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Range and movement of Iowa deer in relation to Pilot Knob State Park, Iowa

by

Michael DeForest Zagata

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of

The Requirements for the Degree of

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Iowa State University
Ames, Iowa

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I. INTRODUCTION

Little is known regarding the home range and movement patterns of white-tailed deer (*Odocoileus virginianus*, Boddaert) in the non-yarding agricultural states of the Midwest, including Iowa. Such information is of interest and has several practical applications as well, especially where permanent cover is scarce. It is of importance for wildlife managers to know how far and how rapidly deer populations spread out from populations wintering in various isolated timber tracts. Such knowledge might provide a clue to the optimum size and location of refuge areas. Such refuges might serve as local escape areas for local deer herds which are especially vulnerable during the hunting season. They may also serve as reservoirs from which adjacent lands might be repopulated in spring when the agricultural crop cover returns. Another point of interest is the acreage and location of agricultural land with respect to potential winter refuges as animals generally depend on waste crops for the bulk of their diet.

The study was designed to provide information on home range and movement of deer in relation to Pilot Knob State Park, a 369-acre tract of timber in north-central Iowa. Specific objectives were to:

1. Determine daily, seasonal and yearly geographical range and movement of deer in the vicinity of

Pilot Knob State Park, Iowa.

2. Determine the effects of crop harvest, weather and hunting pressure on normal movement patterns.

3. Secure data useful for effective deer management.

Intensive field work was conducted during the winter of 1969-70, fall of 1970, and winter and spring of 1971-72. In addition the investigator spent several weekends and quarter breaks on the study area.

A. History of Deer in Iowa

The white-tailed deer was once plentiful along Iowa's wooded waterways (Crane 1933). The severe blizzard of 1848-49 and the slaughter by early settlers during the severe winter of 1856, however, marked the beginning of the decline from which the herds of pioneer days did not recover (Madson 1953). Scott (1937) and Crane (1933) attributed the virtual extirpation of the white-tailed deer in Iowa by the latter half of the 19th century to the combined effects of the blizzard of 1856 and more intensive land use.

During the early part of the 20th century deer remained scarce in Iowa. However, according to Pietsch (1954) and Sanderson and Speaker (1954) deer re-invaded Iowa in the 1940's when they emigrated from Wisconsin and Minnesota.

All repopulation did not occur as a result of natural movement into the state. In 1894, 35 penned deer escaped the William Cuppy farm in Avoca, Pottawattamie County

(Sanderson and Speaker 1954). Later, in 1920, 60 deer escaped from the Singmaster's near Keota, Washington County, and subsequently populated the Skunk River Valley (Sanderson and Speaker 1954). Two deer, purchased from Minnesota, escaped in 1928 and a herd was established at the Ledges State Park, Boone County (Sanderson and Speaker 1954), and in 1943 deer were shipped from the Ledges State Park to Pilot Knob State Park where a herd was established (Salinas 1948). Sanderson and Speaker (1954) reported that in 1948 deer occurred in all but four counties within Iowa and in 1953 the whitetail was present in all counties.

Kline (1965) and Sanderson and Speaker (1954) presented census figures indicating a steady increase in herd size: 100 deer in 1936; 1000 in 1940; 4500 in 1950; 22,468 in 1960; and a peak of 38,000 in 1968 while Gladfelter (1972) indicates a decline with 29,966 in 1971 and 31,258 in 1972. The indicated change in population in the late 1960's and 1970-71 may be more due to a difference in procedures in calculating the population than in actual numbers. Road kills, often used as an index of a trend in population (Jahn 1959, McNeil 1962, Nixon 1965) indicated an increase through 1968 and a slight decrease in 1969 (Gladfelter 1972). Kline (1965) and McNeil (1962) state that the deer herd in Iowa is capable of a 70 per cent annual increase. A realistic figure for recruitment can be obtained by multiplying the winter census estimate by 1.4 (Kline 1965).

A herd with as high a reproductive potential as occurs in Iowa requires abundant habitat with a nutritious food supply. Nixon (1968) states that forest cover is essential for deer survival in the non-yarding states, including Iowa. Moen (1968) however, questions this. Providing timbered habitat for deer in Iowa poses a problem as 88 per cent of the little timber that does exist is grazed; 27 per cent of which is grazed so heavily that no timber reproduction occurs (Thornton and Morgan 1959). Assuming that Midwestern, non-yarding deer require timber it is no wonder that Murphy (1968) felt that woody cover is inadequate in the agricultural range class of the Midwest and that woodland grazing by livestock is an important factor in determining future herd limits.

Hosley (1956) placed the carrying capacity for Iowa deer at 20 animals per section or one deer per 32 acres. Mustard and Wright (1964) and Murphy (1968) expressed the opinion that carrying capacity of Iowa's land to support deer will never be reached, because the tolerance level for deer by farmers will be exceeded first. Queal (1968) found that as the deer herd increased, hunter access to private lands increased due to the change in status of deer from pet to pest. Crawford (1968) sums it all up when he states that we must be able to relate in dollars and cents the comparative value of a deer herd to corn, timber, etc.

Deer are a valuable resource in Iowa and provide aesthetic enjoyment and recreation to thousands of Iowans. In 1953, while deer were rapidly changing from "pet" to "pest," a season was set and hunting of deer in Iowa was allowed for the first time in this century. In that first season, 4782 shotgun and bow hunters purchased deer hunting permits. An unknown number of eligible landowners also hunted. This number has grown, in spite of a restriction on the number of shotgun hunters, until in 1971, 35,165 Iowans spent 618,206 hours of recreation time hunting deer (Gladfelter 1972). The most significant increase is in the number of bow hunters; 10 in 1953 and 6,789 in 1971 (Gladfelter 1972).

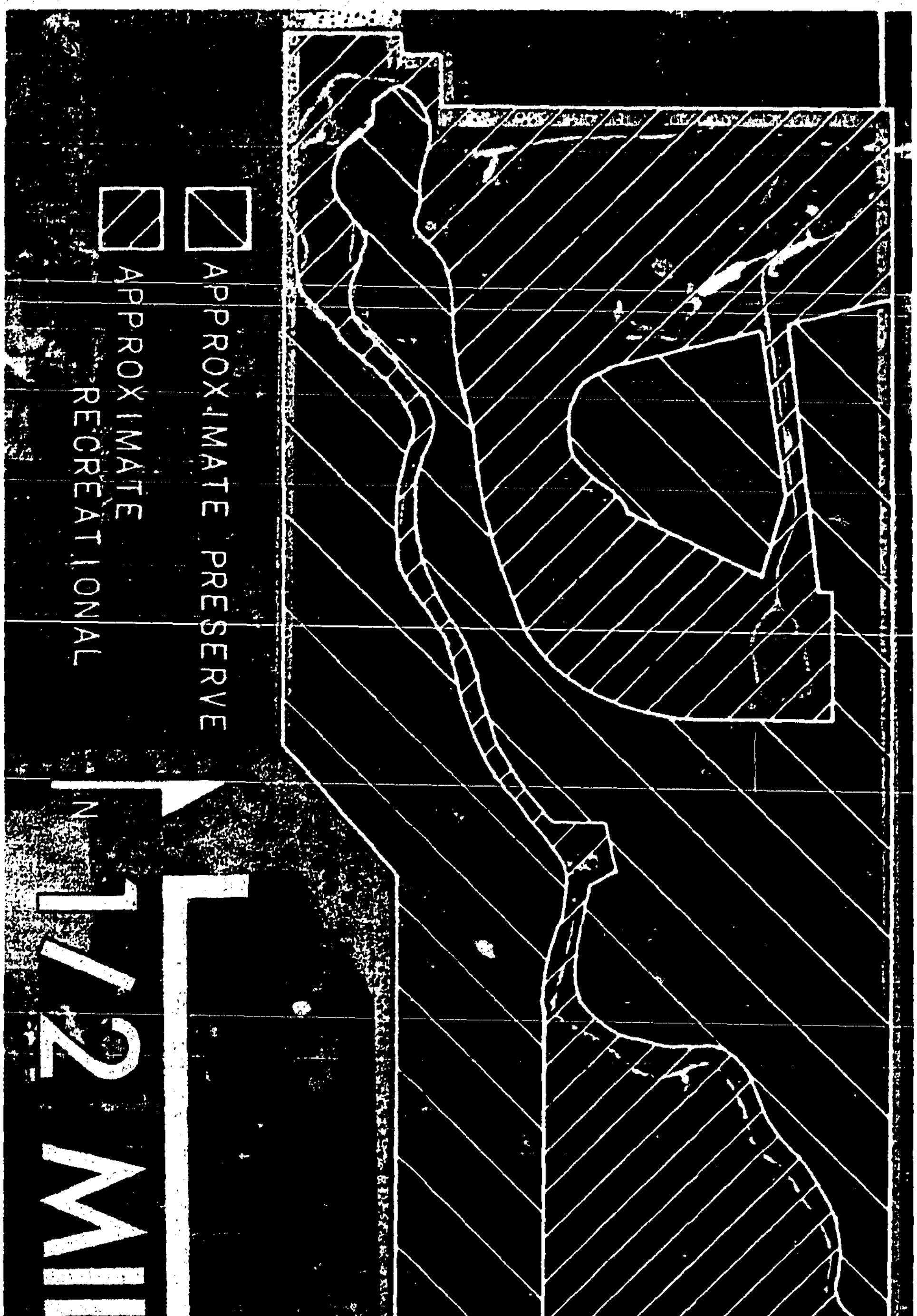
B. History of the Study Area

Settlement of north-central Iowa started in the early 1850's and agricultural practices soon thereafter led to a nearly complete denuding of the landscape of timber. Early settlers reported big game species including bear, elk, deer and "wolves." Of those reported for pioneer days, virtually none remained in the early 1900's. In 1919 conservation minded individuals in Winnebago and Worth counties were actively seeking the establishment of a park 4 miles southeast of Forest City, Iowa. A list of persons contributing to the park is presented in Appendix I. Their efforts came to realization in 1922. H. L. Taylor was appointed the first custodian of the land. In 1924, 237 acres of timber known locally as Pilot Knob was dedicated as a State Park. Alta Nelson (Iowa State Board of Conservation 1925) wrote of the Park's 10,000 visitors in 1925 and how "breathing spots" were becoming fewer all the time. Since its original dedication the Park has grown to 368.8 acres while the amount of timber within its borders has dwindled to approximately 200 acres. In 1969 part of Pilot Knob State Park was dedicated as a State Preserve in order that its unique features be perpetuated (Fig. 1).

The original instigators of the Park are to be applauded for their foresight. At present, Pilot Knob State Park is a timbered oasis in an intensive agricultural area. The four counties surrounding the Park; Cerro Gordo, Hancock, Winnebago, and Worth, have a total of 15,000 acres of timber constituting one per cent of the land (Iowa Forest Industrial Commission 1968). Eighty per cent of this is privately owned and 75 per cent of that is grazed (Thornton and Morgan 1959). It appears that Murphy's (1968) statement regarding the inadequacy of timbered habitat applies to the above counties as well.

With only 1 per cent permanent cover, deer become extremely vulnerable when crops, primarily corn and soybeans, have been harvested in the fall. Timbered areas like Pilot Knob provide seasonal concealment habitat for displaced animals. Since these areas are limited they also serve as

Fig. 1. Aerial photograph of Pilot Knob State Park showing the preserve and recreation components


APPROXIMATE PRESERVE
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hunter concentration areas. Sportsmen hunting deer in the croplands and timber adjacent to the Park have often been disappointed when a "trophy" buck escaped into the confines of the Park where no hunting is allowed.

II. REVIEW OF THE LITERATURE

A. Home Ranges and Their Determination

Early workers interested in animal mobility became concerned with the day to day movement of an animal within a definite area. This area become known as the "home range" of that animal. One of the most workable definitions for home range was provided by Bourliere (1954):

> ...the home range is the area over which the individual or the family group normally travels in search of food...it is not defended by its occupant against other members of the same species, and several home ranges may overlap without giving rise to conflict.

"Home area," "home region," "home range," and "individual range," are a few of the terms used by many authors to describe the same phenomenon, for example: Lay (1942), opossum;[1] Sheldon (1950), red fox; Allen (1943), fox squirrel; Seton (1909), for mammals in general.

Investigators who have employed the concept of home range while working with white-tailed deer include: Byford (1969); Carlsen and Farnes (1957); Dahlberg and Guettinger (1956); Hahn (1945); Hahn and Taylor (1950); Hawkins and Montgomery (1969); Kohn and Mooty (1971); Marchinton and Jeter (1966); Michael (1965); Progulske (1960); Progulske and Baskett (1958); Rongstad and Tester (1969); Sparrowe and Springer (1970); and Tester and Siniff (1965).

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[1]See Appendix II for scientific names of animal species.

The terms "territory" and "home range" have been confused by some authors, however, Burt (1943) made a clear distinction between the two and considers territory as any defended area (Noble 1939) and further states that in territorial species the territory may be considered as the defended portion of the animal's home range.

Burt (1948) described three types of home range: permanent, semipermanent, and seasonal. He describes the permanent type as being exhibited by sedentary animals such as shrews and mice which spend their adult lives in one locality. The small and medium-sized mammals which shift their ranges from time to time, say during the breeding or littering season, typify the semipermanent type. Seasonal home ranges were thought to be typical of migratory animals such as elk (Skinner 1925). Recent information suggests that the white-tailed deer may also occupy a seasonal, if not daily, home range (Byford 1969, Dahlberg and Guettinger 1956, Hawkins and Montgomery 1969, Kohn and Mooty 1971, Michael 1965, Pietsch 1954, Progulske and Baskett 1958, Rongstad and Tester 1969, Sparrowe and Springer 1970, and Tester and Siniff 1965).

Studies of home ranges in the past were based on recapturing or direct observation in the field of animals bearing tags, bells, and artificial markers or animals with recognizable deformities. Tracking under favorable snow cover conditions has also yielded much useful information.

Information gained on the home range of an animal through employment of any of the various techniques has been analyzed in several ways, some of which are described below. Some of their major disadvantages have been outlined in a paper by Hayne (1949). He classified methods used in calculating the size of an animal's home range from trapping records into three categories. The first, termed the "minimum home range" by Mohr (1947) involves the formation of a polygon by connecting the outermost points of capture. Its strength lies in the fact it encompasses the area the animal was known to occupy, but its main shortcoming is that an estimate of home range is impossible if all recaptures are made in a straight line.

The second method extends the home range estimate beyond the actual points of capture, usually one-half the distance to the next trap. If the animal is active throughout the entire additional peripheral strip, its value is questionable. The basic home range, to which boundary strips are added, may be determined in one of two ways. Stickel (1946) and Burt (1943) employed a method which excluded traps where no captures occurred for a given animal; this afforded the investigator opportunity to draw home range boundaries according to his knowledge of the animal and habitat. Allen (1943), Blair (1940), and Haugen (1942) employed a more objective method by using a set of arbitrary rules. According to their system, plotting of home range was completely mechanical and included all traps, even those not frequented by the animal, if they fell within the home range boundary. Difficulties inherent in this method included its failure to allow for habitat interpretation and possible exaggeration of home range size.

A third method of determining home range data from trapping records was based on the greatest distance between points of capture (Burt 1943, Lay 1942, Stuewer 1943, Stickel 1946). In this method, it is assumed the greatest distance between capture sites corresponds to the diameter of a circle, or the long axis of an ellipse, which is the animal's home range. Burt (1943) and Hayne (1949) criticized this method for overestimating the range and suggesting that home ranges correspond to traditional geometric designs in shape.

Many of the early studies of home range were made with small mammals for which traps may be placed in regular grids. The size of the grid may affect the results (Mohr 1947, Hayne 1949) and the apparent size of home range increased with the number of recaptures until a leveling off point was reached. This point reflected the best estimate of home range size according to Haugen (1942) and Dalke and Sime (1938).

Hayne (1949) expressed dissatisfaction with the previous methods of home range analysis, mainly on the ground that regions of maximum activity were not considered. To correct this, Hayne (1949) determined the geographic center of all points of capture, "center of activity," and measured distances from this center to all points of capture. From there these distances were compared to determine various facets of home range including the shifting of ranges and changes in animal activity.

In the past, home ranges of ungulates have been determined principally by sight records of marked animals and the subsequent application of home range methods discussed above. Hahn and Taylor (1950), Dasmann and Taber (1956) and Linsdale and Tomich (1953), Progulske (1960) and Progulske and Baskett (1958) were able to compute home ranges of mule and white-tailed deer in terms of diameter or area occupied.

Today biologists are relying heavily on a relatively new technique, radio-telemetry, for obtaining information on home range. This method employs the use of a radio transmitter (attached to the animal) which emits a signal picked up on a directional antenna attached to a receiver operated by the investigator, who may be miles away. Several directional azmuth bearings are recorded for the animal and then its location is determined through the use of triangulation (Heezen and Tester 1967). This technique allows the investigator to obtain information from the animal in a natural, unmolested state not possible with most earlier techniques. Researchers who have employed radio-telemetry in gaining data on movement and home range of the whitetail include: Cochran

1963; Cochran and Lord 1963; Hawkins and Montgomery 1969; Hawkins et al. 1971; Heezen and Tester 1967; Jeter and Marchinton 1964; Kohn and Mooty 1971; Marchinton and Jeter 1966; Michael 1965; Rongstad and Tester 1969; Sparrowe and Springer 1970; and Tester and Siniff 1965).

Methods used to calculate home range from data gathered by radio-telemetry are similar to those discussed earlier. Marchinton and Jeter (1966) employed a knowledge of habitat in determining range similar to that of Stickel (1946) and Burt (1943). Rongstad and Tester (1969) used a technique similar to that of Allen (1943), Blair (1940) and Haugen (1942) by using a mechanical method of determining which squares were to be included in the home range.

Several investigators have agreed with Hayne's (1949) concept of a center of activity, and terms such as "core" or "sub-area" have arisen to describe these centers (Dahlberg and Guettinger 1956, Hawkins and Montgomery 1969, Kohn and Mooty, 1971, Michael 1965, Rongstad and Tester 1969, Sparrowe and Springer 1970, and Tester and Siniff 1965). Sparrowe and Springer (1970) felt that the use of a polygon to enclose the area formed by connecting the outermost points overestimated the range as deer may use only a small portion of the enclosed area. They reasoned the home range may be the sum of the core or sub-areas and possibly the term daily-home range would be more realistic.

B. Factors Affecting Size of Home Range

Several factors are thought to affect home range size. Generally, large animals have large home ranges (Burt 1943) and those of herbivores are generally smaller than those of carnivores (Seton 1909). Within a species, size of home range may be affected by various factors including sex, age, habitat, season and population density.

In general, males of a species have larger home ranges than females. This has been observed with cottontails (Haugen 1942), red fox (Sheldon 1950) and raccoons (Stuewer 1943). A home range difference between age classes, the greater area being utilized by the adults, was also suggested by most authors on home range of mammals.

Research on the whitetail has yielded information generally in agreement with that obtained for smaller mammals. Hamilton (1962). Hawkins and Montgomery (1969) and Hawkins *et al*. (1971) found males had larger ranges while Marchinton and Jeter (1966) found females had the larger ranges. In general fawns have a smaller range than adults while some disagreement arises over which sex occupies the greater range among juveniles (Hamilton 1962). Sparrowe and Springer (1970) found no difference in total area occupied or total linear distance moved during winter by either sex or age.

The amount of food, water and cover available influences the size of the home range as it undergoes seasonal change.

This has been observed in small mammals by Lay (1942) working with the opossum, and Brown (1953) with the house mouse. Dwindling habitat may cause some mammal populations to spread out during winter, but in yarding and even non-yarding populations of deer the opposite is true (Townsend and Smith 1933, Sparrowe and Springer 1970, Rongstad and Tester 1969, Riordan 1949, Progulske 1960, Pietsch 1954, Kohn and Mooty 1971, Dahlberg and Guettinger 1956, Cook and Hamilton 1942, Carlsen and Farnes 1957 and Byford 1969). More recent studies have indicated a shift in home range of the white-tailed deer due to changing food supplies or other aspects of the habitat on a short-term basis (Byford 1969, Dahlberg and Guettinger 1956, Kohn and Mooty 1971, Michael 1965, Rongstad and Tester 1969, Samuel and Glazener 1970, Sparrowe and Springer 1970, Tester and Siniff 1965).

C. Movements of the Genus *Odocoileus*

1. *Types of movement*

Movements of deer may be divided into four general classifications: migration, emigration, immigration, local movements. Migration is used to denote regular seasonal movement away from and later back to the same area. Emigration or dispersal refers to movement away from an area and does not involve the return to the vacated area (Heape 1931). Immigration denotes movement into an area not previously occupied by the individual. Local movements are those which occur within a home range whether it be seasonal or yearly.

a. Migration   Migrations are exhibited by many of the ungulates including elk (Murie 1951, Skinner 1925), mule deer (Cahalane 1947, Clark 1953, Gilbert and Harris 1958, Gruell and Papez 1963, Leopold *et al.* 1951, McLean 1940, Riordan 1949, Russell 1932), black-tailed deer (Dasmann and Taber 1956, Lindsey 1943, Zwickel *et al.* 1953), white-tailed deer (Schmautz 1949), and red deer (Darling 1937). They are most common in the western mountains and dry areas where seasonal fluctuations cause shifts in carrying capacity of habitat forcing the animals to shift ranges.

b. Emigration   Emigration or dispersal in the white-tailed deer may be the result of social pressures as the fawning season approaches or the rut begins (Hawkins *et al.* 1971, Marchinton and Jeter 1966, Progulske 1960, Maguire and Severinghaus 1954, Caton 1877, Van Etten *et al.* 1965, Severinghaus and Cheatum 1956); population pressure (Hawkins *et al.* 1971, Hunt and Mangus 1954); changes in food supply or all three (Carlsen and Farnes 1957, Dahlberg and Guettinger 1956, Pietsch 1954, Rongstad and Tester 1969, Sparrowe and Springer 1970).

c. Immigration   Whenever an animal expands its range into a new area and remains there, immigration occurs. Pietsch (1954) and Sanderson and Speaker (1954) recount the movement of deer into Iowa from Minnesota and Wisconsin. Studies on dispersal must also consider immigration.

d. <u>Local movement</u> Additional research on animal movement has led to the development of specialized terms for local movement including diel movement, distance between extreme diel locations, minimum total distance moved in a diel period, and average minimum total distance moved in a diel period (Byford 1969, Hawkins and Montgomery 1969, Jeter and Marchinton 1964, Kohn and Mooty 1971, Marchinton and Jeter 1966, Michael 1965, Montgomery 1963, Progulske 1960, Rongstad and Tester 1969, Sparrowe and Springer 1970, Tester and Siniff, Thomas <u>et al</u>. 1964).

Diel movement refers to the distance covered over a 24-hour period. It is difficult to compute exactly as all locations for a particular animal are generally not known and, therefore, some estimate of this distance has generally been used. Marchinton and Jeter (1966) attempt to bracket this distance by employing several measurements, including distance between extreme diel movements (DBE) the greatest distance between any two radio locations of deer during a particular 24-hour tracking period; average distance between extreme diel locations--the arithmetic mean of all telemetrically obtained DBE's for an individual deer; minimum total distance moved in diel period (MTD)--the sum of the distances between sequential locations during a particular 24-hour period of tracking; and, average minimum total distance moved in diel period--the arithmetic mean of all MTD's obtained throughout radio contact.

D. Environmental Factors Affecting Movement

The influence of the daily and seasonal weather phenomena on deer movement has been cited by several authors. In the past, it has been difficult to separate the independent effect of one meteorological factor from the combined effect of all factors including the physiological state of the animal. Darling (1937), while studying red deer, expressed difficulty in distinguishing between the effect of two factors, moisture and temperature, on deer activity. Similar difficulties were encountered by Linsdale and Tomich (1953) while working with mule deer. According to them, "The strength and weakness of light are closely associated with other atmospheric conditions that modify the behavior of deer, and this makes it difficult to detect any influence attributable to light alone." They also stated: "Relative humidity does not act altogether independently of other weather factors..." Loveless (1964) was able to distinguish four meteorological factors with which deer response is most closely correlated: 1. high temperature and low atmospheric moisture; 2. low temperature accompanied by high winds or high moisture or both; 3. presence or absence of ground surface snow; 4. duration and intensity of sunlight.

1. Moisture

"The state of wetness or dryness of the atmosphere is one of the most potent influences on movement of (red) deer, and it does not only depress or excite movement in them itself but may affect the organism to such an extent as to intensify the effect of other influences" (Darling 1937). In relation to the effect of rainfall on movement Darling (1937) wrote: "Rain does not appear to exercise much influence on movement. Steady rain tends to restrict it." Loveless (1967) noted that light rain had little affect on deer activity while a heavy rain drove them to cover. Linsdale and Tomich (1953) wrote regarding the mule deer:

> Deer sometimes feed in the open in light rain. However, rain greatly restricts their activity and movements. A light but steady rain generally forces deer to cover and keeps them there. This may bring a change in daily routine, and ordinarily it requires changes in the kinds of food taken in stormy weather. Long rainy periods can increase the tolerance of deer for rain, but such extended exposure may also be detrimental...

Black-tailed deer in California were stimulated at all hours by precipitation and cloudiness, but were driven to shelter by wind and heavy rains (Dasmann 1954).

Snow is generally thought to stimulate movement, however, Hammerstrom and Blake (1939) found no causative relationship between amounts of snow and movement. Increased movement is often said to precede rain or snow (Ruff 1939, Darling 1937).

Snow has been found to have an accelerating effect on the movements of mule deer (Cahalane 1947, Dasmann and Taber 1956, Leopold *et al.* 1951, Linsdale and Tomich 1953, Loveless 1964).

Increased movement in response to snow has also been reported for the white-tailed deer (Swift 1946, Townsend and Smith 1933).

Hahn (1945) felt there was a definite correlation between white-tailed deer movement, relative humidity and overcast sky in late afternoon. He reported most activity on clear days of low humidity and that as humidity increased activity decreased.

2. Temperature

Darling (1937) and Loveless (1964) reported deer seek areas of minimum temperature change during cold periods and that 20°F is a critical temperature below which deer congregate (Loveless 1964). However, Moen (1968), while working in the agricultural area of Minnesota, noted that deer would bed in exposed areas even during severe weather. Darling (1937) also noted a profound effect of cold related to sexual behavior of the red deer.

Mule deer in California are generally active during most of the day during winter, but become more inactive at midday as spring arrives (Cronemiller and Bartholomew 1950). During warm weather feeding was restricted to the cooler hours during the crepuscular periods and, with the onset of colder temperatures in the fall, it became more widespread throughout the day.

3. Wind

Darling (1937), Hahn (1945), and Loveless (1964) noted that deer do not appear affected by wind except under conditions of extreme cold. Moen (1968) noted no effect of wind even during periods of low temperature. Dasmann (1954) observed deer move to protected openings and leeward hillsides in response to strong winds.

4. Lunar phases

Investigation into the relationship of lunar phases to nocturnal deer activity were conducted by Buss and Harbert (1950) by counting deer at a salt lick in Washington during the summer. Findings showed that most deer appeared at the lick during full moon; the fewest were sighted during new moon.

In relation to the effect of lunar phases on mule deer activity Linsdale and Tomich (1953) wrote:

> The pattern of deer movement, feeding, and resting after dusk on the six nights showed no dependence on moonlight. Generally the alternate feeding and resting periods of afternoon continued into the night... In all, deer made no detectable response to the progressively later moonset in increased activity or prolongation of alternate feeding and resting. Withdrawal to cover in the early hours of the morning is apparently determined by factors other than the presence or absence of moonlight and its intensity.

5. Food

There is general agreement among investigators that a changing food supply induces changes in animal movements (Byford 1969, Carlsen and Farnes 1957, Dahlberg and Guettinger 1956, Kohn and Mooty 1971, Michael 1965, Pietsch 1954, Rongstad and Tester 1969, Sparrowe and Springer 1970). Food is the main factor determining deer activity in both summer and winter (Townsend and Smith 1933).

6. Dogs

Lindsey (1943) stated: "Some dogs habitually harass (white-tailed) deer and frequently run them off their home range. Evidence contrary to this was presented by Dasmann (1954), Progulske and Baskett (1958) and Townsend and Smith (1933).

III. DESCRIPTION OF THE PILOT KNOB AREA

A. Legal Description

Within Ellington Township in the northeast corner of Hancock County, Iowa, lies Pilot Knob State Park. It occupies 368.8 acres legally described as the NW 1/4 Sec. 3 and the NE 1/4 Sec. 4 with two adjacent strips in T. 97N., R. 23 W. (Fig. 2). The park may be reached via U.S. Highway 9, 3-1/2 miles east from Forest City, Iowa, and then south 1 mile on Iowa Highway 332.

Approximately 70 per cent of the park's 368.8 acres is timber; the remaining 30 per cent consists of a bog, two lakes, a meadow, two picnic areas, a camping area, paved road and parking lots. The greater portion of the timber and less developed habitat lies in the eastern half of the park. The western half of the park's northern boundary is bordered by cropland, the eastern half by lightly grazed timber; the eastern boundary by grazed timber and cropland; the eastern half of the southern boundary is bordered by cropland, the western half by grazed timber; and, the western boundary is bordered by pasture and ungrazed timber (Fig. 3). Since its dedication in 1924, the park has not been grazed and no cutting of timber has occurred except for a brief period in the mid 1960's when a portion of the north-facing slope north of the tower was cleared for a ski run. This recreation project did not materialize. However, the

Fig. 2. Aerial photograph of Pilot Knob State Park, Iowa (outlined with dotted border)

Adjacent land patterns are also shown.


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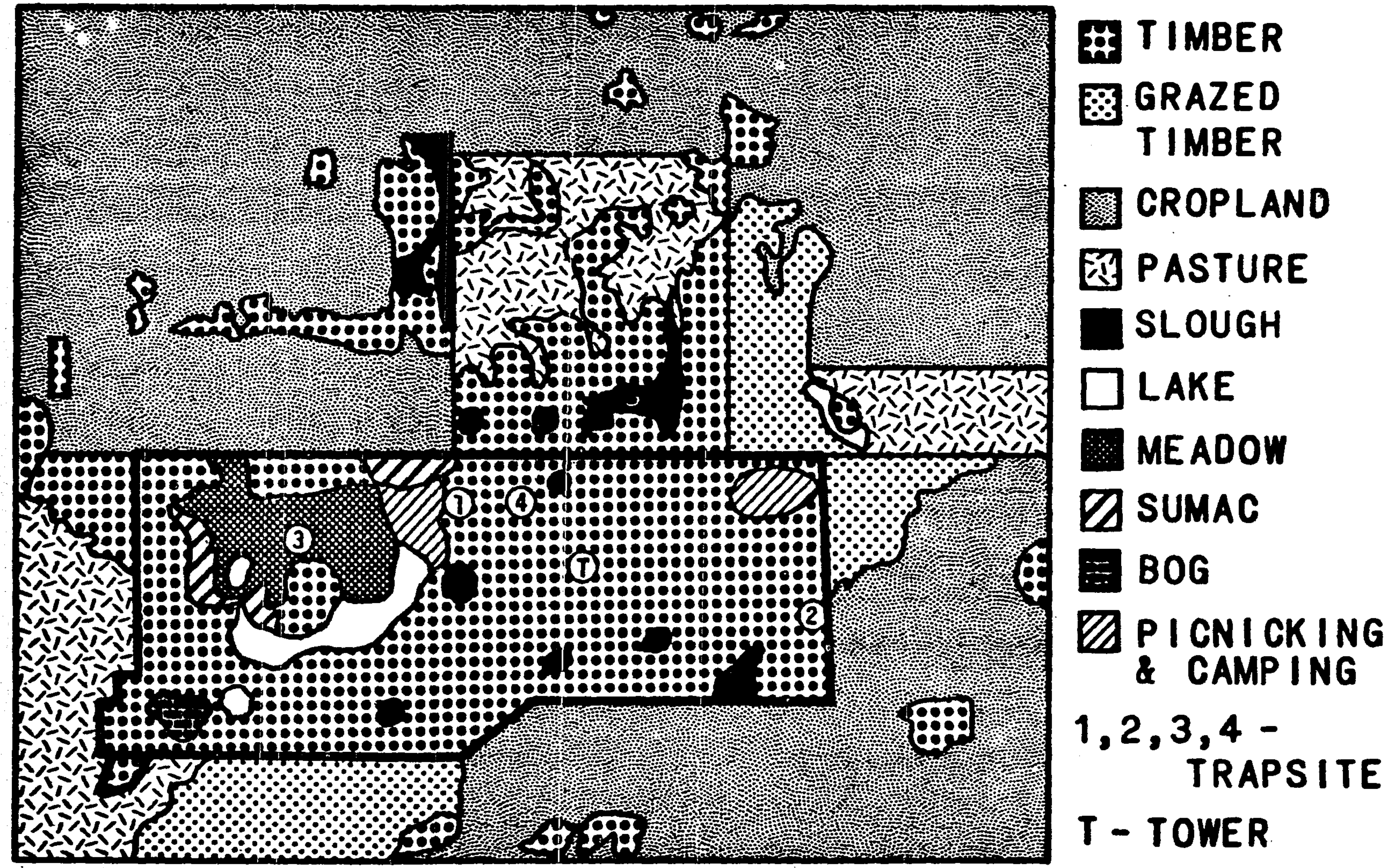

Fig. 3. Cover map of the Pilot Knob study area showing cover types within and surrounding Pilot Knob State Park, Iowa

surrounding land has been subjected to various agricultural practices, including the grazing of timber and planting of corn and soybean row crops.

B. Geology

For a comprehensive description of the geology, climatology, vegetation, and early history of the Pilot Knob area see Blagen (1967).

The major portion of southwestern and south central Minnesota and north central Iowa is a slightly rolling or entirely flat sheet of glacial till (Blagen 1967). Four glacial stages of the Pleistocene affected the geological history of Iowa: the Nebraskan; the Kansan; the Illinoian, and finally the Wisconsin. Four substages were proposed for the latter: Iowan, Tazewell, Cary, and Mankato (Kay and Leighton 1933).

The Des Moines Lobe of the Wisconsin glacier, composed of Cary and Mankato drifts, was the most recent glacial deposition in Iowa, and left four morainal systems: the Altamont; the Algona; the Bemis; and the Humboldt. One of these recessional moraines, the Altamont, extends through the north central part of Iowa; including the four counties surrounding the park. Hills resulting from this glacial deposition have no definite arrangement and vary considerably in size. Pilot Knob is a high point (1450 feet above sea level, 300 feet above the Winnebago River flowing 1-3/4 miles to the south) on this recessional moraine. From the park's tower one can see generally flat land with intervening depressions and irregularly arranged hills.

