappearance rates in the Southeast.

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CHAPTER I

INTRODUCTION

A primary objective in many studies of wildlife populations is to determine population density based on one or more census techniques. All of the five basic census methods described by Overton (1969) (direct counts, animal signs and relative objects, marked animals, reduction of population size and rate of capture, and selective reduction or increase) have been used to estimate population numbers of whitetailed deer (Odocoileus virginianus) or to show a population trend.

Direct counts include techniques such as drive counts (Adams 1938, Morse 1943, Olson 1936), aerial surveys (Petrides 1953), infrared surveys (Parker 1972, McCullough et al. 1969), and extermination (Leopold 1933) which attempt to account for each individual in the population. Also included as direct counts are sample censuses (Tyson 1952), the King method (Erickson 1940, King 1937, Krefting and Fletcher 1941), the Hahn method (Teer 1966), and road-kills (Jahn 1959, McCaffery 1973).

Track counts, pellet groups, and summer beds are three census methods that utilize animal signs as a means of population estimation. Tyson (1959) presented a model of track counts as a function of numbers of deer. Since then,

track counts have been incorporated into research plans where other methods fail to meet the objectives (Brunett and Lambou 1962, Downing et al. 1965, Sittler 1965). Pellet group counts were used extensively by Bennett et al. (1940) and have received much attention in sections of the United States where deterioration or insect damage to pellet groups is insignificant (Neff 1968, Rogers et al. 1958, Thompson 1955, White 1968). Little emphasis has been placed on pellet group counts in the Southeast due to deterioration and insect damage (Downing et al. 1965). Erickson (1940) considered summer deer beds as a valuable index to aid in determining population densities and age classes of deer.

Census methods involving marked animals are very useful in wildlife management when assumptions pertinent to the index are realized. Lewis and Safley (1966), using hunter returns of tagged deer, reported that the Lincoln Index provided the most reliable population estimate when compared to other methods. Standgaard (1967) found that more than two-thirds of the population must be marked to obtain a reliable population estimate when using the Lincoln Index and a mark-reobservation technique on a roe deer (Capreolus capreolus) herd. Lueth (1965) used a modified Schnabel estimator to interpret marked-retrap data from two deer herds in Alabama and found a negative error greater than 10 percent of the "guesstimated" populations.

The Leslie Method and DeLury's Method are two census methods involving reduction of the population size and rate of capture. Lewis and Farrar (1968) attempted to use the Leslie Method on a Tennessee deer herd but received varying results compared to other methods. They concluded that all assumptions basic to the method were not met. Howe (1954) used Delury's Method on the Rifle River Game Area in Michigan and received a higher estimate of the deer herd density than with comparative methods.

The method of selective reduction or increase to estimate wildlife populations was first used by Kelker (1940, 1944) to estimate deer herd density in Utah, while Dasmann (1952) used a similar technique in his deer population research in California.

Wildlife managers are continually developing census methods which will result in a more accurate density estimate of wild populations than established methods. Miller (1957) studied vole movements by using feces tagged with radioactive materials. On the basis of his research, he suggested using radioactive feces tags for determining population densities. Nellis et al. (1967) used Zn-65 as a feces tag for four species of mammals and concluded that the technique was excellent for long-term marking of feces in censusing, home range, and migration studies. Pelton (1972) suggested that radioactive feces tags may be a useful technique for

estimating black bear (Ursus americanus) population density. Based on this suggestion, Marcum (1974) compared radioactively tagged feces with mark-reobservation data as means of estimating black bear population densities. He concluded that the method of radioactively tagged feces was more accurate.

The present study is an initial attempt to determine the population density and distribution of whitetailed deer on the Energy Research and Development Administration's (ERDA) Oak Ridge, Tennessee Reservation. The Oak Ridge National Laboratory (ORNL) deer herd has no known origin. It is hypothesized that the deer herd either developed from a remnant population present when the Reservation was purchased in 1942 or resulted from immigration into the Reservation from adjacent areas in the early 1950's (Howell and Dunaway 1959). Records of the Tennessee Wildlife Resources Agency indicate Anderson and Roane County's first deer hunt, conducted in 1956, yielded a total of seven deer. These two counties were closed to deer hunting in 1957 and reopened in 1962. Total yearly deer harvest for the two counties has fluctuated considerably since 1962 never having been more than 45 deer per season. Anderson County was stocked in 1968 with eight bucks and 35 does (Larry Marcum, personal communication).

Records of deer/vehicle accidents and reported deer observations compiled over the past five years by the

Environmental Sciences Division of ORNL indicate that the deer population on the Reservation is increasing (Story 1975). Because of the physical nature of the Reservation (high-speed roads, scattered plants, and large numbers of workers), the need for good deer herd management is now critical. Thus, a 15 month study was initiated to evaluate density and distribution of the herd. Five techniques for determining density were incorporated into the program. Methods selected were: (1) pellet group surveys, (2) night-lighting counts, (3) roadside counts, (4) radioactive feces tagging, and (5) mark-reobservation. Distribution was determined by using (1) five years of road-kill data, (2) night observations, and (3) pellet group locations on transects.

In order to evaluate the accuracy of the density estimates based upon pellet group surveys and night-lighting counts, these methods were conducted on an area where previous density estimates were considered reliable. The Tennessee Wildlife Resources Agency's Chuck Swan Wildlife Management Area was selected as the control site. This area possesses similar habitat and physiographic characteristics.

A study of the rate of deterioration and/or disappearance of pellet groups was also conducted in conjunction with the evaluation of two techniques for estimating density on the Chuck Swan Wildlife Management Area.

CHAPTER II

DESCRIPTION OF STUDY AREAS

A. ERDA'S OAK RIDGE, TENNESSEE RESERVATION

Location and Physiography

The majority of the present study was conducted on ERDA's Oak Ridge, Tennessee Reservation located within the City of Oak Ridge, Tennessee, in Anderson and Roane Counties (Figure 1). The Reservation consists of 14,762 ha (36,476 acres) of the original 23,828 ha (58,880 acres) purchased in 1942 to serve as a large atomic development and production center (Curlin 1965, Strock 1970).

The Reservation is bounded on the south, west, and east by the Tennessee Valley Authority's Melton Hill and Watts Bar Reservoirs on the Clinch River and on the north by the metropolitan area of the City of Oak Ridge (Curlin 1965).

The Reservation is located in the Ridge and Valley physiographic province of the Great Valley of East Tennessee. It is characterized by a series of alternating ridges and valleys oriented in a southwest-northeast direction, parallel to the Cumberland escarpment (USDA Soil Survey—Roane County, TN 1942).

Elevation ranges from 225.6 m (740 ft) to 414.5 m (1,360 ft) above mean sea level with a maximum relief of 188.9 m

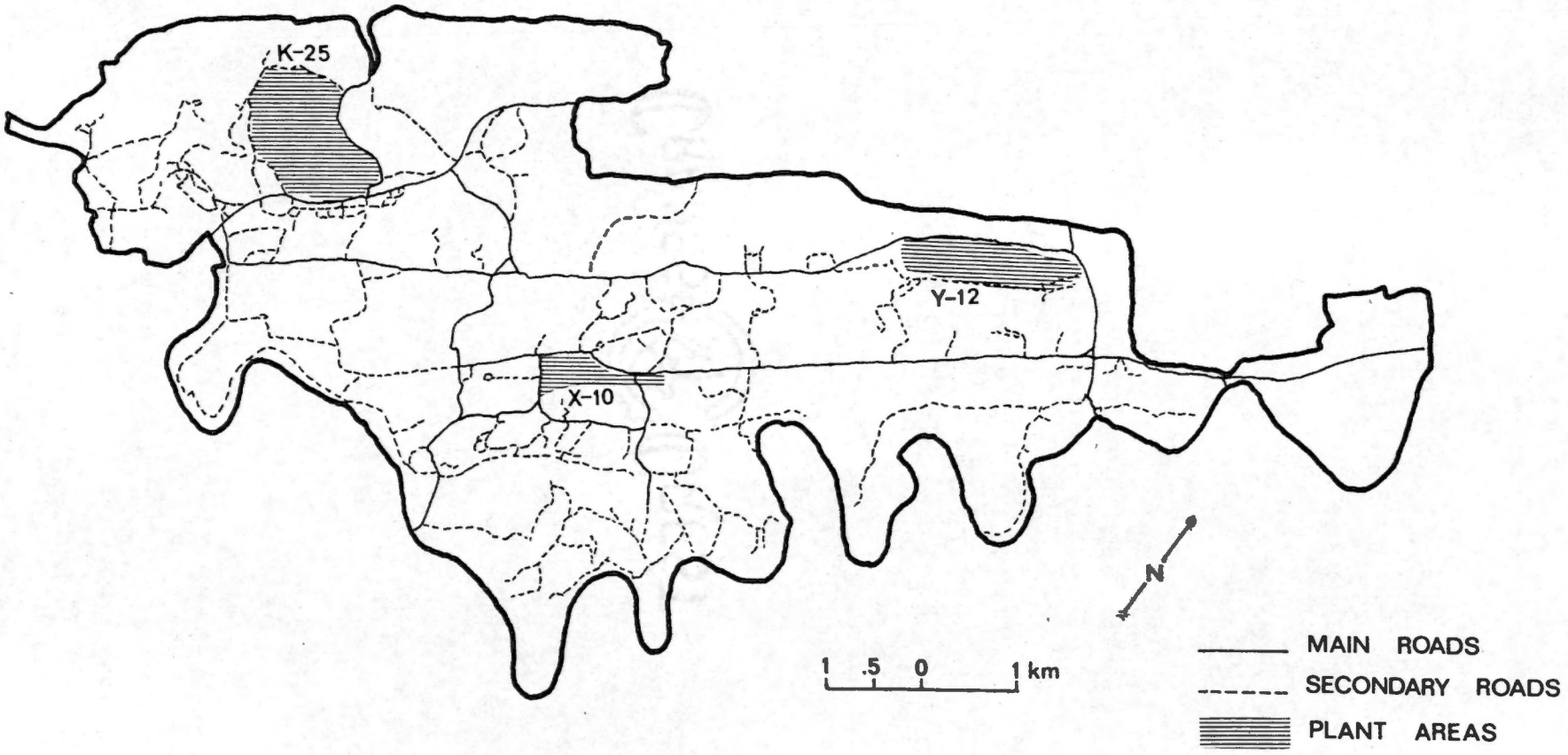

Figure 1. The Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

(620 ft) Curlin 1965). The valleys are deep V-shaped and have steep walls (USDA Soil Survey—Roane County, TN 1942).

Drainage is well developed within the Reservation. A well defined trellis pattern exists with creeks and small streams flowing parallel to the ridges except where they cut sharply to the right or left across the ridges through narrow gaps. Drainage is primarily to the southwest where the creeks and streams empty into the Clinch River (USDA Soil Survey—Roane County, TN 1942).

Division of Area

This study was conducted on 6,340 ha (15,666 acres) in the western end of the Reservation (Figure 2). It is in this area that the majority of whitetailed deer sightings and deer/vehicle accidents have occurred in the past five years (Story 1975). Because of personnel shortages, time, and few observational reports in the eastern portion of the study area, it was considered necessary to divide the study area into two sections, A and B (Figure 2). Section A contained 3,501 ha (8,651 acres) while Section B contained 2,839 ha (7,015 acres). Density estimates in Section A were based upon pellet group surveys, night-lighting counts, roadside counts, radioactive feces tagging, and mark-reobservation reports, while Section B was restricted to pellet group surveys only.

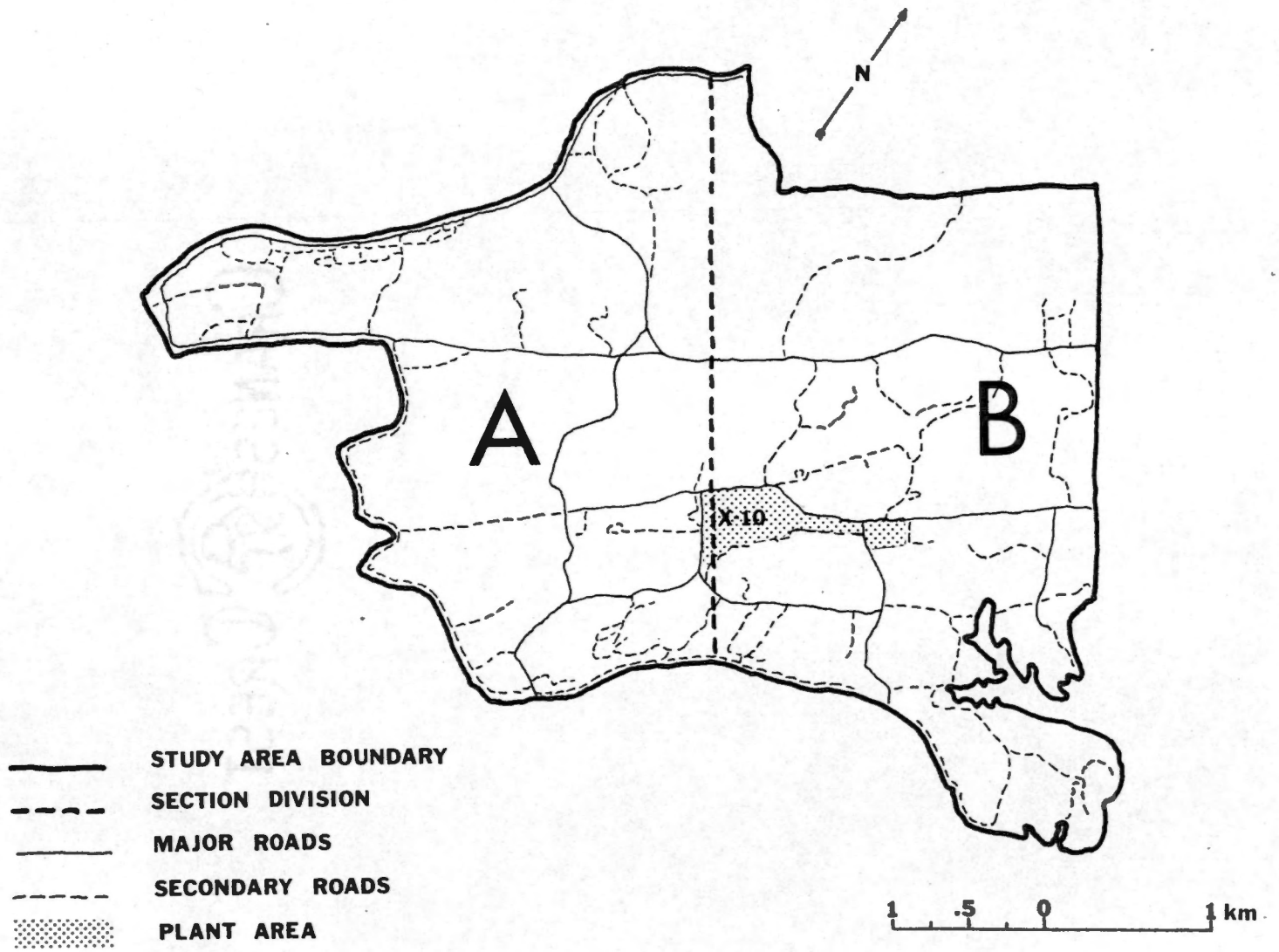

Figure 2. Map of the study area within the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

Reservation Units and Land Management

Five separate plants are located within the Reservation. Three of these, ORNL (X-10), the Y-12 plant, and the Oak Ridge Gaseous Diffusion Plant (K-25), are operated for ERDA by the Union Carbide Nuclear Company. The Cooperative Animal Research Laboratory (CARL) is operated by the University of Tennessee and a small area is occupied by the Experimental Gas Cooled Reactor (EGCR) site (Curlin 1965).

Buffer zones are reserved around each plant for special use and future plant expansion. A total of 4,014 ha (9,919 acres) are located in the buffer zones of X-10, Y-12, and K-25. Of this total, 2,583 ha (6,383 acres) are forested with the larger proportion of forested area located in the X-10 buffer zone. CARL contains 432 ha (1,068 acres) of which 123 ha (304 acres) are forested (Curlin 1965).

The remainder of the Reservation (10,317 ha or 25,493 acres) is devoted to ecological research and commercial timber management. Of this total 9,207 ha (22,750 acres) are forested (Table 1)(Strock 1970).

Because the Reservation forest was formed from a large number of small private tracts of land, there is no written history of the forest before 1942 (Curlin 1965, Strock 1970).

In 1947 a reforestation program was begun by Management Services Incorporated (MSI), an ERDA contractor then responsible for operations of the City of Oak Ridge. At the

TABLE 1

ADMINISTRATIVE UNITS OF THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

Administrative Units	Total Area		Forested Area	
	Hectares (Acres)			
Research and Management	10,317	(25,493)	9,207	(22,750)
ORNL (X-10)	2,422	(5,985)	2,306	(5,698)
Y-12	635	(1,569)	277	(685)
CARL	432	(1,067)	123	(304)
ORGDP (K-25)	957	(2,365)	-----	-----
TOTAL	14,762	(36,476)	11,913	(29,437)

Source: W. G. Strock, Jr., "Forest Management Plan, AEC Oak Ridge Reservation: 1970-1975."

time the MSI program ended in 1960 a total of nine million pine seedlings had been planted on old fields and open areas comprising a total of approximately 1,740 ha (4,300 acres). Species planted on these plantations were shortleaf pine (Pinus echinata), loblolly pine (P. taeda), and eastern white pine (P. strobus) (Strock 1970).

Geology and Soils

The Reservation lies in the northern part of the zone of Red and Yellow Podzolic soils (U.S. Ag. Yearbook 1938). In the mature soils, the color of the A horizon ranges from the brown of the Dewey soils to the very light gray or almost white of the Clarksville soils and that of the subsoil from the red of the Dewey soils to the yellow of the Clarksville soils (USDA Soil Survey—Roane County, TN 1942).

Except for the alluvial and colluvial materials, the parent materials are the residues of decomposition and leaching of consolidated sedimentary rocks—limestone, dolomites, shales, and sandstones. These sedimentary rocks are old, having been formed during the Paleozoic era (USDA Soil Survey—Roan County, TN 1942).

The well-developed soils on gentle slopes of the limestone valleys are medium to strongly acid, containing moderate amounts of organic matter and are intermediate in fertility. Moisture holding capacity of the limestone soils is good. Soils occurring on steep slopes are stony and

cherty, low in organic matter and fertility and are excessively permeable with low water-holding capacity. Sandstone and shale soils are generally shallow, excessively drained and strongly acid with low to moderately low fertility (Curlin 1965). Common soil associations are shown in Table 2 in order of their importance of occurrence on the Reservation.

Climate

The climate of the Reservation is of the humid continental type, with moderate winter and summer temperatures. Mean seasonal temperatures range near 5°C (high 40's F) for winter, 12°C (mid 50's F) for spring, 24°C (mid 70's F) for summer, and 15°C (high 50's F) for fall. The average frost-free period of 196 days extends from April 11 to October 24. The mean annual precipitation is well distributed throughout the year with about 80 percent being equally divided among winter, spring, and summer (USDA Soil Survey—Roane County, TN 1942). Average total precipitation ranges from 127 to 140 cm (50 to 55 inches) annually throughout the Reservation (U.S. Department of Commerce). Precipitation and temperature data for Oak Ridge are given in Table 3.

Flora and Fauna

Over 1,500 higher plant species are recognized in the woodland and herbaceous ecosystems of the Reservation (Olson et al. 1966). Forest associations were formerly classified

TABLE 2

COMMON SOIL ASSOCIATIONS IN ORDER OF THEIR IMPORTANCE OF OCCURRENCE ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

Soil Association	Geologic Origin
Fullerton-Clarksville-Bolton-Greendale	Knox dolomite
Litz-Sequoia-Hamblin-Prader	Conasauga shale
Muskingum-Lehew-Muse-Jefferson	Rome sandstone
Talbot-Colbert-Rockland	Chickamauga limestone
Waynesboro-Nolichuchy-Huntington	Clinch River alluvium

Source: J. W. Curlin, "Forest Management Plan, AEC Oak Ridge Reservation." ORNL-TM-1317.