1. Soils

The soils in most of Hancock (Brown et al. 1935) and Winnebago (Stevenson et al. 1922) counties are Clarion loam of light-buff silt, clay and about 20 per cent sand and gravel. They are highly calcareous except in the knolls where lime has been leached leaving an acidic surface soil (Brown et al. 1935). The undulating nature of the topography makes it subject to drought and erosion.

The subsoil of the recessional moraine consists of material carried and deposited by the glacier and is composed of materials ranging in size from fine clay to large boulders.

C. Climate

The climate of Cerro Gordo, Hancock, Winnebago and Worth counties is temperate, having generally warm summers and cold winters. The mean yearly temperature is 46.0°F and the mean yearly precipitation is 29.99 inches (Shaw and Waite 1964). Since one of the objectives of the study was to measure the effect of harvest on deer movement the temperatures and precipitation values will be divided into two 6-month blocks corresponding to the period from harvest to planting and vice-versa. The first period includes the months of November, December, January, February, March, and April and will be referred to as the winter period; the second period includes May, June, July, August, September and October and will be referred to as the summer period.

The mean temperature over a 30-year interval for the winter period was 28.0°F and 63.9°F for the summer period. Average precipitation for the winter period was 8.29 inches and 21.70 inches for the summer period.

For the 3 years of the study, 1969-71, weather data from the Mason City station was taken from records of the U.S. Department of Commerce, Environmental Data Service (1969-1971) and averaged by month and by period.

The average temperature for the 3-year span was 43.2°F, 2.8°F less than the 30-year average. Average precipitation was 35.72 inches, 5.73 inches more than the 30-year mean.

For the winter periods from 1969-1971 the average temperature was 24.0°F, 4°F colder than the 30-year mean, and for the summer period it was 62.8°F, 1.1°F colder than the normal.

Precipitation for the winter periods through 1969-1971 averaged 10.00 inches or 1.71 inches more than the normal. Precipitation for summer was 25.75 inches, 4.05 inches more than the normal.

D. Vegetation

The park is a timbered oasis in a primarily agricultural region. At one time it had been denuded of both timber and understory.

1. Trees

The predominating trees are oaks, including bur,[1] northern pin, red, and white oak. Aspen have invaded where oak wilt, Dutch elm disease, or unnatural destruction have created openings and sumac is abundant as an edge species. A large walnut grove stands in the eastern half of the park.

Also common are butternut, bitternut hickory, black cherry, chokecherry, basswood, black and green ash, hackberry, boxelder, cottonwood, service berry, wild plum, wild crab and ironwood.

2. Shrubs

Openings created primarily by disease have allowed the growth of a dense understory. Shrubs observed include buttonbush, marsh willow, sumac, poison ivy, wild grape, lead plant, dogwood, rose, hazelnut and prickly ash.

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[1] See Appendix III for scientific names of plant species.

IV. METHODS OF STUDY

Intensive field investigations on deer were conducted at the Pilot Knob study area during three periods: December 1969-February 1970; September-November, 1970; and December, 1971, through May 1972. Frequent weekends and quarter-break recesses were spent at the study area while the investigator was enrolled for course work at Iowa State University, Ames.

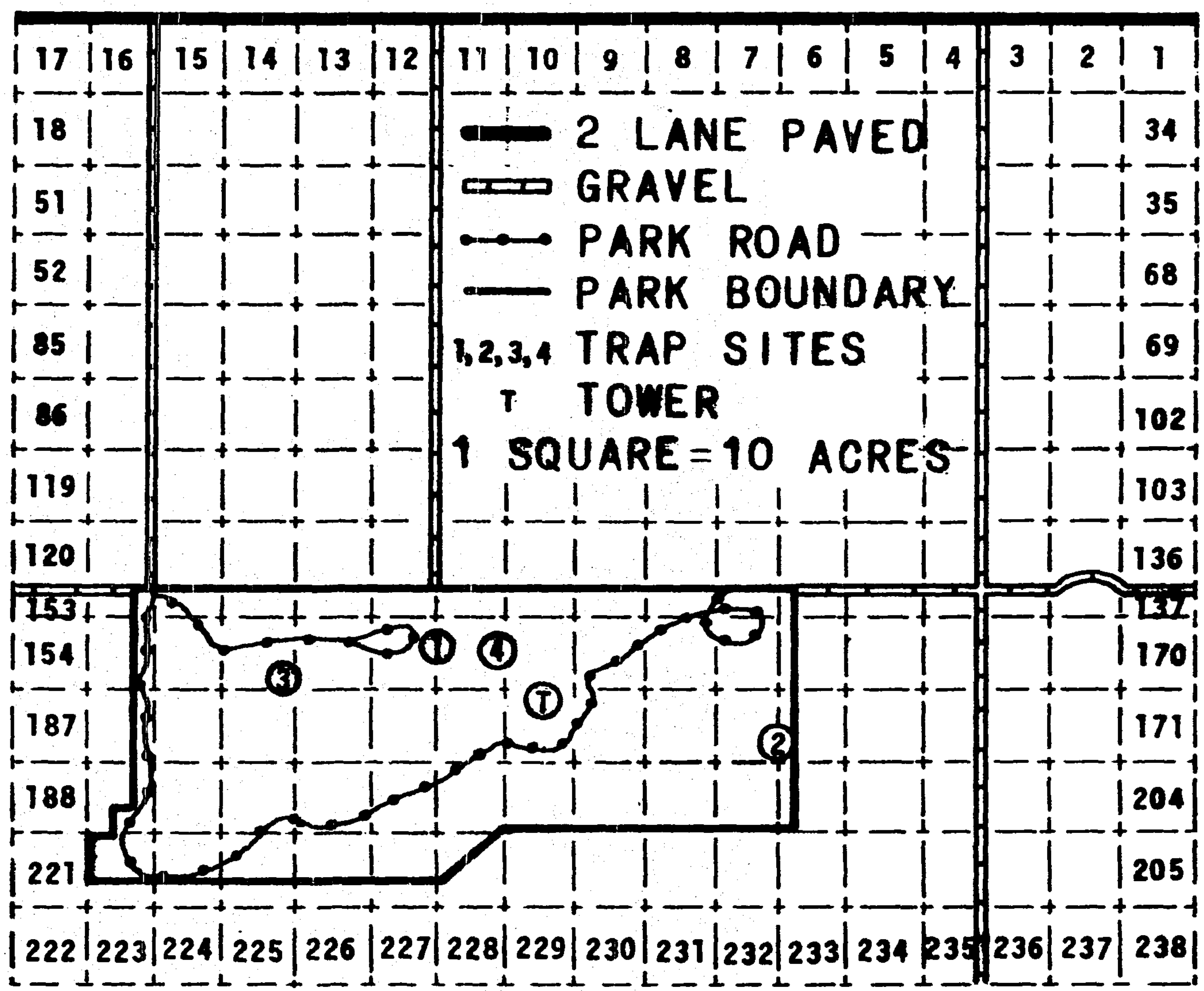
A. Data Recording

Aerial photographs of the park and land immediately adjacent were photographed as a mosaic, and reduced to a scale of 4 inches to the mile. The aerial mosaic includes an area extending 1 mile north of the park to U.S. Highway 9; one-half mile south to an east-west blacktop; one-quarter mile west to the Winnebago County ski tow (W 1/2, SW 1/4, Sec. 3, T. 98 N., R. 23W), and three-quarters mile east of the park boundary (Fig. 2).

Area included in the mosaic was divided into 10-acre grids. Each 10-acre square was numbered consecutively, beginning with the upper right corner, in a serpentine manner (Fig. 4). This numbered grid was inscribed on a clear acetate sheet and superimposed over the aerial mosaic.

Ten cover classifications were mapped for the study area: ungrazed timber, grazed timber, cropland, pasture, slough, lake, meadow, sumac, bog, and picnicking and camping

Fig. 4. Numbered 10-acre grid of the Pilot Knob study area, Iowa


17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
18 34
51 35
52 68
85 69
86 102
119 103
120 136
153 137
154 170
187 171
188 204
221 205
222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238
2 LANE PAVED
GRAVEL
PARK ROAD
PARK BOUNDARY
1,2,3,4 TRAP SITES
T TOWER
1 SQUARE=10 ACRES
1
2
3
4
T

sites (Fig. 3).

Each sighting of a marked or unmarked deer was recorded for the appropriate grid number. Also recorded were data concerning age, sex, behavioral activity, vegetation type, topographic condition, time of sighting, and weather conditions.

1. Hunter questionnaire

A questionnaire was distributed throughout the hunting season to archers hunting in the vicinity of the park (Appendix IV). The purpose of the questionnaire was to secure data on fall movement patterns, age and sex of sighted deer, and the effect of weather, harvesting of crops and hunting pressure on deer movement. Additional information was collected regarding the time of day the hunter was in the field, hours required per deer sighted and percentage success.

B. Capturing and Marking

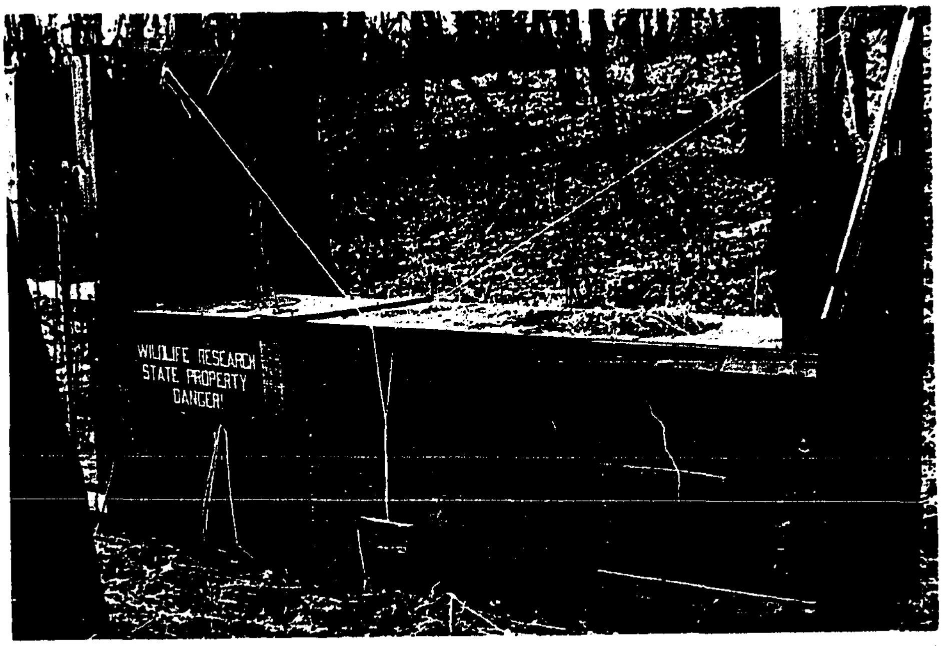
Deer were trapped in a "Stephenson" type box trap (Webb 1943) (Fig. 5, 6) or immobilized with nicotine salicylate (Cap-Chur-Sol, Palmer Chemical and Equipment Company, Douglasville, Georgia).

1. Trapping

Three traps were constructed of 3/4-inch plywood during the 3-year study period, one in 1969-70 and two during the winter of 1970-71. Each trap was 12 feet long, 46 inches

Fig. 5. "Stephenson" type deer trap used to capture deer at Pilot Knob State Park, Iowa

Fig. 6. Trigger mechanism used by the investigator in the "Stephenson" type deer trap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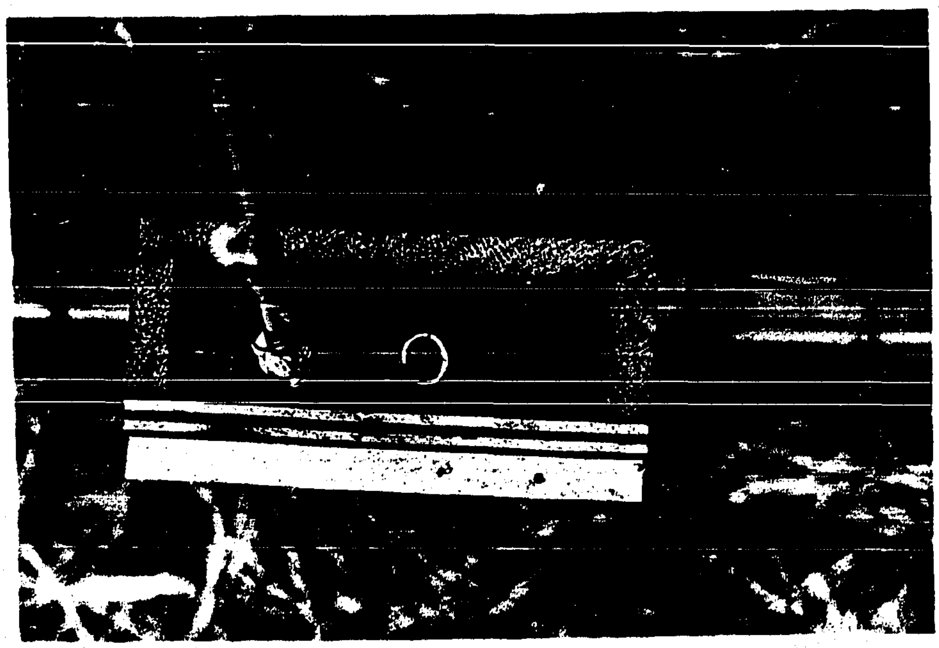
STATE PROPERTY
DANGER!



high and 39 inches wide. A trip wire was strung across the inside 6 feet from the end. Various heights, from 10 to 15 inches above the ground, were tried for the trip wire.

The first trap was constructed of plywood on January 6, 1970, and placed on a well traveled deer trail. Deer were observed using this trail during crepuscular periods while enroute to and from feeding (Site I, grid 159).

Two additonal traps were constructed, one on September 3, 1970, the second on October 20, 1970. The first of these was set at the base of an east-facing slope just inside the eastern park boundary (Site II, grid 176A). In 1969 and 1971 soybeans were grown adjacent to the park's eastern boundary, corn was produced in 1970. Deer moved past Trap Site II while traveling to and from this cropland where they fed at night.

The trap constructed in October was placed in a meadow in close proximity to three major deer trails and an artificial salt lick (Site III, grid 157).

Deer changed their movement pattern in the winter of 1970-71, and, in response to this change, Trap Site I was abandoned on March 19, 1971. The trap from Site I was placed on a flat area at the base of a north-facing slope where deer were often observed bedding (Site IV, grid 160).

On January 11, 1972, the trap at Site II was modified. An 8-foot section of 9 gauge woven-wire fencing with a vertically sliding plywood door at the distal end (as by Ruff 1938) was added to the trap (Fig. 7). The sliding door was supported by a rope attached to the trip mechanism. It was reasoned that deer would be less hesitant in entering the trap if it permitted a view of their surroundings not afforded by the wooden section.

a. Baits used in trapping Corn is the primary food of deer in the midwestern agricultural states, including Iowa (Buxton 1951, Erickson *et al.* 1961, Korschgen 1962, Mustard and Wright 1964, Nixon and McClain 1968, Nixon *et al.* 1971, Watt *et al.* 1967). Therefore this was the first bait selected for use. Alfalfa (McCormack 1958, Dixon and Sumner 1939), and apples (Dixon and Sumner 1939) were also used as primary baits. Other baits that were experimented with included: salt (Progulske and Baskett 1958), minerals, alfalfa pellets, and a mixture of 5 per cent molasses, 20 per cent cracked corn, 30 per cent soybean meal, 25 per cent alfalfa pellets and 20 per cent linseed meal.

Various methods were used in deploying the bait and several combinations of the different baits were tried. In general aromatic baits (alfalfa, apples, molasses) were placed along deer trails in the vicinity of the trap. Trails, whether existing or created by the investigator, which led to the traps were baited more heavily close to the trap. After deer accepted the bait, less was placed on trails and more inside the traps.

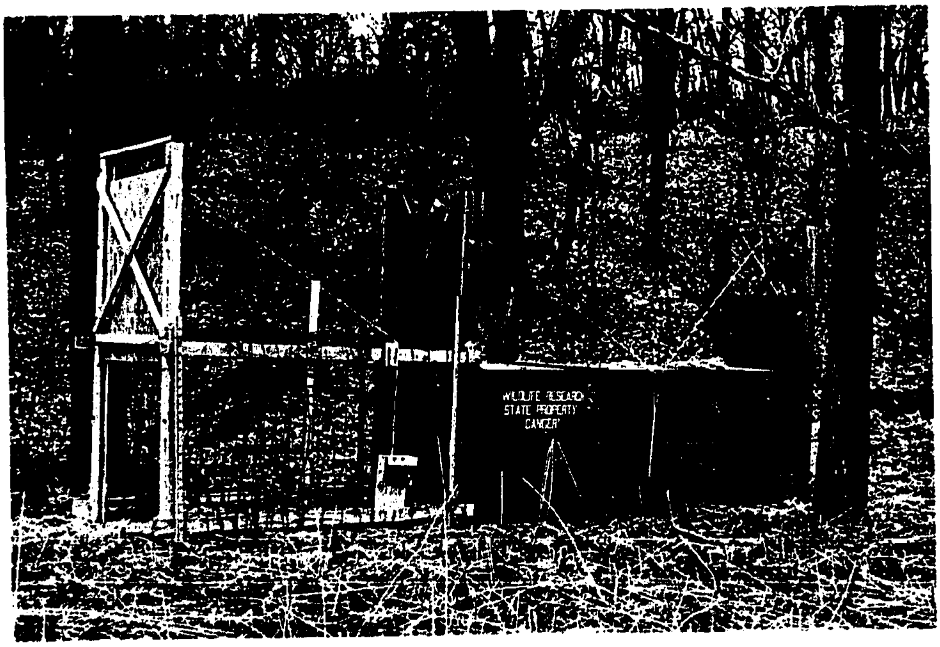
Traps were rebaited approximately 2 hours before sunset. This was done to minimize bait stealing by rodents and harrassment of deer moving to feed. Each trap was checked about 1 hour after sunrise and again when baited in the afternoon. Whenever possible, traps were checked with binoculars to avoid potential harassment and contamination of the trap site with human scent.

b. Handling trapped deer Two techniques were employed for handling trapped deer. Early in the study, the investigator crawled through a small sliding door in the side of the trap and immobilized the deer by grasping its legs. When fully restrained, a main drop door was opened, the deer removed from the trap and "hog-tied."

Another method, although less exciting, required less manpower. A handling crate resembling a miniature trap (Midula 1955) was placed next to the sliding side door of the main trap (Fig. 8). A small opening in the side of the crate allowed light to enter and once the trap door was opened, the deer bolted towards the light. After the deer had entered the crate, the sliding gate was closed and the crate laid on its side. Then the door at the deer's hind legs was opened enough to allow the investigator to draw the rear legs outside where they were tied. Finally, a fore-leg was drawn outside and tied to both hind legs. Once tied, the animal was removed from the crate and prepared for marking. An effort was made to keep the animal on its brisket and its head upright while being tagged and fitted with a collar to reduce the chances of bloating and suffocation.

Fig. 7. Modified "Stephenson" type deer trap showing the 8-foot woven wire extension and sliding gate

Fig. 8. Handling crate, used to restrain deer, positioned near the side-door of the "Stephenson" trap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2. Immobilization techniques

Nicotine salicylate, used by Crockford *et al.* (1957a), Crockford *et al.* (1957b), Hamilton (1960), and Jenkins *et al.* (1955) to capture white-tailed deer, was also used in this study. The drug, prepared by the Palmer Chemical and Equipment Company under the trade name Cap-Chur-Sol at a concentration of 200 mg. per cc, was delivered in a 2 or 3 cc dart (Palmer Chemical and Equipment Company). Both barbed and barbless darts were used, but barbed needles were preferred (Pearson *et al.* 1963).

Four instruments were used to propel the drug-filled dart. The first instrument, a modification of Anderson's (1961) method for anesthetizing deer by arrow, was used by the investigator using a 50 pound-pull longbow and the second was a 140 pound-pull crossbow. Later in the study, Palmer's CO_2 Cap-Chur-Gun was used. This gun was of limited value because it could not be used in cold weather under which conditions it lacked adequate pressure and resultant power. During the second year of the study a Palmer-Powder-Charge-Gun; using 22 caliber blanks for a propellant, was used. Green-wad blanks (low charge) and yellow-wad blanks (medium charge) were used, depending on the distance needed to reach the animal, to propel the dart.

Nicotine dosages varied with the size of the animal and were kept too small initially. As deer tolerance levels were learned, the dosage per pound of estimated body weight was increased.

Three methods were used to get close enough for an accurate hit: tree blinds, stalking, and drives. The most frequently used technique was to sit in a tree blind, located between bedding and feeding areas, during crepuscular periods (Fig. 9). Wind direction and velocity were considered when tree blinds were selected. Bait stations were established near tree blinds to increase chances of deer using a particular trail (Fig. 10).

Drives involving two to six researchers were frequently used during daylight hours. Each drive was designed to move deer past researchers, equipped with immobilizing gear, stationed along known travel lanes. Drivers walked with the wind at their backs and advanced in such a way as to decrease chances of deer moving back through the drivers line.

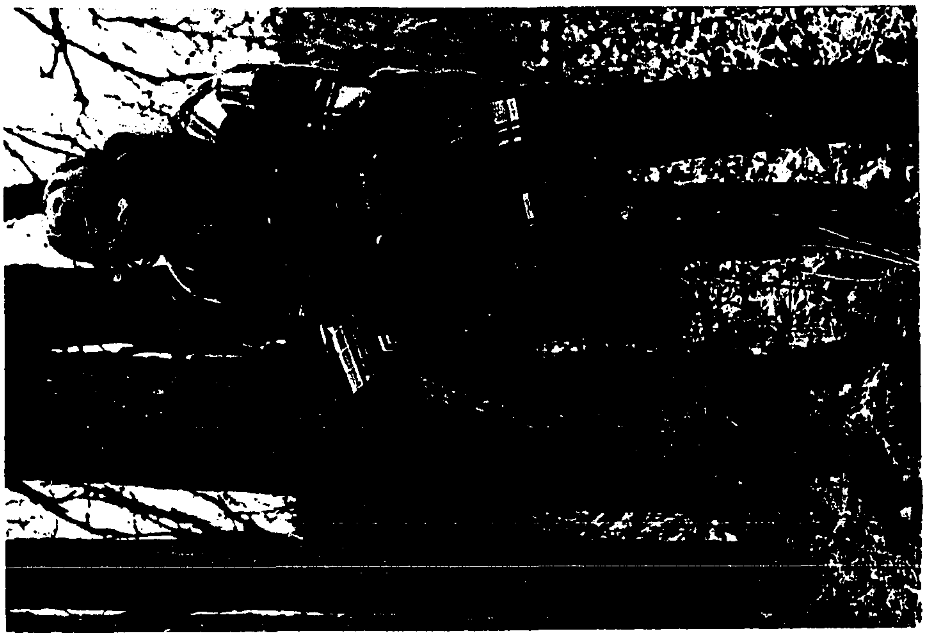
Stalking, a technique involving knowledge of the habitat and the deer's habits, was used during daylight hours. Wind direction, topographical features and an overall knowledge of the study area were considered when using this technique.

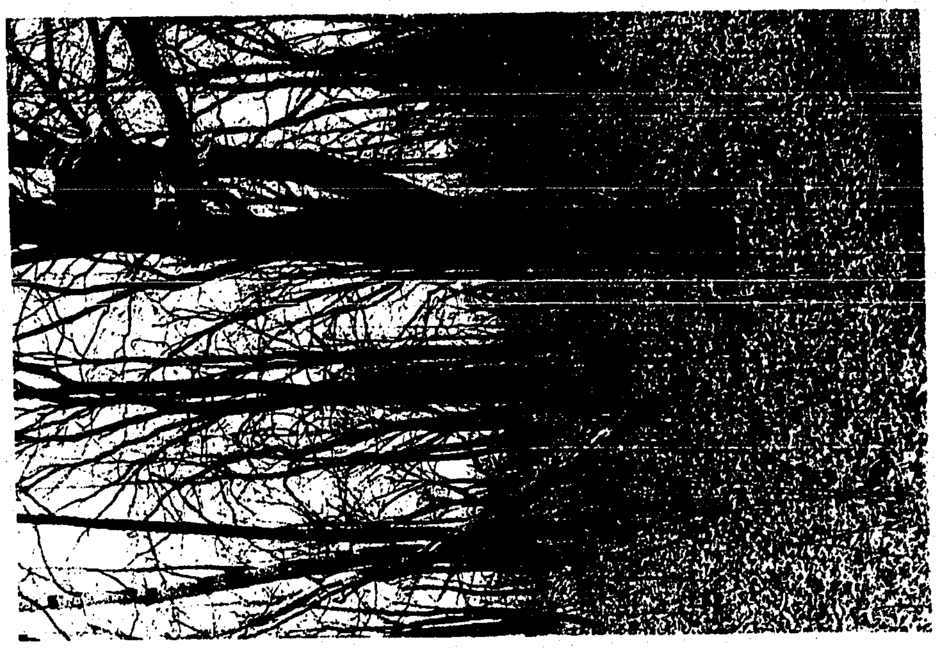
a. Caring for an immobilized deer After darted, a deer was allowed to collapse before any effort was made to approach it. If, after 5 minutes, it did not go down it was tracked as far and as long as possible in an attempt to keep the animal active and thereby prevent mortality caused by delayed reaction to the drug.

Once down, the deer was approached immediately and

Fig. 9. Investigator in a tree blind showing a typical immobilization situation

Fig. 10. Feeding station baited with corn, molasses and oats to attract deer to immobilization sites





hog-tied. Mucous was cleaned from the mouth. Once marked, the animal was raised to a standing position and then led back and forth until it could progress under its own power. The investigator felt this would stimulate circulation and thereby speed up the excretion of the drug.

3. Marking a captured deer

Each captured deer was marked with a numbered metal ear tag, one or two colored polyvinyl streamers and a color-coded collar supporting a radio-transmitter.

a. Ear tags and streamers During the winter of 1969-70 deer were marked with one metal cattle tag (Salt Lake Stamp Co., Salt Lake City, Utah) and a heavy duty colored polyvinyl streamer (Cooley, Inc., Pawtucket, Rhode Island). Bucks were tagged in the right ear, does in the left.

In the winter of 1970-71 two metal tags and one plastic streamer (Safety Flag Co., Pawtucket, Rhode Island) were used. One tag was used to attach the streamer to the right ear of bucks, the left ear of does and the other was placed in the opposite ear to increase the chance of future identification. During both years the ear tag was placed through two thicknesses of plastic, the ear tissue, and then two more thicknesses of plastic (Figs. 11a, 11b).

A third type of attachment was tried in the winter of 1971-72. The metal tag and streamer were attached to a rubber tag, one end of which was flanged (Richey Manufacturing

Fig. 11a. Numbered metal ear tag and colored plastic streamer attached to the right ear of a male fawn

Fig. 11b. Numbered metal ear tag, colored plastic streamer and color-coded collar attached to a female fawn

Company, Brighton, Colorado) (Fig. 12a). The flanged end was folded, inserted through a hole in the ear and allowed to expand once through the ear (Fig. 12b). The flange prevented the tag from pulling out of the ear. A rubber tag and similarly colored streamers were inserted in both ears for both sexes.

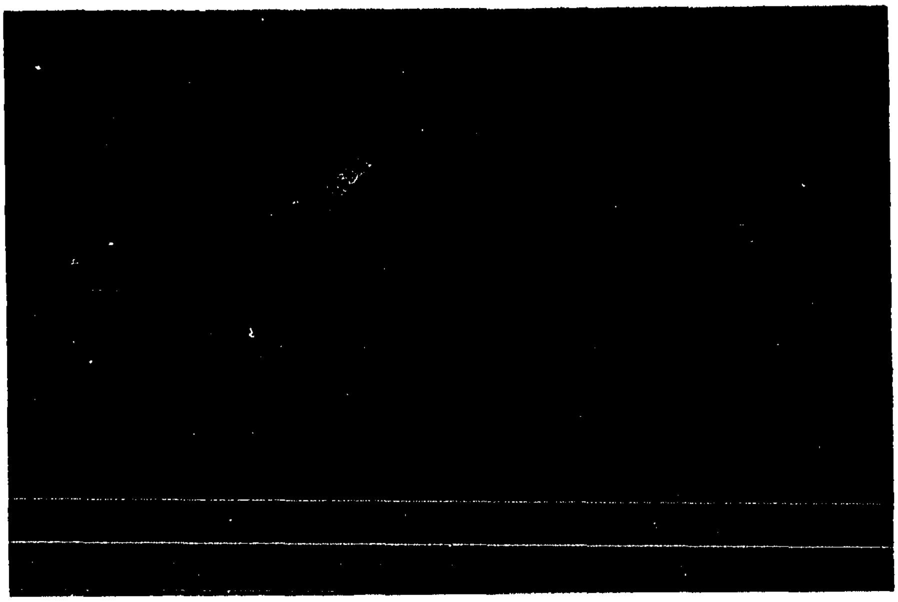
b. Collars Collars were made of 2-inch wide, 6-ply rubberized machine belting joined into a circle with alligator clamps and held by a metal pin (Fig. 13). The standard collar length was 17 inches and 2, 3, 4, and 5 inch pieces with alligator clamps at both ends were finally used in the field as splices to increase the collar length.

Each collar was wrapped with a colored tape, either black or silver and with added designs of colored tape (Fig. 14). In 1971-72, Scotchite reflective tape (Minnesota Mining and Manufacturing Company, St. Paul, Minnesota) (Duerre 1958, Sparrowe and Springer 1970) was added to the collars of two deer to facilitate identification by spotlighting.

c. Transmitters Radio-telemetry transmitters were housed in one of three types of boxes attached to the collar (Fig. 13). The first box was 3x2x1 inches and made of aluminum. It was open on the side next to the collar. The second container developed was made of brass and molded into a three sided 5-inch long cylinder. Wooden plugs were fitted into each end and fastened in place with metal screws. The latest container used was a square cylinder 4x2x2 inches

Fig. 12a. Rubber ear tag, numbered metal tag and plastic streamer used to mark deer during the winter of 1971-72

Fig. 12b. Rubber ear tag showing flange of the rubber ear tag after being inserted through a deer's ear



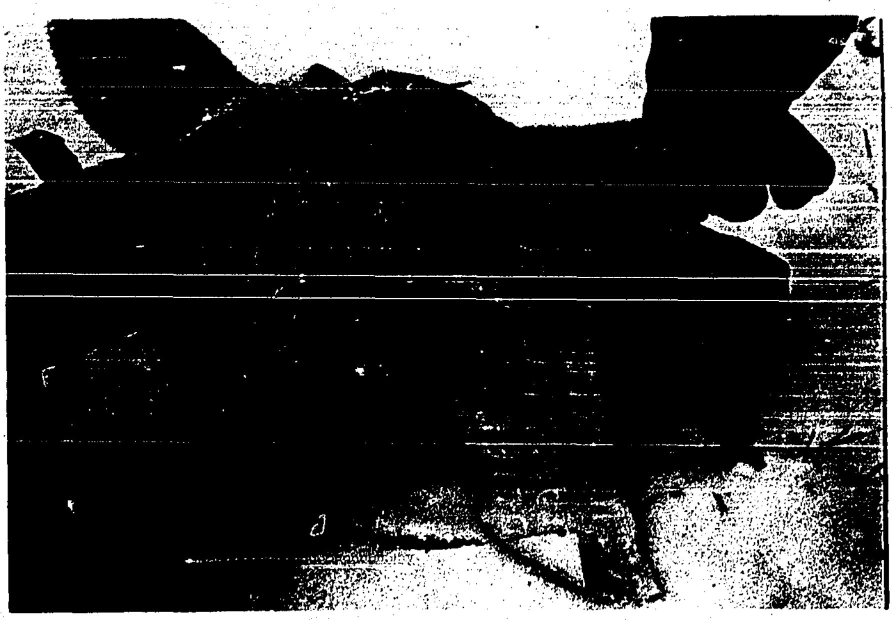


Fig. 13. Collars of 2-inch wide, 6-ply rubberized machine belting joined with alligator clamps and three types of containers used to house the radio transmitters (left - 3x2x1 inch aluminum box; center - 5 inch long aluminum cylinder; right - 4x2x2 inch steel box)

Fig. 14. Color-coded collar and attached radio transmitter

made of steel. The ends were plugged with wooden squares held in place by screws. All containers were bolted to the collars and all openings were sealed with silicon. Each antenna wire was brought out through an opening in the side of the box next to the collar. The spring steel antenna was bolted to the inside of the 6-ply belt and then extended out through the collar (Fig. 15).

The crystals were supplied by Markusen Electronic specialties, Esko, Minn. and Davidson Electronic, Minneapolis, Minnesota and broadcasted between 150 and 152 megacycles (Table 1). Markusen's transmitters emitted a continuous signal and Davidson's was of the interrupted type. Batteries used to power the transmitters were the Duracell Mercury Battery by Mallory, 1.4 volts. Batteries were connected in parallel to provide increased amperage and resultant increased transmission time. In 1971-72 batteries with "tabs" were used to permit making soldering connections without heating the battery which is reported to reduce battery life. Once assembled, the units were fitted snugly into the container and cushioned with styrofoam. Wires were insulated with plastic tubing to reduce chances for a short circuit.

A 12-channel portable receiver supplied by Markusen Electronic Specialties was used to locate radio equipped deer. Either a hand-held directional antenna or a directional antenna mounted on a vehicle roof was used for determining directions of signals.

Fig. 15. Collar, antenna wire, and spring steel antenna inserted through the collar

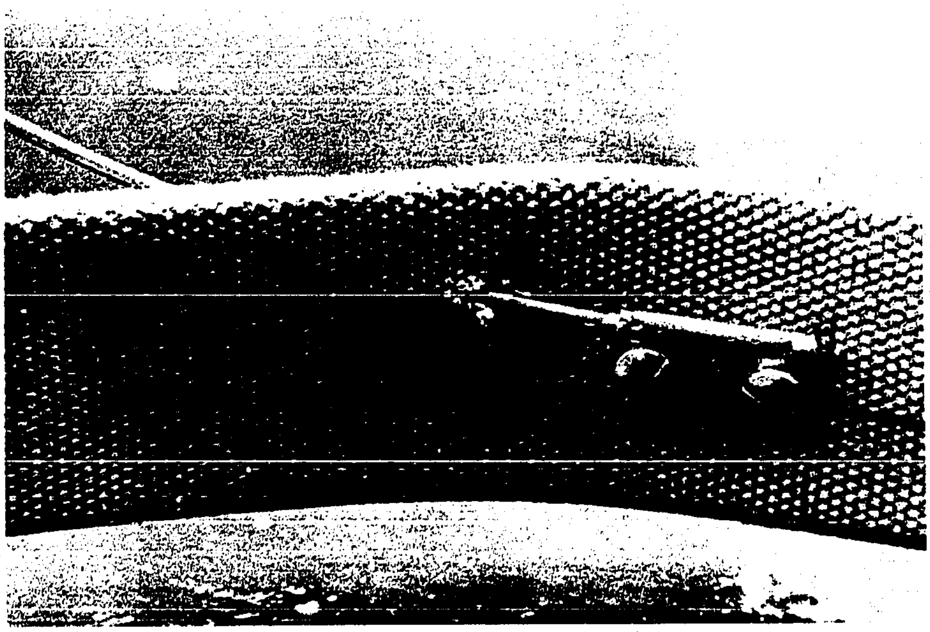


Table 1. Supplier, channel frequency and type of signal emitted for radio-telemetry units used in the study

Channel number	Supplier	Frequency (megacycles)	Signal type
1	Markusen	150.815	Continuous
2	Markusen	150.830	Continuous
3	Markusen	150.845	Continuous
4	Markusen	150.860	Continuous
5	Markusen	150.875	Continuous
5A[a]	Markusen	150.875	Continuous
6	Davidson	150.890	Interrupted
7	Markusen	151.010	Continuous
8	Markusen	151.025	Continuous
10	Markusen	151.055	Continuous
11	Markusen	151.070	Continuous
12	Markusen	151.085	Continuous

[a]Renamed channel 5 to channel 5A after placing same radio on another deer.

C. Recording Location of a Marked Deer

Radio telemetry has been used to track grizzly bears (Craighead *et al.* 1960), skunks (Verts 1963) and deer (Cochran 1963, Cochran and Lord 1963, Cochran *et al.* 1964, Heezen and Tester 1967, Marshall 1960). In this study, techniques similar to those of Heezen and Tester (1967) were used. Directional bearings were recorded with the aid of a directional antenna, Leupold compass and an aerial mosaic of the study area. A line was extended along the azmuth bearing on an acetate overlay. The investigator then moved to another location and took another reading. An effort was made to have the azmuth line of the second bearing lie at right angles to the first azmuth line. This was done to reduce the error polygon (Heezen and Tester 1967). The triangulated location was recorded by grid number, habitat type, topography and then mapped on an acetate overlay. The deer's activity and, when possible, its social association with other deer also was recorded.

After an animal was first marked, an effort was made to become familiar with its home range by following the azmuth line until the animal was sighted. This was also done to check the accuracy of the triangulated location and to gain information on condition of the deer, its social status and the durability of the markers used to identify it.

D. Range and Movement

1. Range

Four facets of home range were studied: estimated seasonal home range, home range major axis, minimum daily movement and average minimum daily movement.

Estimated seasonal home range was determined for marked deer during three winter periods and one spring period. The condition of snow cover versus no snow cover was used to differentiate between winter and spring seasons. The estimated range was calculated in a manner similar to Marchinton and Jeter (1966):

> Minimum home range--the area included within a line connecting the outermost radio locations of the deer during the entire period of telemetric and visual contact. Since some of the ranges were irregularly shaped, an attempt was made to connect locations with lines that would result in the most nearly accurate home range acreage. The technique is similar to the modified minimum area method described by Harvey and Barbour (1965), but differs primarily in that a knowledge of habitat rather than a mechanical procedure was used in determining the minimum [estimated] home range boundaries.

The above method was modified during 1971-72 when ranges for marked deer were plotted separately for the snow or no snow periods.

Home range major axis length was also calculated according to Marchinton and Jeter (1966):

> Home range major axis--a line segment formed by connecting the two radio [or visual] locations of the deer, obtained anytime during the study

> [season], that are the greatest distance apart. In instances where such a line would not lie entirely within the [estimated] minimum home range, it was angled so that it would follow the approximate mid-line of the range and still connect these two radio [or visual] locations.

Minimum daily movement was calculated by connecting the known locations for an animal from the time it was located bedding during the day through feeding at night and back to bedding the following day (a round trip). The line connecting the known locations was measured in miles. The lengths recorded for each marked deer were then analyzed by computer to determine if any variations occurred due to sex, age, period of study, snow or no snow and individual deer.

Average minimum daily movement was calculated by dividing minimum daily movement by two. This yielded an approximate figure for the one-way distance traveled by a deer either to or from a feeding area over the given time interval.

2. Movement

In order to determine the effect of the permanent cover afforded by the park and its immediate surroundings, three types of movement were considered: immigration, emigration (dispersal), and migration.

Immigration was measured indirectly by track counts along gravel roads surrounding the area and directly by aerial census (Petrides 1953) during early and late winter and by sightings of deer during the shotgun deer season.

The effect of the park as a refuge during the hunting season was studied through observations of deer movement along the park border.

Emigration (dispersal) was studied by following radio-equipped deer as they left the area. Several radio-broadcasts, a televison broadcast and numerous newspaper articles were used to alert Iowan's to the possibility of seeing a marked deer. The request was made that any sighting of a marked deer be recorded and then reported to the local conservation officer or directly to the investigator.

Migrational movement to and from the study area was investigated using the same techniques employed in studying dispersal. Animals were marked in the park during winter, observed some distance from the park in summer and then relocated back in the park the following winter.

E. Census Techniques

Deer were censused directly by observation during daylight hours, by spotlighting at night and by conducting aerial counts. Indirect census methods included track counts along gravel roads (Brunett and Lambou 1962), and highway mortality trends (Bellis and Graves 1971, Jahn 1959, McNeil 1962, Nixon 1965).

F. Statistical Analysis

An I.B.M. Model 360-65 computer was used to aid in analysis. Calculations were made according to Snedecor and Cochran (1967).

Data on deer movement during crepuscular periods were recorded on computer punch cards according to the format in Appendix V. Weather data were recorded on prepared forms (Appendix VI) and included: maximum-minimum temperatures, wind direction and velocity, per cent nebulosity, type and amount of precipitation, type ground cover, and amount of snow on the ground. Other data recorded included time of sunrise or sunset, observation time, lunar phase, grid number, number of deer sighted, and age and sex information. Lunar phase was recorded by potential brightness with new moon rated as 1 and full moon rated as 15. All other phases were rated between 1 and 15 as the number of days from new moon increased until full moon and then from 15 to 1 as the number of days from full moon increased until new moon was reached.

Combined effects of sunrise-sunset, lunar phase and weather variables as well as the unique effect of each variable on time of sighting were calculated by multiple regression analysis.

Data on minimum daily movement were recorded according to the format in Appendix VII. Means, ranges and standard deviations were calculated and an analysis of variance performed to determine if significant differences in movement occurred due to study period, season, age and sex.

Information on activity, age and sex, location of sightings and bedding areas and various weather variables were recorded on punch cards according to the format in Appendix VIII. This information was used to determine:

1. Total number of deer sighted for all three study periods
2. Total numbers of deer sighted during each study period
3. Total number of sightings for marked deer
4. Total number of sightings of marked deer for each period
5. Total number of deer seen inside and outside park for all periods, for each period, for marked and unmarked
6. Total numbers of sightings that were adult and juvenile for all periods and for each period
7. Total numbers of sightings that were antlered and antlerless for all periods and for each period
8. How many sightings consisted of deer alone, in two's, three's, four's, five's, six's and over six for all periods and for each period
9. Frequency of occurrence per 10-acre grid for

all periods, for each period and by all periods for marked and unmarked deer and by each period for marked and unmarked deer

10. Ratio of active to bedded deer for each hour of the day for all periods, and for each period separately. Also determine for all periods and for each period for adult versus juvenile; antlered versus antlerless

11. Which grids of habitat are preferred for bedding for all periods, each period and for all periods by marked versus unmarked and for each period by marked versus unmarked

12. Which topography is preferred for bedding for all periods, by each period and for all periods by marked versus unmarked and by each period for marked versus unmarked

13. By multiple regression the effects of weather variables including maximum-minimum temperature, wind direction and velocity, per cent nebulosity, precipitation and ground cover on the selection by deer of a bedding site.

V. RESULTS

A. Capturing and Marking

A total of 13 individual deer was captured, 10 by trap and 3 with nicotine between January 27, 1970 and February 22, 1972 (Table 2).

1. Trapping success

During the winter of 1969-70 one "Stephenson" type deer trap was operated and, in the winters of 1970-71 and 1971-72 three traps were maintained.

The deer trap at Site I, grid 159, was operated for 56 days during 1969-70 and 132 days during the winter of 1970-71 (Table 3). Three individual deer, a female fawn and 2 adult females, were captured at Site I in 1969-70. No deer were captured at this site in 1970-71 (Table 3). A female fawn was recaptured at Site I February 17, 1970.

On February 2, 1970, a German shepherd dog was captured at trap Site I. It caused damage to the trap by chewing extensively on the plywood. No deer were captured in that trap following the dog's capture.

Trap Site I was abandoned and the trap moved to Site IV, grid 160 on March 19, 1971. Two additional deer traps were constructed and placed in operation during the 1970-71 winter. The trap at Site II was operated 134 days in 1970-71 and for 98 days during winter 1971-72. Four deer, 2 male fawns, 1

Table 2. Capture and marking records for deer handled during the winters of 1969-70, 1970-71, and 1971-72 at Pilot Knob State Park, Iowa

Radio channel	Date	Sex	Age	Capture method	Collar color	Tag No.	Ear tagged	Ear streamer color	Ear with streamer
2	1/27/70	F	Fawn	Trap	Black	103	L	Blue	L
4	2/5/70	F	3.5	Trap	Black-red bands	105	L	Yellow	L
3	2/6/70	F	1.5	Trap	Black-yellow bands	107	L	Yellow	L
7	11/22/70	F	Fawn	Trap	Black-white bands	109	L	Yellow	L
-[a]	12/20/70	M	Fawn	Trap	---	110 111	L R	Pink	R
10	1/14/71	F	Fawn	Trap	Black-pink bands	113 112	L R	Green	L
12	2/27/71	M	Fawn	Trap	Silver-red bands	115 116	L R	Orange	R
8	3/2/71	F	1.5	Trap	Silver-orange bands	119 120	L R	Blue	L
11	12/12/71	M	Fawn	Trap	Red	123 121	L R	Pink	R

[a]Died in the process of handling, with death probably due to shock or suffocation from regurgitation.

Table 2 (Continued)

Radio channel	Date	Sex	Age	Capture method	Collar color	Tag No.	Ear tagged	Ear streamer color	Ear with streamer
5	1/18/72	M	2.5	Drug	Yellow-blue bands	136	L	Yellow	R
						135	R		
5A	2/3/72	M	Fawn	Trap	Yellow-blue bands	154	L	Green	L
						155	R	Green	R
6	2/16/72	F	Fawn	Drug	Blue	152	L	Orange	L
						153	R	Orange	R
1	2/22/72	M	1.5	Drug	Red-yellow	157	L	Pink	L
						156	R	Pink	R

Table 3. Days operated and number, sex, and age of deer captured at each trap site during each trapping period

Year	Trap Site I		Trap Site II		Trap Site III		Trap Site IV	
	1/7/70 days set	Deer captured	9/3/70 days set	Deer captured	10/20/70 days set	Deer captured	3/19/71 days set	Deer captured
1969-70	56	1 F. fawn 1 F. adult 1 F. adult 1 F. fawn[a]						
1970-71	132	None	134	1 F. fawn 1 M. fawn[b] 1 F. adult 1 M. fawn	143	1 F. fawn 1 F. fawn[a]	6	None
1971-72	None	None	98	1 M. fawn 1 M. fawn	98	None	98	None
Total	188	3	232	6	241	1	104	0

[a]Recaptured.

[b]Died during the process of handling.

female fawn and an adult female, were captured during the winter of 1970-71. Two deer, both male fawns, were captured in 1971-72.

On February 15, 1972, a Dalmation dog was captured and spent part of the night in the trap at Site II. No deer were captured in this trap following the dog's capture.

The trap at Site III, grid 157, was operated 143 days in 1970-71 and 98 days in 1971-72. One deer, a doe fawn, was captured and subsequently recaptured 14 times at Site III in 1970-71.

At Site IV, the trap was operated 6 days in 1970-71 and 98 days in 1971-72. No deer were captured at this site.

In all, six deer were captured at trap Site II, three at Site I, one at Site III and none at Site IV. When trapping success per period was calculated, the 1969-70 period ranked first with 19 trap nights per deer captured and the 1971-72 period ranked last with 147 trap nights per deer (Table 4). Over all periods, trap Site II was most successful with one capture per 46 trap nights and Site IV least successful with no deer captured in 104 trap nights (Table 4). Only one deer was captured in 241 trap-nights at Site III, but it was retaken 14 times.

Seven fawns, 4 male and 3 female, and three adults, all female, were trapped from 1969-70 through 1971-72 (Table 4). Fawns required 109 trap nights per deer captured, adults 255 trap nights per deer captured. Males (all fawns) required

Table 4. Comparison of trapping success by trap site, period, age, sex and sex by age of captured deer

Trap site	Trap nights/ deer	Period	Trap nights/ deer	Age	Trap nights/ deer	Sex	Trap nights/ deer	Age by sex	Trap nights/ deer
1	63	1969-70	19	Fawn (7)	109	Male (4)	191	Male fawns (4)	191
2	46	1970-71	104	Adult (3)	255	Female (6)	128	Female fawns (3)	255
3	241	1971-72	147					Adult male (0)	---
4	---							Adult female (3)	255
		1969-72	85						

191 trap nights per capture, females 128 trap nights. When compared over age by sex, male fawns required 191 trap nights and female fawns 255 trap-nights per capture (Table 4). Adult females also required 255 trap-nights per capture. Adult males were the most difficult to capture since none were trapped over the 3-year period.

a. Miscellaneous captures Animals other than deer captured in the "Stephenson" type traps included: cottontail rabbit, fox squirrel, chipmunk, German shepherd and Dalmation dogs, and a grey fox.

b. Bait Alfalfa, apples, corn, molasses, and a grain mixture were used as baits. Deer were attracted to the alfalfa, corn and apples but repeatedly left molasses and grain-molasses mixtures untouched. Cottontail rabbits and fox squirrels were attracted to corn, apples and the molasses-grain mixture and often sprung the traps while stealing bait. To avoid this problem, the trip wire was raised to a higher level above the ground and alfalfa bait only was placed inside the traps. Corn and apples were used to lure deer toward the traps.

2. Immobilization success

Ten deer, 9 adults and 1 fawn, were darted with nicotine between March 1971 and March 1972. Two adults, both male, and one female fawn were immobilized successfully (Table 5). All animals immobilized were darted in the front shoulder.

Table 5. Nicotine dosages, arranged in order of increasing amounts, used during the winters of 1970-71 and 1971-72 at Pilot Knob State Park for immobilizing white-tailed deer

Age	Sex	Estimated weight (pounds)	Dosage in mg nicotine	Where darted	Dosage per pound body weight	Response
A	F	170	200	Flank	1.18	
A	F	150	200	Flank	1.33	
A	M	200	300	Shoulder	1.50	Immobi-lized
A	M	180	320	Shoulder	1.78	
A	F	170	320	Flank	1.88	
A	M	200	340	Shoulder	1.70	
A	M	180	380	Shoulder	2.10	Immobi-lized
J	F	140	350	Shoulder	2.50	Immobi-lized
A	F	180	380	Shoulder	2.1	---[a]
A	F	180	380	Flank	2.1	

[a]May not have received the full dosage.

No animals darted in the flank were successfully immobilized. One animal, an adult male, was immobilized with 1.5 mg nicotine per pound estimated body weight. Another adult male was rendered immobile with 2.1 mg per pound estimated body weight, and a female fawn was immobilized with 2.5 mg per pound estimated body weight. Recovery time varied from 50 minutes with 2.1 mg per pound estimated body weight to 130 minutes with 2.5 mg nicotine per pound estimated body weight.

There was considerable variation in response to the drug by individual deer (Table 5). No deer receiving a dosage less than 1.5 mg per pound estimated body weight were immobilized. However, neither were 5 deer receiving 1.5 mg or more per pound estimated body weight. Three adult females received 1.88 mg or more per pound estimated body weight of which none were immobilized. The excellent physical condition of the deer may have been a factor in the variation in the tolerance to the drug.

Reaction time of deer successfully immobilized decreased with an increase in dosage per pound estimated body weight. A large adult male was rendered immobile in 4 minutes with 1.5 mg per pound estimated body weight. He was found leaning against a tree and had to be forcibly lowered to the ground. Another adult male was completely immobile in 50 seconds with 2.1 mg per pound estimated body weight and a female fawn, having received 2.5 mg per pound estimated body weight, was down in 15 seconds.

All darted animals, whether immobilized or not, exhibited the same response to being darted. Initially, they fled for a short distance and then turned and looked back. If no further danger was sensed, their previous activity, generally moving to or from a feeding area, was resumed. The first visible response to the drug was a rapid twitching of the tail and, in some cases, a "buckling" of the hind legs. If the animal did not go down immediately following these visual symptoms, it would bolt and run as far as the investigator was able to observe it in the rolling terrain.

3. <u>Marking results</u>

Thirteen deer, 7 males and 6 females, were marked during the 3-year study period (Table 2). During the winter of 1969-70 three deer, 1 female fawn and two adult females, were marked with a separate radio channel, a collar, ear tag and colored plastic streamer.

Five deer, 2 male fawns, 2 female fawns and an adult female, were marked in the winter of 1970-71. One deer, a male fawn, died during the process of handling with death probably resulting from suffocation as its windpipe was found to contain regurgitated food. One deer, a female fawn, was marked in a manner similar to those marked in 1969-70. The other four were marked with a numbered metal tag and plastic streamer in one ear and a numbered metal tag in the other ear. Each marked deer also received a color-coded collar and unique radio-frequency.

During the winter of 1971-72, 5 deer were marked; 2 adult males, 2 male fawns and 1 female fawn. The first deer, a male fawn, was marked with a numbered metal tag and colored plastic streamer in its right ear and a numbered metal tag in its left ear. The next deer, an adult male, was marked with a rubber ear tag, with a numbered metal tag and colored streamer affixed to it. Each of the next three deer were marked with a new-type rubber ear tag and streamer in each ear. Color-coded collars and telemetry-radios broadcasting on separate frequencies were attached to each deer.

a. Durability of markers   Eight deer were marked with a numbered metal ear tag and colored plastic streamer (Table 6). Maximum streamer life, the period from tagging until the deer was first sighted without the streamer, varied from 16 to 390 days, with a mean of 186 days. Minimum streamer life, the period of time from tagging until the deer was last sighted with the streamer, varied from 12 to 204 days, with a mean of 116 days. Four numbered metal tags, with attached streamers, were found on the ground in good condition.

Color-coded collars proved highly durable and effective as "permanent" markers. Of twelve collars placed on deer only one was lost when it slipped over the deer's head. Its size was too big for the small animal concerned.

Table 6. Effective life of numbered metal tags and colored plastic ear streamers

Channel	Date marked	Last seen with streamer	First seen with streamer	Known max. streamer life (days)	Minimum streamer life (days)	Condition of recovered streamers
2	2/27/70	3/1/70	11/20/70	297	33	good
3	2/6/70	6/27/70	3/3/71	390	141	----
4	2/5/70	8/10/70	12/6/70	304	186	----
7	11/22/70	6/14/71	----	---	204	----
8	2/2/71	5/21/71	12/4/71	306	108	good
10	1/14/71	5/8/71	6/18/71	156	114	----
11	12/12/71	12/23/71	12/27/71	16	12	good
12	2/27/71	7/4/71	7/11/71	134	127	good
			Average	186	Average 116	

Four collars have been recovered after being on a deer for from 2 weeks to 2 years and all were in good condition with individual markings still recognizable. Another collar, attached in January, 1970, was still attached and recognizable in April, 1972.

b. Effective radio life Eleven telemetry radios were assembled and attached to deer in the study (Table 7). In 1969-70, three radios were attached. Their known minimum broadcasting life varied from 32 to 59 days with a mean of 50 days.

Four radios attached in 1970-71 had a known effective life ranging from 60 to 139 days with a mean of 92 days.

In 1971-72 batteries with tabs for soldering wire connections were used to avoid heating while soldering. Four assembled radios had a known minimum broadcasting life varying from 79 to 162 days with a mean of 130 days. The average known broadcasting life of all 11 radios was 91 days but radio channels 1 and 5A were still operating when field studies were terminated on May 23, 1972.

B. Movement Data for Individual Marked Deer, 1969-70

Information on movement of radio equipped deer is based on three deer monitored during the winter of 1969-70, four in 1970-71, and five in the winter and spring of 1971-72. In addition, during the 1971-72 period, 32 sightings were obtained for a doe marked on January 27, 1970.

Table 7. Effective life of radio-transmitters used during the period 1969-70 through 1971-72

Period	Channel	Date radio made operative	Signal type	Number batteries (1.4 volts/ battery)	Last date signal was received	Minimum broadcasting life (days)
1969-70	2	1/27/70	Continuous	2-parallel	3/1/70	32
	3	2/6/70	Continuous	2-parallel	4/4/70	58
	4	2/5/70	Continuous	2-parallel	4/4/70	59
					Average	50
1970-71	7	11/22/70	Continuous	3-parallel	4/9/71	139
	8	3/2/71	Continuous	3-parallel	4/30/71	60
	10	1/14/71	Continuous	3-parallel	4/30/71	107
	12	2/27/71	Continuous	3-parallel	5/1/71	63
					Average	92
1971-72	1	2/21/72	Continuous	3-parallel	5/9/72	94
	5 (5A)[a]	12/15/72	Continuous	3-parallel	5/9/72	162
	6	1/18/72	Interrupted	2-parallel plus 2-series	5/9/72	113
	11	12/12/71	Continuous	3-parallel	5/9/72	150
					Average	130
			Average life 1969-172 -			91

[a]Same telemetry unit used on two deer.

1. <u>Channel 2</u>

Channel 2, a female fawn marked January 27, 1970, occupied an estimated winter range of 243 acres with a major axis length of 1.06 miles (Table 8, Fig. 16). Its winter range included timber inside the park, and timber and cropland outside the park's boundaries. During the winter of 1969-70, Channel 2's estimated known minimum daily movement was calculated at 0.90 mile (round trip). This meant that it moved approximately 0.45 mile to its feeding ground and 0.45 mile from its feeding ground back to its bedding area.

This deer remained in the immediate vicinity of the park throughout 1970. However, she left the study area in the spring of 1971 and, on May 21, 1971, was observed along the Winnebago River about 5 miles northwest of the park (Table 9).

2. <u>Channel 3</u>

Channel 3, a yearling female when marked on February 6, 1970, occupied an estimated winter range of 215 acres with a major axis length of 1.12 miles (Table 8, Fig. 17). Her range included timber inside and outside the park for bedding and cropland peripheral to the park for feeding. During winter, her average minimum daily movement was estimated at 1.22 miles. That spring Channel 3 left the park and spent the summer with a single fawn on the James Wicker farm approximately 6 miles west-northwest of Pilot Knob (Table 9).

Table 8. Data on estimated minimum home range, length of major axis and estimated minimum daily movement for marked deer under snow or no snow conditions during three periods: 1) winter 1969-70, 2) winter 1970-71, and 3) winter and spring 1971-72

Period	Radio channel	Snow condition	Age (years)	Sex	Estimated home range (acres)	Length of major axis (miles)	Est. min. daily movement (miles)	Number sightings and telemetric locations	Study period for each deer
1	2[a]	snow	fawn	F	243	1.06	0.902	32	1/27/70-3/1/70
	4	snow	3.5	F	200	1.12	1.393	33	2/5/70-4/1/70
	3	snow	1.5	F	215	1.12	1.221	29	2/6/70-4/1/70
2	7	snow	fawn	F	307	1.19	1.475	50	11/22/70-3/6/71
	10	snow	fawn	F	145	1.00	1.154	46	1/4/71-3/6/71
	12	snow	fawn	M	49	0.62	0.595	17	2/27/71-3/6/71
	8	snow	1.5	F	198	1.00	1.375	13	3/2/71-3/6/71
3	2[a]	snow	2.5	F	147	0.95	0.900	8	12/13/71-3/19/72
		no snow			190	1.12	0.910	24	3/20/72-4/25/72
	11	snow	fawn	M	504	1.87	1.217	101	12/12/71-3/19/71
		no snow			435	1.72	1.764	86	3/20/71-4/25/71
	5	snow	2.5	M	456	1.60	---	9	1/18/71-1/31/71
		no snow			---	---	---	---	---
	5A	snow	fawn	M	253	1.62	0.966	44	2/3/72-3/19/72
		no snow			176	1.22	0.838	79	3/20/72-4/25/72
	6	snow	fawn	F	210	1.22	1.033	22	2/17/72-3/19/72
		no snow			155	1.62	---	28	3/20/72-4/25/72
	1	snow	1.5	M	85	0.95	0.979	19	2/23/72-3/19/72
		no snow			1129	2.85	1.623	70	3/20/72-4/25/72

[a]Same deer.

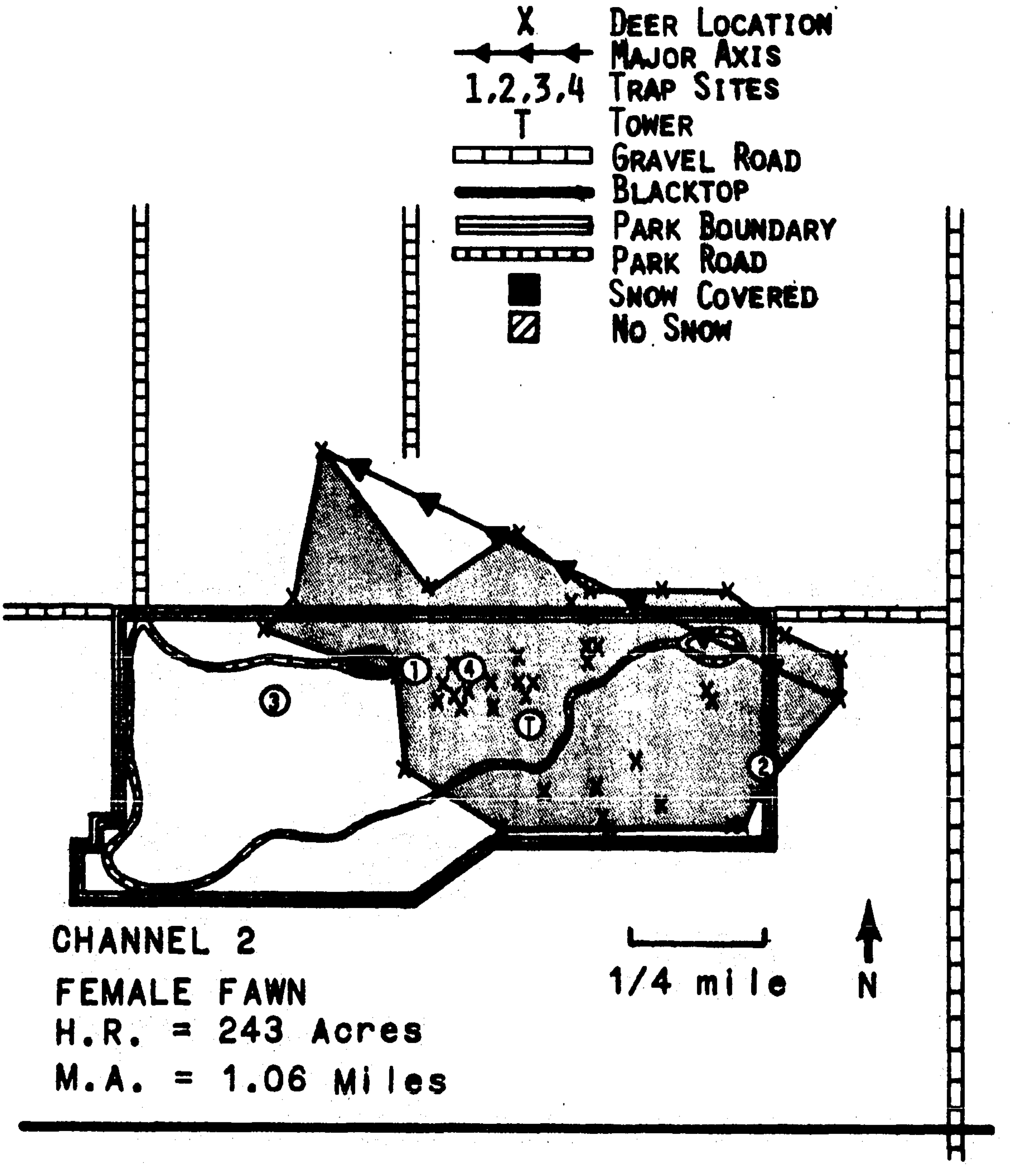


Fig. 16. Estimated seasonal home range (H.R.) and major axis length (M.A.) for Channel 2, a female fawn, from January 27, 1970-March 1, 1970

Table 9. Dispersal data for all deer marked in Pilot Knob State Park, Iowa, from December, 1969, through May, 1972

Channel	Age	Sex	Year	Season	Distance from Park (miles)	Direction of movement from park
2	Fawn	F	1969-70	Winter	0.0	---
			1970	Spring	0.0	---
			1970	Summer	0.0	---
			1970	Fall	0.0	---
			1970-71	Winter	0.0	---
			1971	Spring	5.0	NW
			1971	Summer	5.0	NW
			1971	Fall	0.0	---
			1971-72	Winter	0.0	--
			1972	Spring	0.0	---
			1972	Summer	?	
3	1.5	F	1969-70	Winter	0.0	---
			1970	Spring	6.5	WNW
			1970	Summer	6.5	WNW
			1970	Fall	6.5	WNW
			1970-71	Winter	0.0	---
			1971	Spring	6.5	WNW
			1971	Summer	6.5	WNW
			1971	Fall	0.0	---
			1971-72	Winter	0.0	---
4	3.5	F	1969-70	Winter	0.0	---
			1970	Spring	2.5	SW
			1970	Summer	2.5	SW
			1970	Fall	?	---
			1970-71	Winter	3.2	E

Table 9 (Continued)

Channel	Age	Sex	Year	Season	Distance from park (miles)	Direction of movement from park
7	Fawn	F	1970-71	Winter	0.0	---
			1971	Spring	3.5	S
			1971	Spring	25.0	SE
			1971	Summer	40.0	S
			1971	Summer	38.0	S
8	1.5	F	1970-71	Winter	0.0	---
			1971	Spring	7.8	NE
			1971	Fall	34.0	SE
			1971-72	Winter	43.5	SE
10	Fawn	F	1970-71	Winter	0.0	---
			1971	Spring	0.0	---
12	Fawn	M	1970-71	Winter	0.0	---
			1971	Spring	1.0	S
			1971	Spring	5.0	SE
			1971	Summer	110.0	S
1	1.5	M	1971-72	Winter	0.0	---
			1972	Spring	1.0	S
			1972	Summer	?	
5	2.5	M	1971-72	Winter	0.0	---
			1971-72	Winter	1.0	S
5A	Fawn	M	1971-72	Winter	0.0	---
			1972	Spring	0.0	---
			1972	Summer	?	

Table 9 (Continued)

Channel	Age	Sex	Year	Season	Distance from park (miles	Direction of movement from park
6	Fawn	F	1971-72	Winter	0.0	---
			1972	Spring	1.0	S
			1972	Summer	?	
11	Fawn	M	1971-72	Winter	0.0	---
			1972	Spring	0.0	---
			1972	Summer	?	

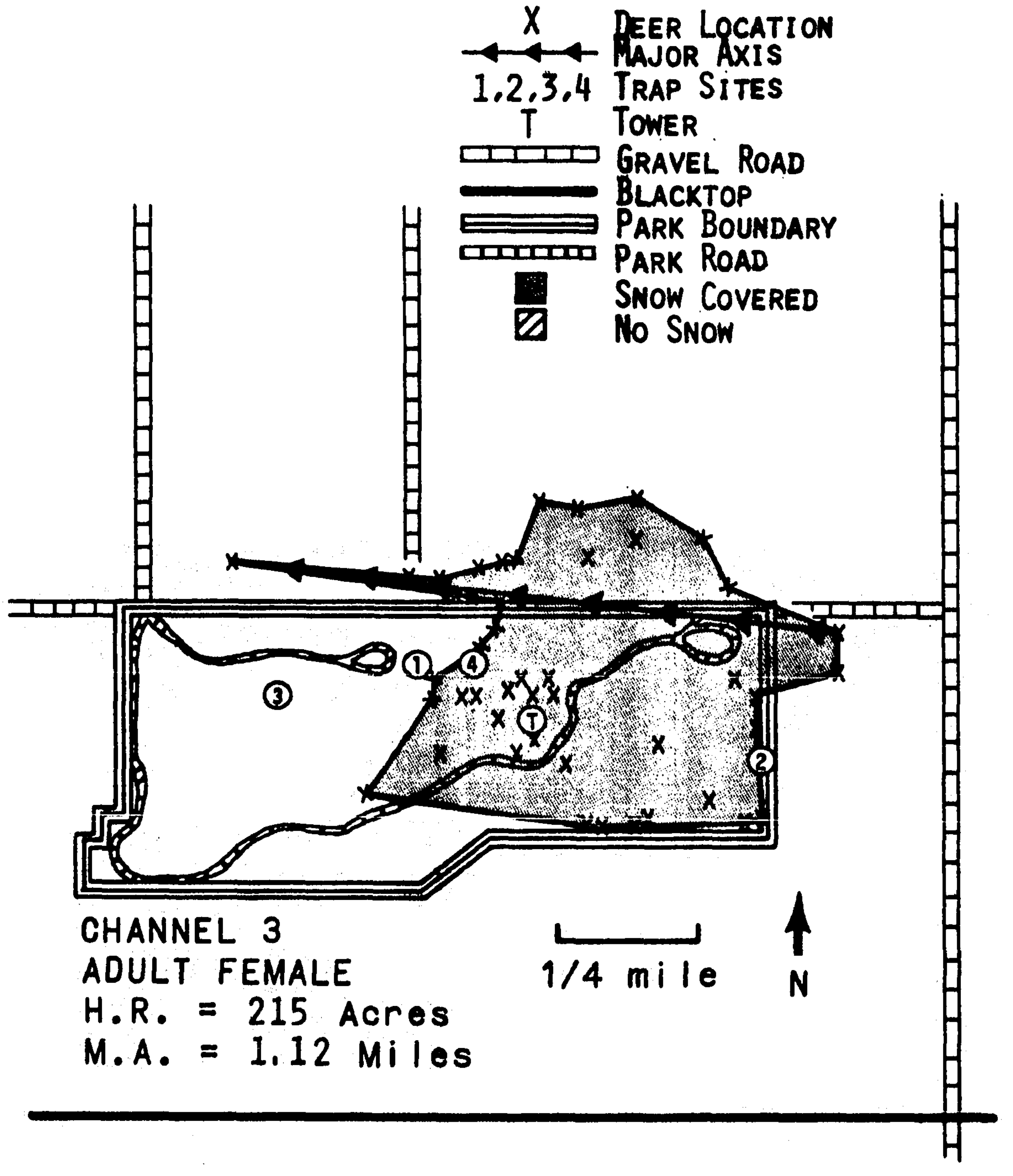


Fig. 17. Estimated seasonal home range (H.R.) and major axis length (M.A.) for Channel 3, a yearling female, from February 6, 1970-April 1, 1970

She and a fawn were observed back in the immediate vicinity of the park on March 3, 1971. On May 6 and June 10, 1971, Channel 3 was again sighted near the James Wicker farm west of Pilot Knob.