TABLE 3

MONTHLY AVERAGE TEMPERATURES AND TOTAL MONTHLY PRECIPITATION
RECORDED AT OAK RIDGE, TENNESSEE

Month	Average Monthly Temperature in Degrees Centigrade (Fahrenheit)				Total Monthly Precipitation in Centimeters (Inches)			
	1960-1974 Average		1975		1960-1974 Average		1975	
January	2.2	(36.9)	5.2	(41.4)	11.6	(4.6)	14.9	(5.9)
February	3.6	(38.5)	6.1	(43.0)	11.4	(4.5)	15.0	(5.9)
March	8.8	(47.8)	7.0	(44.6)	15.7	(6.2)	31.1	(12.2)
April	14.6	(58.2)	12.7	(54.9)	11.3	(4.5)	6.0	(2.4)
May	18.7	(65.6)	20.1	(68.2)	11.0	(4.3)	10.2	(4.0)
June	22.6	(72.6)	22.2	(72.0)	12.5	(4.9)	14.2	(5.6)
July	24.3	(75.8)			14.6	(5.7)		
August	24.1	(75.4)			10.3	(4.1)		
September	21.1	(69.9)			8.8	(3.5)		
October	14.9	(58.8)			8.3	(3.3)		
November	8.7	(47.6)			10.7	(4.2)		
December	4.2	(39.5)			14.6	(5.7)		
				Annual	104.8	(55.4)		

Source: Climatological Data (Tennessee). U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration Environmental Data Service, 1960-1975.

as primarily oak-chestnut but as the chestnut trees were eliminated by the chestnut blight, suppressed or codominant species (oak and hickories) replaced them as major canopy components. Tulip poplar (Liriodendon tulipifera) is abundant near the base of ridge and slope habitats in secondary communities (Taylor 1974). Today two main forest associations are present, mixed hardwoods and pine plantations.

Animal life within the Reservation is continually monitored. Early reports indicated that 65 species of birds nest on the Reservation (Howell 1958) and that at least 27 species of mammals occur there (Howell and Dunaway 1959). Since these early reports, additional avian and mammalian species have been verified but no complete list has been compiled.

B. CHUCK SWAN WILDLIFE MANAGEMENT AREA

Location, Physiography and Soils

The Chuck Swan Wildlife Management Area is located approximately 80 km (50 miles) northeast of ERDA's Oak Ridge Reservation between the Clinch and Powell Rivers in the upper portions of Norris Lake (Figure 3). The area is comprised of 10,049 ha (24,831 acres) of land in Union and Campbell County Tennessee (Lewis and Safley 1966).

Physiographically the area is similar to ERDA's Oak Ridge Reservation. It is located in the same physiographic

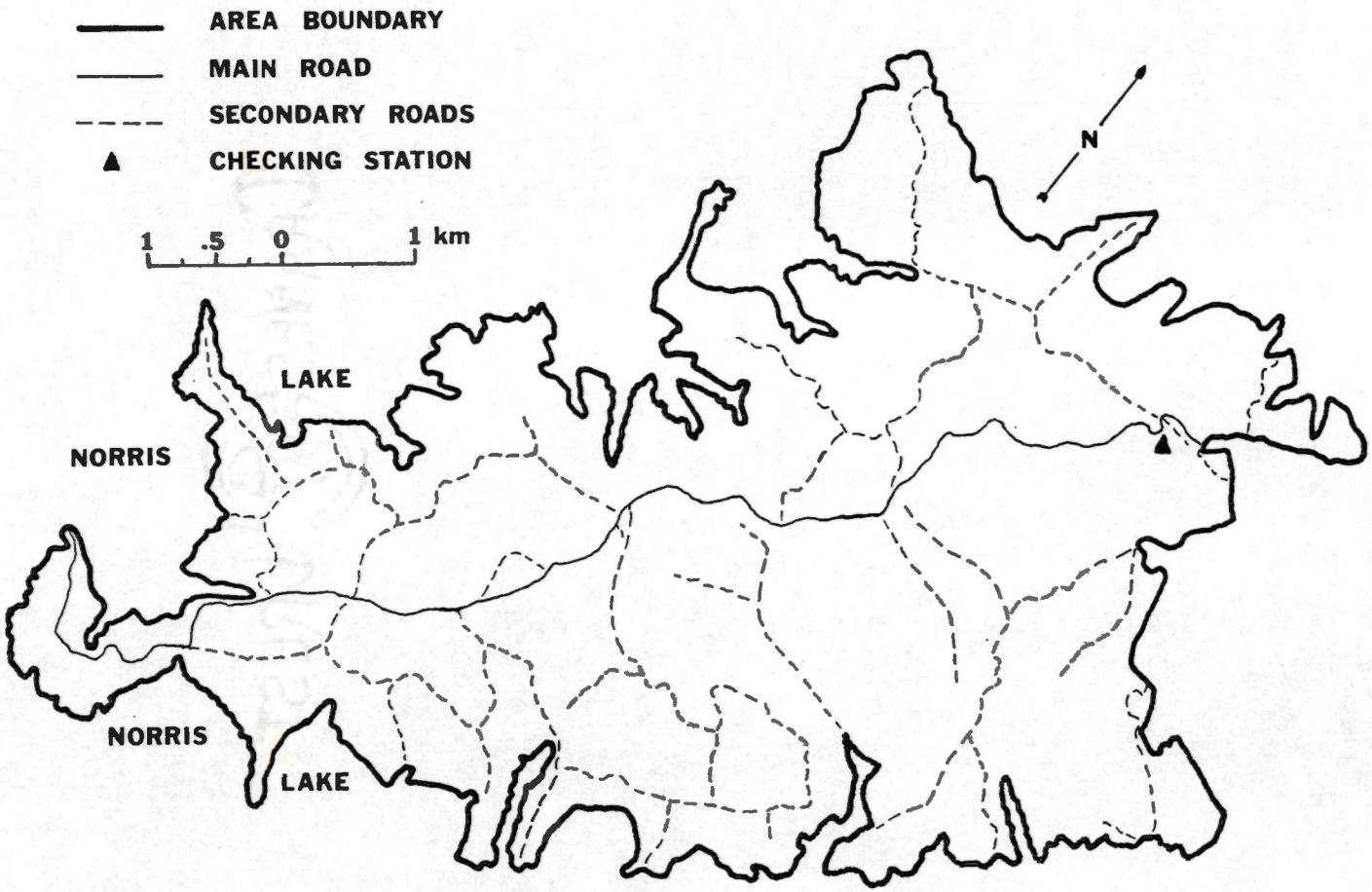

Figure 3. The Chuck Swan Wildlife Management Area.

region and has characteristically well rounded hills with narrow steep-sided V-shaped valleys. Cherty and sandy dolomite and dolomitic limestone of the Knox formation underlie the hills. Many lime sinks are found throughout the area (USDA Soil Survey—Norris Area, TN 1953). Elevation varies from 310.9 m (1,020 ft) to 512 m (1,680 ft) (Lewis and Safley 1966).

Climate

The climate of the Chuck Swan Wildlife Management Area is temperate and continental. The summers are long and warm and the winters are short and open. Mean seasonal temperatures are the same as discussed earlier for the Reservation. The average frost free period of 173 days extends from April 25 to October 16 (USDA Soil Survey—Norris Area, TN 1953). The mean annual precipitation is well distributed throughout the year with the average total precipitation ranging from 127 to 140 cm (50 to 55 inches) annually (U.S. Department of Commerce).

Flora and Fauna

Due to the close proximity and same physiographic region of the Chuck Swan Wildlife Management Area to ERDA's Oak Ridge Reservation, the major forest associations are identical being comprised of mixed hardwoods and pine plantations.

The animal community on the Chuck Swan Wildlife Management Area also coincides with the fauna on ERDA's Oak Ridge Reservation. At present, only one known game species, the wild turkey (Meleagris gallopavo), occurs on the Chuck Swan Area and not on ERDA's Oak Ridge Reservation.

CHAPTER III

METHOD AND MATERIALS

A. ERDA'S OAK RIDGE, TENNESSEE RESERVATION

Capture of Whitetailed Deer

Bait sites. Thirteen bait sites were established between November 6, 1974 and February 10, 1975 (Figure 4 and Appendix A, Table 11). Bait sites were selected for the purpose of using two capture techniques, Michigan box traps and rocket nets. Bait sites were located near game trails or in the vicinity of recent deer observations. The locations were in close proximity to old logging roads in order to decrease construction, maintenance, and trapping time.

One 23 kg (50 lb) block of salt and approximately nine kilograms (20 lb) of shelled yellow corn were placed at each site. The salt block was broken into small pieces to facilitate rapid weathering and leaching. Whitetailed deer seem to prefer salt mixed with soil more than pure salt. The nine kilograms (20 lb) of corn at each site were divided into four piles and placed around the salt within a radius of two meters (6.5 ft). Additional salt and corn were placed on the site when required. Corn was used throughout the winter but discontinued with the onset of spring.

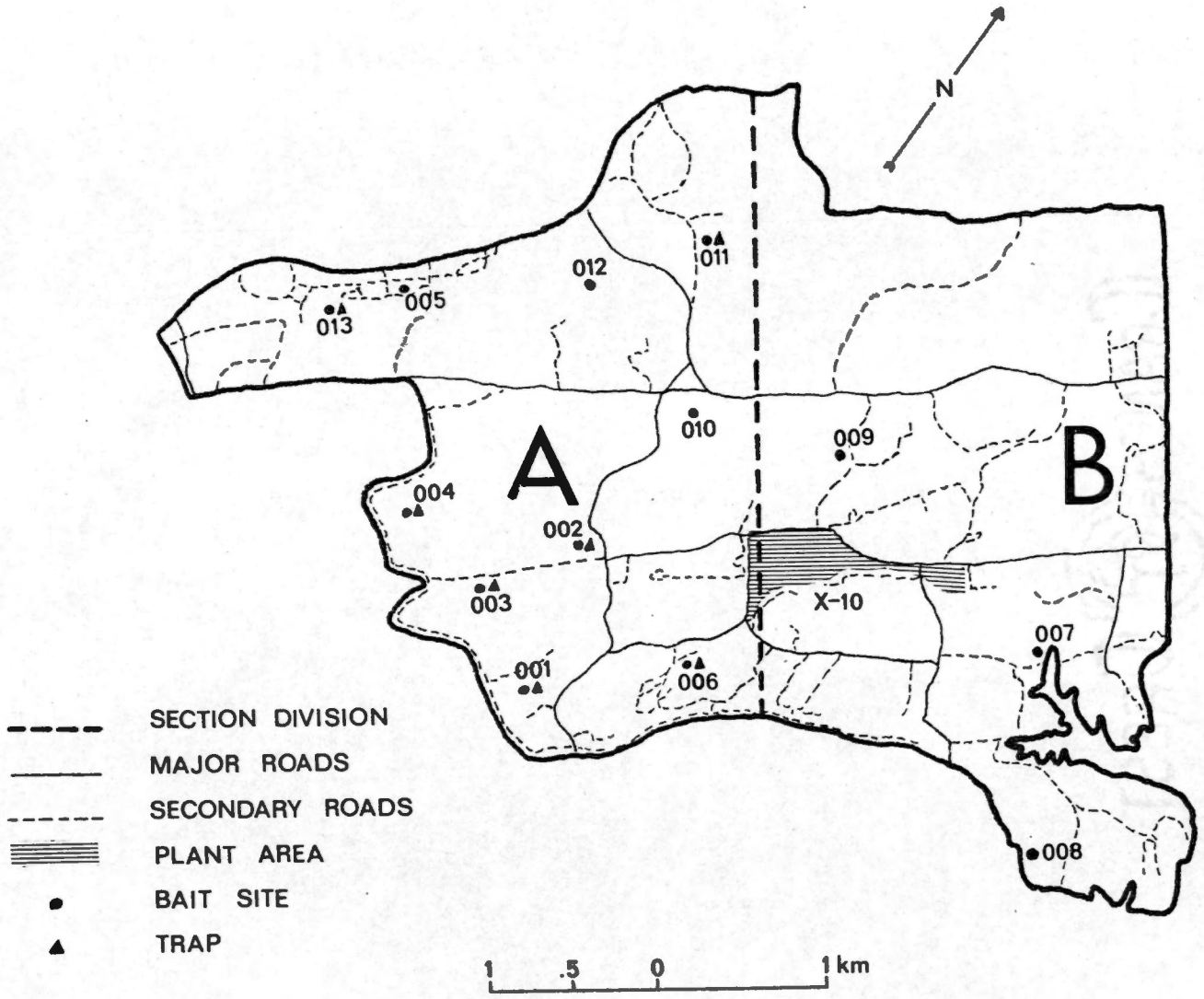

Figure 4. Bait site and trap locations on the study area located on the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

Apples, picked from trees on the Reservation, in addition to salt, were used in and around traps as bait during summer.

Traps. Seven portable Michigan box traps were utilized. Each trap was constructed of four sheets of 1.22 m x 2.44 m (4 x 8 ft), 1.27 cm (.5 in) exterior plywood and 12, 2.44 m x 5.08 cm x 10.16 cm (10 ft, 2 x 4 in) untreated, grade number three, pine boards and designed to be collapsible and light enough so that one man could assemble it in the field (Figure 5). Construction time was approximately three hours with establishment in the field averaging one hour. Two field modifications were made to the traps. Rubber strips were placed on top of the doors to block out all light coming into the trap. Deer were less active and did not try to jump through the small crack between the trap top and door, thus reducing the possibility of injury. The second modification was a 15 x 20 cm (6 x 8 in) notch cut into the top of one door on each trap. This allowed enough space for a dart rifle to be inserted into the trap for immobilization of the animal. A rubber strip also covered this opening.

Material cost for each trap averaged $40.00. The traps proved to be durable and should last at least three years with proper maintenance.

Each trap was placed over a bait site after activity of deer was observed around the site (Appendix A, Table 12). Trapping commenced February 18, 1975 and continued until

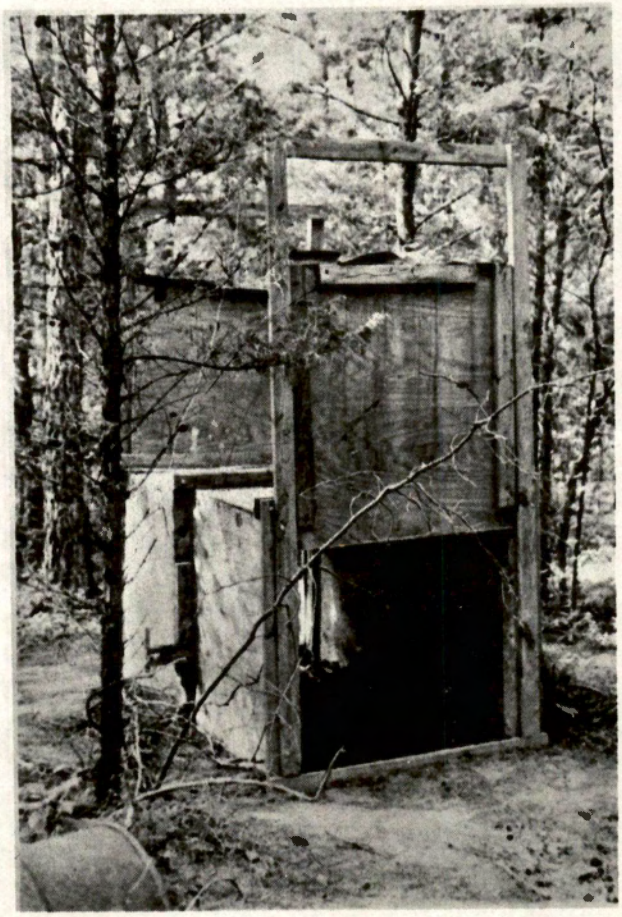

Figure 5. Portable Michigan box trap used on Section A of the study area located on the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

July 27, 1975. Trapping was discontinued three times during this period (May 6-May 7, May 30-June 3, and June 8-June 17). Only six traps were reactivated on June 18, 1975. Trap site 001 was converted into a possible rocket net site.

Immobilization equipment. Immobilization equipment included a Model 171 (Remington Model 581, 22 caliber) dart rifle with a 4x scope, "C" series disposable darts preloaded with succinylcholine chloride ranging from two milligrams to 13 mg (Appendix A, Table 13) (Pneu-Dart, Inc., Williamsport, Pennsylvania), and two sizes of Remington stud drivers (charges), brown and gray. Gray stud drivers (low charge) were used in conjunction with trapped deer while brown stud drivers (high charge) were used for free-ranging deer. Remington stud drivers can be purchased at most building supply stores. The rifle has an effective range of 90 m (100 yds) depending upon the size of the stud driver and gas regulator setting on the rifle. The Pneu-Dart plastic desposable darts are an improvement over metal syringe projectiles due to their light weight, increased range and accuracy and preloaded darts.

Capture of free-ranging deer occurred during late afternoons and night. Roads within Section A were driven an average of 5.4 nights per month from December 1974 through September 1975. Two hand-held, high intensity, aircraft landing lights were used to locate deer. The lights were

connected to the vehicle battery by two 4.6 m (12.5 ft) electrical cords thus allowing independent movement of each light. When one observer spotted an animal within range, he estimated the weight and informed the other observer while still maintaining the location of the animal. The second observer turned off his light, loaded the capture rifle with the appropriate dosage, and took the shot. The operation required at least two people but worked best with three, two observers and one shooter. With two observers, both lights could be trained on the animal at the same time. An average of 10 seconds elapsed from initial observation until the shot was taken.

Rocket net. Rocket net sites were constructed but never used because of low bait site utilization by the deer throughout the study.

Tagging

Visual tags. After immobilization, each deer was examined closely for external parasites, anomalies and injuries; several basic body measurements were taken and weights were estimated. A 2.54 x 1.27 cm (1 x .5 in) plastic, color coded, numbered ear tag was placed in the right ear for future identification. Red tags were placed on bucks and yellow tags on does.

For the purpose of distant identification and confirmed reobservation, neck collars were also used for visual recognition (Wildlife Materials, Inc., Carbondale, Illinois). Doe collars were made from thermoplastic material .39 cm (.2 in) thick and 7.26 cm (3 in) wide. Reflective numbers 10.16 cm (4 in) high, readable at 275 m (300 yds) using 7 x 35 binoculars and 732 m (800 yds) with a 20x spotting scope, were on both sides of the doe collar (Figure 6). Buck collars were constructed of 2.54 cm (1 in) doubled nylon elastic to allow for expansion. The numbered plate was made of .39 cm (.2 in) thick thermoplastic 10.16 cm (4 in) wide and 12.70 cm (5 in) long with 10.16 cm (4 in) high reflective numbers on both sides (Figure 6). Readable distance was the same as doe collars. Both collars were attached by two pop rivets.

Radioactively tagged feces. Based upon the criteria set forth by Pelton and Marcum (1975) for the use of radioactive isotopes as feces tags and the evaluation of four radioisotopes as feces tags of black bear by Marcum (1974), Zn-65 was selected to be used as a feces tag for whitetailed deer. Due to a lack of facilities, there were no control deer to evaluate the rate and duration of radioisotope excretion.

Zinc-65 was purchased from the New England Nuclear Corporation, Boston, Massachusetts, and shipped as chloride

Figure 6. Neck collars and ear tags used on white-tailed deer at the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

compounds in 0.5N HCl at concentrations of 5.84 millicuries per ml. Zinc-65 has a physical half-life of 245 days, a biological half-life of 930 days, an effective half-life of 193 days, gamma energy of 1.12 Mev, and a maximum permissible body burden (MPBB) of 60 μc. The critical organs affected by the isotope are the total body with primary emphasis on the liver and prostate (International Congress on Radiological Protection 1959).

Zinc-65 was diluted using an isotonic saline solution (0.9 percent) so that the final solution of isotope and saline were equal to 50 ml; this dilution resulted in an initial activity of 20 μc per ml of solution. One hundred and twenty microcuries of the solution were carried in a rubber-capped bottle at all times in the field kit. The remainder of the solution was stored in a room specified for such purposes at the University of Tennessee at Knoxville.

Deer were injected with the radioactive solution using a six cubic centimeter disposable syringe with an 18 ga needle. Injections were given intramuscularly in the rump area. Sixty microcuries were injected into each animal.