She returned to the park in fall of 1971, and, on November 26, was shot by a bow hunter while traveling with three fawns in the timber immediately north of the park. On December 4, 1971, she was found partially eaten by foxes. Her collar was still in excellent condition.

3. Channel 4

Channel 4, a 3-1/2 year old female when captured February 5, 1970, occupied an estimated winter range of 200 acres with a major axis length of 1.12 miles (Table 8, Fig. 18). Cover types used included cropland adjacent to the park and timber, both inside and outside the park. During winter, its estimated average minimum daily movement was 1.39 miles. It therefore moved approximately 0.7 mile from its bedding area in the eastern half of the park to its feeding area north of the western half of the park.

In spring of 1970, Channel 4 left the study area and summered with a single fawn on the Kenneth Bige farm about 2.5 miles southwest of the park (Table 9). Channel 4 was often sighted near the willows bordering the banks of the Winnebago River which flows through the farm.

On December 6, 1970, Channel 4, along with three other

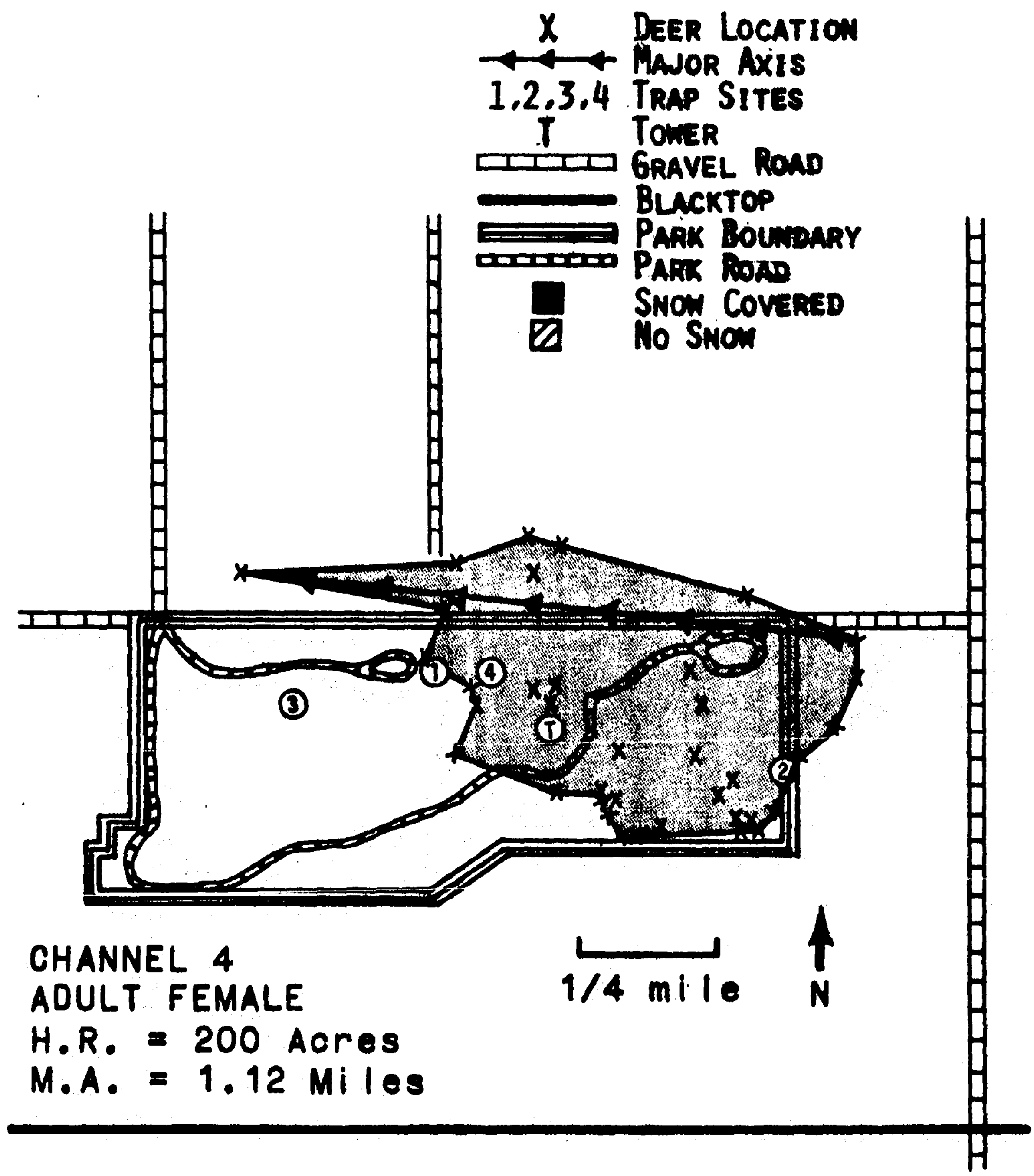


Fig. 18. Estimated seasonal home range (H.R.) and major axis length (M.A.) for Channel 4, a 3-1/2 year old female, from February 5, 1970-April 1, 1970

deer, was killed in the shotgun season near a plum thicket approximately 3.2 miles east of the park. At that time she was found to have lost her streamer and ear tag. Her collar was badly worn and the spring-steel antenna had rusted off near the collar. When killed she was found to have grown a 9-1/2 inch antler, still in velvet, on her right side. No sign of an antler was present the previous winter.

C. Movement Data for Three Marked Deer During 1969-1970

The total range occupied by all three marked deer during the winter of 1969-70 was estimated at 290 acres with a major axis length of 1.12 miles (Fig. 19). Included within the total range were croplands adjacent to the park and timber inside and outside the park.

Average estimated range for the three deer was 219 acres with a major axis 1.10 miles long. The average orientation of the three major axes was in a northwesterly-southeasterly direction indicating a movement pattern from timber used for bedding in the eastern half of the park to cropland for feeding north of the western half of the park. The average minimum daily movement for the three deer was 1.17 miles (round trip). Halving this figure gives a one-way movement of 0.59 mile (between the bedding and feeding sites).

Two of three marked deer (66-2/3 %) were known to have dispersed from the area in the spring following their capture.

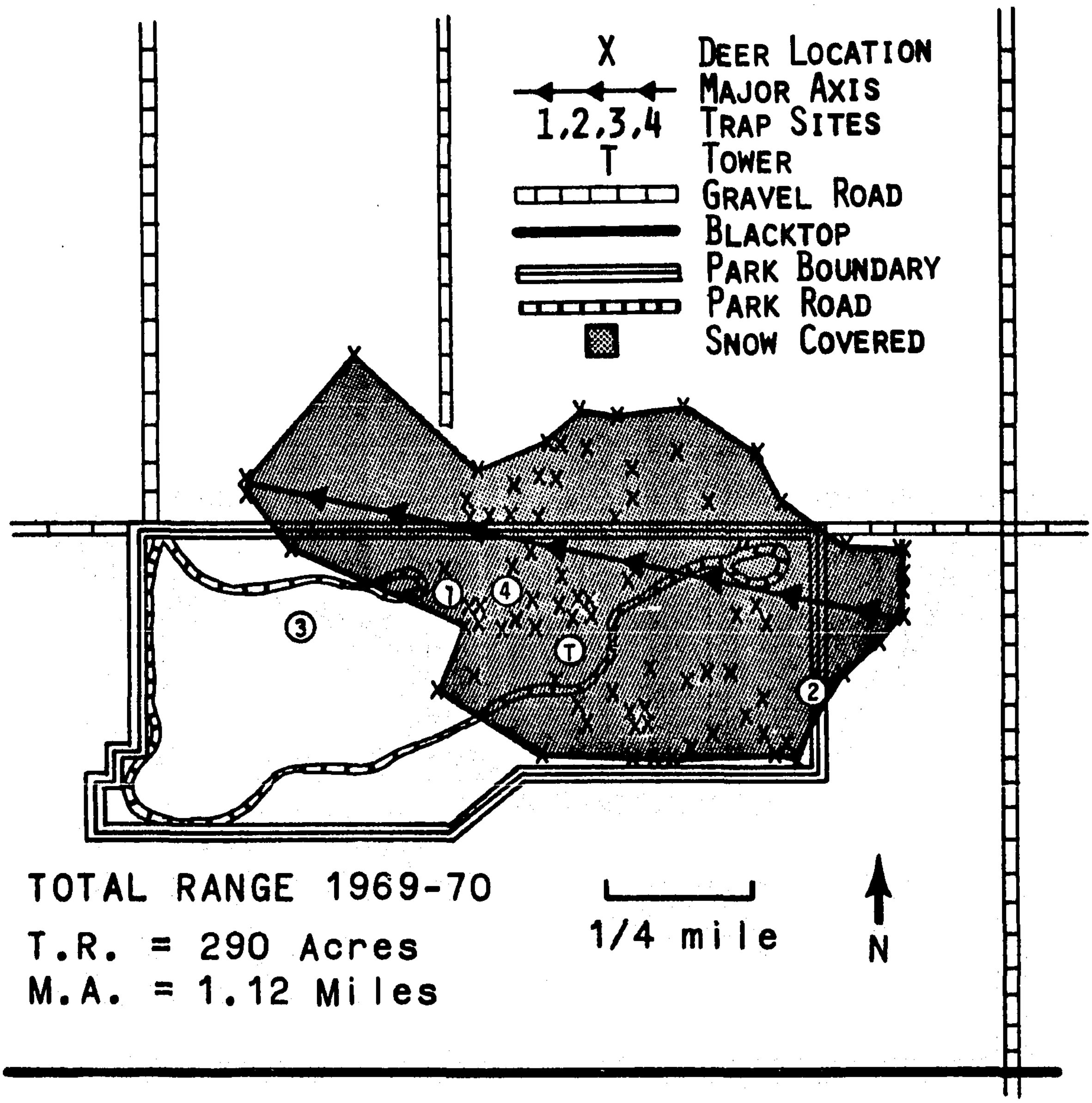


Fig. 19. Estimated total range (T.R.) and major axis length (M.A.) for three deer, 1 female fawn and 2 adult females, marked in winter 1969-70 from January 27-April 1, 1970

Because these deer were captured randomly it is possible that this percentage of dispersal may be indicative for the entire herd.

D. Movement Data for Individual Marked Deer, 1970-71

1. Channel 7

Channel 7, a female fawn trapped November 22, 1970, inhabited an estimated winter range of 307 acres with a major axis 1.19 miles in length and oriented to indicate movement between cropland and timber (Table 8, Fig. 20). Estimated average minimum daily movement for this deer was 1.48 miles.

She left the park late in spring and was sighted about 3.5 miles south on May 18, 1971, and 25 miles southeast, near Rockwell, Iowa, on May 21, 1971 (Table 9). This indicates a movement rate of 7 miles per day. On June 9, 1971, she was sighted while bedded in a meadow south of the Rock Island railroad tracks one mile east of Clarion, Iowa. Clarion is 35 miles southwest from Rockwell and 37 miles south of Pilot Knob State Park. When sighted on June 9, 1971, her streamer and collar were visible. She was last sighted in Galt, Iowa, 9 miles east of Clarion, on June 14, 1971.

2. Channel 8

Channel 8, a yearling doe captured February 2, 1971, occupied an estimated winter range of 198 acres with a major axis length of 1.00 mile (Table 8, Fig. 21). Her average

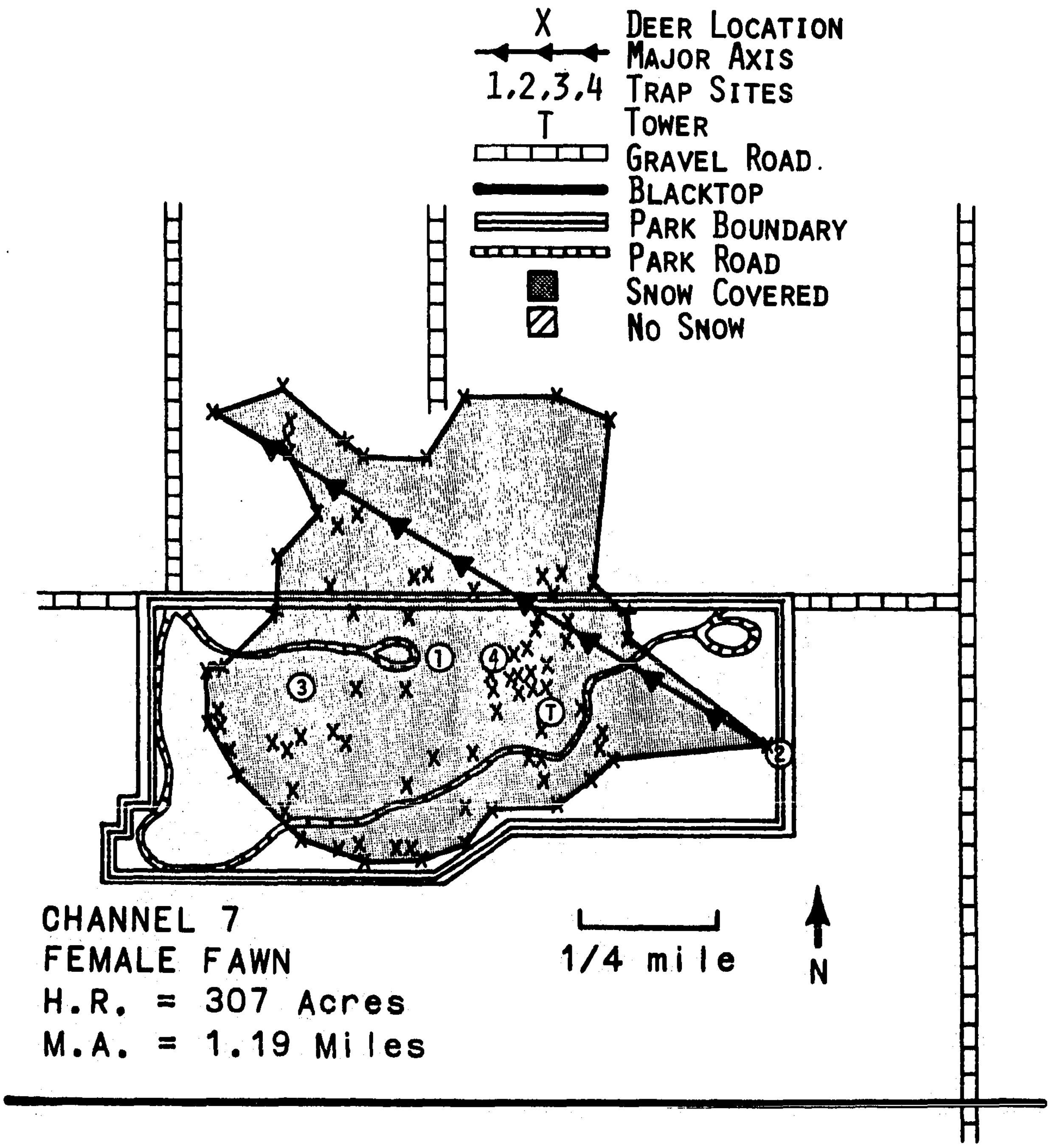


Fig. 20. Estimated seasonal home range (H.R.) and major axis length (M.A.) for Channel 7, a female fawn, from November 22, 1970-March 6, 1971

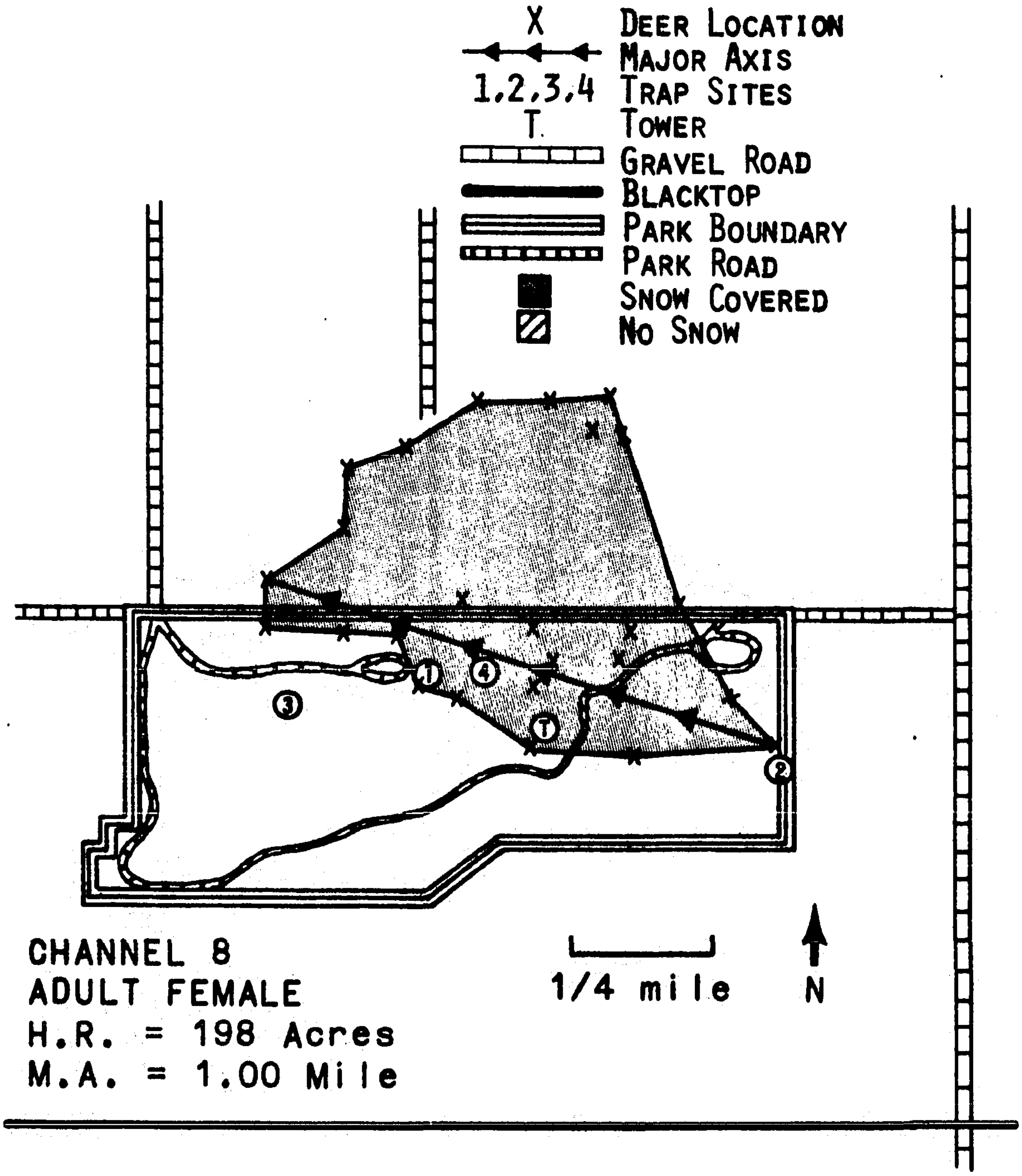


Fig. 21. Estimated seasonal home range (H.R.) and major axis length (M.A.) for Channel 8, a yearling female, from March 2, 1971-March 6, 1971

minimum daily movement was 1.38 miles.

On May 21, 1971, Channel 8 was sighted about 8 miles northeast of the park (1 mile north of Fertile, Iowa) (Table 9). At that time her streamer and collar were visible.

Her streamer was found by a farmer while picking corn in a field west of Rudd, Iowa, on October 23, 1971. This represents a movement of 35.1 miles from her last known location north of Fertile, Iowa. During November, 1971, she was sighted repeatedly in Wentland Woods (state owned) and Gabel's Woods about 2 miles northeast of Floyd, Iowa; 10.4 miles east of Rudd, Iowa. She was wounded by a shotgun hunter in Wentland Woods on December 4, 1971, and traveled south along the Little Cedar River to the Robert Krinkie farm where she was again sighted on December 5 and 6. At that time her collar was visible, the radio was dead and the ear tag and streamer gone. She was observed on several occasions during the winter of 1971-72 while feeding near Wentland Woods by personnel of the Floyd County Conservation Board.

3. <u>Channel 10</u>

Channel 10, a spotted female fawn captured January 14, 1971, inhabited a winter range estimated at 145 acres with a major axis length of 1.00 mile (Table 8, Fig. 22). The range included timber inside and outside the park used primarily for bedding during daylight and cropland used

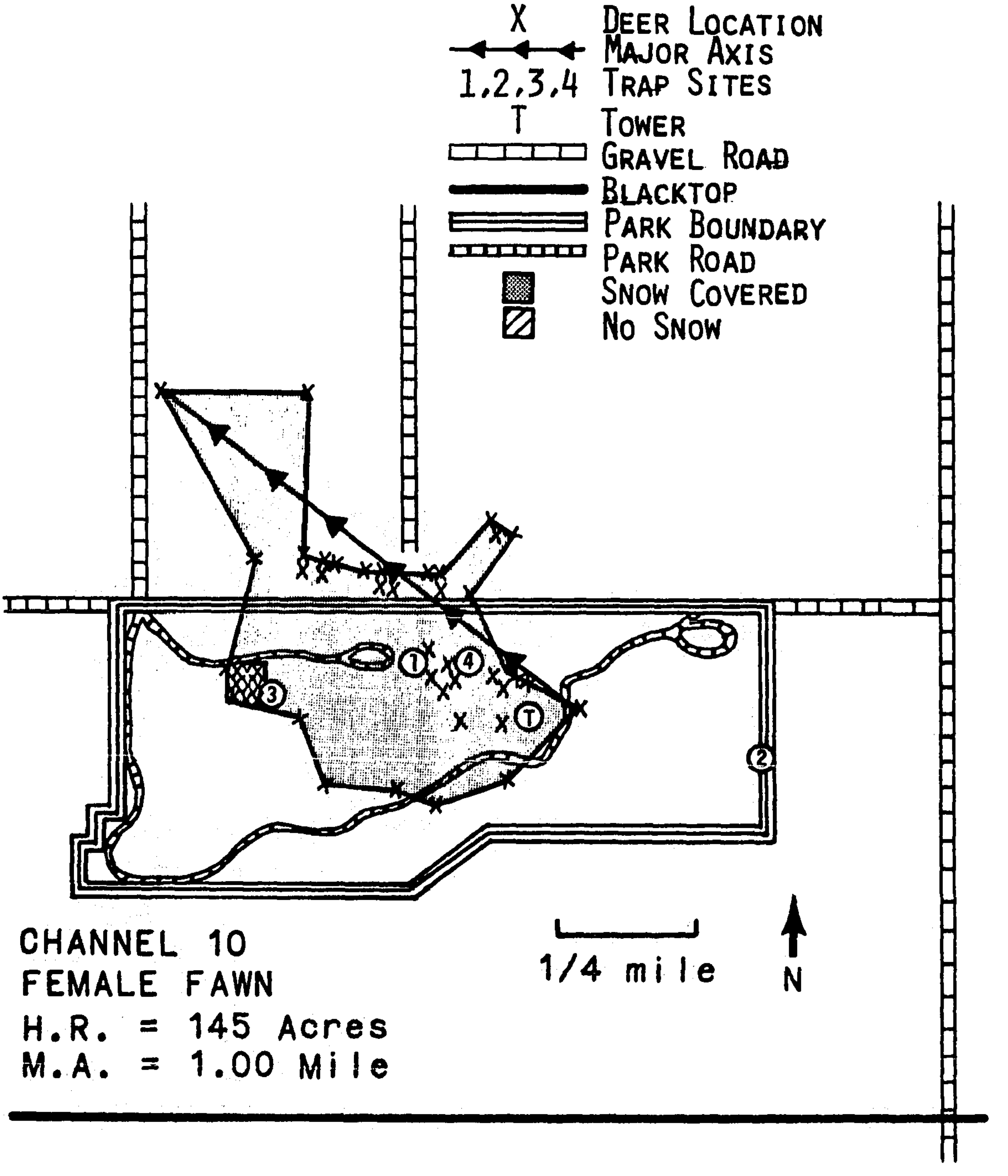


Fig. 22. Estimated seasonal range (H.R.) and major axis length (M.A.) for Channel 10, a spotted female fawn, from January 4, 1971-March 6, 1971

mainly for feeding at night. The average minimum daily movement for this deer was estimated at 1.15 miles (round trip). Both the size of the home range and the minimum daily distance may have been biased because this deer developed a trap habit and was recaptured 14 times in the same trap in a 25-day period.

In spring, as a yearling, Channel 10 apparently remained in the vicinity of the park (Table 9). She was sighted immediately north of the park (grid 120) on May 6 and her collar and streamer were visible. On June 11, 1971, her collar was found on the surface of a plowed field north of the park (grid 124). The field had been plowed May 6, 1971, so the deer must have still been in the vicinity of the park after that date.

4. Channel 12

Channel 12, a male fawn trapped February 27, 1971, occupied the smallest range of all deer captured. Its range consisted of 49 acres including timber inside the park and adjacent cropland. Its major axis length was 0.62 mile (Table 8, Fig. 23). Minimum daily movement for this deer was estimated at 0.60 mile; the shortest movement of any marked deer. In spring, Channel 12 left the park and was sighted in Hanson's Woods approximately 1 mile south of the park (Table 9). The last sighting in Hanson's Woods occurred on May 17, 1971. On May 20, 21, and 23, 1971, he was sighted

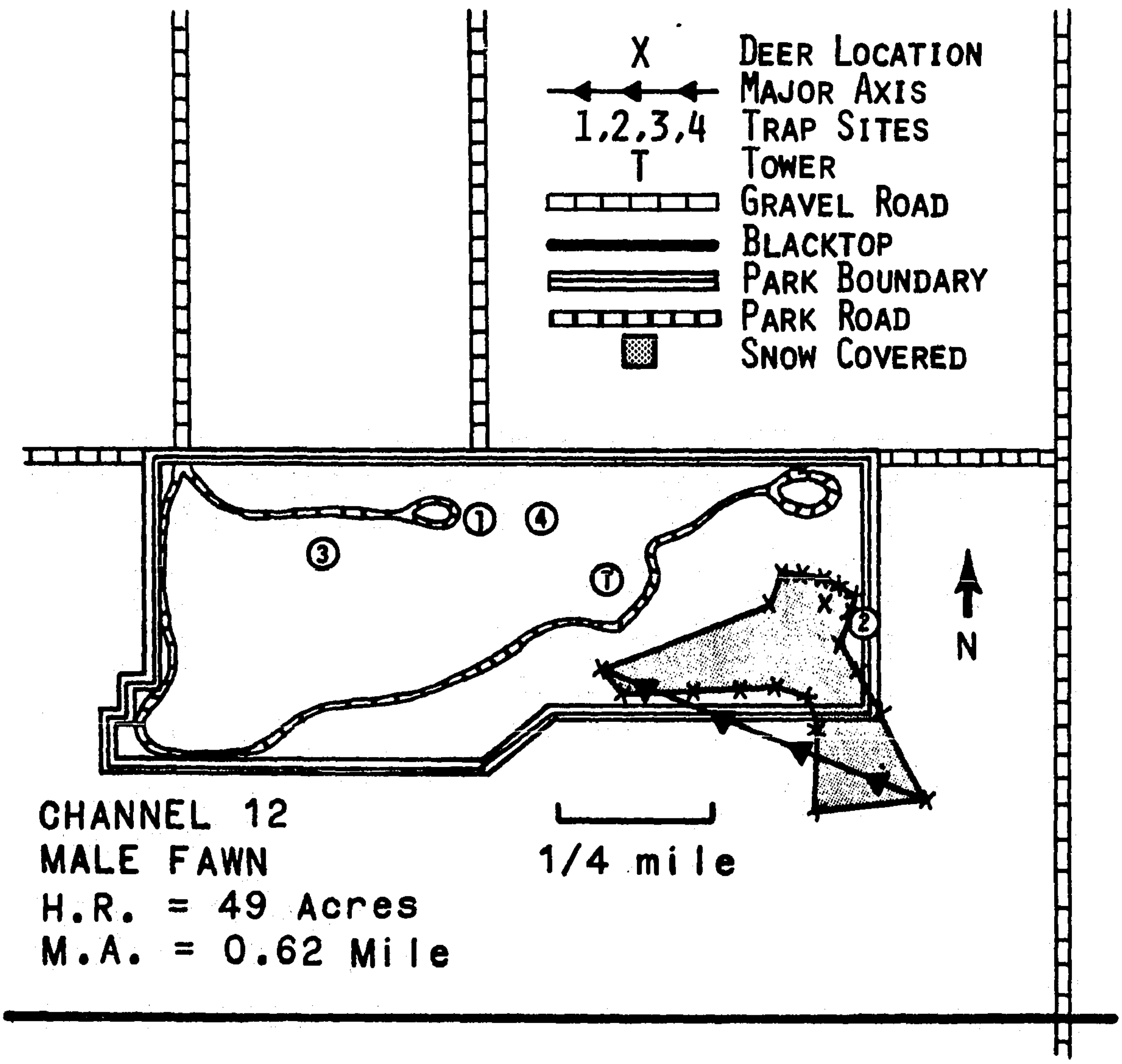


Fig. 23. Estimated seasonal range (H.R.) and major axis length (M.A.) of Channel 12, a male fawn, from February 27, 1971-March 6, 1971

along the Winnebago River where it crosses the blacktop road (S-14) connecting U.S. Highway 9 and Ventura, Iowa; 5.2 miles southeast of the park. From there he moved south to the Whaley farm located along the East Indian River south of Nevada, Iowa, where he was sighted on July 4, 1971. His streamer and collar were present on that date. Robert Franzen, who lives 1 mile east and 1 mile north of Elkhart, Iowa, found Channel 12's streamer and tag on his property July 11, 1971. This represents a movement of 110 miles south of the park.

E. Movement Data for Four Marked Deer During 1970-71

The total range occupied by all four deer marked in the winter of 1970-71 was estimated to be 448 acres with a major axis length of 1.52 miles (Fig. 24). Included within the total range were timber located inside and outside the park used mainly for bedding during daylight and cropland outside the park used primarily for feeding at night.

Average estimated range for the three deer was 175 acres with average major axis length of 0.95 mile. The pattern of movement was similar to that found for deer in 1969-70 and involved movement from bedding areas in the eastern half of the park to feeding areas north of the western half of the park. Average minimum daily movement for the four deer was 1.15 miles which, when halved, indicated a movement of 0.57 mile between feeding and bedding sites.

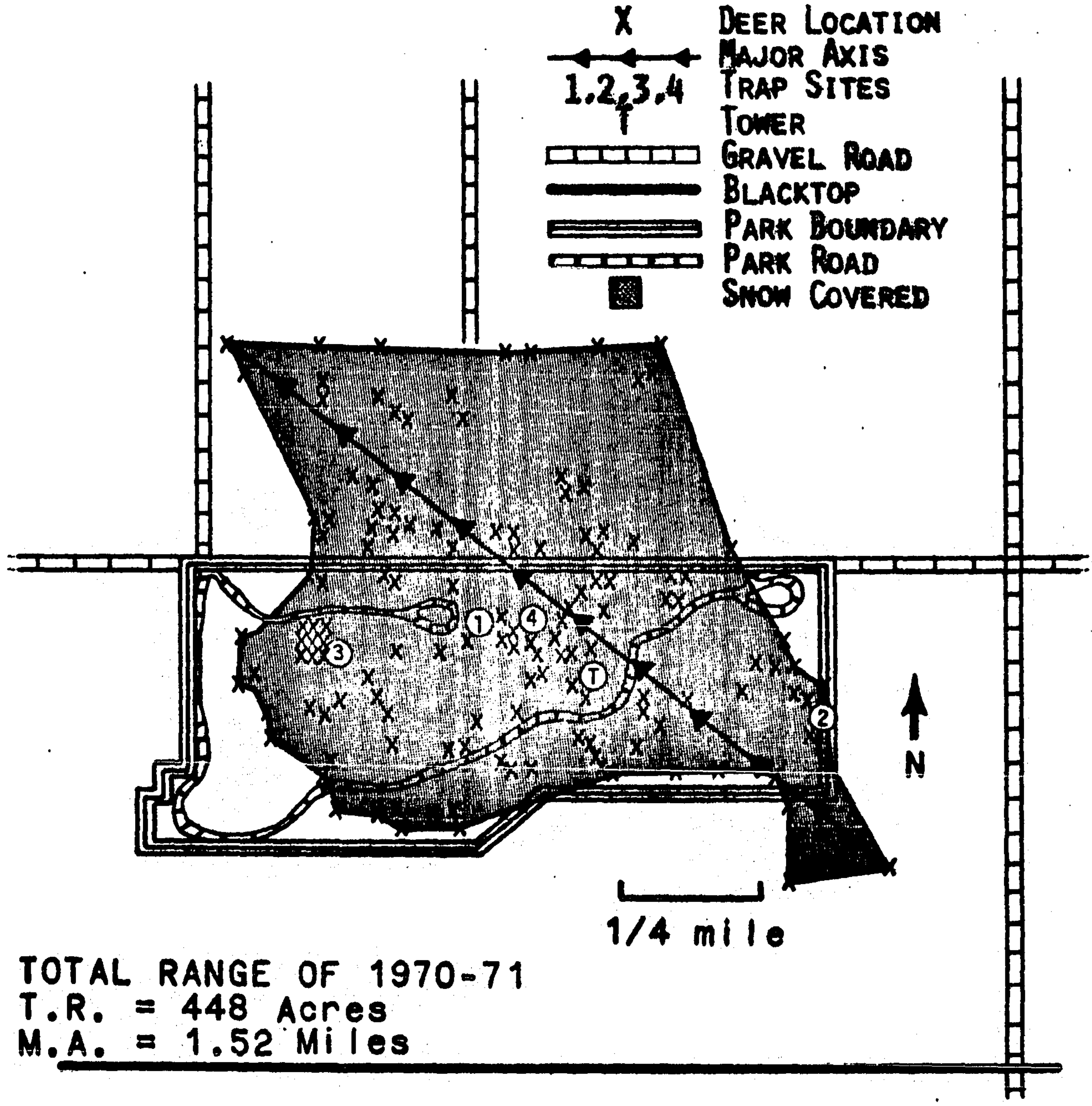


Fig. 24. Estimated total range (T.R.) and major axis length for four deer, 1 male fawn, 2 female fawns and 1 male fawn, marked in winter 1970-71 from November 22, 1970-March 6, 1971

Three of the four deer marked in 1970-71 (1 male fawn, 1 female fawn and 1 adult female) and two deer (adult females) marked in 1969-70 left the park in spring. This represented 83% (5 of 6 marked deer) of the marked deer known to have left the park and dispersed into surrounding lands. Average dispersal distance from the park for the five deer was 43.3 miles.