Index Routes

Night-lighting counts. Roads in Section A (Figure 7) were driven an average of 5.4 nights per month covering 40.23 km (25 miles) each night. Two hand-held aircraft landing

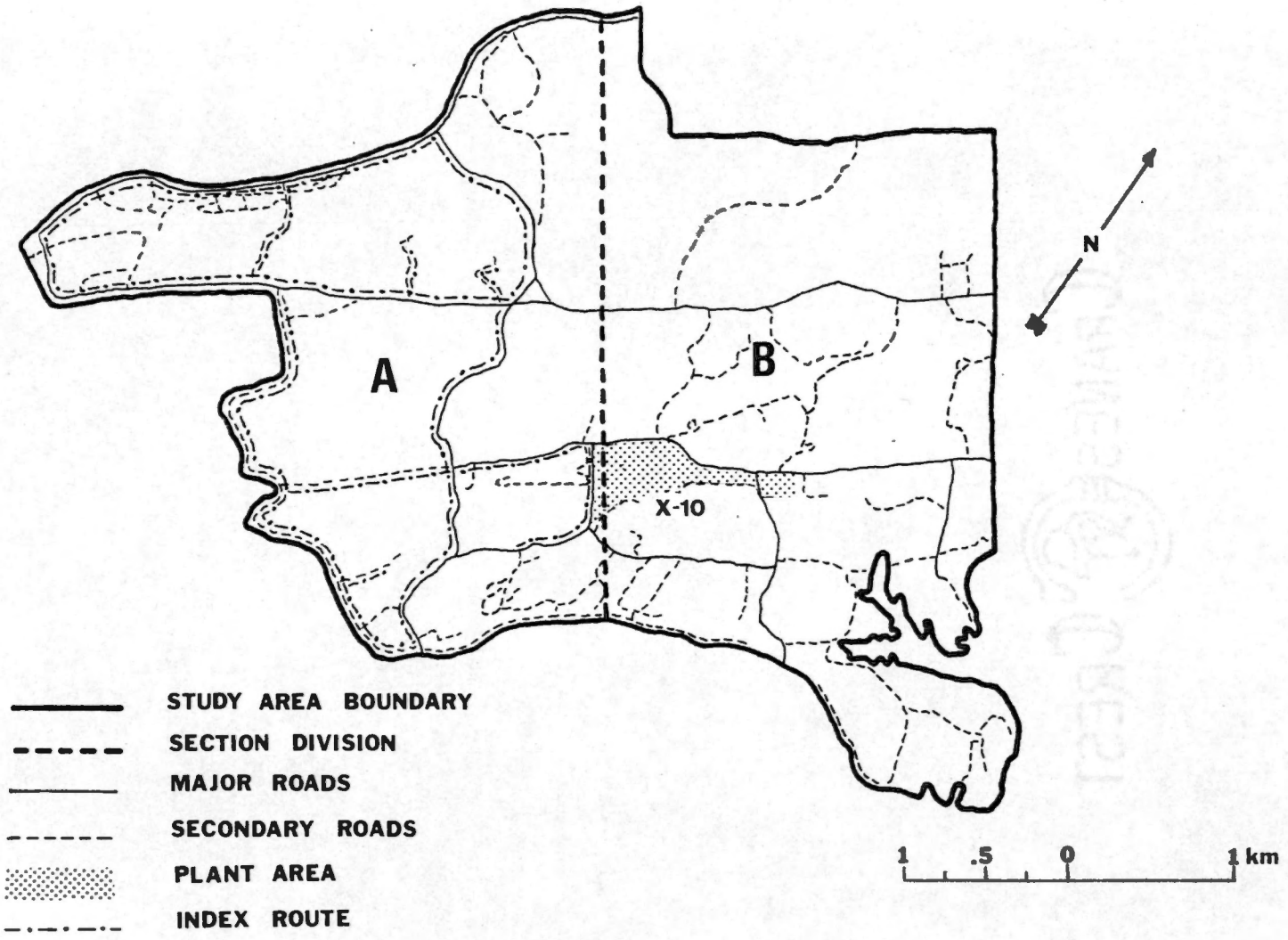

Figure 7. Index route driven at night on Section A of the study area located on the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

lights were used to illuminate the roadside. Approximately 715 ha (1,766 acres) were searched each night. The shortest distance from the deer to the road (transect line) was recorded along with a description of the deer or group of deer and the location of the observation.

Pellet group transects. Twenty-seven permanent transects for pellet group counts were randomly established in January 1975. One transect was located within each administrative grid (reference TVA/AEC Map S-16A 1974) within Sections A and B shown in Figure 8. The transects were 610 m (2,000 ft) long and 3.05 m (10 ft) wide representing a sampled area of 1.14 ha (.46 acres). A total of 30.8 ha (12.4 acres) were sampled. All transects ran perpendicular to physiographic features and vegetational communities of the area. Transects were sampled at four month intervals (January, May, and September 1975).

Pellet groups with a minimum of five pellets were tallied and collected on Section A for scintillation analysis to determine if the pellets were from radioactively tagged deer. Pellet groups with a minimum of five pellets on Section B were only tallied.

Laboratory Analysis of Pellet Groups

Pellet groups collected on Section A were properly labeled in the field, stored in plastic freezer bags, and

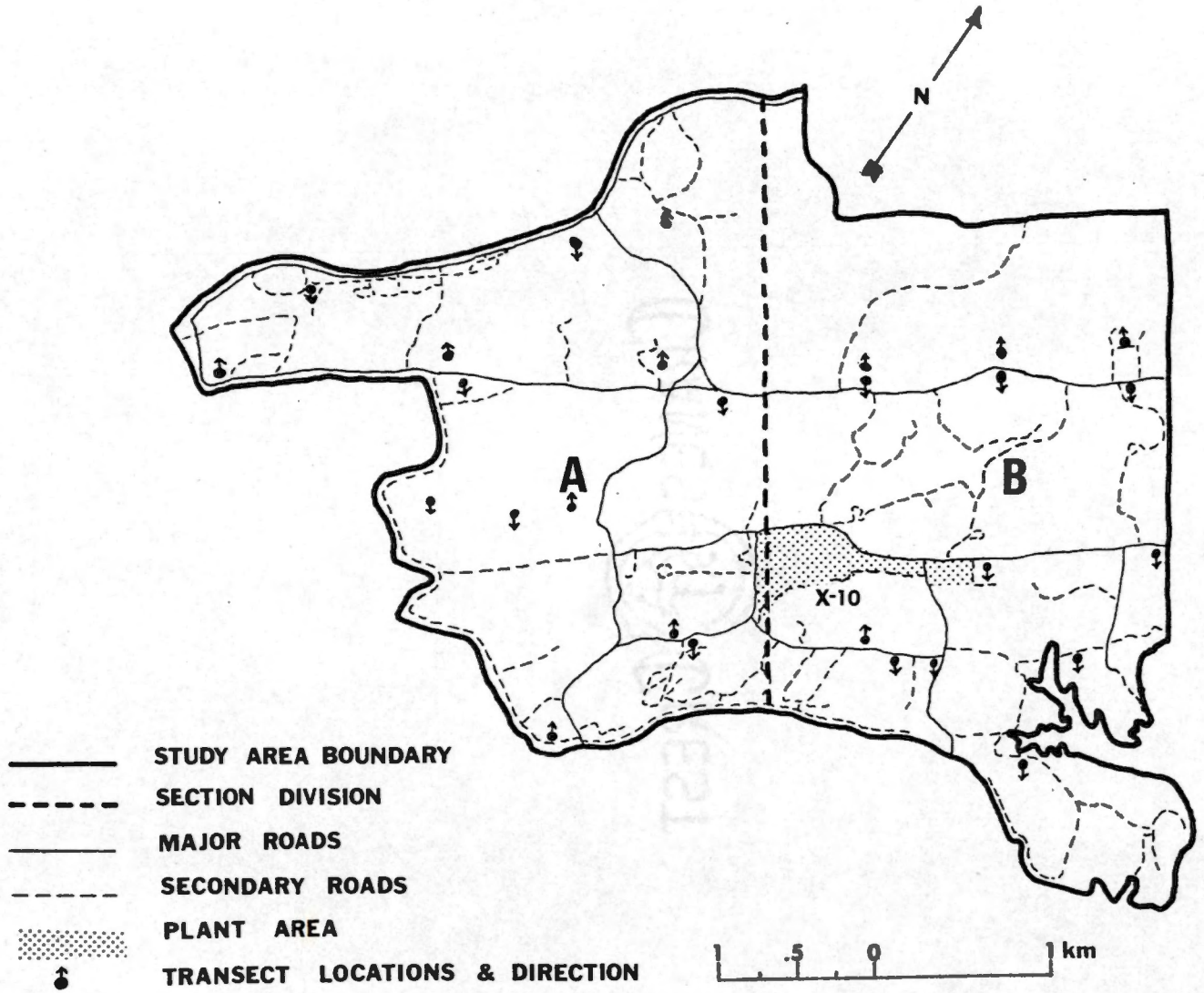

Figure 8. Location of pellet group survey transects on the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

frozen to prevent further deterioration. Prior to scintillation analysis, the pellet groups were dried in an oven for 26 hours at 80°C. Two to five grams of each pellet group sample were placed in a 25 x 150 mm (.98 x 5.91 in) Corning culture tube. The culture tubes were sealed with cotton to prevent spillage and contamination. The Environmental Sciences Division of the Oak Ridge National Laboratory provided a Packard-Auto-Gamma, 3 x 3 Sodium Well Detector Spectrometer coupled to a Nuclear Data ND812 Computer with a hard copy provided by a standard Teletype for scintillation analysis.

Density Estimates

Density estimates were based upon four methods. Schnabel's method (Schnabel 1938) for multiple sampling was used with mark-reobservation data. The King method (King 1937, Howe 1954) was conducted utilizing night-lighting counts of deer. Density determined by pellet group counts was estimated as described by Bennett et al. (1940). The Lincoln Index (Overton 1969) was used with returns of radioactive pellet groups from radioactively tagged deer. Roadside counts were also conducted as a basis for yearly trend analysis.

Distribution

Distribution of deer on the study area was determined by three methods: road-kill locations for the past five

years, whitetailed deer observations at night during the study period, and pellet group locations on transects. Information from each source was plotted on maps of the study area for comparative purposes.

B. CHUCK SWAN WILDLIFE MANAGEMENT AREA

Index Routes

Night-lighting counts. Night-lighting counts were conducted on the Chuck Swan Wildlife Management Area twice a month during July, August, and September 1975. The same 43.5 km (27 miles) were driven each night with no double sampling occurring (Figure 9). Approximately 1,192 ha (2,945 acres) were sampled each night. The density estimate was based on the King method (King 1937, Howe 1954).

Pellet group transects. The Chuck Swan Wildlife Management Area was divided into administrative grids with the same area (232.3 ha or 573.9 acres) as the grids used on ERDA's Oak Ridge, Tennessee Reservation. A pellet group transect was randomly located in each grid that crossed the main road which divides the area. Sixteen pellet group transects, 610 m (2,000 ft) long and 3.05 m (10 ft) wide, were established and cleaned of all pellet groups in June 1975 (Figure 10). The transects were established on azimuths of 20° NW and 20° SE from the main road perpendicular to

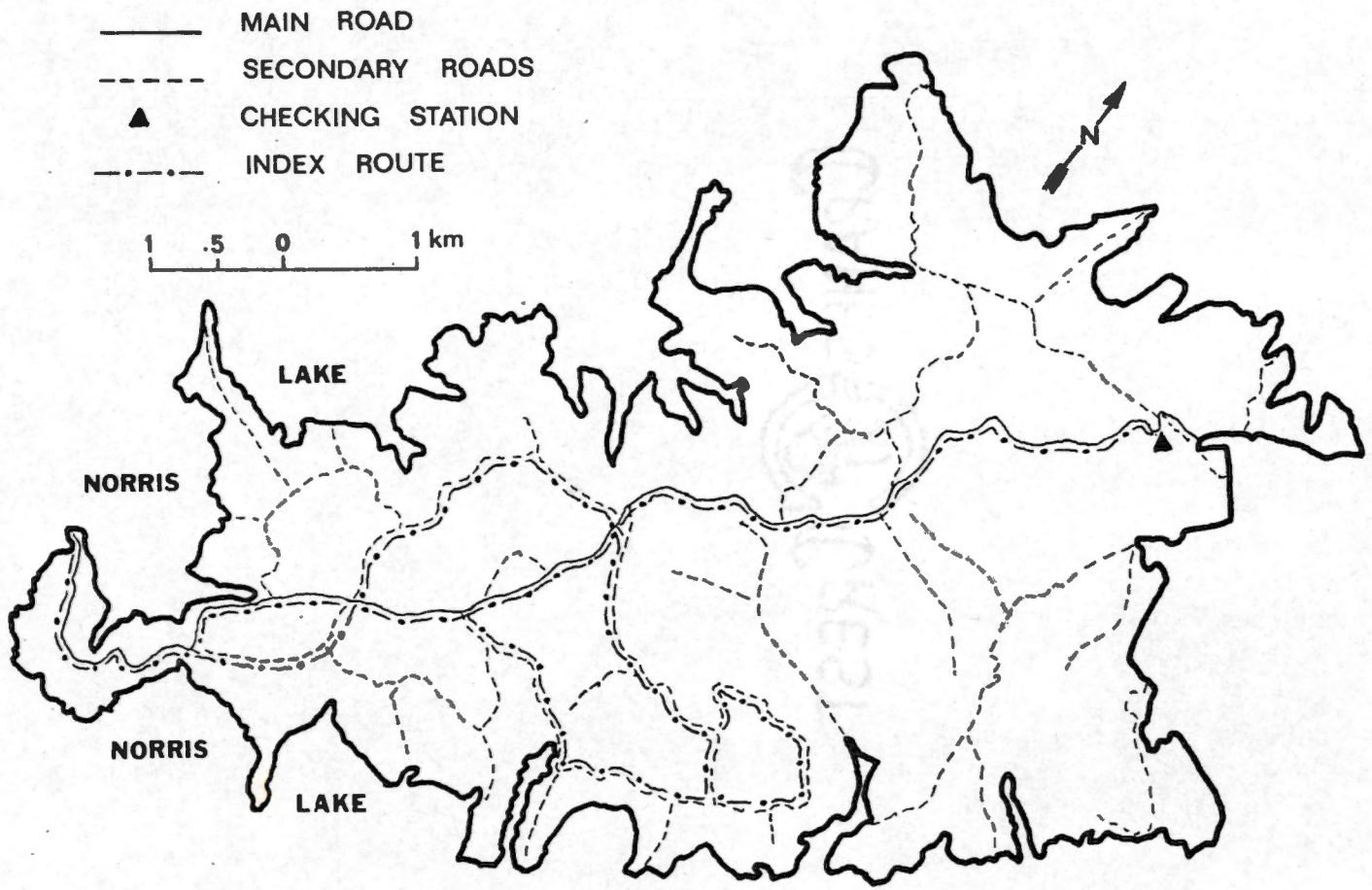

Figure 9. Index route driven at night on the Chuck Swan Wildlife Management Area.

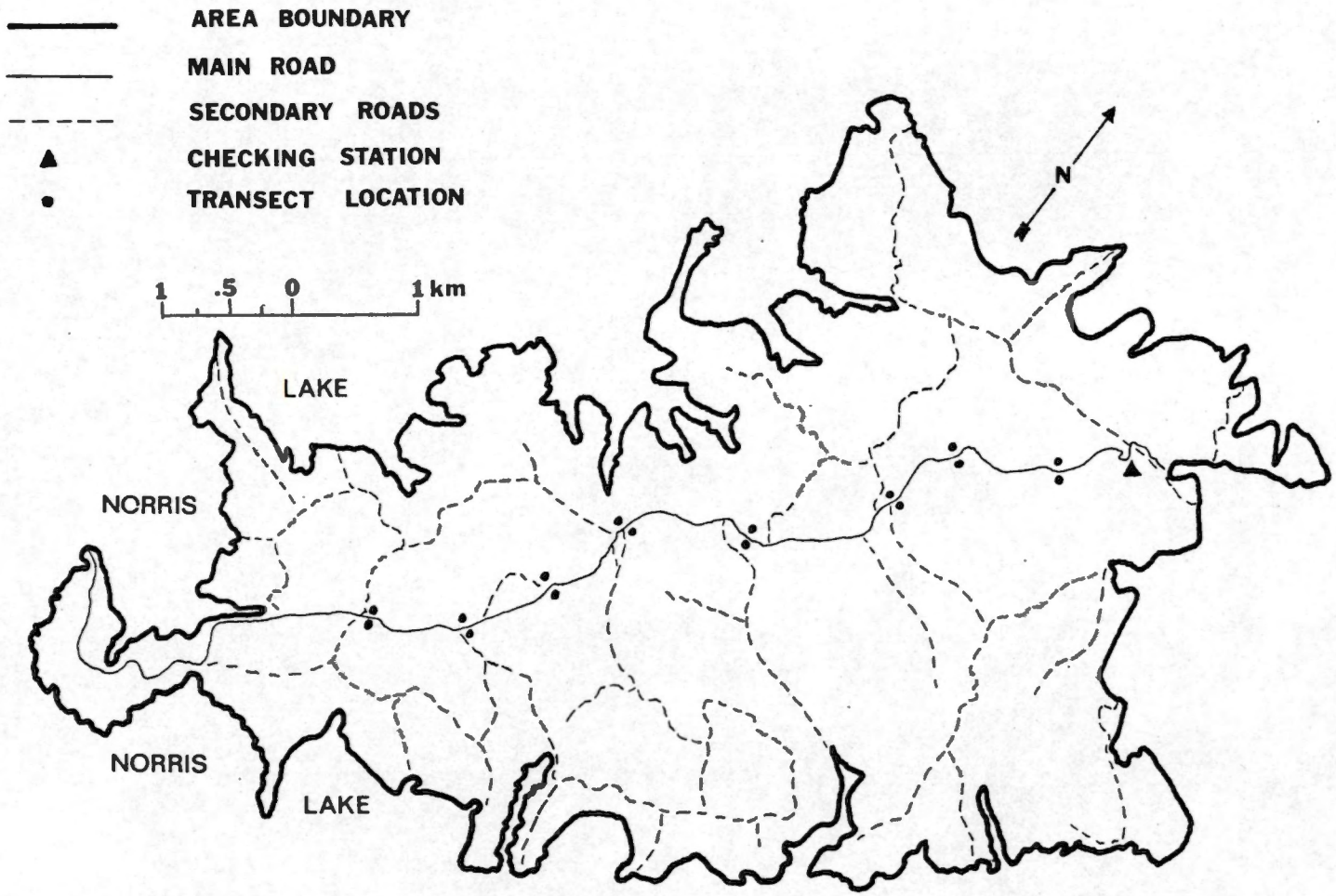

Figure 10. Location of pellet group survey transects on the Chuck Swan Wildlife Management Area.

vegetational communities and physiographic features of the area. Pellet group counts were conducted in July, August, and September 1975. Due to an early leaf fall, transects were not sampled in October as originally planned. A density estimate was determined using the method described by Bennett et al. (1940) and Eberhardt and Van Etten (1956).

Deterioration Study

Because of the controversy over the reliability of the pellet group technique in the Southeast (Overton 1969, Downing et al. 1965) a study of deterioration and/or disappearance of pellet grups was conducted in conjunction with the pellet group counts on the Chuck Swan Wildlife Management Area. Pellet groups counted in July were circled with orange spray paint, new pellet groups counted in August were circled with yellow spray paint, and new pellet groups counted in September were circled with white spray paint. Groups marked in July were checked for deterioration and/or disappearance in August and September and groups marked in August were checked in September. Early leaf fall prevented the study from continuing into October as planned. Five or more pellets had to be present to constitute a pellet group. Five or more pellets in a marked group also had to be present to constitute a pellet group that did not deteriorate and/or disappear during the observation period.

CHAPTER IV

RESULTS AND DISCUSSION

A. ERDA'S OAK RIDGE, TENNESSEE RESERVATION

Evaluation of Capture Methods

A total of 10 deer were captured during the project. Five were captured with a dart rifle using an immobilization agent (succinylcholine chloride) while free-ranging and five were captured in Michigan box traps. Of the 10 captures, only seven deer were tagged with an ear tag, neck collar, and Zn-65; three deer were not tagged due to one escape, one mortality, and one recapture (Table 4, and Appendix A, Table 14). Capture efficiency compared to time expended during the project was low.

Bait site activity. Deer activity, as indicated by tracks around bait sites 001, 002, 003, 004, 005, 006, 011, and 013 was noted within four to five weeks after establishment of the sites. No activity was ever recorded around sites 007, 008, 009, 010, and 012 during the study (Appendix A, Table 17). Deer showed little or no interest in the corn but utilized the leached salt. Corn was likely regarded as a strange food source, due to an absence of agriculture crops on the Reservation. Birds and small mammals were observed eating the corn before deer activity began but corn was used

TABLE 4

CAPTURE RESULTS OF WHITETAILED DEER ON SECTION A OF THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

Capture Number	Capture Date	Capture Method	Disposition
001	December 30, 1974	dart rifle	marked, released
002	March 15, 1975	trap	escaped
003	March 15, 1975	trap	marked, released
004	March 28, 1975	dart rifle	marked, released
005	April 29, 1975	trap	marked, released
006	June 20, 1975	dart rifle	marked, released
007	June 28, 1975	dart rifle	marked, released
008	July 9, 1975	trap	marked, released
009	July 12, 1975	trap	died
010	September 7, 1975	dart rifle	recapture, marked, released

as bait throughout the winter and discontinued with the onset of spring. Corn has been the customary winter bait for deer in the South (Lueth 1965) while in northern sections of the United States, alfalfa hay and natural browse have been used (Olson 1936).

Capture rifle. The capture rifle did not prove to be an effective tool in capturing deer on the Reservation in relation to the time and personnel required to carry out the operation. Biologists of the Tennessee Wildlife Resources Agency have successfully used an identical rifle and drug in situations of high deer densities on large enclosed areas (Robert G. Nichols, personal communication). The main disadvantages encountered on the Reservation were few observations of deer during nightly capture periods, wariness of deer to lights, slow reaction time of deer to succinylcholine chloride when administered by Pneu-Dart darts, and heavy vegetation during late spring and summer which hindered and/or prevented searching for darted deer.

Allen (1970) reported an average latent period of 5.1 minutes for whitetailed deer when using an average dosage level of .084 mg of succinylcholine chloride per kilogram of body weight (.038 mg/lb). The average latent period during this study was nine minutes (average latent period of all deer immobilized, both free-ranging and trapped) when using an average dosage level of .15 mg of succinylcholine chloride

per kilogram of body weight (.06 mg/lb). Two deer reacted to the effects of the drug in less than two minutes. On both occasions hemorrhaging was evident around the wound made by the dart. It was believed that the dart struck a vein thus decreasing latent action of the drug. The remaining seven immobilizations resulted in an average latent period of 11.3 minutes.

During 54 free-ranging capture sessions, 29 deer were darted but only five deer were found and tagged. Obviously, during the 11.3 minute latent period a deer could have moved a considerable distance from the initial darting site and become difficult to find in the heavy vegetation common on the study area. One doe moved almost 0.8 km (0.5 miles) before succumbing to the effect of the drug.

Michigan box traps. A total of 975 trap nights resulted in five captures and one miss. Deer activity continued around trap sites after trap construction. Their primary interest was salt that had leached into the ground around the traps. Deer were sighted around traps several times and frequently tracks were observed inside the trap doorway. As the trapping session progressed, deer went farther into the traps as evidenced by tracks, but trap acceptance time varied at different trap locations. Robert G. Nichols (personal communication) stated that his experience in trapping deer in East Tennessee has shown that the second year after trap

establishment is much more productive than the first year in terms of numbers of deer captured. In contrast, researchers in Alabama have experienced successful trap results in less than a week (Lueth 1965).

Observations of trap sites during October 1975, on the Reservation indicated that deer were using traps more extensively than during the trapping session in the spring and summer of 1975, at which time the traps had only been in the field less than one month prior to setting. This is an indication that deer on the Reservation were becoming accustomed to the traps and depending on the trap sites for their salt supply.

At present density levels, Michigan box traps compared to other methods of capture should prove to be the most economical method of removing deer from the Reservation. However, trapping will not control herd growth unless used extensively. Trapping should not be the only method of herd management.

Density Estimates

Pellet group surveys. Pellet group surveys have been considered as a method of determining whitetailed deer herd trends, population numbers, and distribution since the late 1930's. Considerable effort has been made to evaluate the correct plot size, the number of sample plots required,

defecation rate in relation to habitat utilization, deterioration rate of pellet groups, and accuracy required to establish useful management practices (Neff 1968).

Density estimates of whitetailed deer on the Reservation, based on three pellet group surveys, are quite deceptive in themselves. The survey made in January 1975, was based upon the following assumptions: (1) pellet groups counted were only those deposited since leaf fall, October 15, 1974, (2) daily defecation rate of whitetailed deer on the study area was 13 pellet groups per deer per day, (3) all groups are correctly identified as such and none are missed, and (4) the 1.14 ha (.46 acres) plot is an efficient sampling unit. The equations necessary for density estimates based upon pellet group counts are:

$$t = \frac{1}{a} \Sigma y$$

where t = total deer days of use

a = area of entire sample in acres

Σy = sum of pellet groups over N plots

then,

$$d = \frac{t}{dr}$$

where d = deer utilization per acre

dr = daily defecation rate

then,

$$da = \frac{d}{T}$$

where da = number of deer per acre

T = total time interval between samples in days.

By converting all measurements to metric, the density estimate resulted in one deer per 51 ha (125 acres) on Section A, one deer per 135 ha (333 acres) on Section B, and one deer per 81 ha (200 acres) on the entire study area (Table 5).

Density estimates for the May 1975 and September 1975, pellet group surveys were based upon the same assumptions (a sampling interval of 120 days was known) and equations as the January 1975 survey. Results of the May 1975 pellet group survey were one deer per 134 ha (331 acres) on Section A, one deer per 2,024 ha (5,000 acres) on Section B, and one deer per 203 ha (500 acres) on the entire study area (Table 5). September 1975 results were one deer per 674 ha (1,666 acres) on Section A, one deer per 1,012 ha (2,500 acres) on Section B, and one deer per 809 ha (2,000 acres) on the entire study area (Table 5, and Appendix A, Table 15).

Downing et al. (1965) estimated a known deer population in a Georgia enclosure to be less than 25 percent of its actual size on the basis of a pellet group survey. Further investigation indicated that dung beetles were destroying pellet groups quite readily thus decreasing the sample size. With the four month sampling interval on the Reservation,

TABLE 5

DENSITY ESTIMATES OF WHITETAILED DEER ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION BASED UPON PELLET GROUP SURVEYS

Date Sampled	Section A 1 deer/x ha (acres)	Section B 1 deer/x ha (acres)	Sections A & B Combined 1 deer/x ha (acres)
Jan. 1975	51 (125)	135 (333)	81 (200)
May 1975	134 (331)	2,024 (5,000)	203 (500)
Sept. 1975	674 (1,666)	1,012 (2,500)	809 (2,000)

dung beetles may have contributed to pellet group disappearance but none were observed doing so.

Three pellet groups collected from trapped deer were placed in the field in order to determine pellet group persistence under natural conditions. The three groups were checked for deterioration and/or disappearance twice a week. One group remained for six weeks before breaking down due to weathering. Two groups remained for three weeks. Both were present on the first check of the third week but two days later they were gone.

Large errors in estimates of deer density can result if (1) all pellet groups upon the sample plots are not recorded, or (2) if observers fail to determine accurately those pellet groups dropped during the deposition period (Van Etten and Bennett 1965). Errors dependent upon the first statement could possibly be present in our estimate due to heavy vegetation, especially Japanese honeysuckle (Lonicera japonica) which provided a ground cover several centimeters thick on many sections of the transect lines. No weathered pellet groups were found on top of the Japanese honeysuckle. Occasionally groups would be found in open areas under the honeysuckle. It was believed that a short time after deposition, pellets fall under the honeysuckle and thus out of sight of the searcher. Errors based on the second statement were considered nonexistent because

all known pellet groups on Section A were picked up for scintillation analysis and pellet groups on Section B were destroyed.

Pellet group sampling is more efficient in areas of high pellet group density (Neff 1968). Due to the very low number of pellet groups per hectare on the Reservation (average 6.57 groups per hectare or 2.66 per acre), the efficiency of the method at the present herd level is extremely low. If pellet group surveys are to be continued on the Reservation, the data should be used only as a rough index for yearly comparisons until herd density is high enough to allow efficient sampling by this method.

Van Etten and Bennett (1965) suggested that a small plot size of .008 ha (.02 acres) be used when conducting pellet group surveys. This small sample area allows a much more thorough search to be conducted by utilizing double coverage of the plot. In the situation that exists on the Reservation, smaller plots would be more beneficial than line transects. The main advantage would not only be the accuracy of the count but also the economy of time and money allocated for the project.

Night-lighting counts. Night-lighting counts were conducted on Section A with attempts at free-ranging capture. Monthly density estimates were calculated using the King method. The King method uses a doubled average of all

flushing distances and the total length of census lines to calculate the area populated by the deer observed (Howe 1954).

Expanding the formula for the King method from

$$Nt = \frac{CF}{\bar{d}2L}$$

where Nt = deer per square mile

C = conversion factor to put $\bar{d}2L$ and Nt in same units

F = total number of deer flushed

d = average flushing distance in yards perpendicular to census line

L = length of census line in miles

to

$$Nt = \frac{(a)\ (y_1)\ F}{(d)\,2\,(L)\ (y)}$$

where a = acres per square mile

y_1 = square yards per acre

y = yards per mile

we get a usable formula that allows us to calculate the number of deer present, based upon our observations, per square mile (converted to metric). Monthly density estimates along with the mean density estimate for the entire study period are shown in Table 6. The mean density estimate of one deer per 114 ha (281 acres) or a total estimate of 31 deer on Section A was low compared to a "guesstimated"

TABLE 6

DENSITY ESTIMATES OF WHITETAILED DEER ON SECTION A OF THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION BASED UPON THE KING METHOD OF DENSITY ESTIMATION

Census	Number of Deer Observed	Average Distance To Census Line (yds)	Density Estimate (deer/mi^2)	Month
1	4	50.00	2.82	
2	4	50.00	2.82	
3	5	64.00	2.75	December
4	6	50.00	1.41	1974
5	6	45.00	4.69	
			$\bar{\Sigma}$ 2.90	
6	4	63.75	2.21	
7	1	100.00	.35	January
8	1	100.00	.35	1975
9	6	37.50	5.62	
			$\bar{\Sigma}$ 2.14	
10	2	130.00	.54	
11	3	150.00	.70	
12	1	25.00	1.41	
13	1	50.00	.70	February
14	3	200.00	.51	1975
15	4	18.75	7.51	
16	5	20.00	8.80	
17	3	15.00	7.04	
			$\bar{\Sigma}$ 3.40	
18	4	35.00	4.02	
19	3	80.00	1.32	
20	4	70.00	2.01	March
21	3	100.00	1.06	1975
22	7	180.00	1.37	
			$\bar{\Sigma}$ 1.96	

TABLE 6 (continued)

Census	Number of Deer Observed	Average Distance To Census Line (yds)	Density Estimate (deer/mi^2)	Month
23	3	100.00	1.06	
24	8	51.25	5.49	
25	2	50.00	1.14	April
26	0	0	0	1975
27	1	50.00	.70	
			Σ 1.73	
28	0	0	0	
29	0	0	0	May
30	8	37.50	7.51	1975
			Σ 2.50	
31	2	100.00	.70	
32	4	48.75	2.89	
33	5	68.00	2.59	
34	1	5.00	7.04	June
35	5	64.00	2.75	1975
36	3	25.00	3.17	
37	2	40.00	1.76	
38	0	0	0	
39	4	85.00	1.66	
			Σ 2.51	
40	2	35.00	2.01	
41	0	0	0	
42	2	20.00	3.52	July
43	1	20.00	1.76	1975
44	2	40.00	1.76	
45	0	0	0	
46	1	20.00	1.76	
47	1	35.00	1.01	
			Σ 1.48	
48	5	45.00	3.91	
49	1	30.00	1.17	August
50	4	73.75	1.91	1975
			Σ 2.33	

TABLE 6 (continued)

Census	Number of Deer Observed	Average Distance To Census Line (yds)	Density Estimate (deer/mi^2)	Month
51	0	0	0	
52	2	40.00	1.76	September
53	6	55.83	3.78	1975
			$\bar{\Sigma}$ 1.85	

Mean density estimate = 2.28/mi^2 (1 deer/114 ha or 281 acres).

Section A has a total estimated density of 31 deer.

$P\ (1.65/mi^2 < N < 2.91/mi^2) = 0.95$

$P\ (23 < N < 40) = 0.95$

density of one deer per 60 ha (150 acres) derived from night-light counts during October and November 1974.

Night-lighting trips were conducted regardless of weather conditions with the exceptions of heavy rain and heavy fog which restricted observational distance to only a few meters. Progulski and Duerre (1964) reported that nightly deer sightings fluctuated respectively with increases and decreases in temperature. They also noted that a change in habitat due to seasonal and physiological changes due to fawning and antler development decreased observations. Observations fluctuated directly with temperature during December 1974 and January, February, and March 1975. Deer were also more elusive in open areas and more observations were made in and around thick cover during July than had been made previously. This was thought to be the result of fawning and antler development.

Three areas within Section A where deer were consistently observed were disturbed by construction and/or other research activities during this study (Figure 11). The area along Bear Creek Road west of White Wing Road experienced considerable disturbance due to earthen core sampling and surveying for a proposed nuclear recycling plant. This area had received high priority early in the study based upon many reported deer observations by ORNL personnel. Few deer observations were made in this area with the exception of the

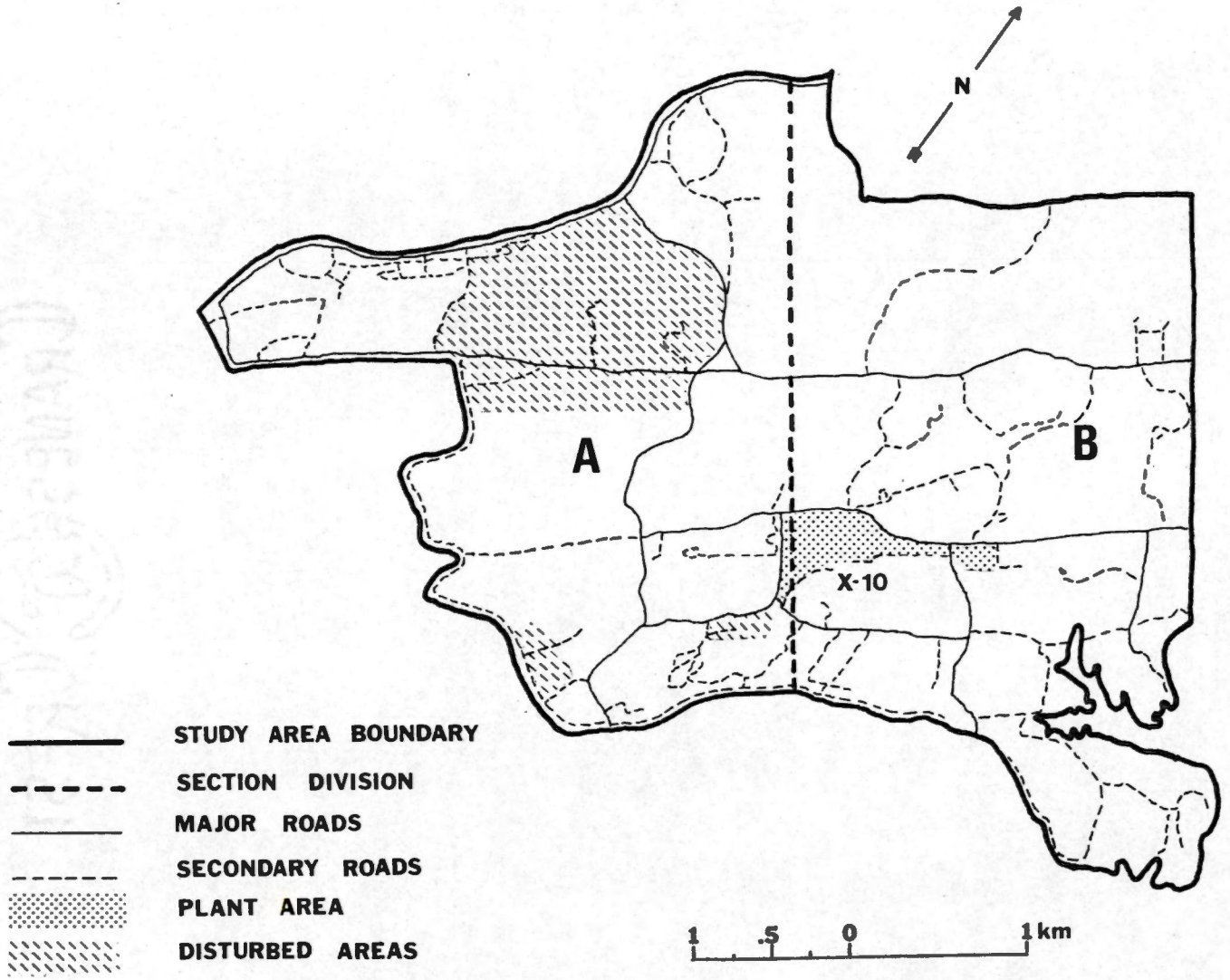

Figure 11. Areas within Section A of the study area located on the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation that experienced disturbance between December 1974 and September 1975.

large field adjacent to the intersection of Bear Creek and White Wing Roads. Burial Ground Number Three adjacent to Lagoon Road was a prime area of deer observation early in the study. Increased human activity around the burial ground started in late May 1975 and deer observations decreased. Road and drainage improvements were implemented around the burial ground in late July 1975 and observations of deer ceased. An ORNL employee was caught night-lighting the field on one occasion thus contributing to the overall harassment. The 0800 Area proved to be an excellent location to observe deer until increased research in July 1975 by ORNL personnel required a mobile home size trailer to be installed on the lower section of the area. Deer observations decreased immediately. Deer that were seen were extremely wary of our presence. Increased forestry activity on the Reservation did not seem to hinder deer observations. In fact, it may have increased observations by opening up areas that before were too dense to search.

Night-lighting counts conducted by Howe (1954) and subjected to the King method of density estimation resulted in an estimate considerably higher than estimated by other means. He suggested that deer seen at distances greater than 96 m (105 yds) tend to raise the average distance without proportionately adding to the total number of observations. Concurrent research conducted by the author,

which will be discussed in detail in a later section, on an area of previously estimated deer density indicated that the King method was consistently low in its estimate of deer density based on night-light counts.

Roadside counts. Roadside counts of upland game provide a useful index to species density in some states (Overton 1969). Due to the low numbers of deer seen during a one night observation period on the Reservation, a better index of the herd density may be the number of kilometers traversed to observe one deer (Table 7). During this study one deer was observed for every 11 km (6.8 miles) driven during a nightly observational period. If similar data can be collected and recorded over several years, it can prove useful as an index to herd density with minimum time expended during an organized monitoring program.

Radioactive feces tagging. Three pellet groups of the 32 pellet groups collected on Section A for scintillation analysis proved to be positive (Appendix A, Table 16); that is, the pellet groups came from one or more of the seven deer marked with Zn-65. Based upon these data the density estimated by the Lincoln Index was 75 deer or one deer per 47 ha (115 acres). The estimate was obtained from the formula:

$$N = \frac{Mn}{x}$$

TABLE 7

NUMBER OF KILOMETERS PER WHITETAILED DEER OBSERVED ON SECTION A OF THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

Month	Distance Driven Kilometers (Miles)	Number of Deer Observed	One deer per X Kilometers (Miles)
December 1974	431 (268)	32	14 (8)
January 1975	309 (192)	21	15 (9)
February 1975	673 (418)	52	13 (8)
March 1975	311 (193)	55	6 (4)
April 1975	385 (239)	42	9 (6)
May 1975	203 (126)	14	15 (9)
June 1975	692 (430)	88	8 (5)
July 1975	663 (412)	51	13 (8)
August 1975	227 (141)	27	8 (5)
September 1975	206 (128)	22	9 (6)
			11 (6.8)

where N = population estimate

M = number of marked individuals in the population

n = number of observations of animals in the population

x = number of observations of marked animals

$$N = \frac{(7)(32)}{3} = 75$$

$$P\ (17 < N < 276)\ 0.95$$

Assumptions underlying this method are (Seber 1973): (1) the population is closed, so that N is constant, (2) all animals have the same probability of being caught in the first sample, (3) marking does not affect the catchability of an animal, (4) the second sample is a simple random sample, (5) animals do not lose their marks in the time between the two samples, and (6) all animals are reported on recovery in the second sample. Marcum (1974) proposed a seventh assumption when computing estimates based on radioactively tagged and untagged feces: the ratio of tagged to untagged feces collected from the study area is proportional to the ratio of tagged to untagged animals in the study area.