F. Movement Data for Individual Marked Deer, 1971-72

Five deer, 2 male fawns, 2 adult males and 1 female fawn, were marked and monitored during winter of 1971-72 (snow cover) and spring (no snow cover) of 1972. In addition, movement data was recorded for an adult female marked in 1969-70, Channel 2, traveling with a newly radioed deer. Size of estimated home range, length of major axis and estimated minimum daily movement were compared for the period with snow cover versus the period lacking snow cover.

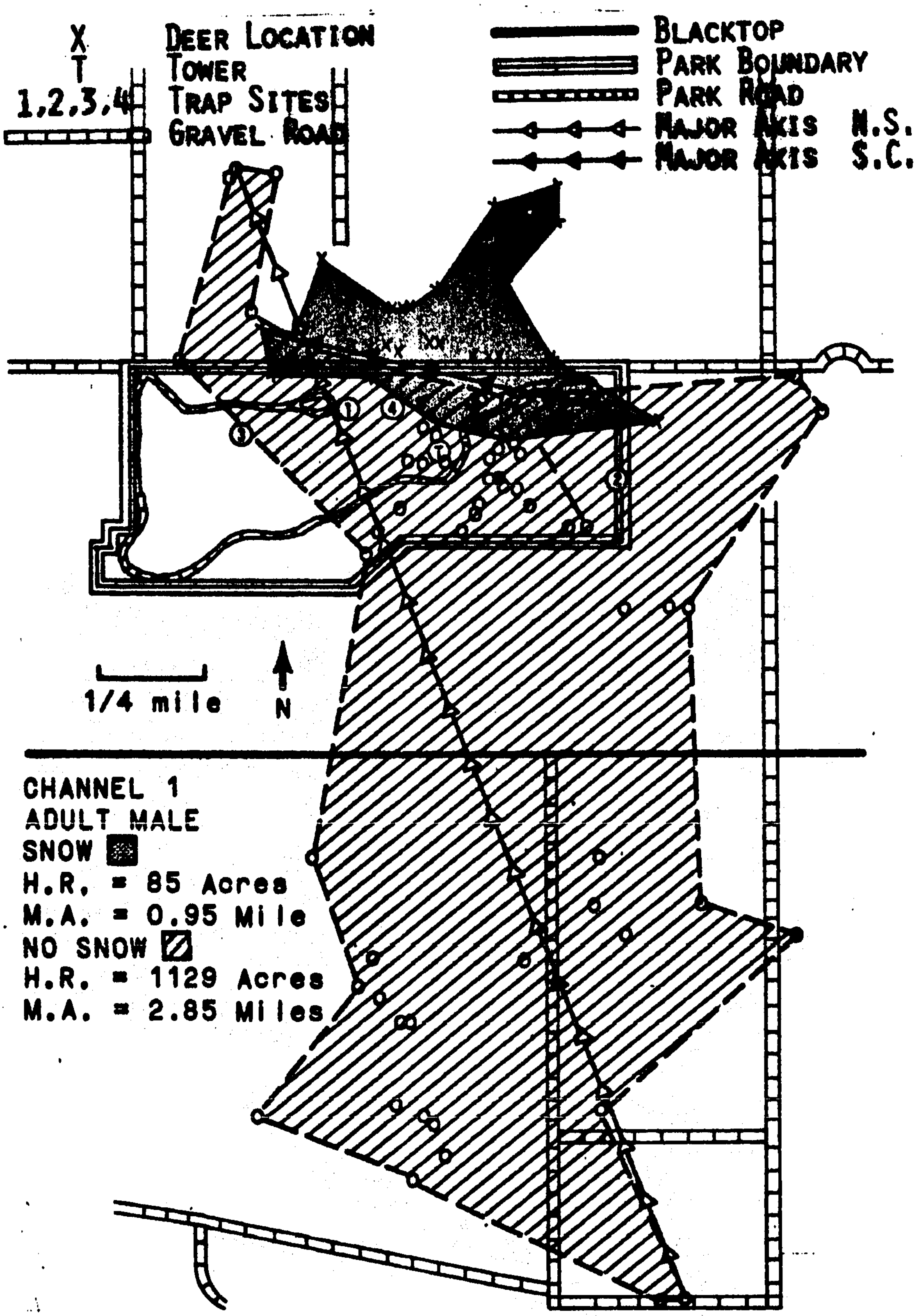
1. Channel 1

Channel 1, a 1-3/4-year old male deer marked February 22, 1972, inhabited a range of 85 acres with a major axis length of 0.95 mile while the ground was snow covered; February 23, 1972-March 19, 1972 (Table 8, Fig. 25). After the snow melted his estimated home range expanded in a southward direction and included 1129 acres of timber, brush and cropland. The major axis during this period was 2.85 miles long.

During the period of snow cover minimum daily movement

Fig. 25. Estimated home range and major axis length for Channel 1, an adult male, for two periods: 1) ground snow covered; 2) ground lacking snow

(Home range = H.R., major axis = M.A.)


X DEER LOCATION
T TOWER
1,2,3,4 TRAP SITES
GRAVEL ROAD
BLACKTOP
PARK BOUNDARY
PARK ROAD
MAJOR AXIS N.S.
MAJOR AXIS S.C.
1/4 mile
N
CHANNEL 1
ADULT MALE
SNOW
H.R. = 85 Acres
M.A. = 0.95 Mile
NO SNOW
H.R. = 1129 Acres
M.A. = 2.85 Miles

(round trip) for Channel 1 was estimated at 0.98 mile. After snow melted it increased to 1.62 miles. During both periods the deer moved between bedding sites in timber to feeding sites in croplands during crepuscular periods. Minimum movement was 0.4 mile and maximum movement was 2.4 miles. For both periods the averages were: home range = 607 acres; major axis = 1.90 miles; and minimum daily movement = 1.30 miles.

In the spring of 1972, Channel 1 left the park for prolonged periods on several occasions (Table 9, Fig. 25). He would bed in the grazed timber 1 mile south of the park and forage in adjacent croplands.

2. <u>Channel 2</u>

Channel 2, a 2.5 year old female, was observed back in the park on December 13, 1971, traveling with three fawns. She was sighted 32 times during winter and early spring and was generally in the company of Channel 5A, a male fawn, although she was also sighted with Channel 11, a male fawn, on two occasions. While the ground was snow covered (winter 1971-72), channel 2 occupied an estimated range of 147 acres with a major axis length of 0.95 mile. When spring, a period of no snow cover, arrived, her range shifted slightly. It consisted of 190 acres with a major axis 1.12 miles in length (Fig. 26). In both winter and spring the range consisted of timber inside and outside the park and cropland outside the

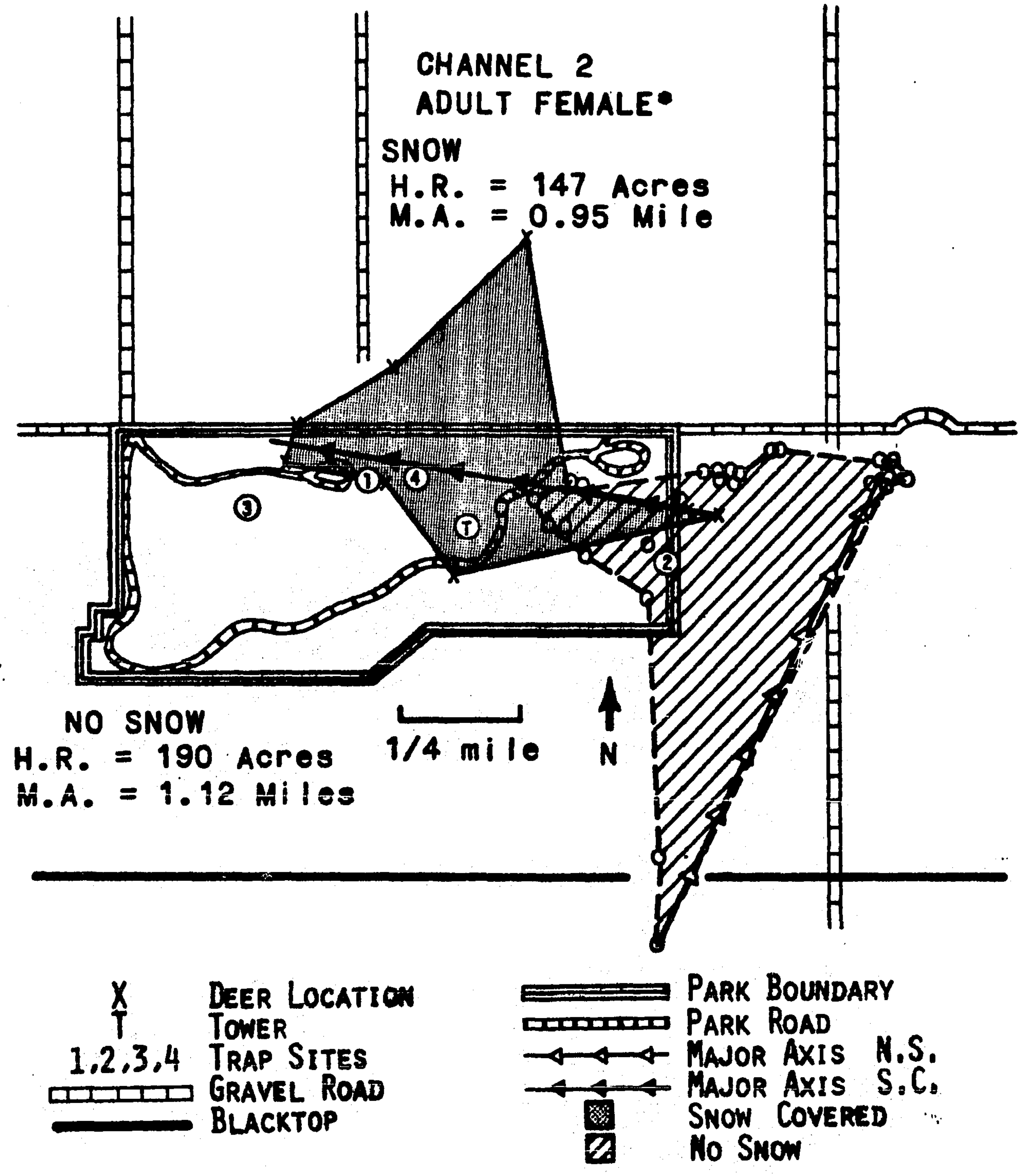


Fig. 26. Estimated home range and major axis length for Channel 2, now an adult female, for two periods: 1) ground snow covered; 2) ground lacking snow (home range = H.R., major axis = M.A.)

park. In winter, her minimum daily movement to and from feeding was estimated at 0.90 mile and in spring at 0.91 mile. Therefore, in each of the three observation periods she moved approximately 0.45 mile to and from feeding. Age and snow condition did not affect the distance moved.

3. Channel 5

Channel 5, a 2.5-year old male immobilized January 18, 1972, occupied a range of 456 acres with a major axis length of 1.60 miles (Table 8, Fig. 27). No estimate of minimum daily movement was obtained for Channel 5 because he was killed by an automobile one-half mile south of the park two weeks after his capture.

4. Channel 5A

Channel 5A, a male fawn trapped February 13, 1972, inhabited a winter range of 253 acres with a major axis 1.62 miles long (Table 8, Fig. 28). Minimum daily movement during the period of snow cover was estimated at 0.97 mile. Cropland north and east of the park and timber inside and outside the park were included in the range.

In spring Channel 5A's home range shifted slightly to the east (Fig. 28). It consisted of 176 acres including cropland east and south of the park and timber within the park. Its major axis was 1.22 miles in length. Minimum daily movement was estimated at 0.84 mile, a slight decrease from the period of snow cover. When averaged over both

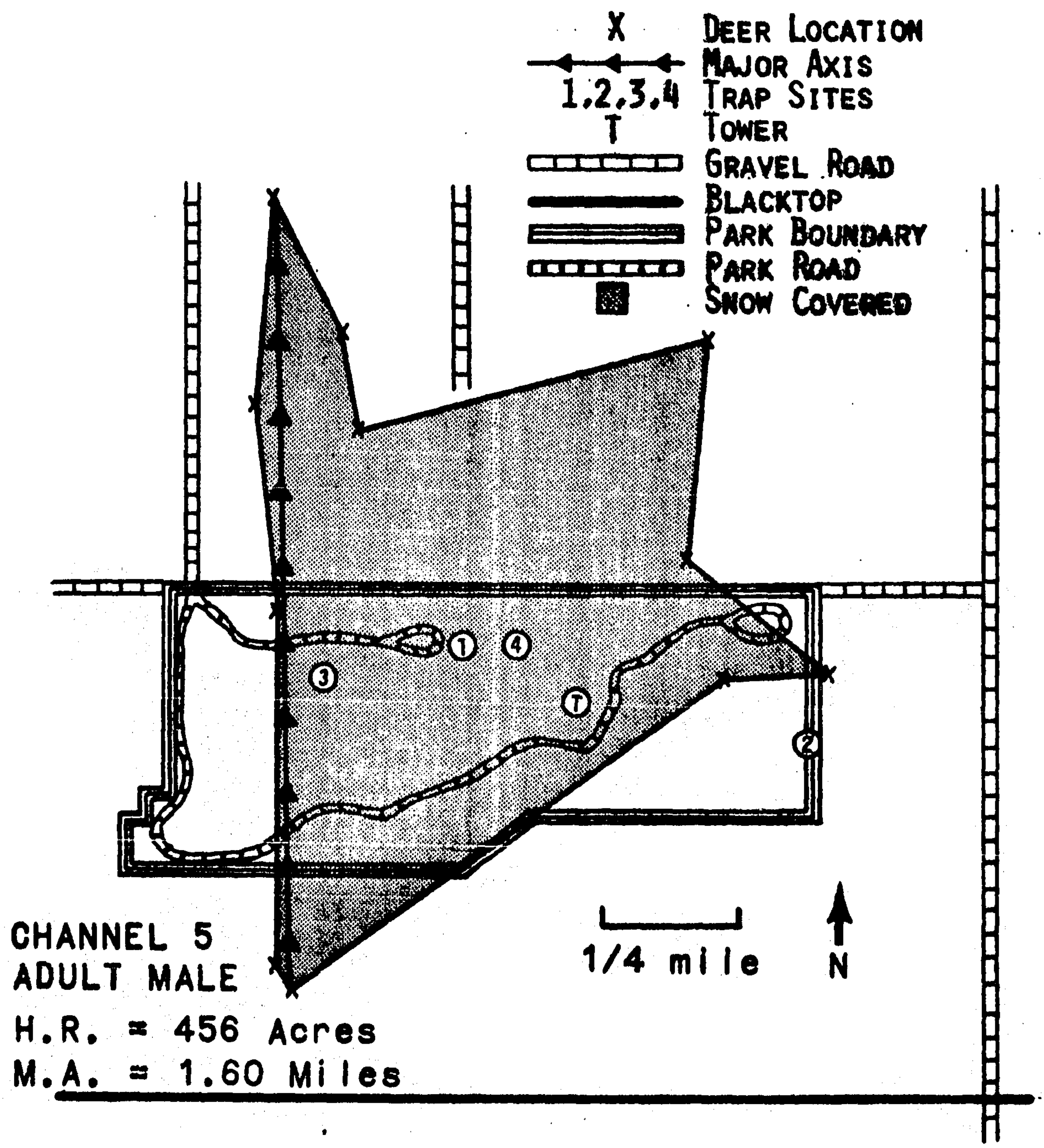


Fig. 27. Estimated seasonal home range (H.R.) and major axis length (M.A.) for Channel 5, a 2.5-year old male, from January 18-31, 1972

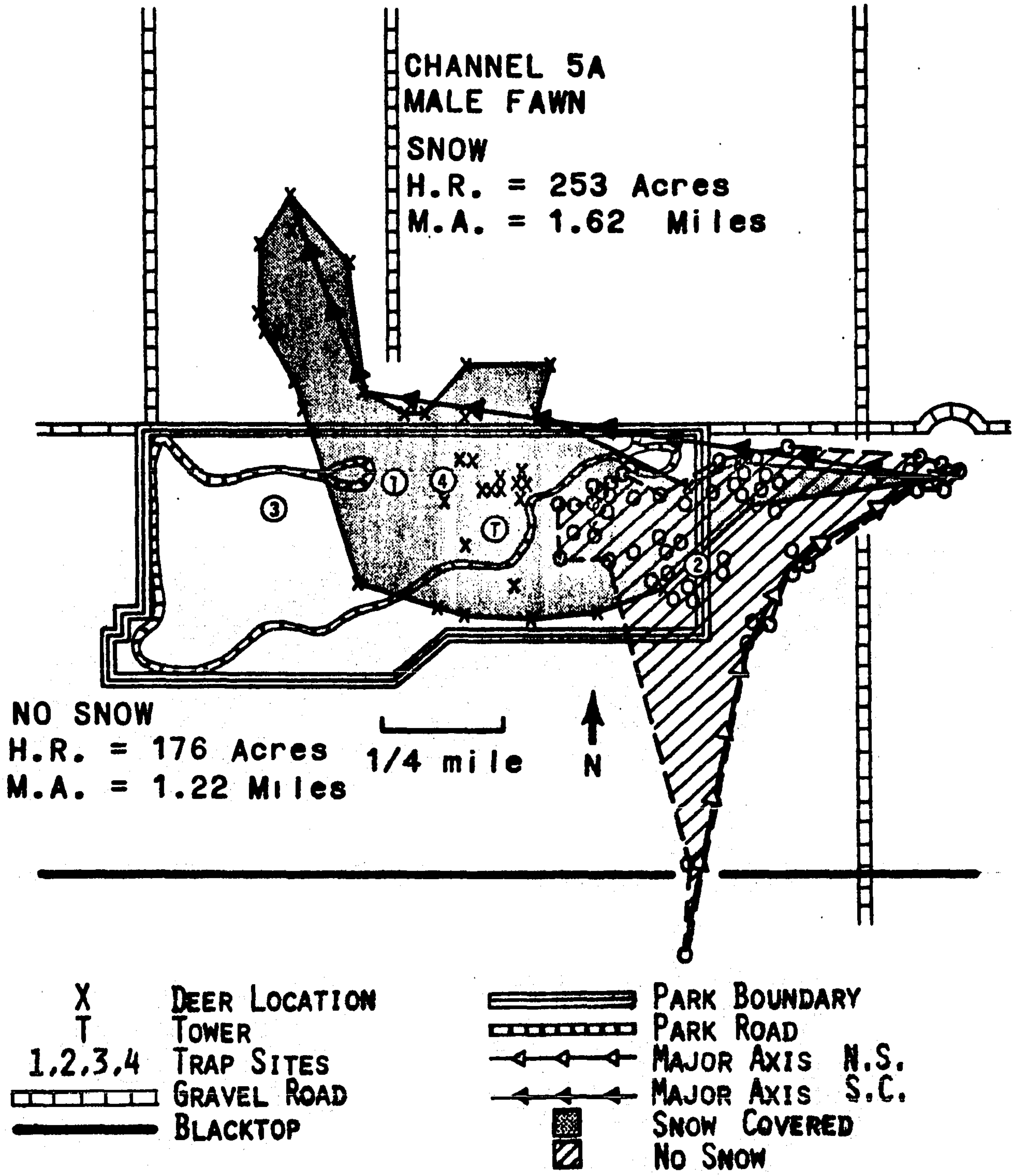


Fig. 28. Estimated home range and major axis length for Channel 5A, a male fawn, for two periods: 1) ground snow covered; 2) ground lacking snow (home range = H.R., major axis = M.A.)

periods, movement data were: home range = 215 acres; major axis = 1.42 miles; and minimum daily movement = 0.85 miles.

5. Channel 6

Channel 6, a female fawn immobilized February 16, 1972, occupied a winter range of 210 acres with a major axis length of 1.22 miles (Table 8, Fig. 29). This range included timber and cropland outside the park and timber inside. Estimated minimum daily movement (round trip) was 1.03 miles. A one-way trip between feeding and bedding areas was approximately 0.52 mile.

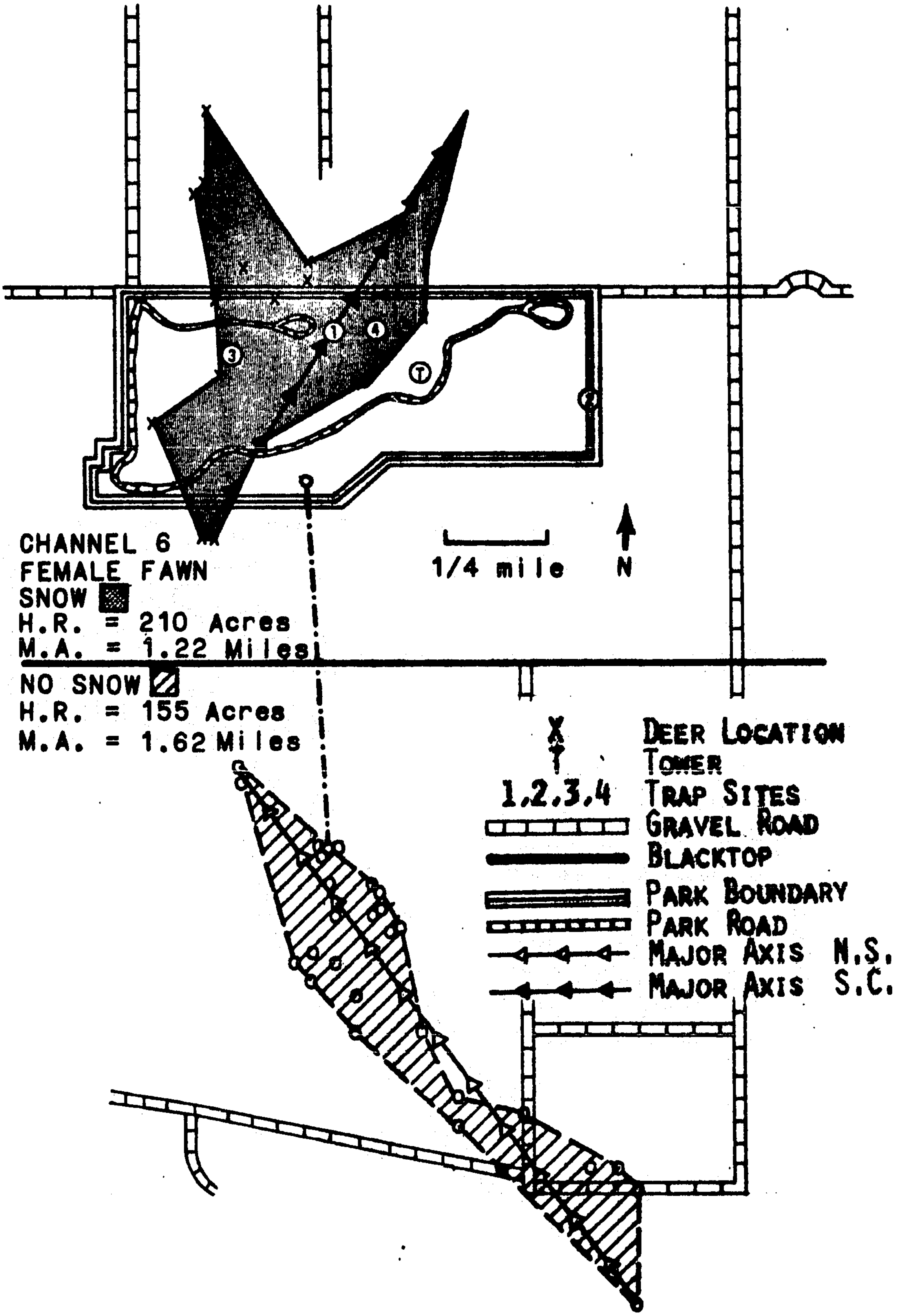
After the winter cutoff date of March 19, 1972, Channel 6 was located in the park only once. After March 20, 1972, all telemetric and visual contacts were outside the park. Channel 6 shifted her range to Hanson's Woods about 1 mile south of the park. Her spring range consisted of 155 acres including brush, grazed timber and cropland. No minimum daily movement was determined for Channel 6 after the range shift.

Average home range for the two periods was 183 acres and average major axis length was 1.42 miles

6. Channel 11

Channel 11, a male fawn trapped December 12, 1971, inhabited a range of 504 acres with a major axis 1.87 miles long while the ground was snow covered (Table 8, Fig. 30). The range included cropland and timber north and west of the park and timber within the park. Minimum daily movement

Fig. 29. Estimated home range and major axis length for Channel 6, a female fawn, for two periods: 1) ground snow covered; 2) ground lacking snow (home range = H.R., major axis = M.A.)


CHANNEL 6
FEMALE FAWN
SNOW
H.R. = 210 Acres
M.A. = 1.22 Miles
NO SNOW
H.R. = 155 Acres
M.A. = 1.62 Miles
1/4 mile
N
DEER LOCATION
TOWER
1,2,3,4 TRAP SITES
GRAVEL ROAD
BLACKTOP
PARK BOUNDARY
PARK ROAD
MAJOR AXIS N.S.
MAJOR AXIS S.C.

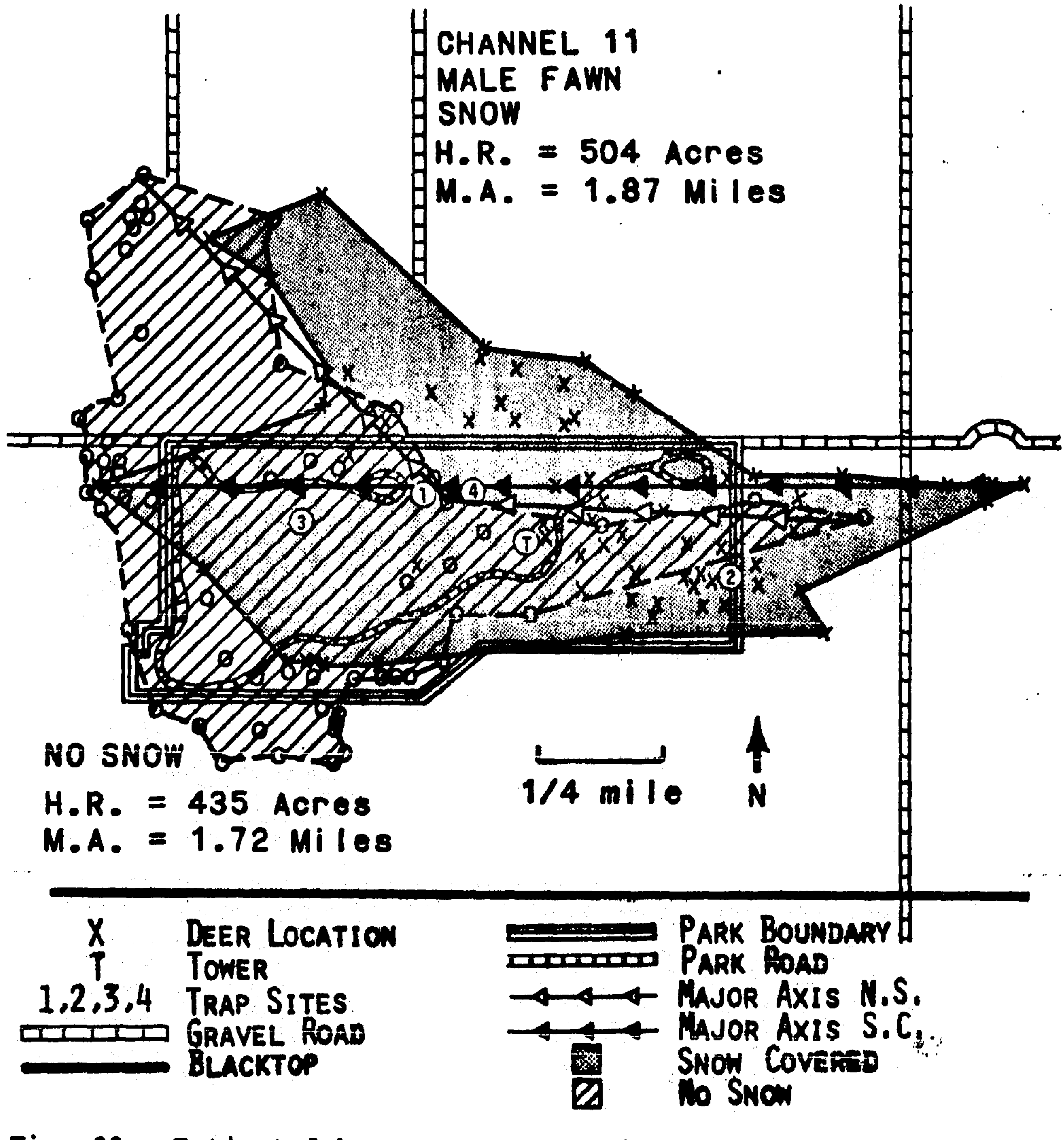


Fig. 30. Estimated home range and major axis length for Channel 11, a male fawn, for two periods: 1) ground snow covered, 2) ground lacking snow (home range = H.R., major axis = M.A.)

during the period of snow cover was estimated at 1.22 miles. Minimum daily movement increased from 1.22 miles to 1.76 miles during the period of no snow.

Average range for the two periods was 470 acres with the average major axis length being 1.80 miles. The average over both periods for minimum daily movement was 1.49 miles.

G. Movement Data for All Deer Located During Winter 1971-72 and Spring 1972

Six marked deer occupied a total winter range of 562 acres during the winter of 1971-72 (Fig. 31). The major axis of that range was 1.87 miles long. In spring this range expanded greatly as one deer alone occupied a range of 1129 acres.

During the period of snow the average range size for 6 deer was 276 acres with a major axis length of 1.37 miles. The estimated minimum daily movement for five deer during that period was 1.02 miles.

Later, after the snow melted, the average range size for the six deer was 348 acres with a major axis length of 1.71 miles. Minimum daily movement for the four deer was 1.28 miles. There was a slight increase in each movement descriptor after the snow had melted. Deer expanded their range into grazed timber and brush where they were absent during the severe winter months.

Two of 6 marked deer known to utilize the park during the winter of 1971-72 left the park in the spring of 1972.

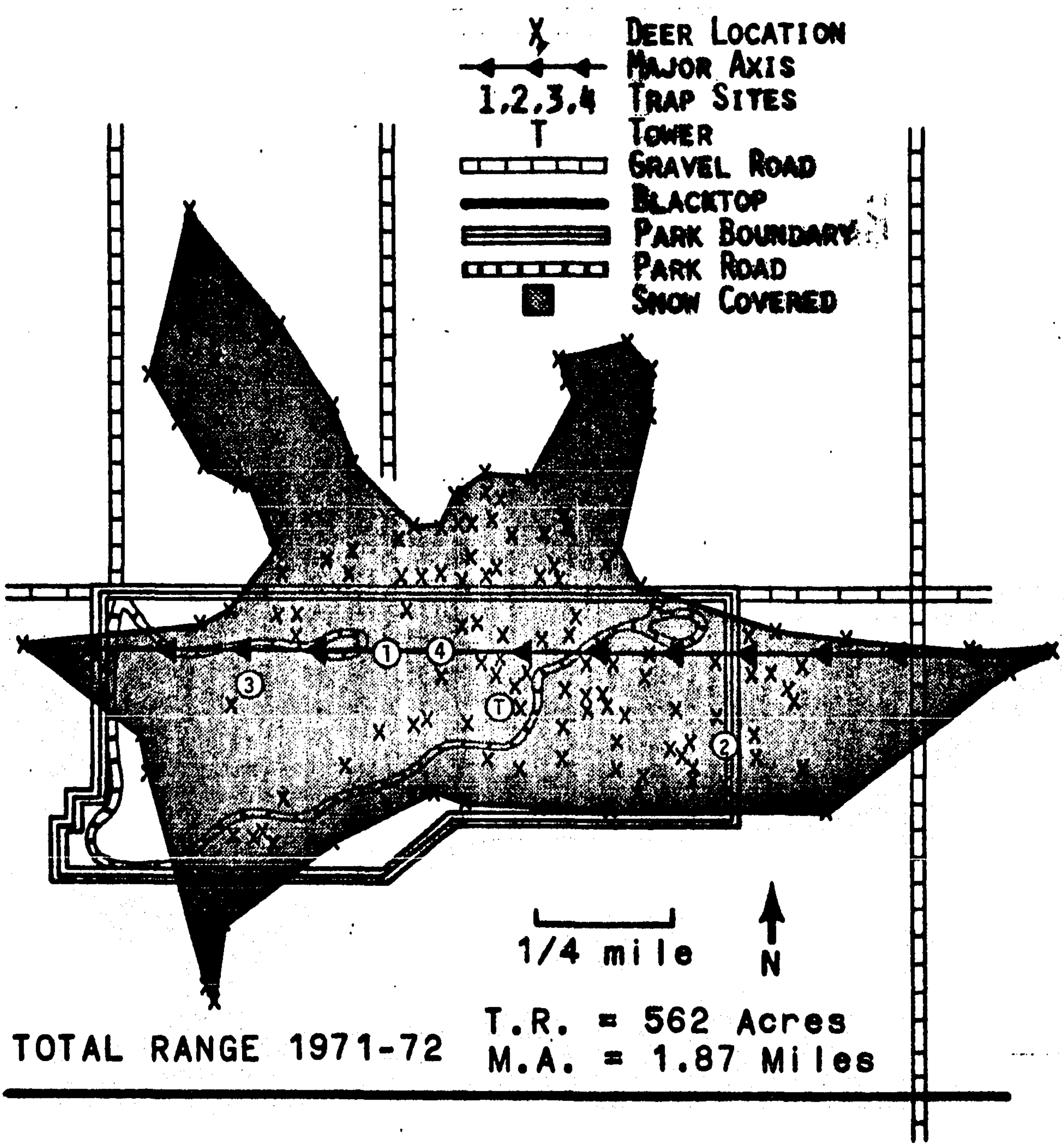


Fig. 31. Estimated total range (T.R.) and major axis length (M.A.) of 6 deer inhabiting Pilot Knob State Park during the winter of 1971-72

H. Movement Data for All Marked Deer, 1969-72

The average home range for all periods for all marked deer was 283 acres. When taken for all deer over all periods, the major axis length was 1.33 miles. Minimum daily movement averaged for all deer over the four periods was 1.20 miles (round trip).