The Lincoln Index has been used by several biologists in estimating deer populations. Lewis and Safley (1966) used hunter tag returns while Standgaard (1967) based his estimate on reobservations of tagged animals. Both studies

reported reliable estimates. Because of a small number of marked deer (7), a small sample size of pellet groups (32), and a small number of radioactively tagged pellet groups (3), it is difficult to justify the reliability of the estimate. This is reflected in the wide confidence interval ($17 < N < 276$) at the 95 percent level of significance.

Mark and reobservation. The Schnabel method (1938) was used to estimate a population number from mark-reobservation data collected in Section A. With this technique, it was possible to collect data throughout the study period. The data more closely fit a binomial distribution. Therefore, Schnabel's binominal model,

$$N'' = \frac{\Sigma(n_i M_i)}{m_i + 1}$$

where N'' = population estimate

n_i = total sample taken in the ith period

M_i = total number of marked animals in the population at the start of the ith period

m_i = number of marked samples in n_i,

according to Seber (1973), was used for the calculation. This method assumes that: (1) the population is closed, (2) mortality rates among marked and unmarked individuals are the same, (3) marks are not lost, (4) marks are recognizable, (5) recruitment is negligible, (6) marked and

unmarked animals are randomly mixed, and (7) every member of the population has an equal chance of contributing to the estimate (Seber 1973, Marcum 1974).

The population was estimated to be 70 deer or one deer per 50 ha (124 acres). This result was based on only seven marked deer and 18 reobservations therefore yielding a relative wide confidence interval ($43 < N < 116$) at the 95 percent level of probability (Table 8).

Researchers working with known populations have reported varying results when using marked animals as bases for density estimates. Brady (1973) reported that the Schnabel method provided estimates as much as 50 percent lower than known density levels of cottontail rabbits (Sylvilagus floridanus) within an enclosure. He attributed this to cottontail behavior and trap shyness. Standgaard (1967) determined that at least two-thirds of a population should be marked to yield satisfactory results when working with a mark-reobservation program. Lueth (1965) stated that although the Schnabel method may not meet the requirements (within 5 or 10 percent of the real population) of a population estimator, at least it allows us to possess a workable knowledge of the population.

Distribution

Road-kill locations. Whitetailed deer road-kills on the Reservation from 1969-September 1975 indicate that a higher

TABLE 8

DENSITY ESTIMATE OF WHITETAILED DEER ON SECTION A OF THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION AS DETERMINED BY MARK-REOBSERVATION DATA USING THE SCHNABEL METHOD

Date	n_i	m_i	M_i	n_iM_i
December 1974	32	0	0	0
January 1975	21	0	1	21
February 1975	52	3	1	52
March 1975	55	1	1	55
April 1975	42	1	3	126
May 1975	14	0	4	56
June 1975	88	3	4	352
July 1975	51	5	6	306
August 1975	27	4	7	189
September 1975	22	1	7	154
		18		1,311

$$N = \frac{\Sigma(n_iM_i)}{m_i + 1} = \frac{1,311}{19} = 69$$

$$P\ (43 < N < 116) = 0.95$$

deer density exists on the western section (Section A) of the study area than on the eastern section (Section B). Thirty-three deer have been killed in vehicle/deer accidents on White Wing Road, Bear Creek Road west of the White Wing Road/Bear Creek Road intersection, and on the Oak Ridge Turnpike west of the White Wing Road intersection. Bethel Valley Road east of the White Wing Road intersection to the 7600 Area (three miles east of X-10) has experienced 11 road-kills during the five year recording period (Figure 12) (Story 1975). The Oak Ridge Turnpike and White Wing Road are the main public arteries east and west and north and south. Therefore, they experience a greater amount of vehicle traffic at all times of the day than do Bethel Valley Road and Bear Creek Road. However, during shift changes at the plants, all exit roads experience heavy traffic.

MaCaffery (1973) reported that whitetailed deer road-kills provided a useful index to deer population changes in Wisconsin and correlated well with trends in registered buck harvests. Road-kills on the Reservation certainly indicate that the ORNL deer herd is building in number and expanding from the hypothesized point of entry in the western end of the Reservation.

Night observations. Night observations of deer in Section A indicated high densities in three of the same general areas as indicated by road-kills: (1) the

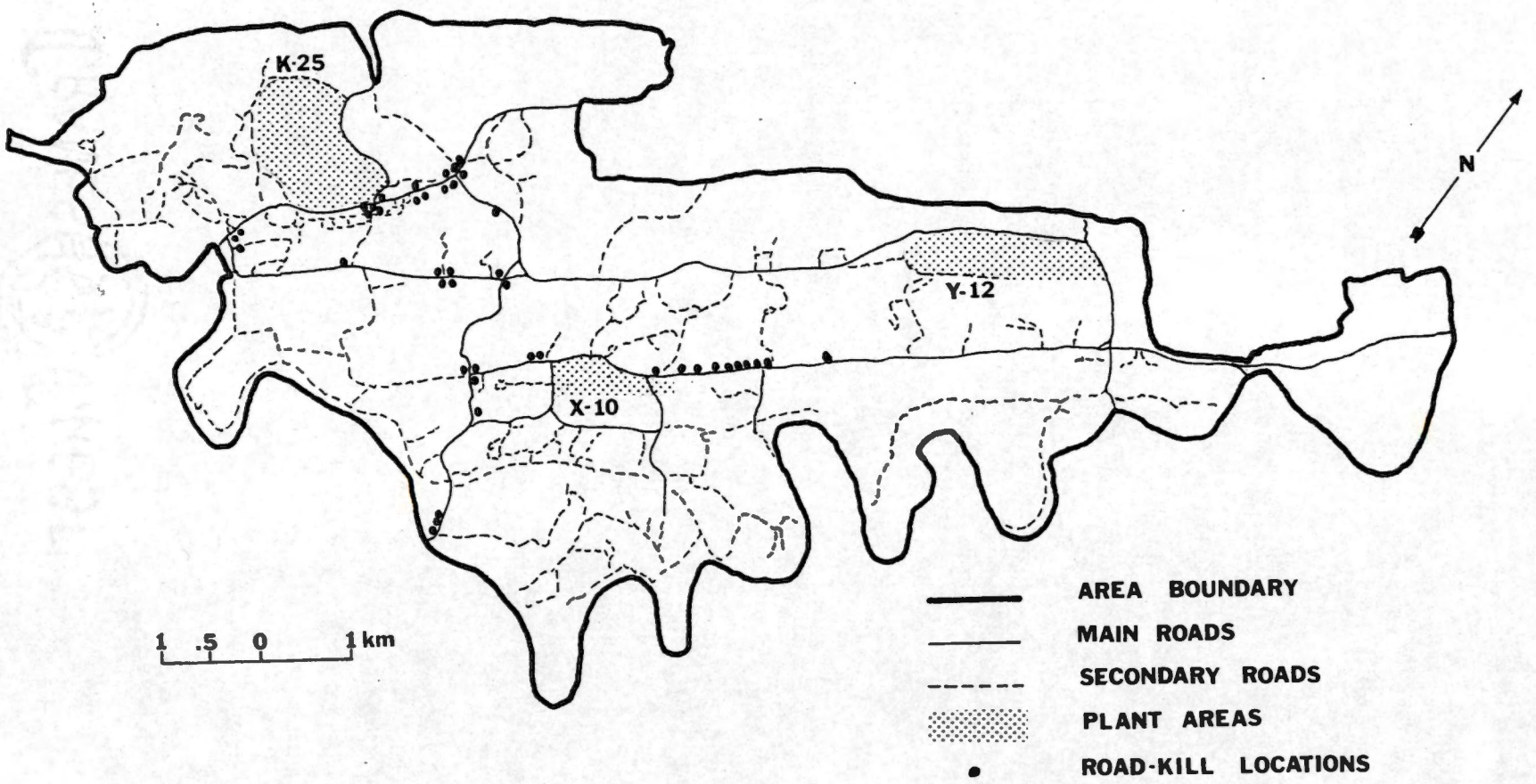

Figure 12. Road-kill locations of whitetailed deer from 1969 through September 1975 on the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

intersection of Bear Creek Road and White Wing Road, (2) north White Wing Road near the Oak Ridge Turnpike intersection, and (3) the old house sites south of Oak Ridge Turnpike in the K-25 area. Other high density locations were the 0800 Area, ORNL Burial Ground Number Three, and White Wing Road/power line intersection atop Chestnut Ridge (Figure 13, and Appendix B, Figure 15 thru Figure 24). All of the above areas yielded higher monthly counts of deer than any other locations in Section A.

Pellet group locations. Even though pellet group counts were too low for a valid density estimate, group locations should indicate relative deer densities assuming recognition of pellet groups is the same in all sampled sections. Pellet group locations in Section A showed high deer densities in two of the same areas as night observations and road-kills: (1) the 0800 Area and (2) the area north of ORNL Burial Ground Number Three (Figure 14).

B. CHUCK SWAN WILDLIFE MANAGEMENT AREA

Evaluation of Pellet Group Surveys

To evaluate the results of pellet group surveys on the Oak Ridge Reservation, it was necessary to test the method on an area of previously determined density. The Chuck Swan Wildlife Management Area has a well monitored deer herd based on several census techniques. These techniques include

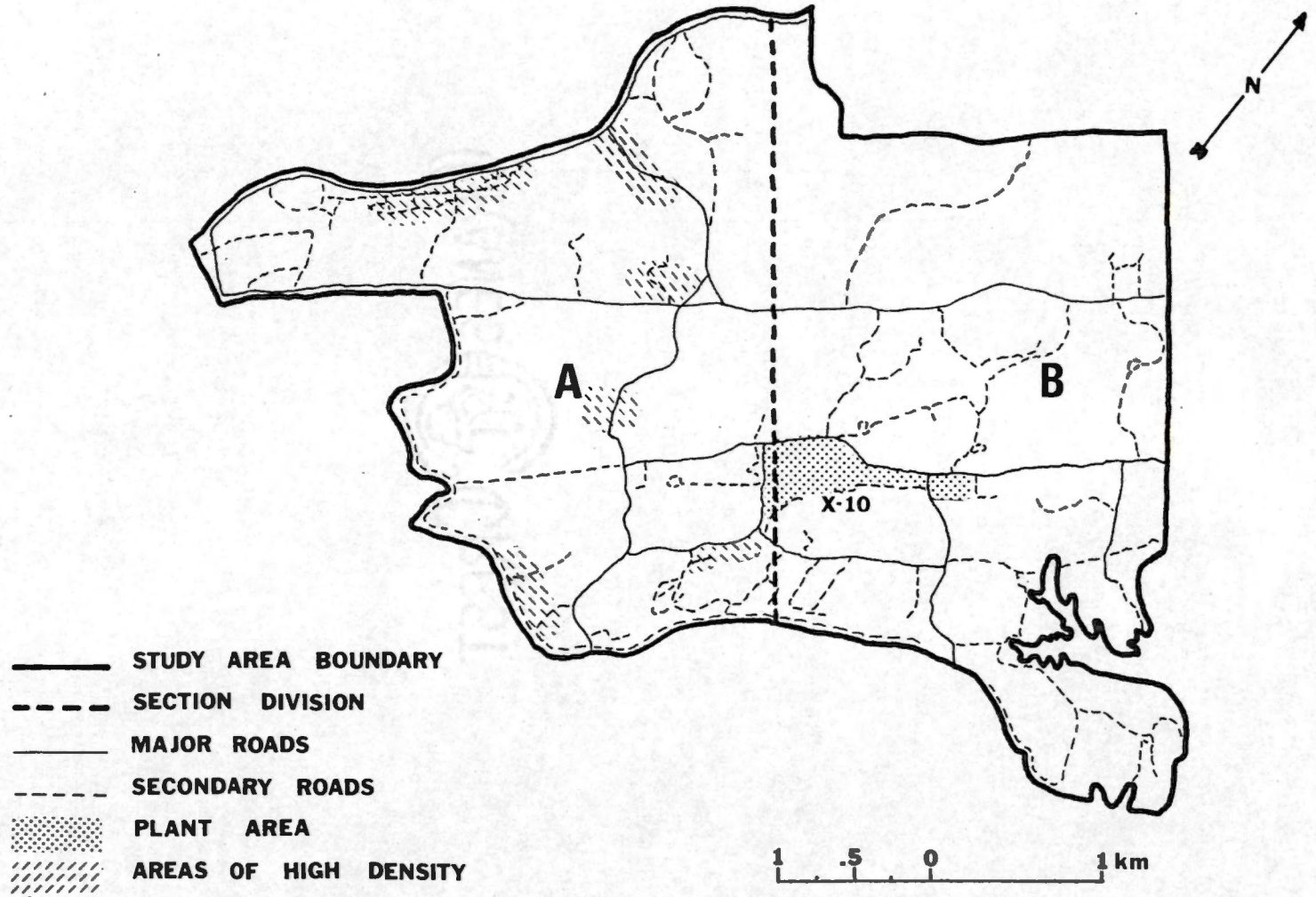

Figure 13. High density areas of whitetailed deer determined by night-light counts from December 1974 through September 1975 on Section A of the study area located on the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

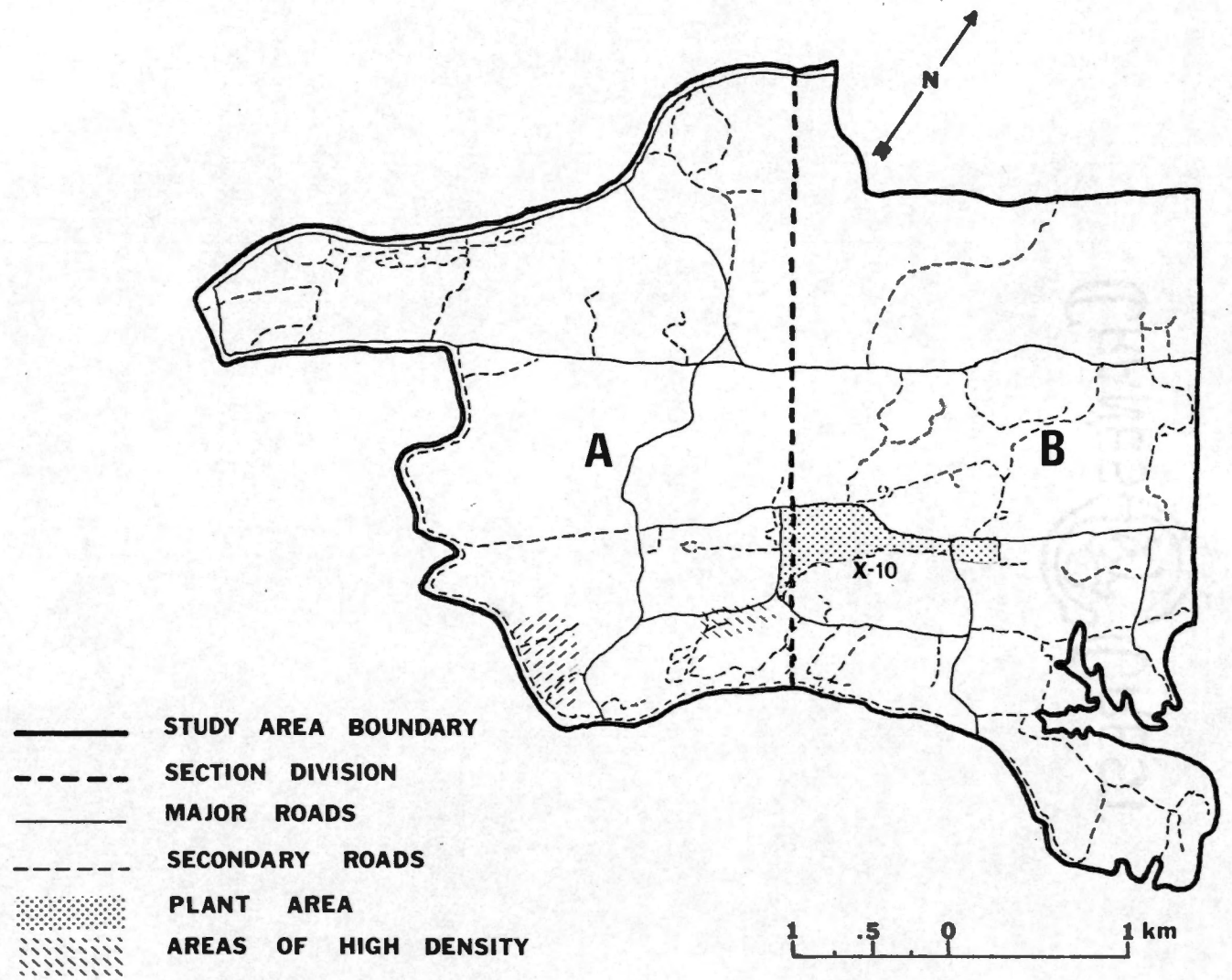

Figure 14. High density areas of whitetailed deer determined by pellet group surveys on the study area located on the Energy Research and Development Administration's Oak Ridge, Tennessee Reservation.

the Lincoln Index, sex-age-kill method, percent of kill, minimum standing crop, and minimum fawn crop conducted in the 1960's by Lewis and Safley (1966). Current estimates have been based upon hunter-kill data. The present density was estimated at one deer per 4.05 ha (10 acres) (Carl Rogers, area manager, personal communication).

Pellet group survey results, based on a 30 day sampling interval as compared to a 120 day sampling interval on the Reservation, were very close to the density estimate determined by hunter-kill data. Density estimates for July, August, and September 1975, were respectively one deer per 3.11 ha (7.68 acres), one deer per 4.05 ha (10 acres), and one deer per 5.78 ha (14.28 acres). The average estimate for the three-month period was one deer per 4.31 ha (10.66 acres), which agrees with the estimate made by the Tennessee Wildlife Resources Agency.

Evaluation of Night-lighting Counts

Night-lighting counts were conducted on the Chuck Swan Wildlife Management Area and data were subjected to the King method of density estimation. These counts were made, as were the pellet group surveys, for comparative purposes in evaluating the technique on an area of previously determined density. The density estimate was based upon counts conducted in July, August, and September 1975 (Table 9). The average estimate for this time period was one deer per

TABLE 9

ESTIMATED DENSITY OF WHITETAILED DEER ON THE CHUCK SWAN WILDLIFE MANAGEMENT AREA BASED UPON NIGHT-LIGHTING COUNTS AND THE KING METHOD OF DENSITY ESTIMATION

Date	Number of Deer Observed	Average Distance from Census Line (yards)	Density Per Square Mile
7/2/75	75	74.47	35.45
7/24/75	95	74.53	44.87
			$\bar{\Sigma}$ 40.16
8/20/75	59	123.22	16.85
8/26/75	55	120.36	16.85
			$\bar{\Sigma}$ 16.85
9/9/75	65	121.62	18.81
9/24/75	168	90.32	65.47
			$\bar{\Sigma}$ 42.14

Mean density estimate = 33.05/mi^2 (1 deer/7.83 ha or 19.36 acres).

P (17.37/mi^2 < N < 48.73/mi^2) = 0.95

Total density estimate = 1,283 deer.

P (1430 < N < 1891) = 0.95

7.83 ha (19.36 acres) or 1.9 times lower than the density estimated by the Tennessee Wildlife Resources Agency.

Pellet Group Deterioration

Pellet group deterioration and/or disappearance has received considerable concern since the incorporation of pellet group surveys into whitetailed deer census techniques in the late 1930's. Attempts to use the pellet index in the Southeast have been unsuccessful due to deterioration and/or disappearance (Overton 1969).

It became evident in searching for pellet groups on the Reservation that either the deer herd was too small to census by this method or that deterioration and/or disappearance of pellet groups were significantly high. This low incidence of pellet groups on the Reservation required that a study be conducted to determine the rate of deterioration and/or disappearance of pellet groups in this geographic region.

Three hundred and eighty-one pellet groups were located and marked on 16 transects lines in July 1975. The transects were cleaned of all pellet groups in June 1975, therefore, pellet groups marked in July could have ranged in age from one to 30 days. Of the 381 pellet groups marked in July, only 19 or 5 percent were not found 30 days later in August. Of the same 381 pellet groups marked in July, 75 or a total of 20 percent were not found 60 days later in September. Two hundred and sixty-five new groups on the same transects

were marked in August 1975 and checked again in September. A total of 63 or 24 percent were not found (Appendix A, Table 18). This is an indication that pellet group deterioration and/or disappearance is variable in the Southeast.

A deterioration study conducted by Patric and Bernhardt (1960) in Adirondack forests concluded that groups persist for long periods in that area. Some groups remained evident for as long as 2.5 years and in many areas pellet groups 1.5 years old looked very similar to groups only six months old. Van Etten and Bennett (1965) determined that pellet groups deposited on dry, closed hardwood sites demonstrated the lowest rate of deterioration in Michigan while pellets deposited on closed, swampy sites demonstrated the highest. Excessive moisture and heavy rains seem to be the primary factors in pellet group deterioration. Wallmo et al. (1962) reported that heavy rains had a significant effect on the persistence of pellet groups. They lost as high as 91 percent of all marked groups after four heavy rains on their study area in Texas.

It is evident, based upon the above data, that deterioration and/or disappearance of pellet groups in the Southeast as compared to other sections of the United States would invalidate the use of pellet group counts based on long sampling intervals but a short sampling interval of one month

seems to be appropriate based on the reported results. This study lasted only three months but the preliminary data showed promising results that should be pursued further.

CHAPTER V

SUMMARY AND CONCLUSIONS

The concern of ORNL personnel for proper land management and their knowledge of the biotic potential of whitetailed deer in a nonhuntable situation prompted this study.

Information on low density whitetailed deer herds seems to be restricted primarily to state and federal reports dealing with basic management programs. The validity and accuracy of estimating low density herds, to the knowledge of the author, has not been discussed in current literature. This provided the major problem basic to this thesis.

The "guesstimated" density at the beginning of the program, based upon reports and guided field trips to previously observed deer use areas by ORNL personnel, was one deer per 20 ha (50 acres). Once the program was started, it was evident that this "guesstimated" density was too high. Initial surveillance of the proposed study area conducted by night-lighting during October and November 1974 resulted in an average of five deer per night while driving an average of 70 km (43 miles). Realizing the situation that existed, four census techniques were incorporated into the program: (1) pellet group surveys, (2) night-light counts using the King method of density estimation, (3) mark-reobservation using the Schnabel method, (4) radioactively tagged feces

using the Lincoln Index. It was thought that by comparing results based upon four methods of density estimation instead of one that a better understanding of the density could be achieved. Roadside counts were conducted for an index of density.

Pellet group surveys based upon conventional time intervals of six months or one year have been regarded unreliable as a density index for whitetailed deer in the Southeast (Overton 1969). Pellet group surveys were incorporated into this program not only for a density index but also for the purpose of evaluating sample time intervals basic to the index. The major advantage of pellet group surveys is that they are well adapted to random sampling thus reducing inherent biases of other sampling methods (Coggin 1970).

Pellet group surveys on Sections A and B of the Reservation sampled 5.03 ha (12.42 acres) in January, May, and September 1975 (120 day sampling interval). An average of 18.69 pellet groups per hectare (7.57 groups per acre), based upon the January and May counts, was considered too low for a valid density estimate of the study area. To further evaluate the pellet group surveys, a concurrent pellet group survey, sampling 2.98 ha (7.36 acres) was installed on the Chuck Swan Wildlife Management Area. Density estimates were based on a 30 day sampling interval

and were conducted during July, August, and September 1975. The average estimate for the three sampling periods was identical to the estimate of the Tennessee Wildlife Resources Agency of one deer per 4.05 ha (10 acres) (Table 10).

Pellet group surveys conducted on the Chuck Swan Wildlife Management Area indicate that pellet group surveys can be a reliable estimate of deer density in the Southeast if a sampling interval of 30 days is used. However, it is suggested that a pellet group density of at least 65 groups per hectare (30 groups per acre) be present before a reliable estimate is made. Pellet group surveys on permanent plots on the Reservation may prove to be a valid index to herd growth when incorporated into a monitoring program of yearly comparisons.

Pellet group deterioration and/or disappearance over a sampling interval greater than 30 days is an important factor when using pellet group surveys in the Southeast. It was found during this study that of 381 pellet groups ranging from one to 30 days of age when marked in July 1975, 19 or 5 percent were not found 30 days later in August and 75 or 20 percent were not found 60 days later in September. New groups (265) marked in August on the same transects exhibited a 24 percent deterioration and/or disappearance rate in only one month.

Deterioration and/or disappearance is extremely important when working with pellet group surveys and time

TABLE 10

COMPARISON OF DENSITY ESTIMATES OF WHITETAILED DEER ON SECTION A OF THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION AND THE TENNESSEE WILDLIFE RESOURCES AGENCY'S CHUCK SWAN WILDLIFE MANAGEMENT AREA

Estimated Number of Deer								
ERDA's Oak Ridge Reservation						TWRA's Chuck Swan Wildlife Management Area[a]			
Pellet Group Counts		Mark-Reobservation (Schnabel's Method)	Night-Light Counts (King Method)		Radioactively Tagged Feces (Lincoln Index)	Pellet Group Counts		Night-Light Counts (King Method)	
Jan 1975	69	69[b]	Dec 1974	40	75[c]	Jul 1975	3,231	Jul 1974	1,541
May 1975	26		Jan 1975	29		Aug 1975	2,481	Aug 1974	639
Sep 1975	5		Feb 1975	46		Sep 1975	1,739	Sep 1975	1,605
	Σ 33		Mar 1975	27			2,484		1,262
			Apr 1975	24					
			May 1975	34					
			Jun 1975	37					
			Jul 1975	20					
			Aug 1975	32					
			Sep 1975	25					
				Σ 31					

[a]TWRA estimate 1 deer/4.05 ha (10 acres) or 2,484 deer.

[b]Estimate based on continuous sampling (Dec. 1970-Sept. 1975).

[c]Estimate based on total returns during two sampling periods.

is the primary variable of the method. Deterioration and/or disappearance rates based upon sampling interval and season of sampling should be determined if pellet group surveys are to be successful in the Southeast.

Density estimates on Section A of the Reservation based upon night-lighting (King method), mark-reobservation (Schnabel's method), and radioactively tagged feces (Lincoln Index) were respectively 31 deer (one deer/114 ha or 281 acres), 69 deer (one deer/51 ha or 125 acres), and 75 deer (one deer/47 ha or 115 acres) (Table 10). Confidence intervals around each estimate were large at the 95 percent level of probability due to the small sample size in each estimate. Even though a large confidence interval exists around each estimate, the estimates based upon mark-reobservation and radioactively tagged feces are representative of the whitetailed deer density on Section A of the Reservation. This is based not only on the estimates themselves, but also the low count of pellet groups on established transects and a lack of visible browsing, especially on strawberry bush (Euonymus americanus) which is considered an "ice cream" food for deer and is rather abundant on the Reservation.

The night-lighting estimate of 31 deer on Section A of the Reservation appears to be too low. Night-lighting efforts conducted on the Chuck Swan Wildlife Management Area during

July, August, and September 1975 yielded an estimate of 1,283 deer. This estimate is 1.9 times lower than estimated by the Tennessee Wildlife Resources Agency and the previously discussed pellet group survey. Based upon this result, one can assume that the night-lighting estimate on Section A of the study area on the Reservation is too low by approximately one half. If this is indeed true, by correcting the estimate of Section A appropriately, the estimate becomes 60 deer or one deer per 60 ha (148 acres). Comparing this corrected estimate to the estimates based upon mark-reobservation (69 deer) and radioactively tagged feces (75 deer), the result is a maximum difference of only 15 deer. This indicates that the three estimates exhibit little variability and provide a maximum estimate of one deer per 40 ha (98 acres) and a minimum estimate of one deer per 60 ha (148 acres).

This low estimate may indicate that one or two possible factors exist on the Reservation with regard to the deer herd. First, the herd may be in the establishment phase. Lewis (1970) noted that population growth is slow when a few individuals are first introduced into or enter unoccupied habitat, but if conditions are ideal rapid herd growth may follow. The second possibility is that the herd may be stagnated in the establishment phase. The inability of the herd to escape from this initial phase may be attributed to pressures from free-running dogs (three different dog packs

observed during study), poaching (known occurrences), and/or low range quality (Lewis 1970).

Distribution based upon road-kill data, night observations, and pellet group locations on transects indicate that the areas of high deer density were (1) the 0800 Area, (2) Burial Ground Number Three area, (3) Chestnut Ridge Gap on White Wing Road, (4) Bear Creek and White Wing Road intersection, (5) the old construction camp site southeast of K-25, and (6) Bethel Valley from the 7600 Area, west to X-10.

CHAPTER VI

RECOMMENDATIONS

A. MONITORING PROGRAM

1. Monitor the population closely by establishing systematic night-light counts twice monthly from March-May and October-December. Use the count as an index for yearly comparisons. Use the King strip method to estimate population density.

2. Establish permanent pellet group surveys based on transects or plots. The sampling configuration and total sampling area will depend upon the amount of time and the number of personnel allocated for the project. Plots are more economical in respect to personnel. Clean areas to be sampled of all pellet groups in late October (after leaf fall) and sample again for density estimate one month later.

3. Establish browse transects and sample in mid-winter.

4. Initiate investigations into the movement ecology of the whitetailed deer on the Reservation. Results of studies into movement ecology should help increase the efficiency of herd control through live-trapping and could determine factors most important in influencing deer/vehicle accidents.

B. CONTROL PROGRAM

When the Environmental Science Division feels it is necessary to initiate control efforts on the deer herd based on their monitoring program, the following recommendations are made. These recommendations are listed in order of increasing efficiency of removal.

1. In cooperation with the Tennessee Wildlife Resources Agency, initiate a trap-removal program.
2. Initiate a direct reduction program conducted by Environmental Science Division personnel in conjunction with physiological and/or other research of whitetailed deer on the Reservation.
3. Organize strictly controlled public hunts utilizing archery equipment and/or shotguns with buckshot.

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APPENDIXES

APPENDIX A

DATA TABLES

TABLE 11

BAIT SITE ESTABLISHMENT, BAIT AND PROPOSED CAPTURE METHOD OF WHITETAILED DEER ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

Bait Site Number	Date Established	Bait	Proposed Capture Method
001	November 6, 1974	Corn/salt	Rocket net
002	November 6, 1974	Corn/salt	Rocket net
003*	November 6, 1974	Corn/salt	Box trap
004	November 6, 1974	Corn/salt	Rocket net
005	November 6, 1974	Corn/salt	Rocket net
006	November 6, 1974	Corn/salt	Rocket net
007	November 12, 1974	Corn/salt	Box trap
008	November 12, 1974	Corn/salt	Box trap
009	November 27, 1974	Corn/salt	Box trap
010	November 27, 1974	Corn/salt	Box trap
011	November 27, 1974	Corn/salt	Box trap
012	December 26, 1974	Corn/salt	Box trap
013*	February 10, 1975	Corn/salt	Box trap

*Old established salt licks.

TABLE 12

DATES OF MICHIGAN BOX TRAP CONSTRUCTION ON PREBAITED SITES ON SECTION A OF THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

Bait Site	Date of Trap Construction on Prebait Site
003	December 3, 1974
011	December 18, 1974
006	January 13, 1975
001	January 22, 1975
004	January 25, 1975
013	February 10, 1975
002	February 10, 1975

TABLE 13

SUCCINYLCHOLINE CHLORIDE DOSAGES FOR WHITETAILED DEER USING PNEU-DART EQUIPMENT[1]

Dosage (mg)	Range of Deer Weight (kg) (lbs)
2	13-18 (30-40)
3	18-27 (40-60)
4	22-31 (50-70)
5	31-40 (70-90)
6	40-49 (90-110)
7	49-58 (110-130)
8	63-72 (140-160)
9	72-81 (160-180)
10	81-90 (180-200)
11	90-99 (200-220)
12	99-108 (220-240)
13	108-117 (240-260)

[1]Personal communication, Robert Nichols.

TABLE 14

CAPTURE RESULTS ON SECTION A OF THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

Date	Capture Number	Sex	Ear Tag Color	Ear Tag Number	Neck Collar Number	Zn-65	Capture Location
12/30/74	001	male	red	1	10	yes	Bear Creek & White Wing Road Intersection
3/15/75	002	female	--------escaped----------			no	McNew Hollow
3/15/75	003	male	red	2	11	yes	McNew Hollow
3/28/75	004	male	red	3	12	yes	White Wing Road & power line junction atop Chestnut Ridge
4/29/75	005	male	red	4	13	yes	Trap adjacent to White Wing Road on south side of Chestnut Ridge
5/20/75	006	female	yellow	1	1	yes	0800 Area
5/28/75	007	female	yellow	3	2	yes	0800 Area
6/9/75	008	female	yellow	4	3	yes	Trap site 003 at old salt lick on lower Bethel Valley Road
6/12/75	009	male	-----trap mortality----------			no	Trap adjacent to White Wing Road on south side of Chestnut Ridge
9/7/75	010	male (recapture—neck collar replaced)	red	1	14	no	Bear Creek & White Wing Road Intersection

TABLE 15

NUMBER OF PELLET GROUPS FOUND ON EACH PELLET GROUP TRANSECT ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

January 1975				May 1975				September 1975			
Section A		Section B		Section A		Section B		Section A		Section B	
Transect Number	Number of Groups	Transect Number	Number of Groups	Transect Number	Number of Groups	Transect Number	Number of Groups	Transect Number	Number of Groups	Transect Number	Number of Groups
1	--	3	--	1	--	3	--	1	--	3	--
2	1	9	0	2	0	9	0	2	0	9	0
4	2	10	0	4	0	10	0	4	0	10	0
5	1	11	0	5	0	11	0	5	0	11	0
6	9	15	0	6	0	15	0	6	1	15	0
7	5	16	2	7	4	16	0	7	0	16	0
8	0	17	2	8	3	17	1	8	0	17	1
12	2	21	1	12	0	21	1	12	0	21	2
13	0	22	6	13	0	22	0	13	0	22	1
14	0	23	0	14	2	23	0	14	0	23	0
18	5	26	5	18	2	26	0	18	0	26	0
19	8	27	0	19	0	27	0	19	0	27	0
20	3	28	4	20	7	28	0	20	0	28	0
24	13	29	0	24	4	29	0	24	2	29	0
25	1			25	0			25	2		
Total	50	Total	20	Total	22	Total	2	Total	5	Total	4

TABLE 16

ZN-65 SCINTILLATION ANALYSIS OF PELLET GROUPS TAKEN FROM PELLET GROUP TRANSECTS ON SECTION A OF THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

Group Number	Line Number	Location On Line[a]	Dry Weight (grams)	DPM	DPM/Gram
001	A-18	900/1000	4	57.0049	14.2512
002	A-18	500/600	5	39.7534	7.9507
003	A-8	1200/1300	3	34.5029	11.5009
004	A-8	100/200	3	36.0030	12.0010
005	A-8	100/200	3	72.0061	24.0020
006	A-7	100/200	3	18.7515	6.2505
007	A-7	900/1000	2	42.7715	21.3858
008	A-7	100/200	3	-12.7564	-4.2521
009	A-7	800/900	2	19.5097	9.7548
010	A-14	800/900	3	27.7639	9.2546
011	A-14	600/700	4	9.0045	2.2511
012	A-24	300/400	3	25.5128	8.5042
013	A-24	400/500	3	28.5143	9.5048
014	A-24	0/100	3	-23.2617	-7.7539[b]
015	A-24	300/400	3	1844.4290	614.8097[b]
016	A-24	1600/1700	3	-34.5215	-11.5072[b]
017	A-20	1500/1600	3	3270.5390	1090.1797[b]
018	A-20	1000/1100	4	3.0018	.7505
019	A-20	1400/1500	3	66.7916	22.2639
020	A-20	1400/1500	4	82.5515	20.6379
021	A-20	1000/1100	3	16.5102	5.5034
022	A-20	1000/1100	3	20.2626	6.7542
023	A-20	1000/1100	3	114.8215	38.2738
024	A-20	1200/1300	4	7.5046	1.8762
025	A-20	1200/1300	3	52.5579	17.5193[b]
026	A-20	1400/1500	2	148.6639	74.3320[b]
027	A-20	1400/1500	3	-12.0132	-4.0044
028[c]	A-25	700/800	2	10.5115	5.2558
029	A-25	1100/1200	3	18.7707	6.2569
030	A-24	1900/2000	3	-27.7806	-9.2602
031	A-24	1800/1900	3	131.3948	43.7983
032	A-6	1000/1100	3	4.5048	1.5016

[a]Location given between 100 ft markers on transect.

[b]Feces from radioactively tagged deer.

[c]Second sampling period.

TABLE 17

BAIT SITE ACTIVITY BY WHITETAILED DEER ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

Bait Site Number	Date of Bait Site Establishment	Date of First Deer Activity
001	November 6, 1974	November 22, 1974
002	November 6, 1974	November 22, 1974
003	November 6, 1974	November 6, 1974
004	November 6, 1974	November 22, 1974
005	November 6, 1974	December 2, 1974
006	November 6, 1974	November 22, 1974
007	November 12, 1974	----------[2]
008	November 12, 1974	----------[2]
009	November 27, 1974	----------[2]
010	November 27, 1974	----------[2]
011	November 27, 1974	January 5, 1975
012	December 26, 1974	----------[2]
013[1]	February 10, 1974	February 10, 1975

[1]Old salt lick.

[2]No activity during monitoring period (date of establishment through February 15, 1975).

TABLE 18

PELLET GROUP DETERIORATION RESULTS FROM THE CHUCK SWAN WILDLIFE MANAGEMENT AREA

Transect Number	Number of Pellet Groups Marked in July 1975	Number of Marked Pellet Groups Deteriorated		Number of Pellet Groups Marked in August 1975	Number of Marked Pellet Groups Deteriorated
		Aug.	Sept.		Sept.
001	3	0	0	3	1
002	4	0	0	2	2
003	97	0	3	22	1
004	3	1	0	1	1
005	12	3	1	8	0
006	20	1	4	21	7
007	18	1	4	4	1
008	23	4	8	3	2
009	20	3	5	25	9
010	15	1	3	25	5
011	8	1	2	9	0
012	50	0	3	54	10
013	43	3	6	31	6
014	7	0	1	6	1
015	18	0	5	23	8
016	40	1	11	28	9
	381	19	56	265	63

APPENDIX B

MONTHLY OBSERVATIONAL LOCATIONS OF WHITETAILED DEER FROM DECEMBER 1975 THROUGH SEPTEMBER 1975 DETERMINED BY NIGHT-LIGHTING SECTION A OF THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

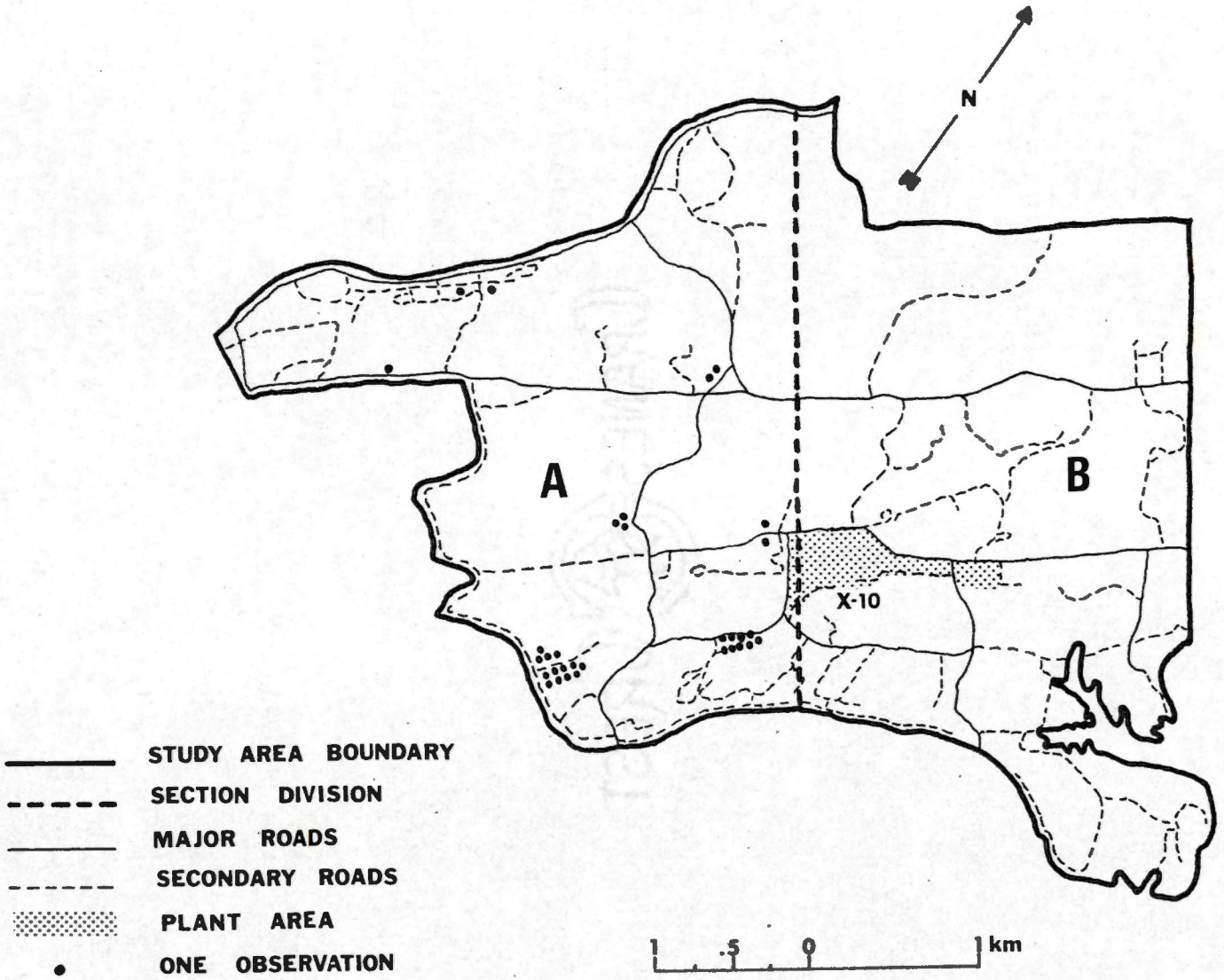

Figure 15. Whitetailed deer observations during December 1974.