The total winter home range for the 12 marked deer from 1969-72 was 684 acres with a major axis 1.87 miles long (Fig. 32).

I. Statistical Analysis of Movement Data

Three aspects of deer movement were estimated; home range size, major axis length, and minimum daily movement (round trip). Each of the dependent variables were compared with the means of independent variables including period, age and sex to determine if they affected the dependent variables. An analysis of variance was performed using the models:

HR = P A P x A S P x S A x S P x A x S

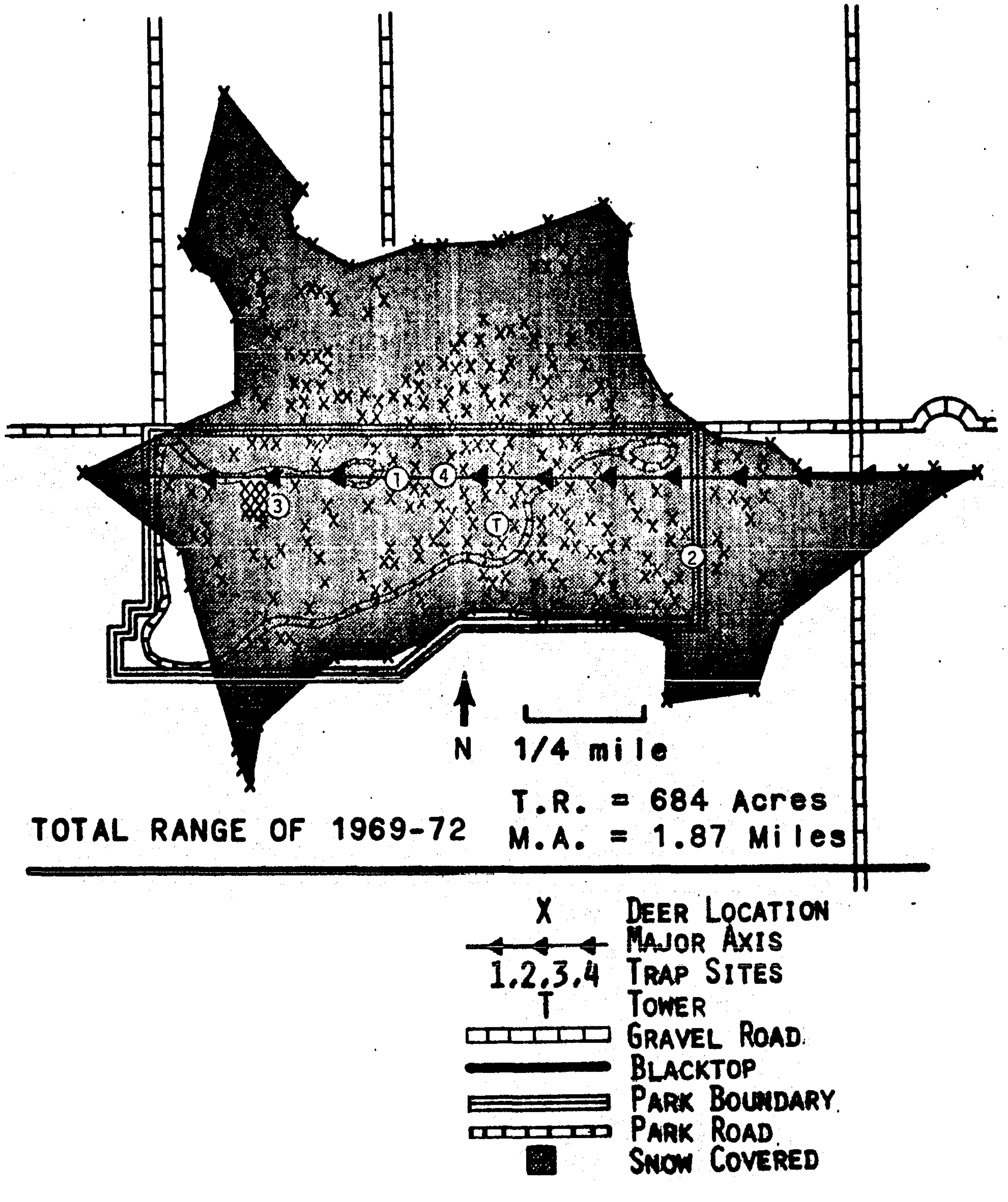
MA = P A P x A S P x S A x S P x A x S

MDM = P A P x S S P x S A x S P x A x S

HR = home range, MA = major axis, MDM = minimum daily movement, P = period, A = age, and S = sex.

Because there were too few degrees of freedom and no means for some classifications, the above model could not be used. For example, no males were captured during the 1969-70

Fig. 32. Total estimated winter range (T.R.) and major axis length (M.A.) for 12 deer marked between 1969-72 at the Pilot Knob study area


N
1/4 mile
TOTAL RANGE OF 1969-72
T.R. = 684 Acres
M.A. = 1.87 Miles
X DEER LOCATION
MAJOR AXIS
1,2,3,4 TRAP SITES
T TOWER
GRAVEL ROAD
BLACKTOP
PARK BOUNDARY
PARK ROAD
SNOW COVERED

winter period.

To obtain a more valid estimate of the effects of the independent variables and their interactions as regression analysis was performed using these models:

HR = P A P x A S A x S

MA = P A P x A S A x S

MDM = P A P x A S A x S

Hr = home range, MA = major axis, MDM = minimum daily movement, P = period, A = age, and S = sex.

The model was designed to have fewer cells lacking a mean and had more degrees of freedom than the larger model used in the analysis of variance. Because the data were not balanced it was felt that the adjusted means used in the regression procedure would yield more valid results. Sample size and distribution was a definite problem and only a low percentage of the variation in parameters measured was explained by the model. Means for all categories and interactions are given in Table 10 for all periods and Table 11 for periods three and four. Raw data, from which means were derived are given in Appendix IX.

A high correlation coefficient (0.92) existed between home range size and major axis length when taken over all four periods or for periods three and four only, the correlation coefficient was 0.94. The major axis is, of course, one component of range size. Correlations with other variables will most likely be similar for both home range size and major

Table 10. Means for home range size, major axis length, and minimum daily movement of marked deer for four periods: winter 1969-70, winter 1970-71, winter 1971-72, and spring 1971-72

	1969-70 Snow		1970-71 Snow		1971-72 Snow		1971-72 No snow		All periods mean by sex	All periods mean by age and sex	
	Fawn	Adult	Fawn	Adult	Fawn	Adult	Fawn	Adult		Fawn	Adult
Male											
HR[a]			49		379	271	306	1129	386	283	557
MA[a]			0.62		1.75	1.28	1.47	2.85	1.56	1.41	1.80
MDM[a]			0.60		1.14	0.98	1.30	1.62	1.23	1.17	1.43
N[a]			1		2	2	2	1	8	5	3
Female											
HR	243	208	226	198	210	147	155	190	201	212	190
MA	1.06	1.12	1.10	1.00	1.22	0.95	1.62	1.12	1.14	1.22	1.06
MDM	0.90	1.28	1.35	1.38	1.03			0.91	1.15	1.10	1.23
N	1	2	2	1	1	1	1	1	10	5	5

	Mean by period				Total mean	Mean by age	
HR	219	175	276	417	283	248	328
MA	1.10	0.95	1.37	1.71	1.33	1.31	1.34
MDM	1.11	1.19	1.11	1.35	1.20	1.15	1.31
N	3	4	6	5	18	10	8

[a] HR = home range (acres); MA = major axis length (miles); MDM = minimum daily movement (miles); N = number of deer included in the mean.

axis length.

1. Home range size

Home range size was estimated for 12 different deer. The mean range for all deer taken over the four periods was 283 acres; standard deviation 244 acres. Range size varied from 49 to 1129 acres (Table 10).

During winter 1971-72 and spring 1972 home range was estimated for five deer. The overall mean for the two periods was 328 acres with a standard deviation of 310 acres. Range size varied from 85 to 1129 acres (Table 11).

Unique effects of each variable on home range size were determined and F-tests made to determine if the independent variable effects and interaction were significant at the 0.05 level (Table 12). Sixty-seven per cent of the variation in home range size was accounted for by the complete model for all periods and 64 per cent over periods 3 and 4. The regression for range size using the complete model was not significant ($F = 1.43$, Prob. $F > 0.05$).

a. Period effect Mean range sizes for the four periods were 219, 175, 276, and 417 acres respectively. No significant difference was found when all periods were considered ($F = 0.91$, Prob. $F > 0.05$).

Means for range size of five deer measured in both periods 3 and 4 were 240 and 417 acres respectively. Ranges varied widely and large residuals resulted when predicted values were

Table 11. Means for home range size, major axis length and minimum daily movement of marked deer measured during two periods: winter (snow) 1971-72, and spring (no snow) 1971-72

	1971-72 Snow		1971-72 No snow		All periods mean by sex	All periods mean by age and sex	
	Fawn	Adult	Fawn	Adult		Fawn	Adult
Male							
HR[a]	379	85	306	1129	430	342	607
MA[a]	1.75	0.95	1.47	2.85	1.71	1.61	1.90
MDM[a]	1.14	0.98	1.30	1.62	1.26	1.22	1.43
N[a]	2	1	2	1	6	4	2
Female							
HR	210	147	155	190	176	183	169
MA	1.22	0.95	1.62	1.12	1.23	1.42	1.04
MDM	1.03			0.91	0.98	1.03	0.91
N	1	1	1	1	4	2	2
	Mean by period				Total mean	Mean by age	
HR	240		417		328	289	388
MA	1.32		1.71		1.51	1.55	1.47
MDM	1.11		1.35		1.23	1.20	1.33
N	5		5		10	6	4

[a]HR = home range (acres); MA = Major axis length (miles); MDM = minimum daily movement (miles); N = number of deer in the mean.

Table 12. Effect of independent variables period, age, sex and their interactions on the dependent variables home range size, major axis length and minimum daily movement as determined by regression analysis using the model: range size, major axis length, minimum daily movement = period, age, period x age, sex, age x sex.

	Complete model F	Period F	Age F	Period x age F	Sex F	Age x sex F	% total variation explained by the model
All periods							
HR[a]	1.43	0.91	1.94	1.56	4.12	2.76	67
MA[a]	2.03	1.61	1.16	1.89	3.63	4.19	70
MDM	2.25*	3.09*	2.34	3.69*	1.80	8.05*	12
df[a]	9	3	1	3	1	1	
Periods 3 and 4							
HR	1.40	1.73	0.46	2.83	2.59	0.56	64
MA	1.43	2.20	0.02	2.67	2.40	0.99	64
MDM	2.47*	7.20*	1.16	2.60	4.77*	2.61	12
df	5	1	1	1	1	1	

[a]HR = home range (acres); MA = major axis length (miles); MDM = minimum daily movement (miles); df = degrees of freedom.

*Probability F < 0.05.

subtracted from observed values. No significant difference was found between range sizes over the two periods (F = 1.73, Prob. F > 0.05).

b. Age effect Mean range size for fawns was 248 acres and 328 acres for adults when calculated over the four periods. Range size for 7 fawns varied from 49 to 504 acres and from 85 to 1129 acres for 6 adults. The wide range again resulted in large residuals. No significant difference of range size by age was found when the 4 periods were taken collectively (F = 1.94, Prob. F > 0.05).

For periods three and four, the mean range sizes were 289 acres for fawns and 388 acres for adults. Range sizes varied from 155 to 435 acres for fawns and from 85 to 1129 acres for adults. No significant difference in range size due to age was found (F = 0.46, Prob. F > 0.05).

c. Period by age interaction Means for 7 fawns were 243, 167, 322, and 255 acres and 208, 198, 229 and 660 acres respectively for 6 adults when calculated over the four periods. Range size varied from 155 to 504 acres for fawns and from 205 to 1127 acres for adults. When the relationship of the interaction of period times age was measured over the four periods, no significant difference was found (F = 1.56, Prob. F > 0.05).

For periods three and four only, the combined means for three fawns were 322 and 255 acres and 229 and 660 acres respectively for two adults. During the two periods, range size ranged from 155 to 504 acres for fawns and 85 to 1129 acres for adults. Large residuals resulting from the wide variation in the data made it difficult to determine if a significant relationship existed between range size and the interaction of period times age ($F = 2.83$, Prob. $F > 0.05$).

d. Sex effect The overall mean home range size for males was 386 acres and, for females, it was 201 acres. No significant difference in home range size due to sex was found when measured over the four periods ($F = 4.12$, Prob. $F > 0.05$).

For periods three and four, mean range size was 430 acres for males and 176 acres for females. This would appear to indicate a trend toward larger range sizes for males, but again the variability of the data and the same sample size resulted in an insignificant F value ($F = 2.59$, Prob. $F > 0.05$).

e. Effect of age by sex interaction Fawn means for range size were 283 acres for males and 212 acres for females. Range means of adults were 557 acres for males and 190 acres for females. Male fawns had larger ranges than female fawns and adult males had larger ranges than adult females but this relationship was not significant when tested ($F = 2.76$, Prob. $F > 0.05$). A larger sample size might bear out some of the trends indicated in this study.

Range sizes appeared to differ significantly by age and sex for periods three and four. Fawn means were 342 acres for males and 183 acres for females. Adult range means were 607 acres for males and 169 acres for females. When tested, however, no significant difference was found ($F = 0.56$, Prob. $F > 0.05$).

2. Major axis length

Major axis length was estimated for 12 different deer. The mean range for all deer taken over the four periods was 1.33 miles; standard deviation 0.50 mile. Major axis length varied from 0.62 to 2.85 miles (Table 10).

During winter 1971-72 and spring 1972 major axis length was estimated for five deer. The overall mean for the two periods was 1.51 miles with a standard deviation of 0.57 mile. Axis length during the two periods ranged from 0.95 to 2.85 miles (Table 11).

Unique effects of each variable and their interactions on major axis length were determined and F-tests made to determine if the effects were significant at the 0.05 level (Table 12). The regression analysis for axis length using all the variables and interactions indicated no significant effects ($F = 2.03$, Prob. $F > 0.05$) for all periods and no significant relationship for periods three and four ($F =$

1.43, Prob F > 0.05). Seventy per cent of the variation in length was explained by the model when used for all periods and 64 per cent was accounted for during periods three and four.

a. Period effect Mean major axis lengths for the four periods were 1.10, 0.95, 1.37, and 1.71 miles respectively. Axis lengths varied widely and large residuals resulted when predicted values were subtracted from observed values. No significant difference in axis length due to period effect was found (F = 1.61, Prob F > 0.05).

Means for major axis lengths of five deer measured in periods three and four were 1.32 and 1.71 acres respectively. When the period effect was tested, no significant effect was found (F = 2.20, Prob F > 0.05).

b. Age effect Mean axis length for fawns was 1.31 miles for fawns and 1.34 miles for adults when computed over the four periods. Major axis length for 7 fawns varied from 0.62 to 1.87 miles and from 0.95 to 2.85 miles for 6 adults. The wide variation in axis lengths resulted in large residuals. No significant difference in range size by age was found when the four periods were taken collectively (F = 1.16, Prob. F > 0.05).

For periods three and four, the mean axes lengths were 1.55 miles for fawns and 1.47 miles for adults. Major axis lengths varied from 1.22 to 1.75 miles for fawns and from

0.95 to 2.85 miles for adults. Results of the F-test indicated no significant difference in range size due to age (F = 0.02, Prob. F > 0.05).

c. Period by age interaction Means of fawns, taken by period, were 1.06, 0.94, 1.57, and 1.52 miles and 1.12, 1.00, 1.17, and 1.99 miles respectively for adults. Major axis lengths were determined for all marked deer in all periods. They varied widely as did home range sizes. Major axis lengths were determined for all marked deer in all periods. They varied widely as did home range sizes. This was to be expected as major axis length and home range size were strongly correlated (C = 0.92). When the effect of the interaction of period times age on major axis length was measured, no significant relationship was found (F = 1.89, Prob. F > 0.05).

For periods three and four only, the combined means for fawns were 1.57 and 1.52 miles and 0.95 and 1.99 miles respectively for two adults. During the two periods major axes length varied from 1.22 to 1.87 miles for fawns and from 0.95 to 2.85 miles for adults. No significant relationship of the effect of period times age interaction was found over the two periods (F = 2.67, Prob. F > 0.05).

d. Sex effect The mean major axis length for all males over the four periods was 1.56 miles and for females, 1.14 miles. From visual inspection it appeared that a significant difference in axis length due to sex existed. However, small sample size and a wide variability in axis lengths again proved limiting. No significant difference in axis length due to sex was found (F = 3.63, Prob. F > 0.05).

For periods three and four, mean major axis length was 1.71 miles for males and 1.23 miles for females. These data also indicates a longer axis length for males but, when tested, no significant difference was found (F = 2.40 Prob. F > 0.50).

e. <u>Effect of age by sex interaction</u> Fawn means for axis length were 1.41 miles for males and 1.22 miles for females. For adults the axis length means were 1.80 miles for males and 1.06 miles for females. Over the four periods, male fawns averaged longer axes than female fawns and adult males averaged considerably longer axes than female adults. This relationship was not significant when tested (F = 4.19 Prob. F > 0.05). However, it was significant at the 0.10 level of significance.

Major axis lengths also appeared to differ significantly by age and sex during periods three (snow cover) and four (no snow cover). Fawn means were 1.61 miles for males and 1.42 miles for females. Adult means for axis length were 1.90 and 1.04 miles respectively. When tested, however, no significant difference in major axis length due to the age times sex interaction effect was found (F = 0.99, Prob. F > 0.05).

3. Minimum daily movement

Minimum daily movement (round trip) was estimated for 12 different deer. The mean minimum daily movement for all deer taken over the four periods was 1.20 miles; standard deviation 0.57 mile. Minimum daily movement varied from 0.60 to 1.76 miles (Appendix IX).

During winter 1971-72 and spring 1972 minimum daily movement was estimated for five deer. The overall mean for the two periods was 1.23 miles, standard deviation 0.57 mile. Minimum daily movement during the two periods ranged from 0.84 to 1.76 miles (Appendix IX).

The same model was used in a regression analysis to determine the overall effect, the unique effect of each variable and the interaction effect on minimum daily movement. The regression analysis results for the overall effect indicated a significant effect on movement by the variables and their interactions (F = 2.25, Prob. F < 0.05). A significant relationship was also found when the analysis was made for periods three and four only (F = 2.47, Prob. F < 0.05).

Caution in interpretation of the results was in order however. Only 12 per cent of the variation in movement was explained by the model for all periods and for periods three and four only.

a. Period effect   Mean minimum daily movement for the four periods were 1.11, 1.19, 1.11 and 1.35 miles respectively. Movement distances varied widely and large residuals resulted when predicted values were subtracted from observed values. A significant difference in daily minimum distance moved due to period effect was found ($F = 3.09$, Prob. $F < 0.05$).

Means for movement distances of five deer measured in periods three and four were 1.11 and 1.35 miles respectively. When the effect of period on distance moved was tested, a significant relationship was found ($F = 7.20$, Prob. $F < 0.05$). This indicated that deer move further between bedding and feeding sites with no snow cover than they do with snow cover.

b. Age effect   Mean minimum daily movement for fawns was 1.15 miles and 1.31 miles for adults when calculated over the four periods (Table 10). Movement distance for 7 fawns ranged from 0.60 to 1.76 miles and from 0.90 to 1.62 miles for adults (Appendix IX). No significant difference in daily distance moved due to age was found ($F = 2.34$, Prob. $F > 0.05$).

For periods three and four, the mean movement distances were 1.20 miles for fawns and 1.33 miles for adults. Minimum daily movement varied from 0.84 to 1.76 miles for fawns and 0.90 to 1.62 miles for adults. Results of the F-test indicated no significant difference in distance moved due to age ($F = 1.16$, Prob. $F > 0.05$).

c. Period by age interaction   Mean distances moved by fawns taken by period were 0.90, 1.16, 1.13, and 1.30 miles and 1.28, 1.38, 0.98, and 1.44 miles respectively for adults. When the effect of the period times age interaction on minimum daily movement was tested, a significant relationship was shown ($F = 3.69$, Prob. $F < 0.05$). This was indicated by visual observation as adults moved further, on the average, than fawns in all but the winter of 1971-72 (Period 3).

For periods three and four only, the means for three fawns were 1.12 and 1.30 miles and 0.98 and 1.44 miles for adults. During the two periods, distance moved varied from 0.84 to 1.76 miles for fawns and from 0.90 to 1.62 miles for adults. No significant relationship was found on the effect of period times age interaction on distance moved over the two periods ($F = 2.60$, Prob. $F > 0.50$) (Table 12).

d. Sex effect   The mean minimum distance moved for all males over the four periods was 1.23 miles for males and 1.15 miles for females. No significant difference in daily distance moved due to sex was found ($F = 1.80$, Prob. $F > 0.05$).

For periods three and four mean major axis length was 1.26 miles for males and 0.98 miles for females. When tested, a significant relationship between sex and the daily distance moved during the periods of snow and no snow was found ($F = 4.77$, Prob. $F < 0.05$). From these data it may be stated that on a distance moved per day basis, males move farther than females.

e. Effect of age by sex interaction Fawn means for minimum daily movement moved were 1.17 miles for males and 1.10 miles for females. For adults the movement means were 1.43 miles for males and 1.23 miles for females. Over the four periods, male fawns averaged slightly greater daily movement distances than female fawns and adult males averaged 0.2 mile more per day than females. This relationship was significant at the 0.05 level ($F = 8.05$).

Minimum daily movements also appeared to differ significantly by age and sex during periods three and four. Fawn means were 1.22 miles for males and 1.03 miles for females. Adult means were 1.43 miles for males and 0.91 miles for females. When tested, a significant difference in minimum daily movement due to the age times sex interaction was not found ($F = 2.61$, Prob. $F > 0.05$).

J. Deer Located by Telemetry or Visual Sighting

During the period from December 1969 through April 1972 there were 4262 deer sighted or located by telemetry in 1552 observations for an average of 2.7 deer per sighting (standard deviation = 4.2). A breakdown of the numbers seen per period was given in Table 13. Of all the deer sighted, 1899 were adults and 2336 were fawns. Eight-hundred fifty-seven sightings were made of antlered deer and 3376 sightings were recorded for antlerless deer. Activity for sighted deer consisted of 1478 sightings of bedded deer and 2783 sightings of active deer.

A total of 851 locations of sightings were recorded for marked deer. The number varied by period in proportion to the number of deer marked and the age and sex of marked deer (Table 13).

1. Location with respect to the park

Of the 4262 deer located during the 3-year period, 2710 were outside the park and 1552 were inside its boundaries. The investigator spent approximately two-thirds of the field time inside and one-third outside the park. However the time outside was spent during prime time for observation as deer were moving and were more exposed. Because of the variables involved it was not realistic to say that deer occurred more often outside than inside the park even though the figures for total locations indicate this.

Table 13. Number of sightings of deer at the Pilot Knob study area by period, age, sex and activity

	Period	No. of deer	All deer	Adults	Fawns	Antlered	Antlerless	Bedded	Active
All deer	1		774	390	381	94	679	275	498
	2		1127	510	614	164	958	321	805
	3		2361	999	1341	599	1739	882	1480
	Total		4262	1899	2336	857	3376	1478	2783
Marked deer	1	3	139	85	53	0	138	58	81
	2	4	163	36	125	21	142	42	119
	3	6	549	154	372	312	213	217	332
	Total		851	275	550	333	493	317	532

During the 1969-70 period, 773 deer were located. Of those, 251 were outside the park. These included 19 locations for three marked deer and 232 for unmarked deer (Table 14). The 552 deer locations inside the park consisted of 120 for marked and 402 for unmarked.

For the 1970-71 winter period, 1129 deer were located. Of the total locations, 756 were outside and 373 inside the park. Marked deer were located 99 times inside and 64 times outside the park. Unmarked deer were located 274 times inside and 692 times outside the park's borders.

The total number of deer locations for the winter of 1971-72 exceeded that for any other period. Of the 2360 deer located, 1703 were outside and 657 were within the park. More locations of marked and unmarked were made outside the park than inside it.

In 1969, 120 locations of marked deer were within the park and 19 were outside its borders. During the winter of 1970-71, 99 locations were within and 64 were outside the park. However, in 1971-72, only 204 locations were within the park and 345 were outside its boundary. This same trend was true of unmarked deer. Locations inside the park exceeded those outside the park in 1969 by 170. In 1971-72, locations outside the park exceeded those within the park by 905. Deer were sighted more often outside than inside the park in 1971-72. A variable which was not constant throughout

Table 14. Location of marked and unmarked deer with respect to Pilot Knob State Park by three periods: 1969-70, 1970-71, 1971-72

	Deer located inside park						
	Marked			Unmarked			
Period	No. deer	Mean	S.D.	No. deer	Mean	S.D.	Total deer inside
1969-70	120	1.36	1.4	402	2.74	4.4	522
1970-71	99	1.14	0.5	274	2.58	3.9	373
1971-72	204	1.37	1.7	453	4.31	7.7	657
Totals	423			1129			1552

	Deer located outside park							
	Marked			Unmarked				
Period	No. deer	Mean	S.D.	No. deer	Mean	S.D.	Total deer inside	Total deer
1969-70	19	1.27	0.8	232	2.76	3.5	251	773
1970-71	64	1.83	2.3	692	3.16	4.6	756	1129
1971-72	345	1.77	2.4	1358	3.97	4.9	1703	2360
Totals	428			2282			2710	4262

the study and may have been a factor in this phenomena was the increased usage of the park by snowmobilers and free ranging dogs.

Deer were sighted more frequently in grids closer to the park and were sighted more often north of the park than south of it (Appendix X). The number of grids where deer were sighted increased during each subsequent winter: 1969-70 - 61 grids used; 1970-71 - 85 grids used; and 1971-72 - 133 grids used. The increase between 1969-70 and 1970-71 was difficult to explain. The population sizes during both years were about the same (45 deer) and both winters appeared similar (Table 15).

Two explanations are possible for the large increase in grid usage during the winter of 1971-72. They are an increase in population from 45 to 70 deer and a milder winter (Table 15). It was interesting to note that both the population size and the number of grids used increased by a factor of 1.6 times.

Table 15. Total snowfall, number of days with one or more inches of snow on the ground and mean temperature for winters of 1969-72 (winter months include December, January, February and March)

Winter	Total snowfall (inches)	Number of days with 1 or more inches of snow on the ground	Mean temperature for 4-month period (°F)
1969-70	44	107	17
1970-71	69	117	16
1971-72	25	98	18

K. Deer Sighted During Crepuscular Periods

A total of 1197 deer were sighted in 444 observations made during crepuscular periods; 588 adults and 610 juveniles. There were 165 antlered, 922 antlerless deer and 96 unknown deer sighted.

A regression analysis was performed to determine the combined and unique effects of light intensity, weather, and time variables on the number of deer observed on their way to and from feeding areas during crepuscular periods. The format used in recording data is shown in Appendix V.

1. Deer movement at dawn

The investigator and 18 bow hunters made 188 observations within an hour before or after sunrise during which 517 deer were sighted (Table 16). Of the known deer, juveniles constituted the greatest number per sighting (1.45) and antlered deer the least (0.36).

Table 16. Number of deer sighted, mean number of deer per sighting, and standard deviation of the mean for deer observations made at dawn

	Number of deer sighted	Mean number of deer sighted	Standard deviation
Total deer[a]	517	2.75	3.48
Adults	254	1.35	1.34
Juveniles	272	1.45	2.41
Antlered	68	0.36	0.54
Anterless	398	2.12	2.87
Unknown	42	0.22	1.00

[a]A total of 188 observations were made during which deer were sighted.

A regression analysis to determine the combined and unique effects of various independent variables was performed using the model:

Deer, adults, juveniles, anterless, antlered, unknown = sunrise time, time of sighting, location, lunar phase, minimum temperature, maximum temperature, wind direction, wind velocity, nebulosity, type of precipitation, amount of precipitation, type of ground cover (bare or snow), amount of snow.

Combined and unique effects were examined by F-tests, slope determination (B-value) and T-tests for HO:B = O. Results are presented in Table 17 and only those variables with an F or T value with a probability less than 0.05 are discussed in the text.

a. <u>All deer</u> An average of 2.75 deer were sighted during 188 observations (517 deer). When all the independent variables were fitted to the model with total deer as the dependent variable a significant relationship was obtained (F = 2.84, Prob. F < 0.05). However, this model only accounted for 18 per cent of the variability in the number of deer sighted.

A significant relationship existed between the number of deer sighted and the time of sunrise (F = 11.11, Prob. F < 0.05) (Table 17). The slope of this regression line (-0.04) was also significant T = 03.33, Prob. T < 0.05). This indicates that fewer deer are sighted the further away from sunrise time the observations were made. One might have expected this because it was generally too dark to observe very long before sunrise and the deer have moved out of the fields and returned to the timber before long after sunrise.

Table 17. The F-values, slopes (B) and T-values (HO:B=O) for the unique effect of each independent variable in the regression model: Deer, adults, juvenile, antlerless, antlered, unknown = sunrise, time of sighting, location, lunar phase, minimum temperature, maximum temperature, wind direction, wind velocity, nebulosity, type of precipitation, amount of precipitation, type of ground cover, amount of snow

	Deer			Adults			Juveniles		
	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O
Sunrise	11.11[a]	-0.04	-3.33[b]	3.40	-0.01	-1.84	16.24[a]	-0.03	-4.03[b]
Time of sighting	0.27	0.00	0.52	0.00	-0.00	-0.01	0.83	0.00	0.91
Location	1.26	-0.01	-1.12	1.38	-0.01	-1.17	1.69	-0.01	-1.30
Lunar phase	0.06	-0.02	-0.25	0.04	0.00	0.19	0.79	-0.04	-0.89
Minimum temp.	0.27	-0.02	-0.52	0.01	-0.00	-0.13	0.15	-0.01	-0.39
Maximum temp.	0.11	-0.01	-0.33	0.05	0.00	0.23	1.35	-0.03	-1.16
Wind direction	4.97[a]	-0.25	-2.23[b]	2.34	-0.07	-1.53	4.86[a]	-0.17	-2.21[b]
Wind velocity	1.97	0.07	1.40	0.19	0.01	0.44	1.94	0.04	1.39
Nebulosity	0.00	-0.00	-0.01	0.01	-0.00	-0.09	0.34	0.00	0.59
Type of precip.	0.16	0.14	0.40	0.29	0.08	0.54	0.01	-0.02	-0.10

[a]Prob. F < 0.05.

[b]Prob. T < 0.05.

Table 17 (Continued)

	Deer			Adults			Juveniles		
	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O
Amount of precip.	2.63	-0.50	-1.62	3.62	-0.23	-1.90	1.44	-0.25	-1.20
Ground cover	4.90[a]	1.79	2.21[b]	3.64[a]	0.62	1.91[b]	5.81[a]	1.32	2.41[b]
Amount of snow	0.20	0.04	0.44	0.37	0.02	0.61	0.01	0.01	0.09

	Anterless			Antlered			Unknown		
	F-value	B-value (slope	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O
Sunrise	15.81[a]	-0.04	-3.98[b]	0.07	-0.00	-0.26	0.03	0.00	-0.17
Time of sighting	0.21	0.00	0.46	1.32	-0.00	-1.15	0.89	0.00	0.94
Location	1.02	-0.01	-1.01	0.30	-0.00	-0.54	0.17	-0.00	-0.41
Lunar phase	0.52	-0.04	-0.72	0.00	-0.00	-0.00	0.20	0.01	0.45
Minimum temp.	0.09	-0.01	-0.31	2.22	-0.01	-1.49	0.02	-0.00	-0.13
Maximum temp.	0.24	-0.01	-0.49	0.15	-0.00	-0.39	0.45	0.01	0.66
Wind direction	4.62[a]	-0.20	-2.15[b]	0.00	0.00	0.05	0.00	0.00	0.02
Wind velocity	0.67	0.03	-0.82	0.00	0.00	0.06	2.16	0.02	1.47

Table 17 (Continued)

	Anterless			Antlered			Unknown		
	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O
Nebulosity	0.01	0.00	0.07	2.07	0.00	1.44	0.30	-0.00	-0.54
Type of precip.	0.02	0.04	0.15	1.55	-0.07	-1.24	1.10	0.12	1.05
Amount of precip.	0.76	-0.21	-0.87	2.37	-0.07	-1.54	1.89	-0.13	-1.37
Ground cover	6.38[a]	1.66	2.53[b]	0.14	-0.05	-0.37	0.17	0.10	0.42
Amount of snow	1.35	0.08	1.16	0.24	-0.01	-0.49	0.26	-0.01	-0.51

Wind direction had a significant effect on the number of deer sighted in the morning (F = 4.97, Prob. F < 0.05). The slope of the regression line was negative (0.25) and significant (T = -2.23, Prob. T < 0.05). Wind direction was coded from one through 8. North was numbered one and the numbering system continued in a clockwise manner with northwest being number 8. According to the slope, most deer were sighted when the wind was from the north. This was expected as the deer moved from the fields north of the park past the investigator and south into the park. Therefore it is difficult to determine if deer were responding to a weather factor as such, the investigator's sçent, or both.

Ground cover also exerted a significant effect on the number of deer sighted (F = 4.90, Prob. F < 0.05). Ground cover was coded as bare ground or snow cover. The regression slope was 1.79 (T = 2.21, Prob. T < 0.05). Therefore, on the whole, 1.79 more deer were seen per sighting with snow than without snow. This may have been due to increased visibility.

Lunar phase, maximum temperature, nebulosity and type of precipitation exerted the least significant effects on the number of deer seen (Table 17).

b. Adult deer An average of 1.35 adult deer were sighted during 188 observations (254 deer). When all the independent variables were fitted to the model with adult deer as the independent variable a significant relationship was not obtained (F = 1.42, Prob. F > 0.05). This model accounted for 10 per cent of the total variability in the number of adults sighted.

Only one significant relationship was found to exist between number of adults sighted and the variables included in the model (Table 17). Ground cover was shown to have effected the number of adults sighted as more were observed per sighting with snow cover (F = 3.64, Prob. F < 0.05).

c. Juvenile deer An average of 1.45 juvenile deer were sighted during 188 observations (272 deer). The regression analysis, with juveniles as the dependent variable and all independent variables included, was significant (F = 3.54, Prob. F < 0.05) and accounted for 21 per cent of the variability in number of juveniles sighted.

The effect of sunrise time on the number of juveniles seen was found to be highly significant (F = 16.24, Prob. F < 0.05). The negative slope (-0.03) of the regression line for sunrise effect indicated that fewer deer were sighted the further from sunrise time (earlier or later) the observations were made (T = 4.03, Prob. T < 0.05).

Wind direction (F = 4.86, Prob. F < 0.05) and snow cover (F = 5.81, Prob. F < 0.05) also exerted a significant effect on the number of juveniles sighted.

d. Antlerless deer An average of 2.12 anterless deer were sighted during 188 observations (398 deer). The overall effect of the independent variables fitted to the model with antlerless deer as the dependent variable was found significant (F = 3.27, Prob. F < 0.05). This model accounted for 20 per cent of the variability in numbers of antlerless deer seen.

Three of the variables tested were found to have a significant effect at the 0.05 level on the number of antlerless deer seen. They were: sunrise time (F = 15.81), wind direction (F = 4.62), and ground cover-snow (F = 6.38). Slopes for the regression lines for those three variables (Table 17) indicated trends similar to those observed for all deer sighted.

e. Antlered deer An average of 0.36 antlered deer was sighted during 188 observations (68 deer). The regression analysis, with antlered deer as the dependent variable and all the independent variables included, was not found significant (F = 1.13, Prob. F > 0.05). The model accounted for 8 per cent of the variation in number sighted.

No significant relationships were found to exist between the number of antlered deer sighted and any of the independent variables included in the model. This may be indicative of an earlier return to bedding areas by antlered deer thus reducing the chance of their being sighted.

f. <u>Unknown deer</u> This category contains deer that could not be identified by age or by sex. Only 42 deer were placed in that category. On the average, only 1 deer was placed in this category for every five observations. The model, with unknown deer as the dependent variable, accounted for 5 per cent of the variation. None of the variables tested were found to have a significant effect on numbers sighted.

2. <u>Deer movement at dusk</u>

The investigator and several bowhunters made 259 observations within one hour before or after sunset during which 680 deer were sighted (Table 18). Of the identifiable deer sighted, 1.31 juveniles and 1.33 adults were observed per sighting. Antlerless deer constituted the greatest number per sighting (2.02) and antlered deer the least (0.37).

A regression analysis to determine the combined and unique effects of various independent variables was performed using the model:

> Deer, adults, juveniles, antlerless, antlered, unknown = sunset time, time of sighting, location, lunar phase, minimum temperature, maximum temperature, wind direction, wind velocity, nebulosity, type of precipitation, amount of precipitation, type of ground cover, amount of snow.

Table 18. Number of deer sighted, mean number of deer per sighting, and standard deviation of the mean for deer observations made at dusk

	Number of deer sighted	Mean number of deer sighting	Standard deviation
Total deer[a]	680	2.63	2.74
Adults	344	1.33	1.20
Juveniles	338	1.31	1.79
Antlered	97	0.37	0.65
Antlerless	524	2.02	2.47
Unknowns	54	0.21	1.08

[a]A total of 259 observations were made during which deer were sighted.

The same tests and criteria for discussion used in analyzing deer movement at dawn were applied.

a. <u>All deer</u> An average of 2.63 deer were sighted during 259 observations (680 deer). When all the independent variables were fitted to the regression model with total deer as the dependent variable a significant relationship was obtained ($F = 3.24$, Prob. $F < 0.05$). This model accounted for 15 per cent of the variation in number of deer per sighting.

A significant relationship was found to exist between the number of deer sighted and the time of sunset ($F = 3.40$, Prob. $F < 0.05$) (Table 19). The B-value (slope) was

Table 19. The F-values, slopes (B) and T-values (HO:B=O) for the unique effects of each independent variable in the regression model: deer, adults, juveniles, antlerless, antlered, unknown = sunset, time of sighting, location, lunar phase, minimum temperature, maximum temperature, wind direction, wind velocity, nebulosity, type of precipitation, amount of precipitation, type of ground cover, amount of snow

	Deer			Adults			Juveniles		
	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O
Sunset	3.40[a]	0.00	1.84[b]	0.80	0.00	0.89	4.97[a]	0.01	2.23[b]
Time of sighting	1.16	0.00	1.07	0.83	0.00	0.91	1.13	0.00	1.06
Location	0.27	0.00	0.52	0.84	-0.00	-0.92	2.15	0.00	1.47
Lunar phase	2.80	-0.07	-1.67	3.40	-0.04	-1.84	1.62	-0.04	-1.27
Min. Temp.	4.06[a]	-0.03	-2.01[b]	2.76	-0.01	-1.66	3.90[a]	-0.02	-1.97[b]
Max. Temp.	0.00	0.00	0.05	0.14	0.00	0.37	0.03	-0.00	-0.17
Wind direc.	0.61	-0.07	-0.78	0.10	-0.01	-0.32	0.77	-0.05	-0.88
Wind velocity	3.88[a]	0.07	1.97[b]	1.09	0.02	1.04	4.95[a]	0.05	2.23[b]
Nebulosity	0.52	0.00	0.72	1.38	0.00	1.17	0.08	0.00	0.29
Type of precip.	0.50	-0.16	-0.70	2.05	-0.14	-1.43	0.00	-0.00	-0.03
Amount of precip.	0.22	0.09	0.46	0.06	0.02	0.25	0.37	0.08	0.61
Ground cover	2.60	1.11	1.61	2.49	0.48	1.58	1.99	0.63	1.41
Amt. snow	0.87	-0.05	-0.93	0.18	-0.01	-0.42	1.44	-0.04	-1.20

[a]Prog. F < 0.05.

[b]Prob. T < 0.05.

Table 19 (Continued)

	Antlerless			Antlered			Unknown		
	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O	F-value	B-value (slope)	T for HO:B=O
Sunset	3.48[a]	0.01	1.87[b]	0.76	-0.00	-0.87	0.48	0.00	0.70
Time of sighting	0.00	0.00	0.05	0.87	0.00	0.93	3.65[a]	0.00	1.91[b]
Location	1.98	0.01	1.41	1.98	-0.00	-1.41	1.56	-0.00	-1.25
Lunar phase	2.18	0.06	-1.48	0.87	-0.01	-0.93	0.32	-0.01	-0.57
Min. Temp.	2.90	-0.03	-1.70	13.02[a]	-0.01	-3.61[b]	1.10	0.01	1.05
Max. Temp.	0.82	0.02	0.91	4.82[a]	0.01	2.19[b]	10.79[a]	-0.03	-3.28[b]
Wind direc.	0.36	-0.05	-0.60	0.22	0.01	0.47	1.28	-0.04	-1.13
Wind veloc.	4.13[a]	0.06	2.03[b]	0.03	0.00	0.17	0.08	0.00	0.28
Nebulosity	0.46	0.00	0.68	0.00	-0.00	-0.00	0.16	0.00	0.40
Type of precip.	0.33	-0.16	-0.57	0.36	-0.03	-0.60	0.25	-0.05	-0.50
Amount of precip.	0.26	0.09	0.51	1.08	-0.05	-1.04	0.33	0.04	0.57
Ground cover	3.30	1.14	1.82	0.00	-0.01	-0.06	0.09	-0.08	-0.30
Amount of snow	0.10	-0.02	-0.31	0.72	-0.01	-0.85	0.61	-0.02	-0.78

significant (T = 1.84, Prob. T < 0.05) and positive indicating that more deer were sighted after sunset.

Minimum temperature was found to have a significant effect on the number of deer sighted (F = 4.06, Prob. F < 0.05). The slope of the regression line, -0.03, was significant when tested with HO:B=O (T = -2.01, Prob. T < 0.05). Temperature was coded such that the negative slope would indicate more deer were seen with colder temperatures than with warm ones. Because these observations were made during winter when heat requirements are intense this appeared logical.

The effect of wind velocity on total deer sighted per observation was also significant (F = 3.88, Prob. F < 0.05). The slope was 0.07 and significant at the 0.05 level (T = 1.97). The fact that it was positive was somewhat of a surprise as it was generally accepted that deer avoid wind. In this instance the number of deer sighted increased by a rate of 0.07 with each increase of one mile per hour in wind velocity.

Neither minimum temperature nor wind velocity were found to exert a significant effect on the number of deer sighted at dawn. However, wind direction did affect dawn sightings but did not significantly affect dusk sightings.

b. Adult deer   An average of 1.33 adult deer were sighted during 259 observations (344 deer). The regression analysis, with adults as the dependent variable and all independent variables included, was significant (F = 2.35, Prob. F < 0.05) and accounted for 11 per cent of the variability number of adults per sighting.

No significant effects of independent variables on number of adults sighted were found using the regression model.

c. <u>Juvenile deer</u> An average of 1.31 juvenile deer were sighted during 259 observations (338 deer). The regression analysis, with juveniles as the independent variable, showed a significant effect due to the combined independent variables (F = 3.40, Prob. F < 0.05) and the model accounted for 15 per cent of the variability.

Time of sunset, minimum temperature and wind velocity affected juvenile sightings much the same as they did adult sightings. The three variables were significant at the 0.05 level with F-values of 4.97, 3.90, and 4.95 respectively.

d. <u>Antlerless deer</u> An average of 2.02 anterless deer were sighted during 259 observations (524 deer). The overall effect on the dependent variable (antlerless deer) of the independent variables was found significant (F = 2.62, Prob. F < 0.05). The model accounted for 12 per cent of the variability.

Time of sunset and wind velocity had positive effects (slopes = 0.01 and 0.06) on the number of antlerless deer per sighting and both were significant at the 0.05 level (F =

3.48 and 4.13).

e. Antlered deer An average of 0.37 antlered deer was observed per sighting for 259 sightings (97 deer). The regression analysis, with antlered deer as the dependent variable and all independent variables included, was found significant ($F = 2.22$, Prob. $F < 0.05$) and the model accounted for 11 per cent of the variation in numbers.

Time of sunset was not found to have a significant effect at the 0.05 level on the number of antlered deer sighted. This may indicate post daylight movement by bucks thus eliminating them from the analysis.

Effect of minimum temperature was highly significant ($F = 13.02$, Prob. $F < 0.05$) and the slope of the regression for its effect was negative (Table 19). This indicated more males sighted with colder temperatures. However, for the first time, effect of maximum temperature was also significant ($F = 4.82$, Prob. $F < 0.05$) and here the slope was positive (0.01). This indicates a slight increase in males sighted with an increase in temperature. Possibly adult male movement is enhanced by a change, whether positive or negative, in temperature.

f. Unknown deer Fifty-four deer were observed but not identified by age or sex. On the average only 1 deer was placed in this category for every five observations. The model, with unknown deer as the dependent variable, accounted for 8 per cent of the variation, and the combined effects of all the fitted independent variables was significant (F = 1.72, Prob. F < 0.05).

Time of sighting exerted a significant effect on the number of unknown deer sighted (F = 3.65, Prob. F < 0.05). The slope of the regression for time of sighting was positive (0.004) and significant when tested by HO:B=O (T = 1.91, Prob. T < 0.05). This indicated an increase in the number of unknown deer sighted as it became darker.

Maximum temperature also had a significant effect on the number of unknown deer sighted (F = 10.79, Prob. F < 0.05). The slope was negative (-0.03) indicating fewer unknown deer sighted with lower temperatures. This may have been due to the investigator's inherent intolerance for cold.

Results of track counts made along the park road and the road paralleling its north border indicate that the deer included in the above analysis represent the first to move out of timber at night and the last to enter timber in the morning. Track counts indicate that movement peaks after it is too dark to see at night and again before it is light enough to see in the morning.

L. Deer Activity for the 24-Hour Period

The time of sighting, age, sex and activity of each deer observed was recorded for 4262 sightings (Appendix XI, XII, XIII). The information on activity was divided into two classes; bedded and active. Results showing activity over the three year period were graphed according to the number of deer either bedded or active for each hour of the day (Fig. 33).

More deer were observed bedded at 1000, 1400 and 2100 hours than at any other time of day. Peaks for total sighting of active deer were at 0600, 0700, 1100, 1700 and 1800 hours. These peaks correspond to periods of feeding activity. The investigator observed more deer during the early morning and evening feeding periods than during the mid-day period because deer moved longer distances during crepuscular periods and because they moved in more open cover.

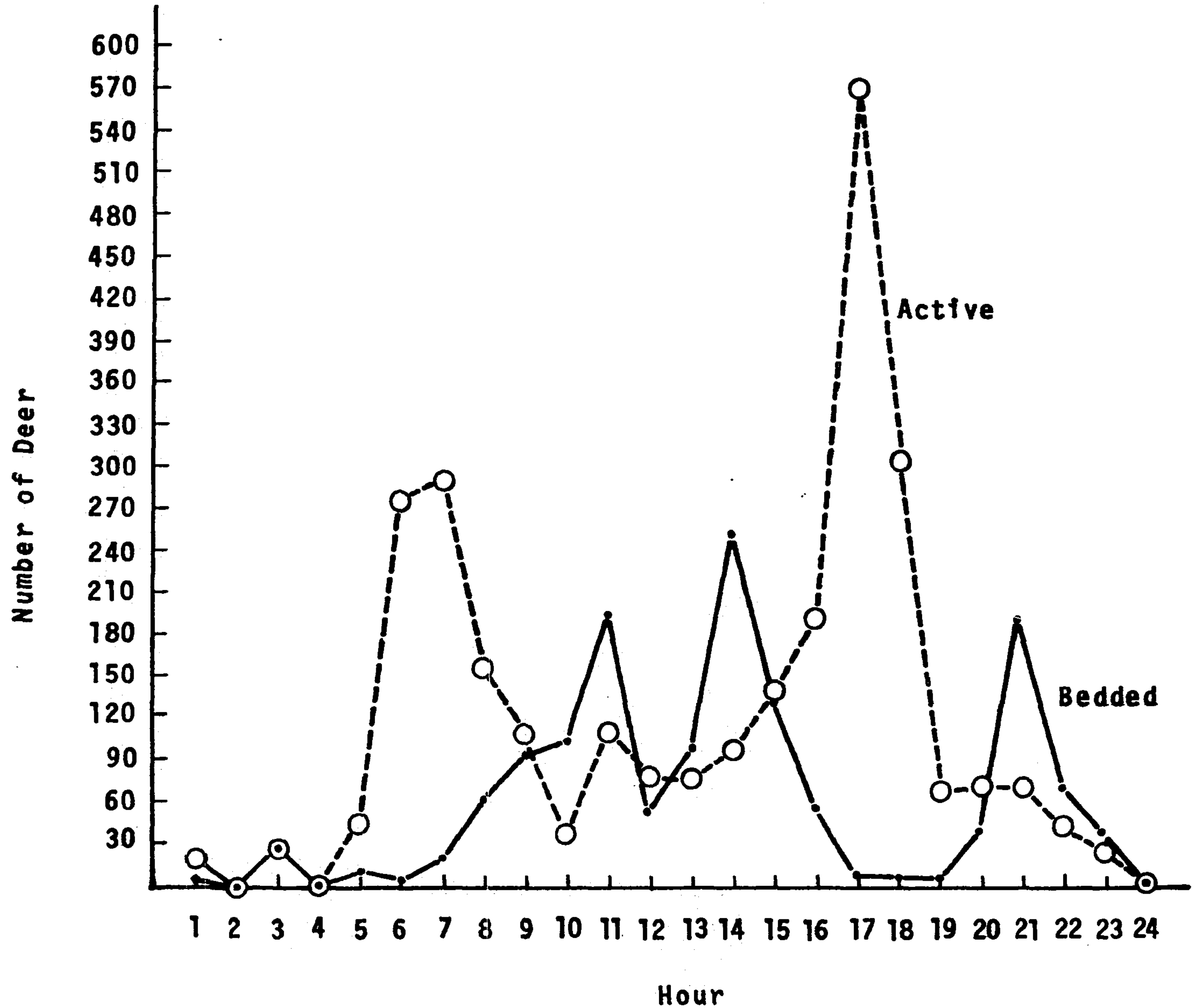


Fig. 33. Activity of sighted deer for each hour during the winters of 1969-72

M. Deer Sightings in Relation to Cover Type and Topography

1. Cover type

A total of 1540 acres were mapped according to ten categories of cover type (Fig. 3, Table 20). The total number of deer sighted in each type, the mean number of deer per sighting and the number of times deer were sighted in any one type are presented in Table 20.

Acreage for each type was computed and used to determine the occurrence of deer per 10-acres of a specific type (Table 20). The resulting figure indicates a preference index for the 10 cover types. Deer appear to prefer ungrazed timber (49 deer per 10 acres) over grazed timber (24 deer per 10 acres). This preference is strengthened when the visibility in the two types is considered. One could see more area at a time in the grazed timber and therefore would have been more likely to sight any deer present. A variable not fully accounted for was the amount of time spent in the two areas. Most (two-thirds) of the investigator's time was spent in the park where only ungrazed timber occurs.

For cropland the index was smaller than expected because the investigator spent considerable time during prime hours observing the croplands. The light factor probably was significant in explaining this. Although deer were easy to sight in the open cropland during winter they generally moved during crepuscular periods when the amount of light limited

Table 20. Number of deer, frequency of sightings, mean number of deer per sighting, and cover type preference for 10 categories of cover type

Cover type	Number of deer	Frequency	Mean number of deer/ sighting	Standard deviation	Amount of cover type (acres)	Occurrence of deer/ 10 acres
Ungrazed timber	2113	899	2.35	4.0	434	49
Grazed timber	274	109	2.50	2.8	113	24
Cropland	1471	425	3.46	4.8	728	20
Pasture	138	38	3.63	6.6	156	9
Slough	47	9	5.22	7.5	25	19
Lake[a]	7	3	2.33	1.5	24	3
Meadow	54	30	1.80	1.3	4	135
Sumac	115	43	2.70	2.7	28	41
Bog	0	0	0.00	0.00	19	0
Camping and picnicking	43	16	2.69	1.3	13	33
	4262				1540	

[a]Lake was frozen over.

visibility.

The index value for meadow was surprisingly high. When analyzed, however, it seems logical. Cover classed as meadow was within the park and close to the bedding area. As deer moved toward the cropland to feed they arrived at the meadow while there was still enough light to observe them. This plus the lack of cover made it easy to spot any deer moving through the meadow.

On the basis of occurrence per 10 acres, deer were found often in sumac and in areas classified for picnicking and camping. Time was the important factor here as deer moved through these cover types on their way between feeding and bedding areas during crepuscular periods.

Deer showed an avoidance for pasture. The index for this type is very low even though deer occurring in this cover would be easy to spot.

When the means for the number of deer seen per observation were examined for the 10 types, visibility seemed to be an important factor. Means for deer in open areas (cropland, pasture, slough) were higher than those for sightings in heavy cover. This indicates that more of the deer present were sighted in open as compared to dense cover. It may also have been due to larger numbers of deer having been present in one place while feeding in the open areas.

2. Topography

Thirteen categories were selected to describe the topography of the study area (Table 21). Deer were sighted most often on flat areas. Approximately the same number of sightings were made on north-facing as on south-facing slopes. There was nearly equal opportunity for deer to be present on both types of slope.

A topographical map of the area does not exist. Therefore it was not feasible to determine what percentage of the whole topography belonged to the various classifications. Because of this no index for preference was calculated.

N. Effect of Topography, Cover Type and Weather on Number of Deer Sighted

1. All deer

To aid in determining the effect of 11 independent variables on the number of deer sighted per observation a regression analysis was performed using the model:

Deer = topography, cover type, maximum temperature, minimum temperature, wind direction, wind velocity, nebulosity, type of precipitation, amount of precipitation, ground cover, amount of snow.

When the unique effect of maximum temperature holding all other variables constant was tested it was found to have a significant influence on the number of deer sighted (F =

Table 21. Number of deer, frequency of sightings and mean number of deer per sighting for 13 categories of topography

Topography	Number of deer	Frequency	Mean number of deer/sighting	Standard deviation
Flat	1310	405	3.23	4.6
Knoll	223	82	2.72	7.9
North-south ridge	79	21	3.76	4.4
East-west ridge	51	21	2.43	4.6
North-facing slope	584	268	2.18	2.7
Northeast-facing slope	75	31	2.42	2.7
East-facing slope	428	168	2.55	3.7
Southeast-facing slope	148	87	1.70	1.4
South-facing slope	817	278	2.94	4.9
Southwest-facing slope	33	16	2.06	3.0
West-facing slope	408	136	3.01	3.5
Northwest-facing slope	100	56	1.79	2.1
Valley bottom				
Total	4262			

4.99, Prob. $F < 0.05$) (Table 22). The slope of the regression line (-0.28) indicates that number of deer sighted decreased as the temperature increased. This was logical because most of the observations were made during winter when the ground was snow covered. Higher temperatures melted snow thus making deer more difficult to see.

Ground cover had a very significant effect on the number of deer seen per sighting ($F = 11.28$, Prob. $F < 0.05$). Snow cover made deer easier to see. The slope of the regression line (0.93) indicates that approximately one more deer was observed with snow than without it. The lack of foliage during the winter (snow) period probably contributed to the increased visibility of deer.

Variables that appeared to have very little effect on the number of deer seen per sighting included: minimum temperature, wind direction, nebulosity, amount of precipitation and amount of snow. The lack in wind direction effect may have been due to the investigator's attempt to use the wind while stalking.

A few trends, though not significant, were indicated by the results of the regression analysis. The number of deer seen per observation decreased with an increase in the amount of precipitation and also with an increase in wind velocity.

2. Bedded deer

The same model was fitted for the regression analysis on sightings of bedded deer except that only bedded deer were considered in the dependent variable.

Only one variable, cover type, had a significant effect on the number of bedded deer seen per sighting ($F = 4.78$, Prob. $F < 0.05$) (Table 22).

It was surprising that the type of ground cover did not significantly affect the number of bedded deer seen per sighting ($F = 0.31$, Prob. $F > 0.05$). The slope of the regression line (0.34) indicates that 0.34 more deer were seen per sighting with snow than without it.

The amount of snow on the ground nearly had a significant effect on numbers seen ($F = 3.63$, Prob. $F > 0.05$). The regression slope was positive (0.11) indicating an increase in the number of deer seen per sighting with an increase in snow depth.

O. Movement in Relation to Crops

During daylight hours deer generally bedded in the timber. They generally spent the nocturnal period feeding and/or bedding in croplands surrounding the park. Movement between bedding and feeding sites occurred during the dawn and dusk crepuscular periods along well established deer trails. The trails used most frequently by deer varied slightly each winter from 1969 through 1972

Table 22. Effects of 11 independent variables on the total number of deer sighted and the number of deer sighted while bedded at the Pilot Knob study area, Iowa, based on 1572 observations

Variable	All deer		Bedded deer	
	F-value	B-value (slope)	F-value	B-value (slope)
Topography	1.41	0.23	0.99	0.08
Cover type	3.04	-0.11	4.78*	0.46
Maximum temperature	4.99*	-0.28	0.68	-0.02
Minimum temperature	0.44	0.01	0.02	-0.00
Wind direction	0.06	-0.01	0.00	-0.01
Wind velocity	2.63	-0.03	1.01	-0.04
Nebulosity	0.70	-0.00	0.49	-0.00
Type of precipitation	1.29	0.15	0.86	0.23
Amount of precipitation	0.50	-0.10	0.94	-0.25
Ground cover (bare or snow)	11.28*	0.93	0.31	0.34
Amount of snow	0.36	0.02	3.63	0.11

*Prob. $F < 0.05$.

(Figs. 34a, 35a, 36a). This was due to the changing crop pattern in the fields surrounding the park (Fig. 34b, 35b, 36b).

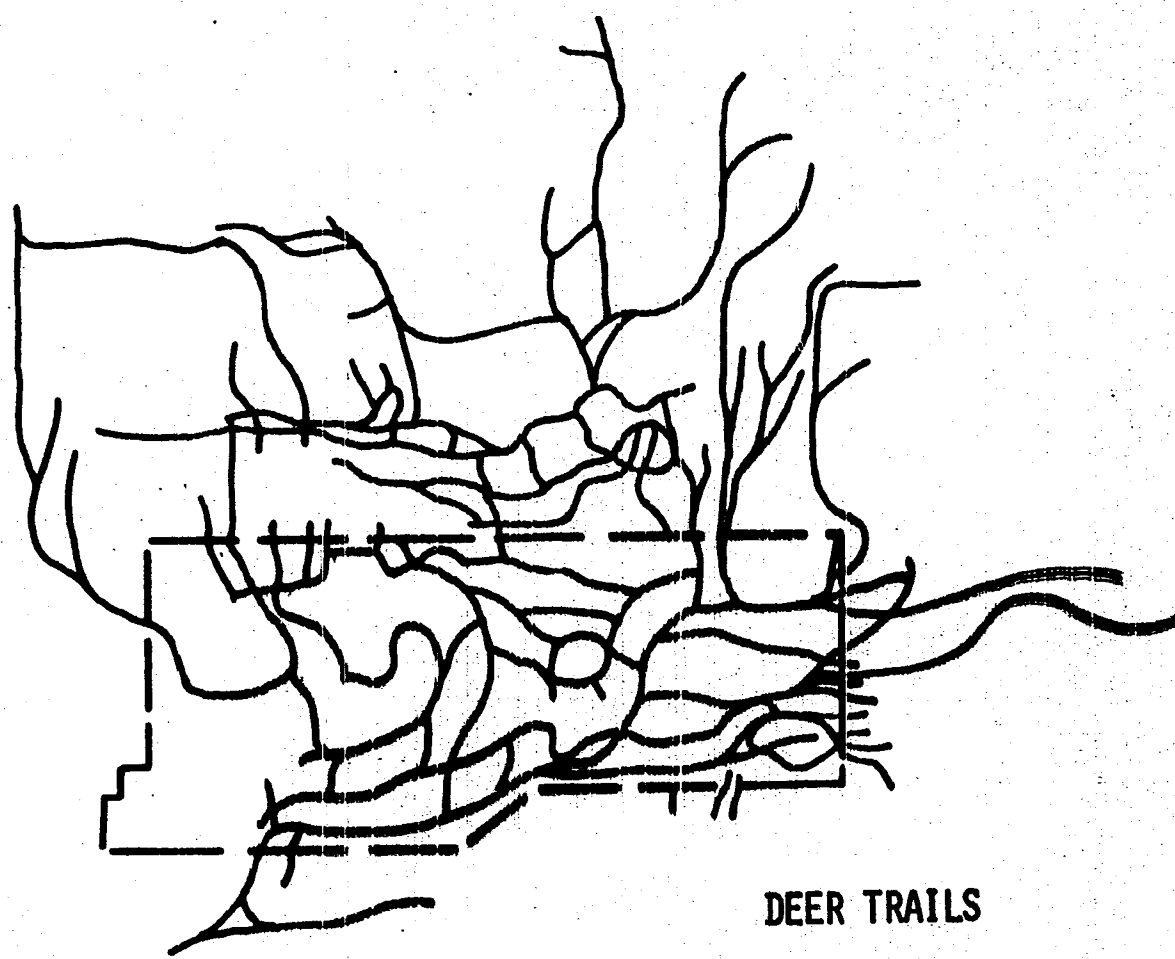
The major trails in the park ran east-west or north-south. Those running north-south connected northern feeding areas with trails within the park used for local movement around the bedding sites. There were several heavily traveled trails along the eastern border which led into a field planted to either corn or soybeans.

Trails followed the path of least resistance and were quickly re-established after a fresh snowfall. Apparently, the trails were established by deer inhabiting the study area during fall. This was indicated by the placement of tree blinds along well used trails by bow hunters hunting around the park (Appendix IV).

Once out of the timber, there was little cover in fields where row-crops of corn and soybeans had been harvested. Deer tended to avoid observation by traveling during crepuscular or dark periods and by moving along the side of ridges and knolls. They generally moved along the side of ridges so as to keep the ridge between themselves and a road.