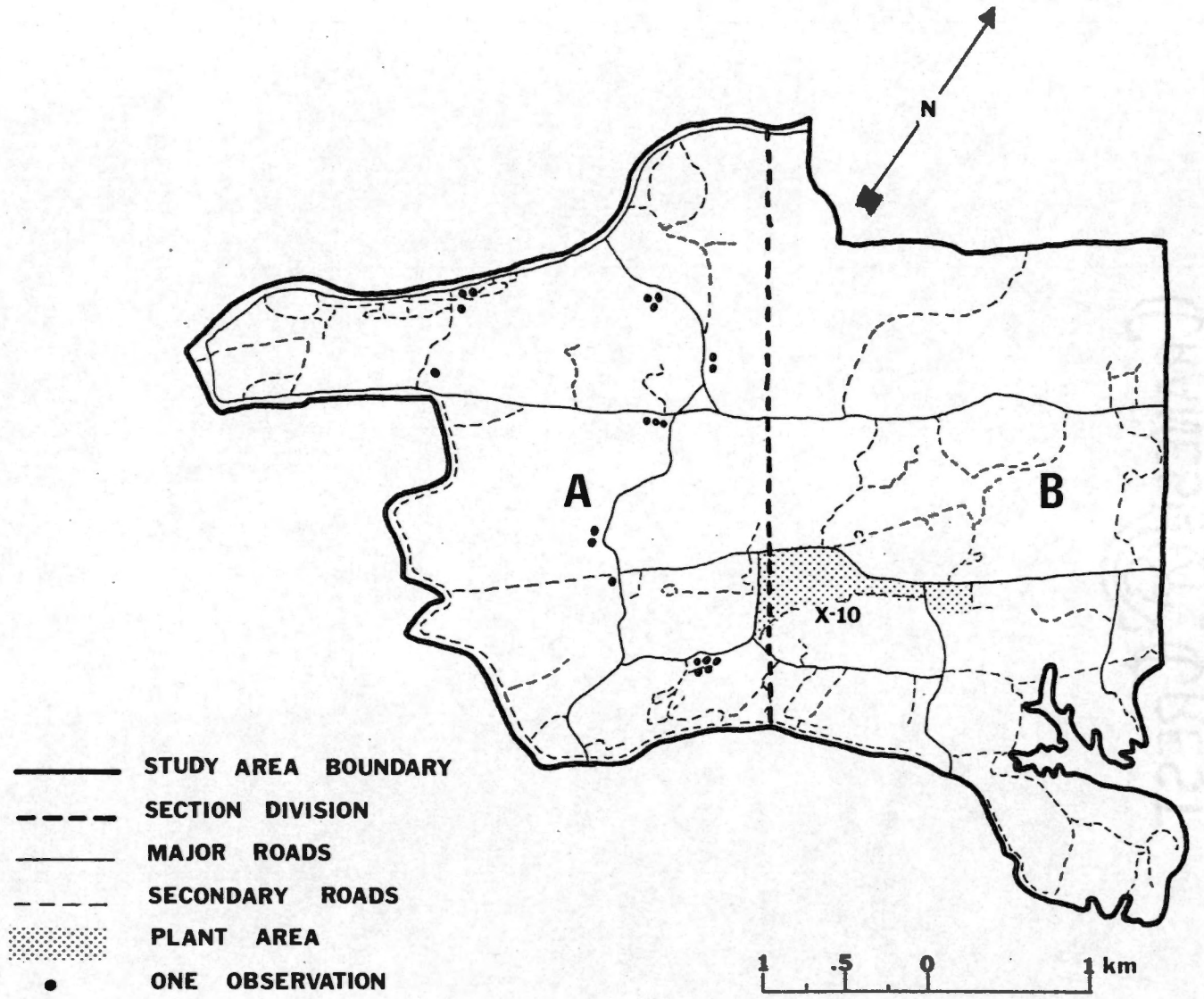

Figure 16. Whitetailed deer observations during January 1975.

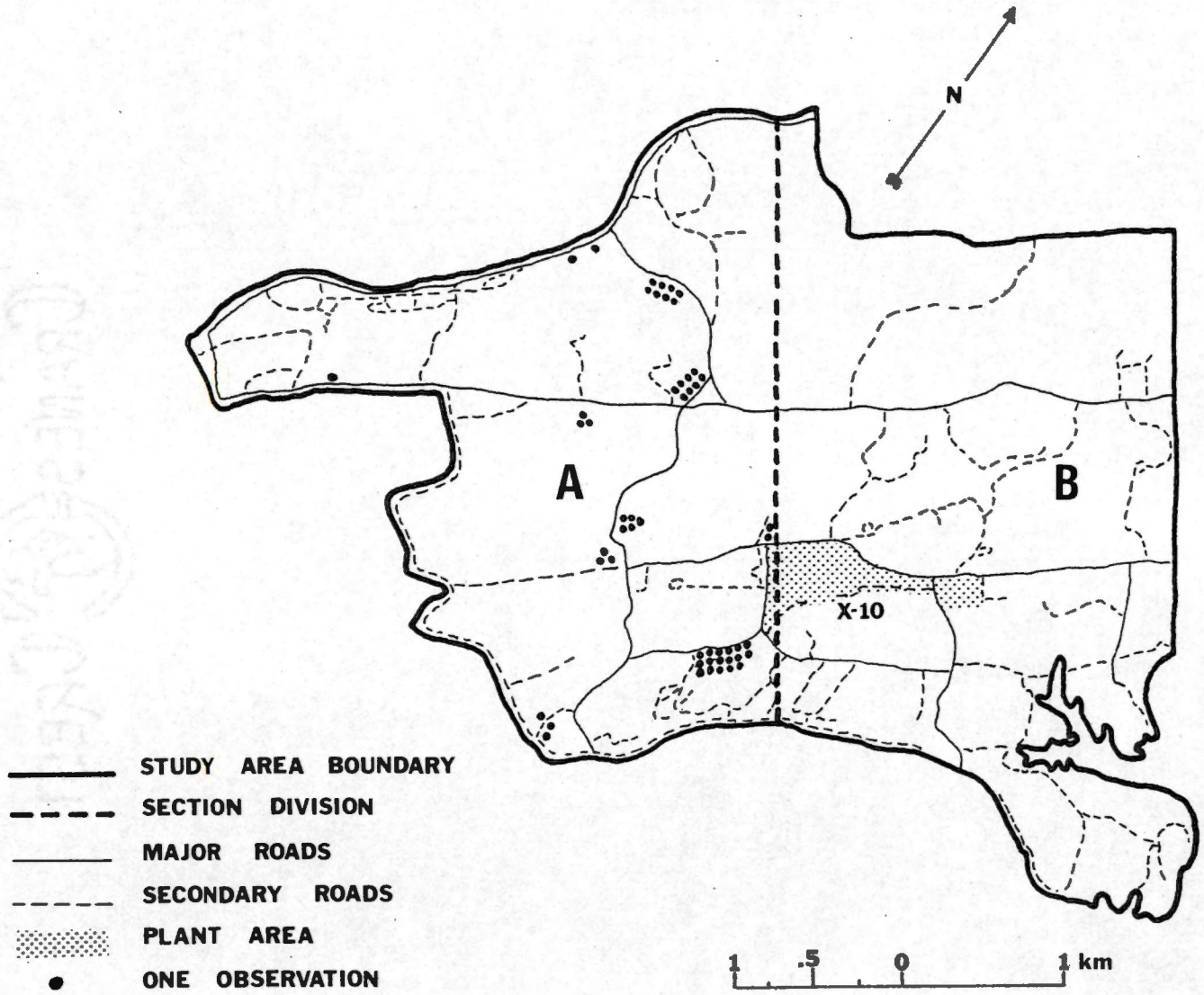

Figure 17. Whitetailed deer observations during February 1975.

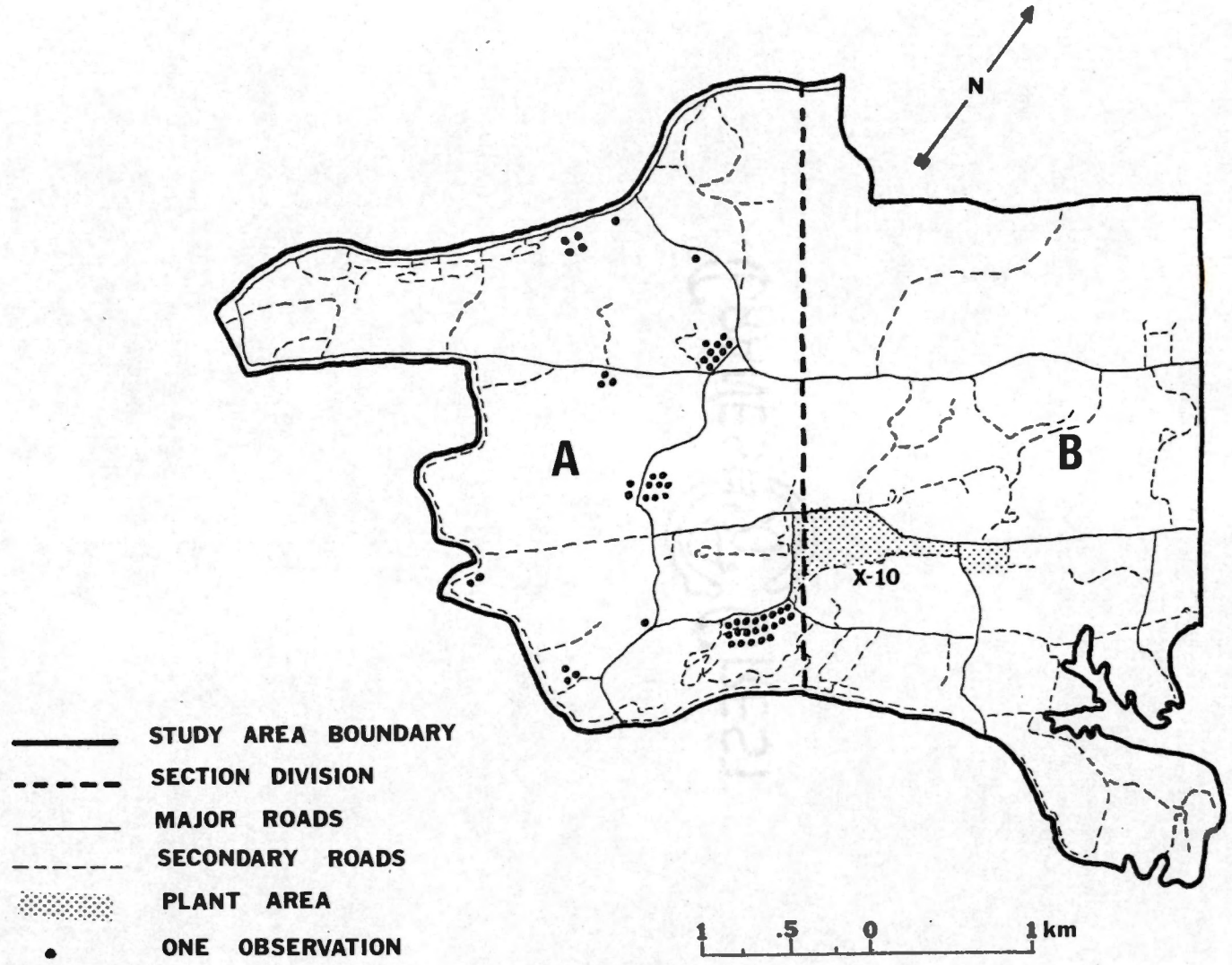

Figure 18. Whitetailed deer observations during March 1975.

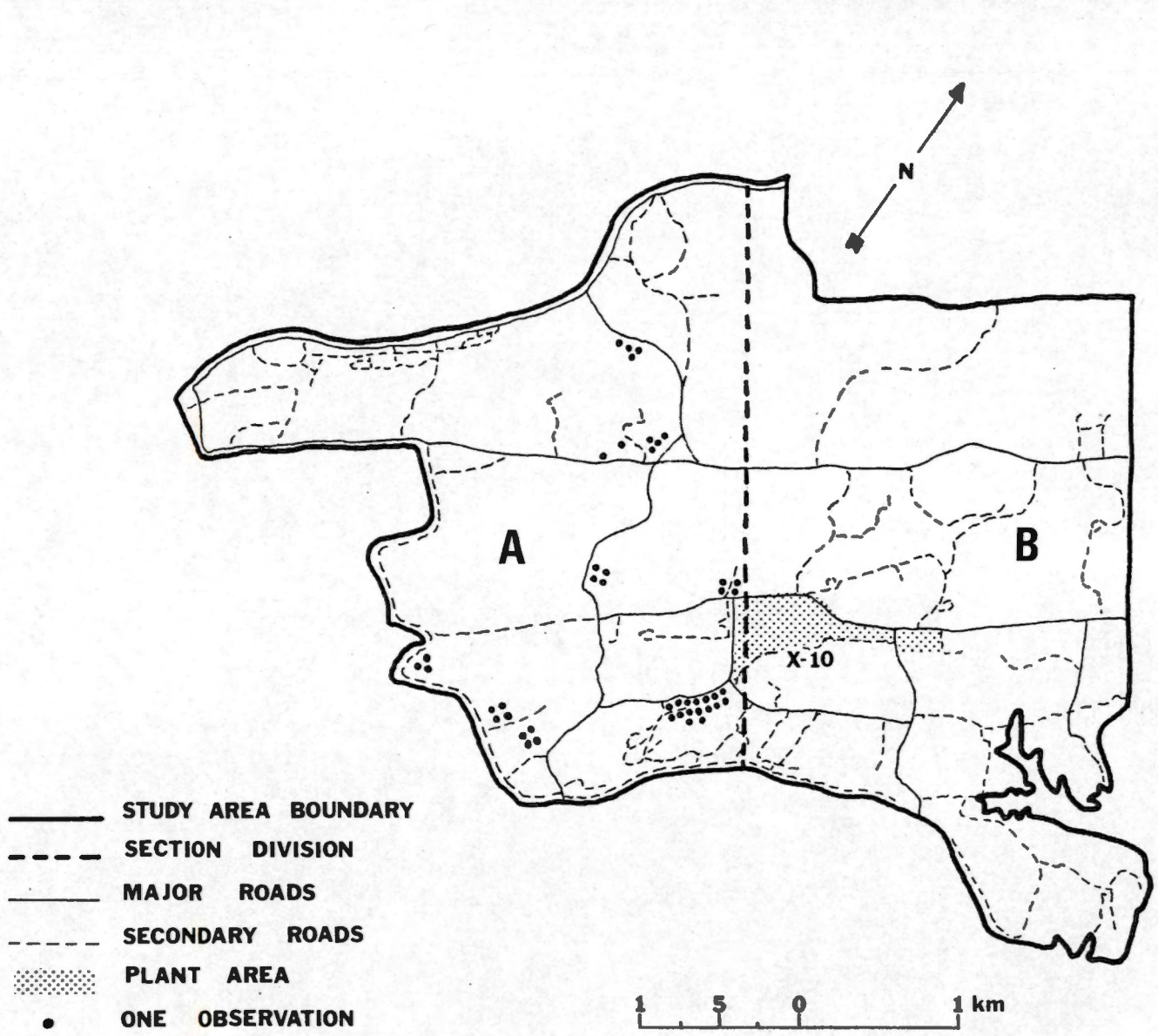

Figure 19. Whitetailed deer observations during April 1975.

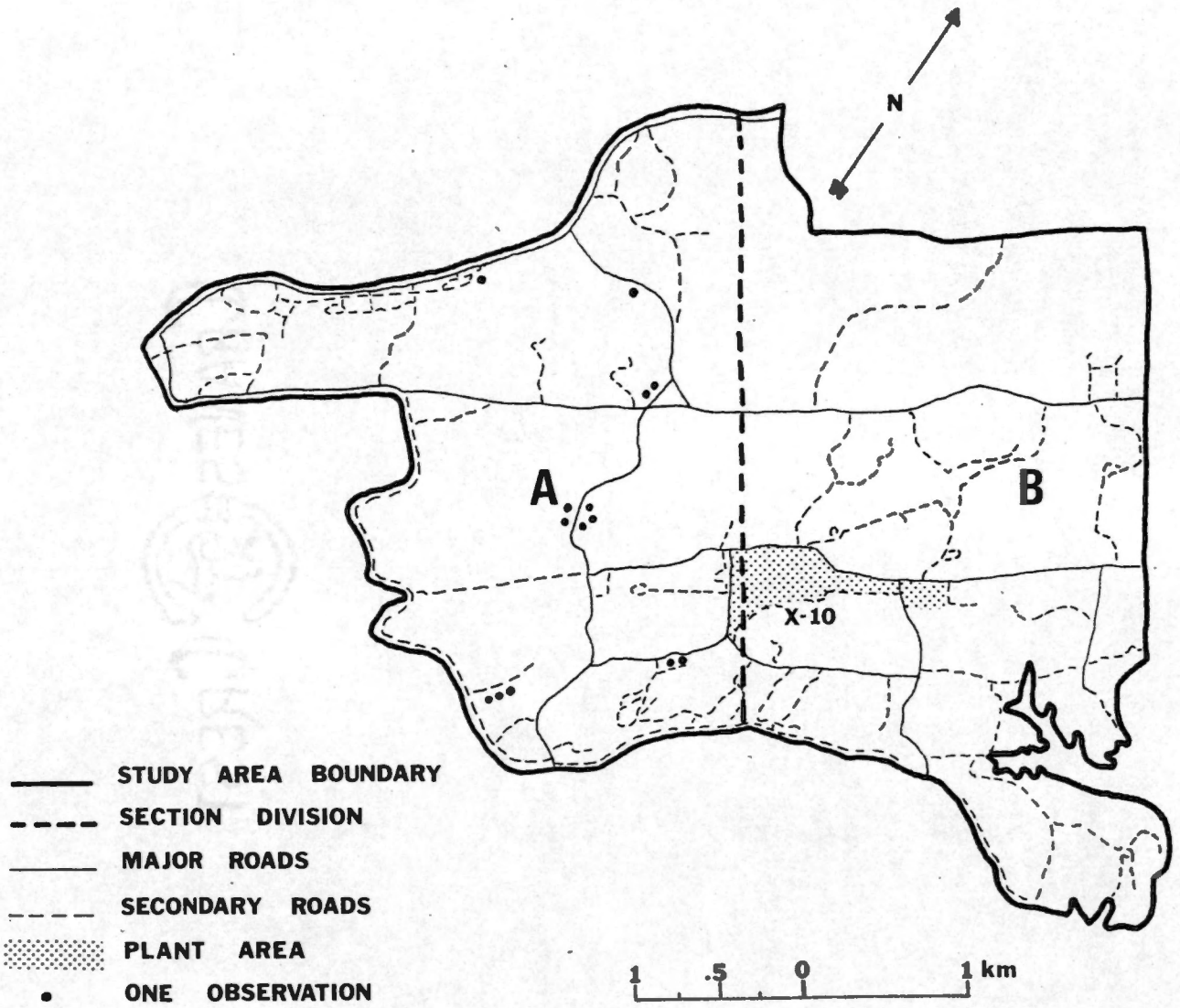

Figure 20. Whitetailed deer observations during May 1975.

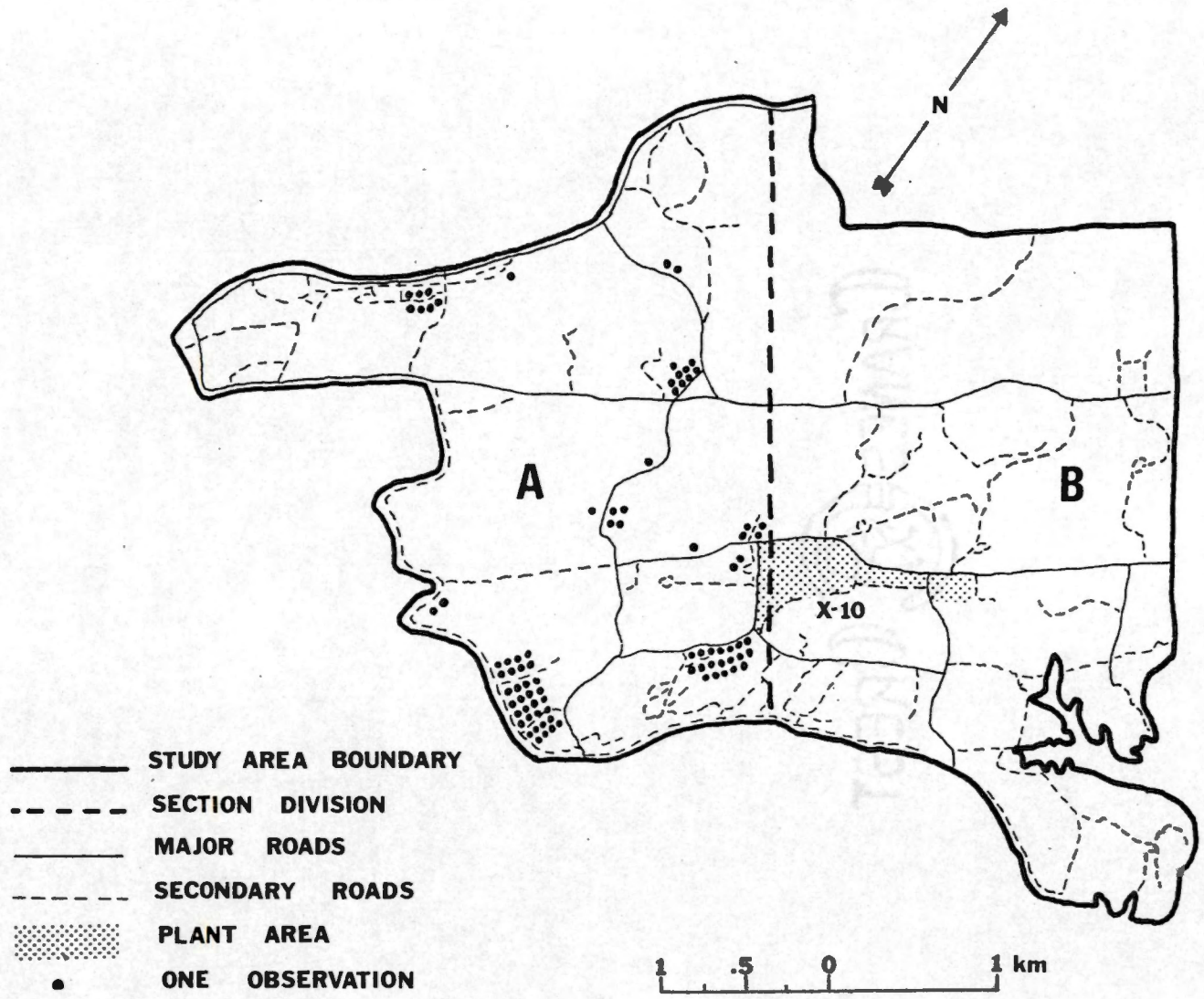

Figure 21. Whitetailed deer observations during June 1975.

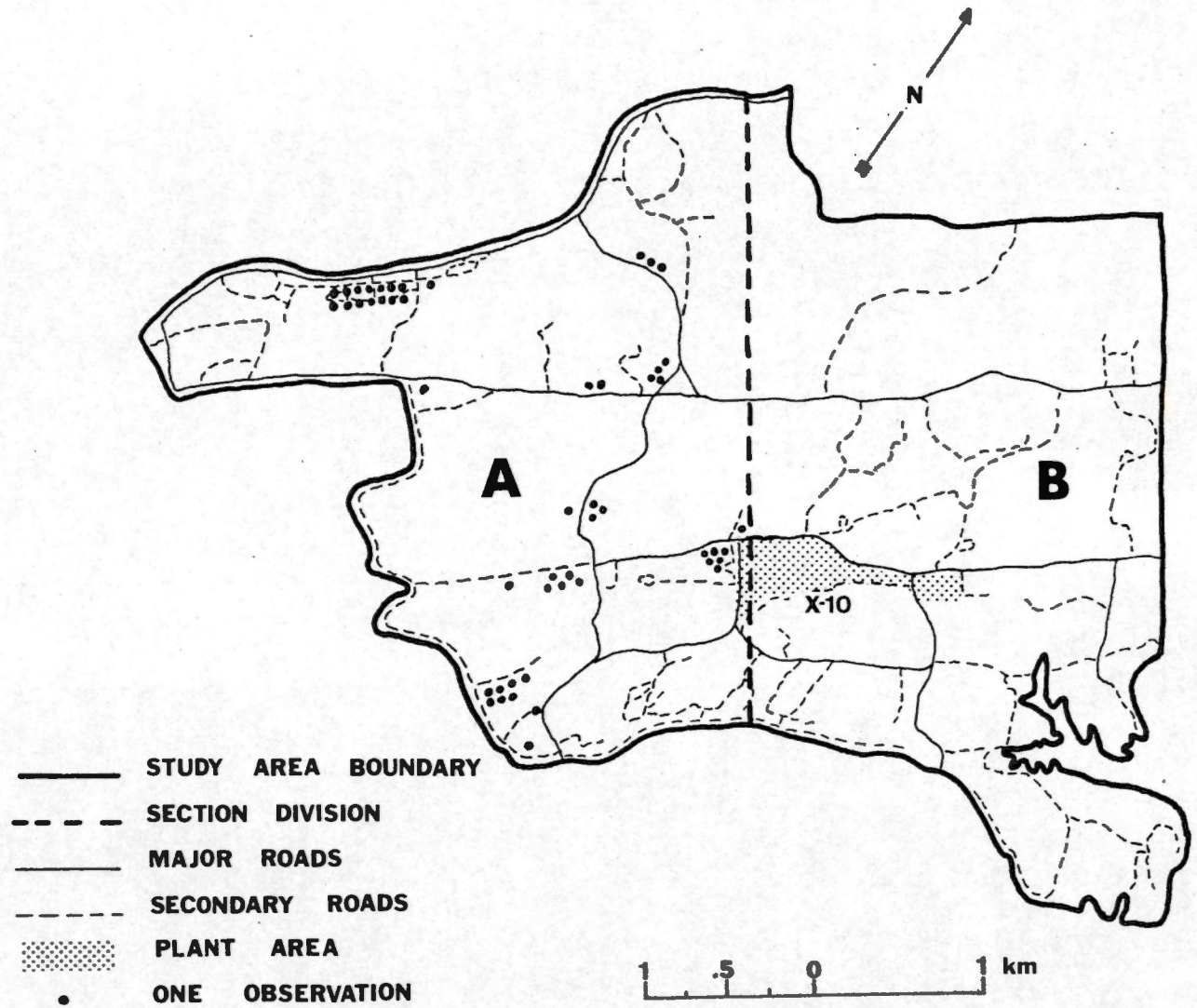

Figure 22. Whitetailed deer observations during July 1975.

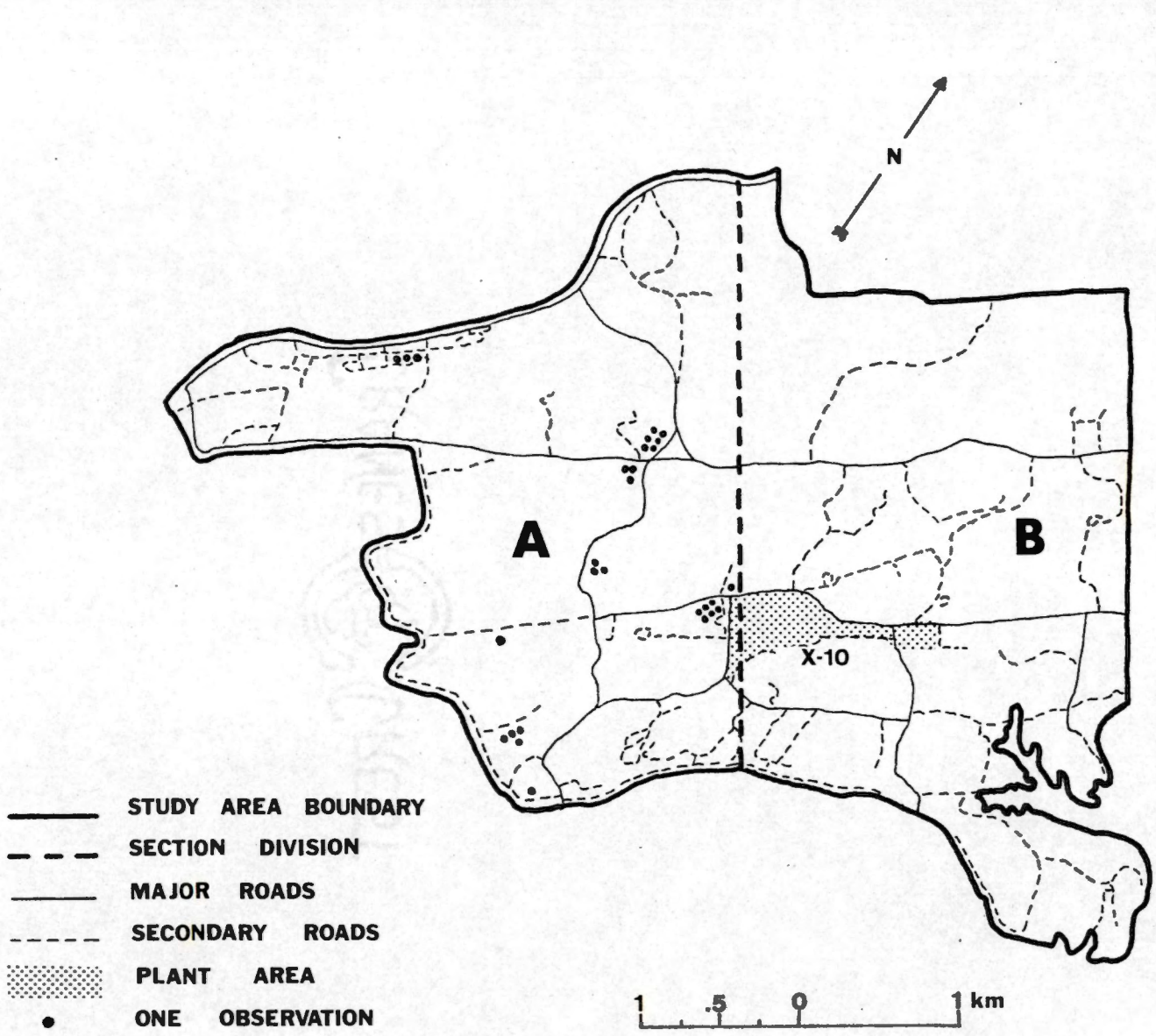

Figure 23. Whitetailed deer observations during August 1975.

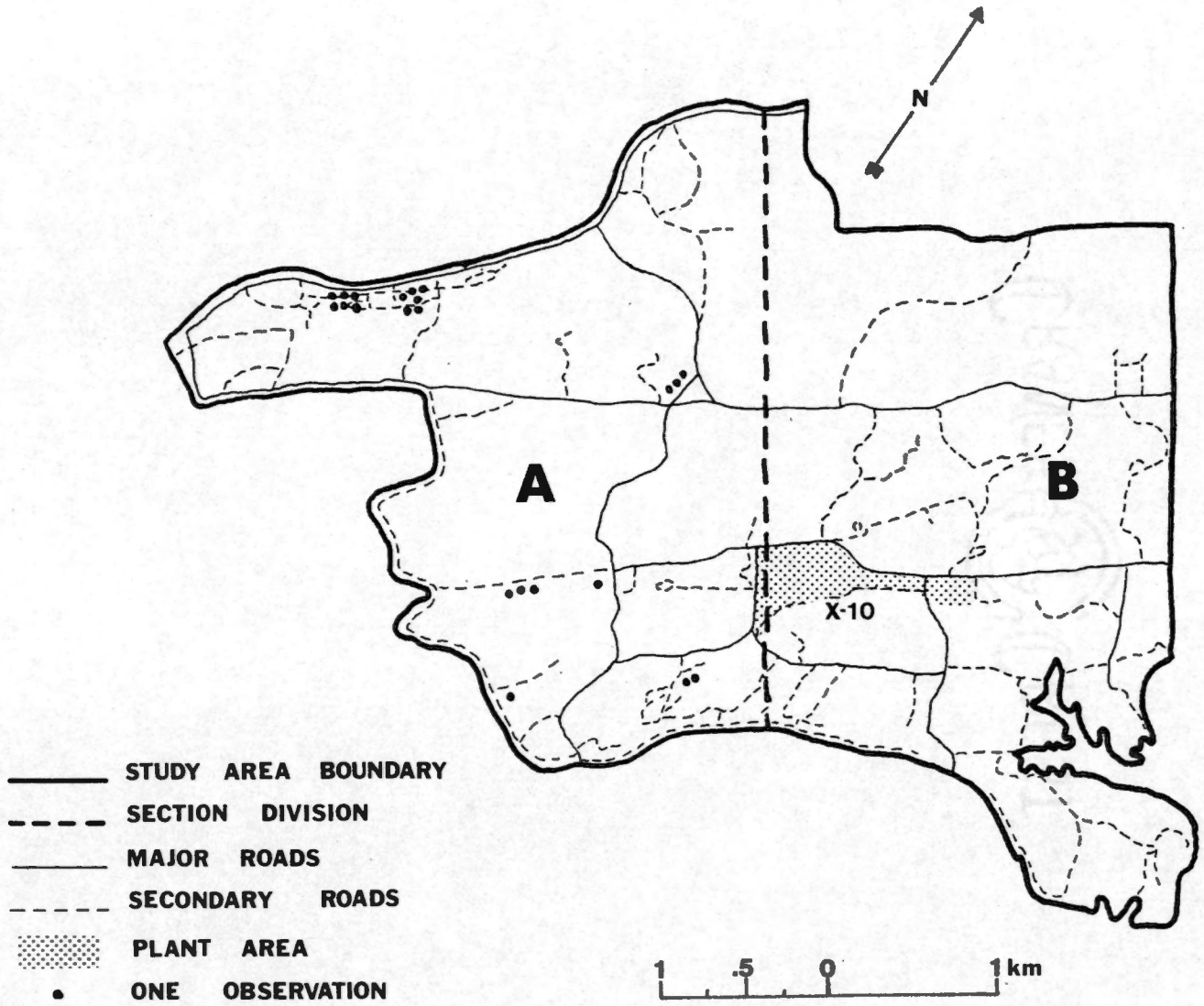

Figure 24. Whitetailed deer observations during September 1975.

APPENDIX C

OBSERVATIONS OF GRAY FOX BETWEEN DECEMBER 1974 AND SEPTEMBER 1975 ON THE STUDY AREA LOCATED ON THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION'S OAK RIDGE, TENNESSEE RESERVATION

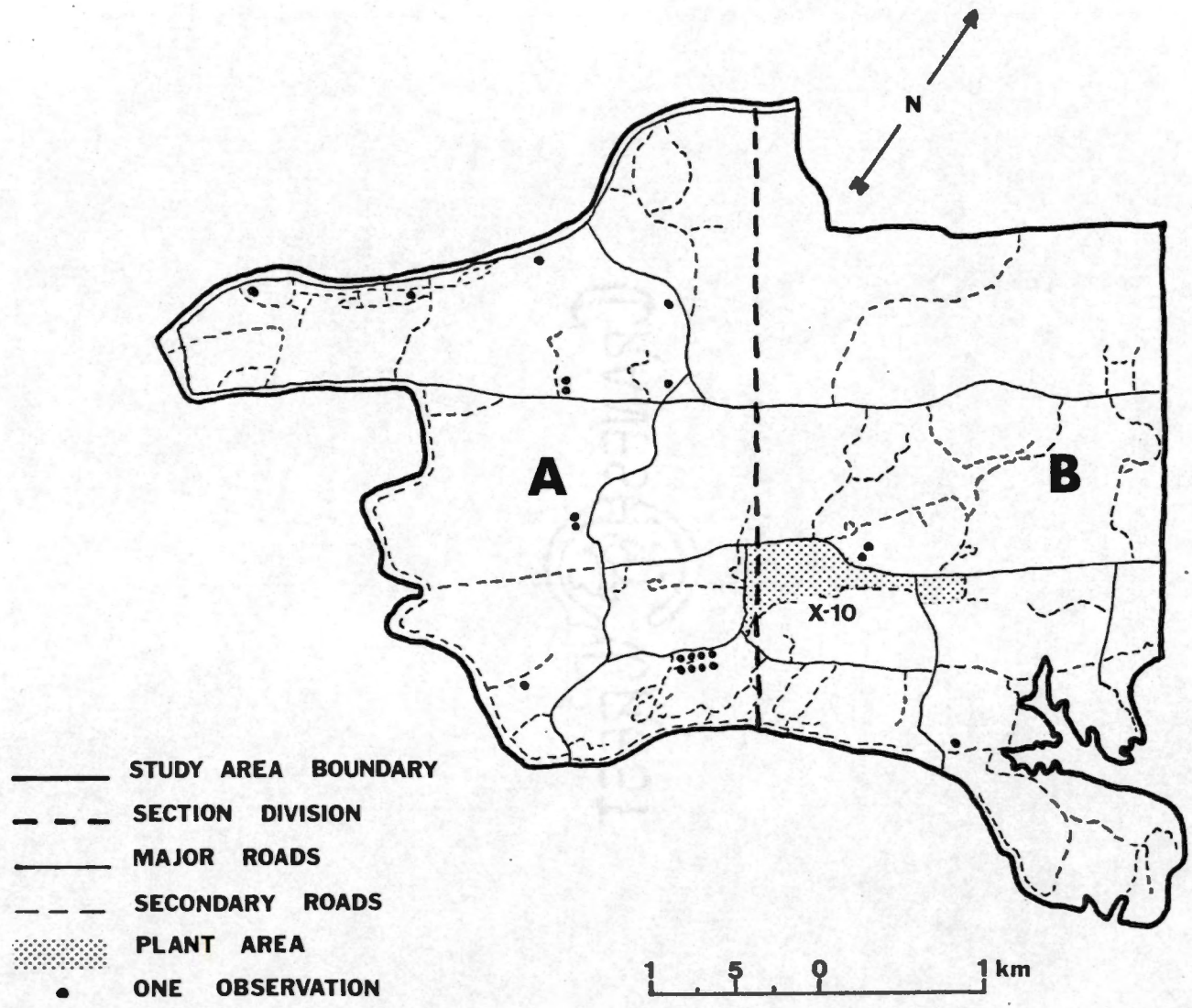

Figure 25. Observations of gray fox between December 1974 and September 1975.

VITA

Dwight Charles Flynn was born in Sevierville, Tennessee, on June 11, 1947. He graduated from Sevier County High School in June 1965. In September of 1965 he entered the University of Tennessee and received a Bachelor of Science degree in Forestry in June 1969. He served in the United States Air Force from November 1969 to August 1973 when he was honorably discharged. In September 1973 he entered the graduate program at the University of Tennessee in Wildlife and Fisheries Science. In September 1974 he accepted a Graduate Research Assistantship in the Department of Forestry, University of Tennessee. He received his Master of Science degree in Wildlife and Fisheries Science in March 1976. He is married to the former Linda Ellen Mathers of Pipestone, Minnesota.