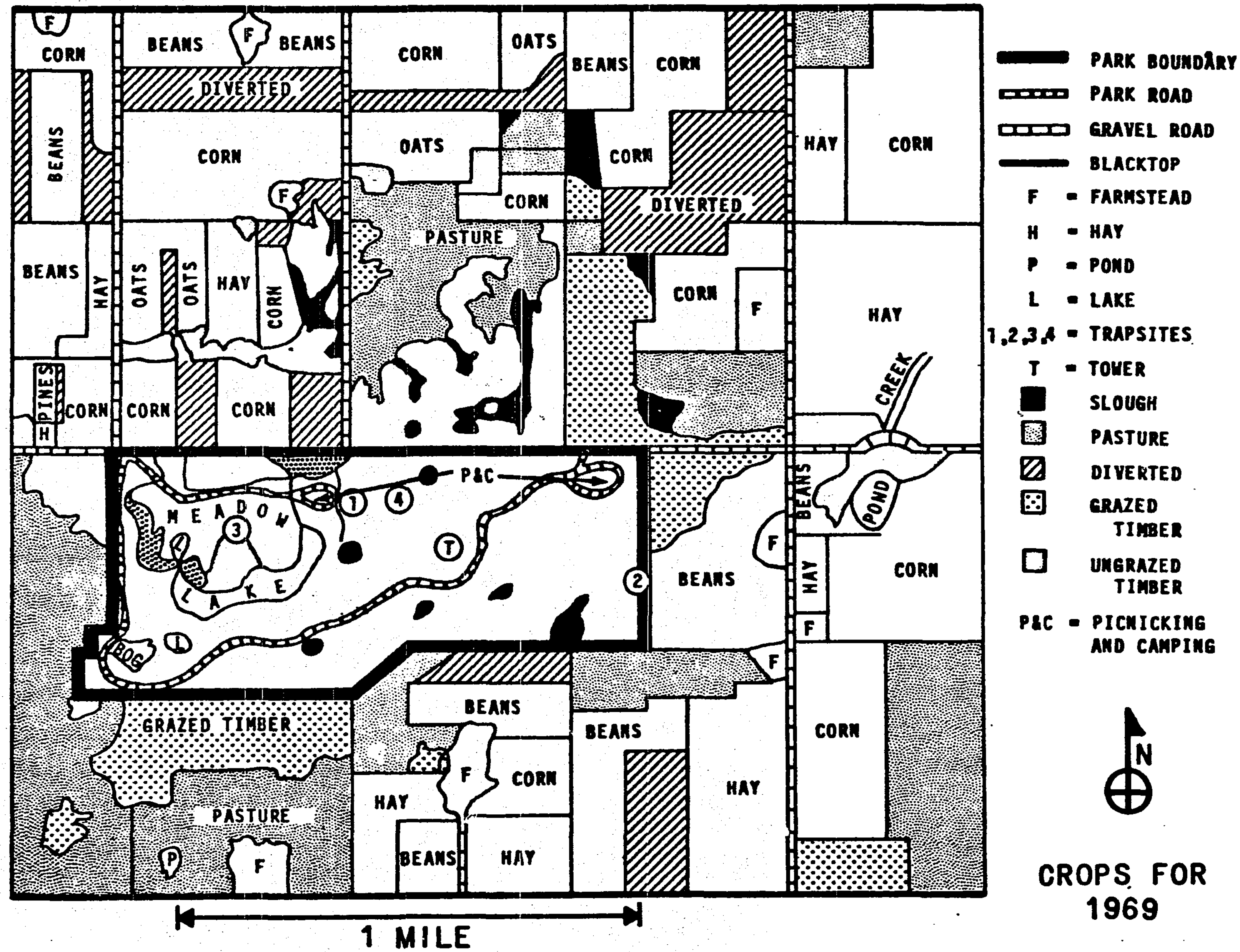
Fig. 34a. Overlay showing the most heavily used deer trails at the Pilot Knob study area during the winter of 1969-70

Fig. 34b. Cover map of the Pilot Knob study area emphasizing the crop pattern existing during the winter of 1969-70

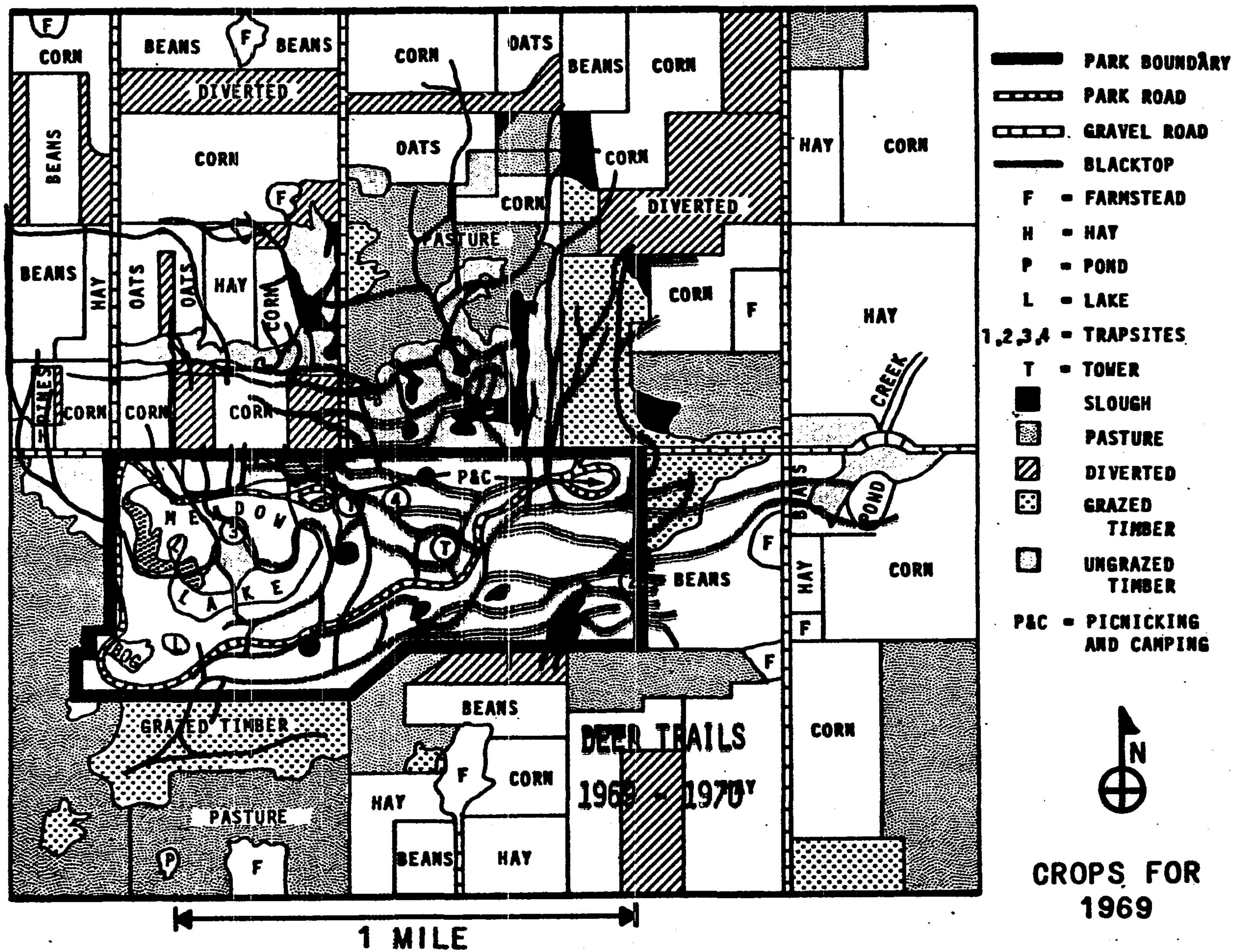


DEER TRAILS

1969 - 1970



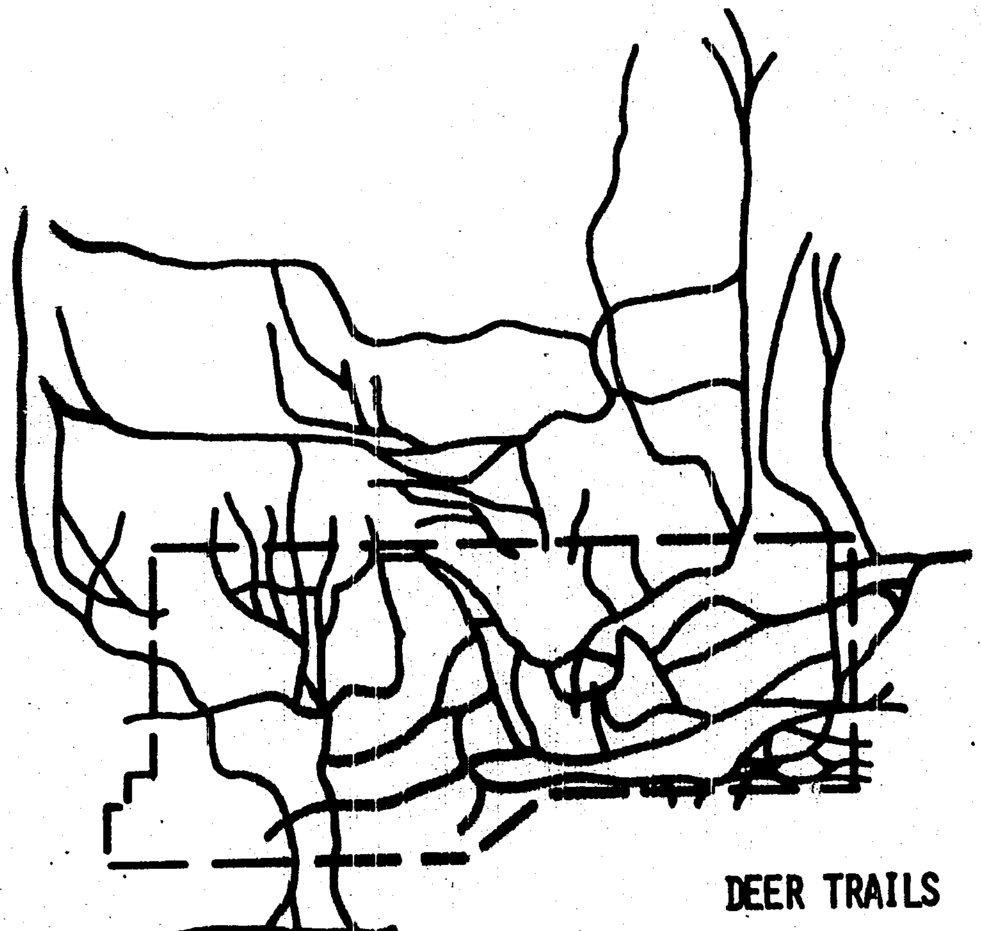
CROPS FOR 1969



CROPS FOR 1969

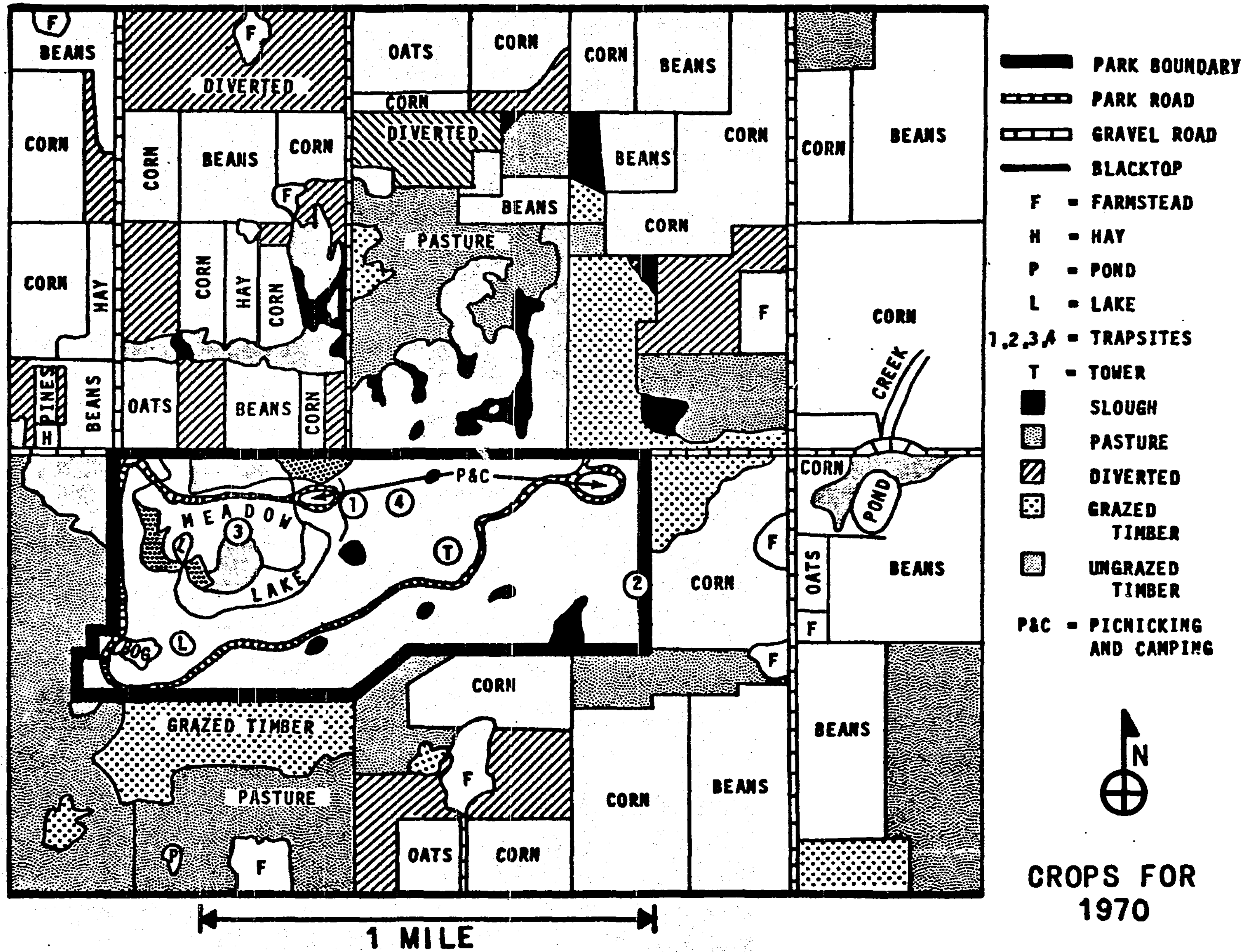
Fig. 35a. Overlay showing the most heavily used deer trails at the Pilot Knob study area during the winter of 1970-71

Fig. 35b. Cover map of the Pilot Knob study area emphasizing the crop pattern existing during the winter of 1970-71

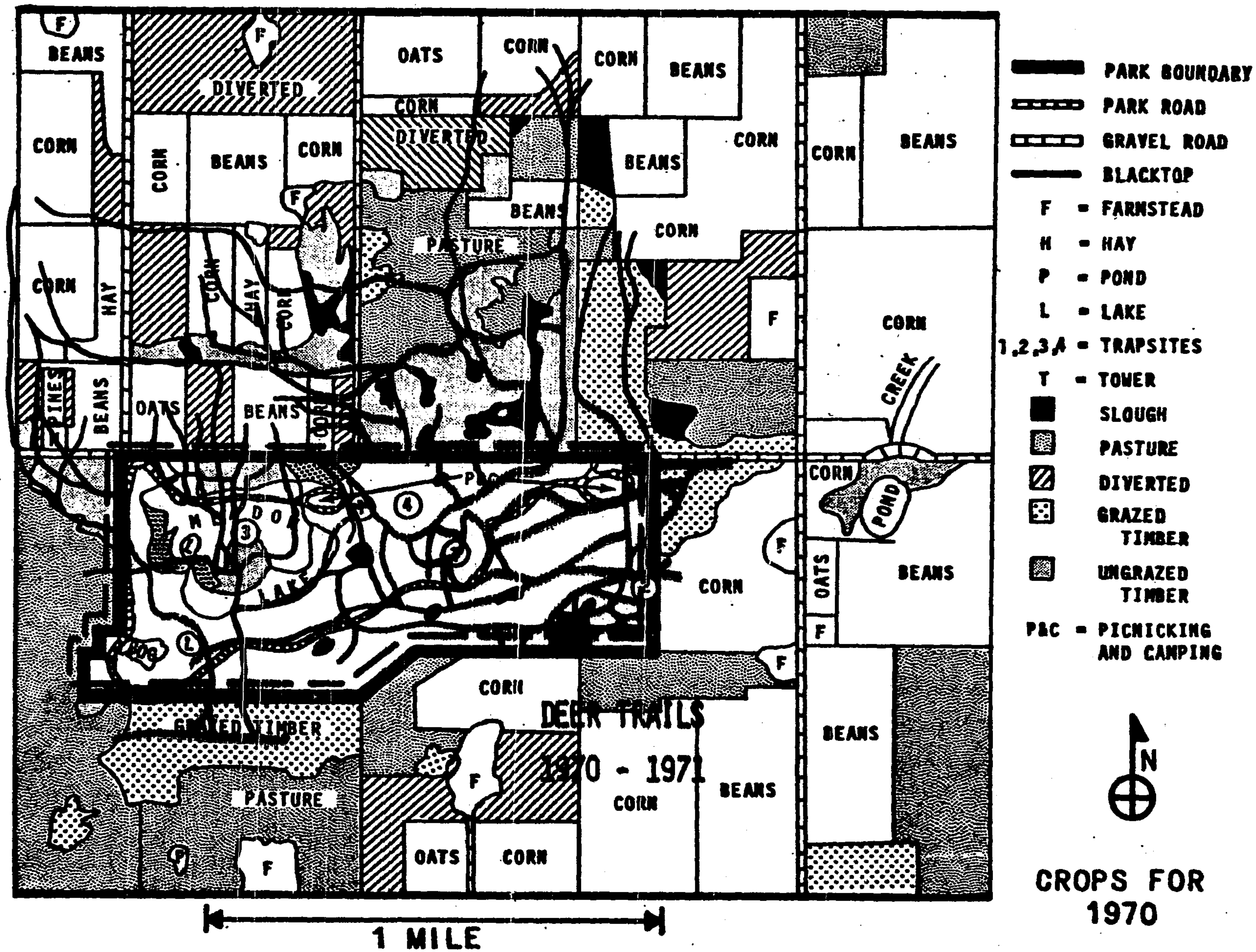


DEER TRAILS

1970 - 1971



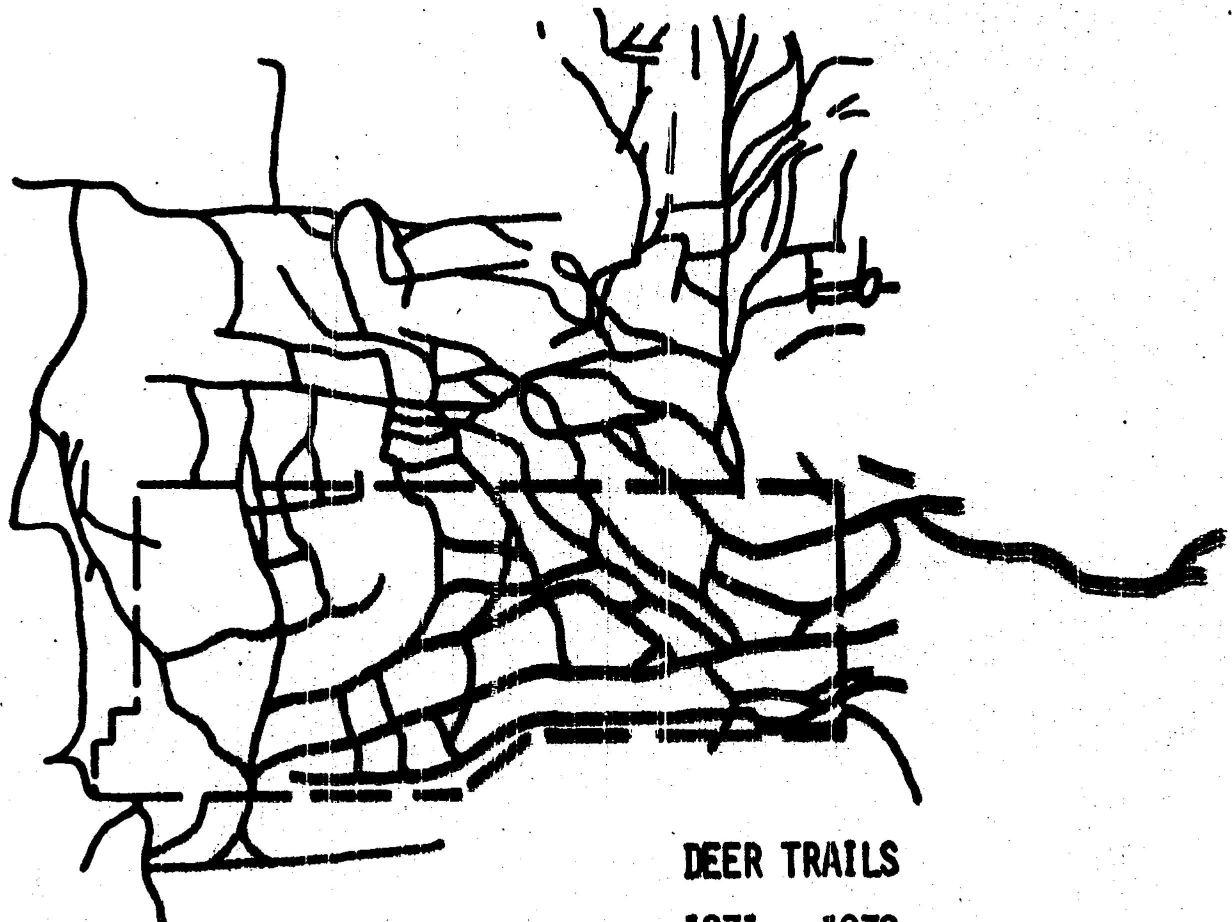
CROPS FOR 1970



CROPS FOR 1970

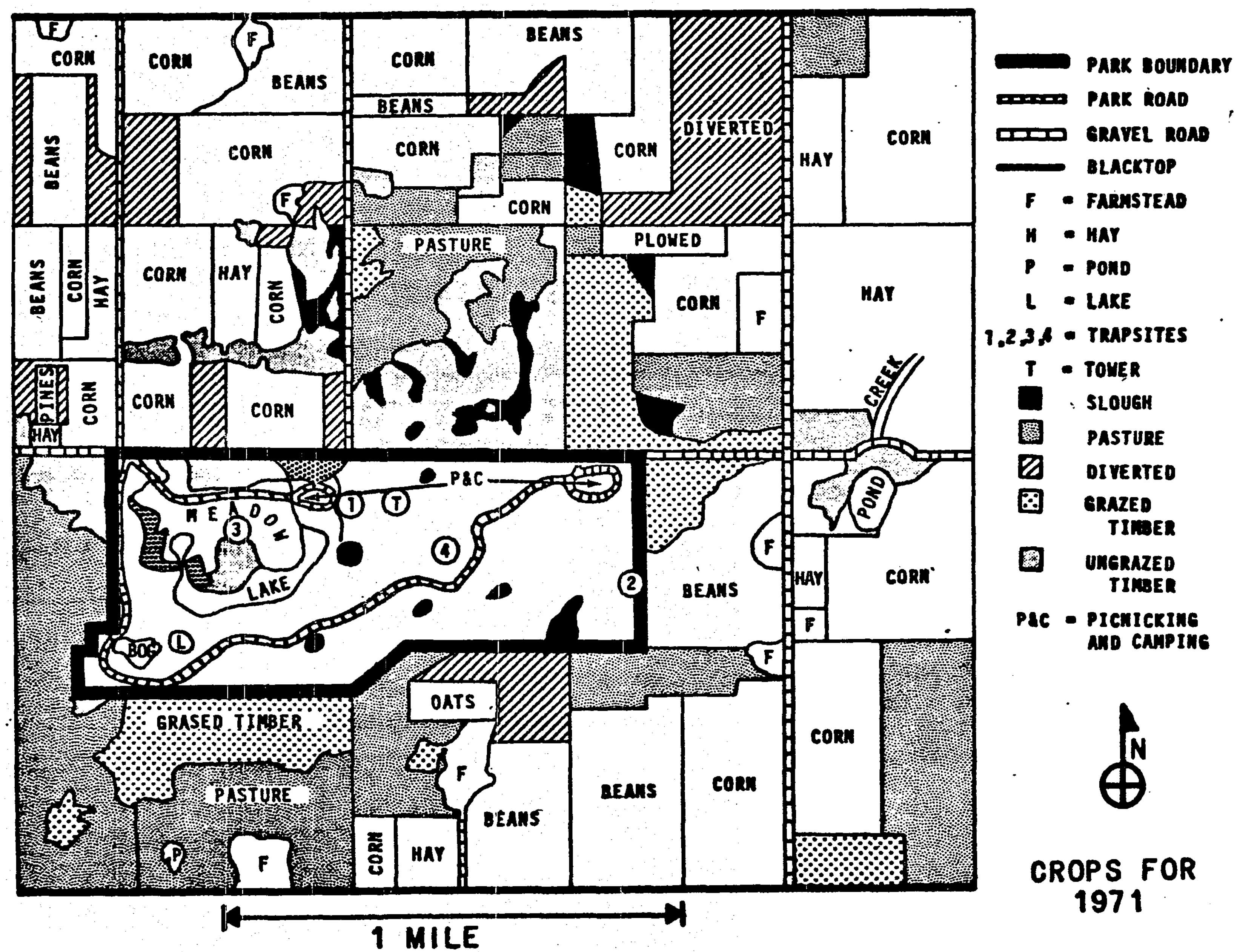
Fig. 36a. Overlay showing the most heavily used trails at the Pilot Knob study area during the winter of 1971-72

Fig. 36b. Cover map of the Pilot Knob study area emphasizing the crop pattern existing during the winter of 1971-72

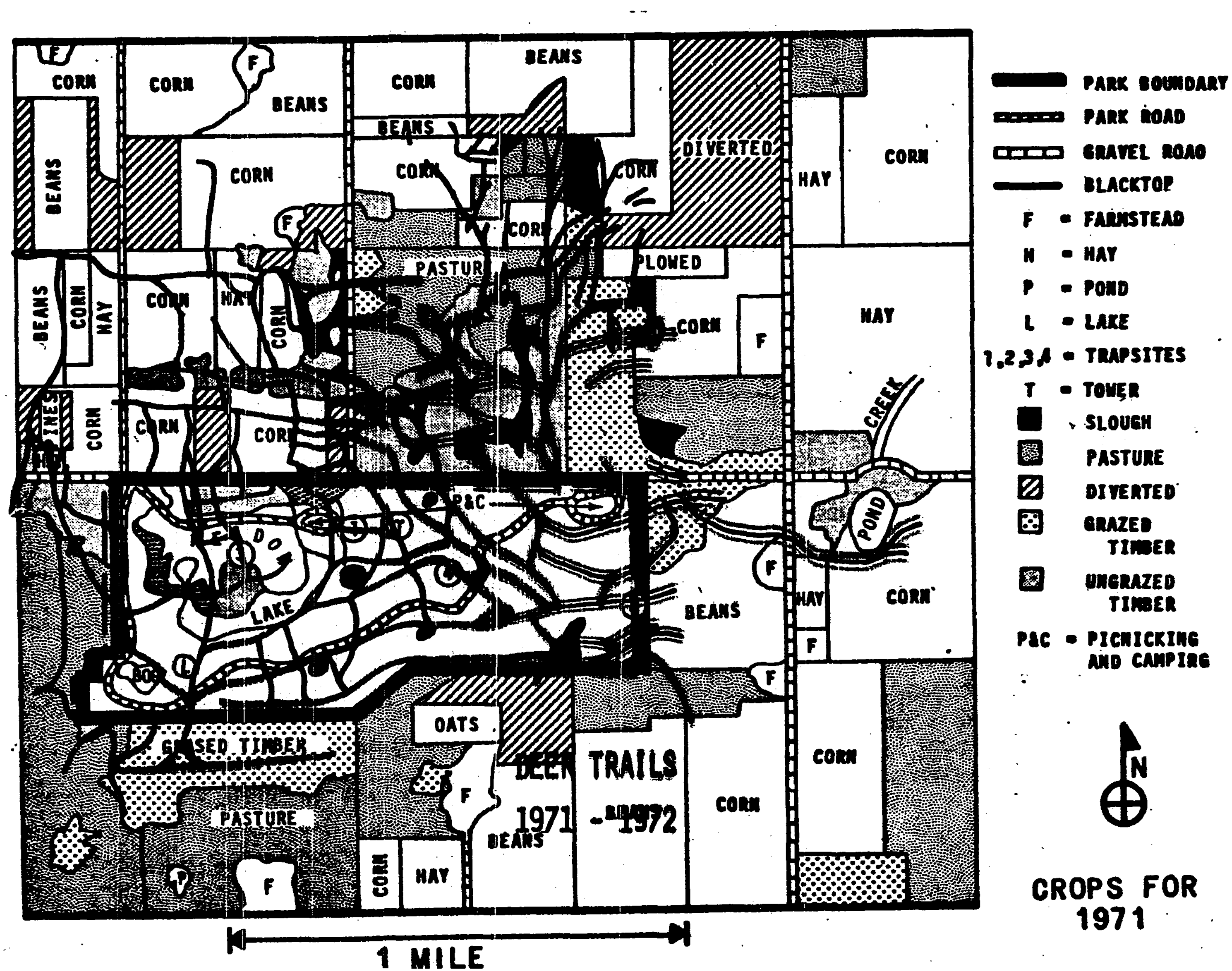


DEER TRAILS

1971 - 1972



CROPS FOR 1971



CROPS FOR 1971

P. Response to Hunting Pressure

Deer were observed moving toward and entering the park after being molested by hunters up to 1 mile from the park. They were also observed entering the park along its northern border after being harassed while in the timber to the north. Eleven deer, wounded outside the park, were known to have entered Pilot Knob State Park while being pursued.

This demonstrates the value of a refuge like the park in maintaining a deer herd in open farming country. Deer are very vulnerable in this intensively farmed area and, when harassed, move through cover until they are no longer molested. When suitable cover and protection from further harassment is found, they remain.

Q. Hunting and Highway Mortality

1. Hunting results

Iowa law prohibits hunting in State parks but hunting is often allowed on private lands immediately surrounding a park. This is the case at Pilot Knob State Park. Both bowhunters and shotgun hunters are allowed to hunt on land surrounding the park and both hunt the area intensively. At least 50 tree-blinds are known to exist in the timber adjacent to the park's northern boundary.

The bowhunting season lasts about 2 months and the gunning season lasts 2 days. Because of the long season the investigator had the opportunity to solicit the bow hunters' help in securing data regarding movement and hunter success.

a. <u>Hunter questionnaire</u> In 1970 bowhunters hunting in the vicinity of Pilot Knob State Park provided much useful data by responding to a questionnaire. In 1970, the bow hunting season began September 26 and continued through November 26, 1970. In order to ascertain movement patterns, the area north of the Park was divided according to habitat and natural boundaries (Appendix IV).

Area I is northwest of the Park and consists of a 10-acre tract of timber which provides a good crossing point from timber west of the Park. The remainder of the area consists of cropland and diverted acreage and provides the observer with a long range of observation.

Area II is north of the western half of the Park. It is bordered by timber on the south and includes an east-west tract of timber a half-mile north of the Park which separates cropland and diverted acreage to its north and south and also affords a natural run from the timber to the east. This area is relatively open and provides a long-range view.

Area III is north of the eastern half of the Park and consists of pastured timber. As of now there is a thick understory in certain areas and sloughs are dispersed throughout. The hilly terrain and limited light during prime hours shorten the range of effective observation.

During September the best sighting record per unit of time occurred in the open areas (I and II) as might be expected due to the heavier foliage cover in the more timbered area. This does not mean, however, that more deer were present in these areas (Tables 23, 24, 25). The same advantage persisted through October, but in November Area III produced the best time to sighting ratio. This may have been due to an alteration in movement patterns or to the increased visibility due to the loss of foliage.

Adult bucks were the most difficult to see during all months and in each area, except during November in Area III. Here the large number of deer whose sex remained unknown may have been a biasing factor.

Area I was the best area as far as seeing deer, but the small numbers may not reflect the situation as accurately as the results in Areas II and III. Area II probably was the best all around area to hunt in while Area III produced the most bucks sighted per unit of time (Table 24).

It should be noted that these sightings were made during bowhunting hours. The average hunter spent about 2 hours either in the early morning, late evening or both. Iowa law allows hunting by bow from one-half hour before sunrise and one-half hour after sunset. It appears that this permits the hunter to take advantage of the "trickle" movement to and from feeding areas but these hours miss the peak movement which occurs later in the evening and earlier in the morning.

Table 23. Monthly record of deer sighted by hunters in three areas adjacent to Pilot Knob State Park during the 1970 bow hunting season

	September		October		November	
	Number deer sighted	Minutes required per sighting	Number deer sighted	Minutes required per sighting	Number deer sighted	Minutes required per sighting
Area I - West of Route 332						
Total deer	19	43.1	24	66.8	1	135
Male	2	410.0	3	535.0	1	135
Female	11	74.5	11	145.9	0	0
Unknown	6	136.6	10	160.5	0	0
Time in minutes spent by hunters	820		1605		135	
Area II - Between Route 332 and McGrady's Woods						
Total deer	34	173.6	31	356.6	30	223.0
Male	6	984.1	7	1579.2	9	741.6
Female	16	369.0	15	737.0	14	476.7
Unknown	12	492.0	9	1228.3	7	953.5
Time in minutes spent by hunters	5905		11,055		6675	
Area III - McGrady's and Bang's Woods						
Total deer	13	276.0	11	537.2	34	188.8
Male	7	591.4	0	-	11	583.6
Female	6	690.0	4	1477.5	6	1070.0
Unknown	2	2070.0	7	844.2	17	377.6
Time in minutes spent by hunters	4140		5910		6420	

Table 24. Record of deer sighted by hunters in three areas adjacent to Pilot Knob State Park during the entire 1970 bow hunting season

	Area I		Area II		Area III	
	Number deer sighted	Minutes required per sighting	Number deer sighted	Minutes required per sighting	Number deer sighted	Minutes required per sighting
Total deer	44	58.1	95	248.7	60	274.5
Male	6	426.6	22	1074.3	18	915.0
Female	22	116.3	45	525.2	16	1029.3
Unknown	16	160.0	28	844.1	26	633.4
Time spent in minutes by hunters	2560		23,635		16,470	

Table 25. Total deer sighted for the three areas combined during the 1970 bow hunting season

	Number deer sighted	Minutes required per sighting
Total deer	199	214.3
Male	46	927.5
Female	83	514.0
Unknown	70	609.5
Time spent in minutes by hunters -	42,665[a]	

[a]One deer sighted for every 3.5 hours hunting.

Despite the handicaps, bowhunters in this area averaged one sighting for every 3.5 hours in the field. They sighted one buck every 15.4 hours and a known adult doe every 8.6 hours (Table 25). The buck sighting is actually high when one considers that a theoretically even sex-ratio plus fawns (usually twins) would put the herd at 3 antlerless deer to each antlered one.

b. Hunter success Five deer were known bagged by shotgun hunters in the vicinity of the park in 1969. Twenty were known bagged in 1970, 10 by bowhunters and 10 by shotgun hunters, and 22 were harvested in 1971; 17 by bowhunters and 5 by shotgun hunters (Table 26).

The bowhunters killed a total of 15 adult males, 5 adult females, 3 male and 4 female fawns. Although the sample size was small, selection for adult males by bowhunters was indicated because, on the average, only one of four deer in the population is an adult male.

Shotgun hunters killed a total of 5 adult males, 8 adult females and 4 male and 3 female fawns. These data indicate a more random harvest by shotgun hunters which was to be expected due to the greater shooting distance involved and the short season.

Figures giving the deer kill for the state of Iowa show that during 1970 and 1971 fawns constituted more than 45 per cent of the kill (Gladfelter 1972). Fawns made up 35 per cent

Table 26. Deer harvested in the vicinity of Pilot Knob State Park, Iowa, by bow and shotgun hunters during 1969, 1970, and 1971 seasons

	Bow hunters				Shotgun hunters				
	Adult		Juvenile		Adult		Juveniles		
	Male	Female	Male	Female	Male	Female	Male	Female	Total
1969						4	1		5
1970	4	3	1	2	4	2	2	2	20
1971	11	2	2	2	1	2	1	1	22
Total	15	5	3	4	5	8	4	3	47

of the kill for bowhunters and 47 per cent for shotgun hunters. Apparently bow hunters were selecting for older deer.

2. Highway mortality

During 1970 and 1971, 90 deer were known to have been killed by automobile in Winnebago and Worth Counties, Iowa (data obtained from Wilfrid Macheak, conservation officer). Deer killed included; 23 adult males, 30 adult females, 20 male fawns and 17 female fawns (Table 27). Nine deer were not identified by age and/or sex.

Two peak periods were found when kill data was examined. They were: spring, March-May; and fall, October-December. The spring period encompasses the time when deer are dispersing from wintering areas, family groups are breaking up and gravid females are looking for a fawning area. The fall period encompasses the rutting period and the time when cover is being removed as a result of crop harvesting.

A total of 37 deer were killed during the 1970 and 1971 spring period. Fifteen of those killed were adult females, 8 were adult males and 14 were fawns (Table 27). This contrasts with the fall period when 34 deer were killed (Fig. 37). Nine of the deer killed then were adult females, 12 were adult males, and 13 were fawns. More adult females were killed in spring and more adult males were killed during fall. This corresponds to increased movement by adult

Table 27. Summary of highway mortality for 1970 and 1971 by month, age and sex[a]

	1970					1971						Total 1970-71			
	Adult		Fawn		Total	Adult		Fawn		Total	Total	Adult		Fawn	
Month	M	F	M	F	1970	M	F	M	F	1971	1970-71	M	F	M	F
Jan.	1	0	1	0	2	0	0	1	0	1	3	1	0	2	0
Feb.	0	2	0	1	3	0	0	0	0	0	3	0	2	0	1
Mar.	1	3	1	1	6	1	7	2	0	10	16	2	10	3	1
Apr.	1	0	3	3	7	1	0	1	2	4	11	2	0	4	5
May	2	3	0	0	5	2	2	1	0	5	10	4	5	1	0
June	2	1	0	0	3	0	1	0	0	1	4	2	2	0	0
July	0	1	0	0	1	0	0	1	1	2	3	0	1	1	1
Aug.	0	0	0	2	2	0	1	0	0	1	3	0	1	0	2
Sept.	0	0	1	1	2	0	0	1	0	1	3	0	0	2	1
Oct.	1	1	2	0	4	0	0	0	0	0	4	1	1	2	0
Nov.	7	5	0	1	13	3	0	3	2	8	21	10	5	3	3
Dec.	1	2	2	2	7	0	1	0	1	2	9	1	3	2	3
Total					55					35	90	23	30	20	17

[a]Data obtained from the records of Wilfrid Macheak, conservation officer for Winnebago and Worth Counties.

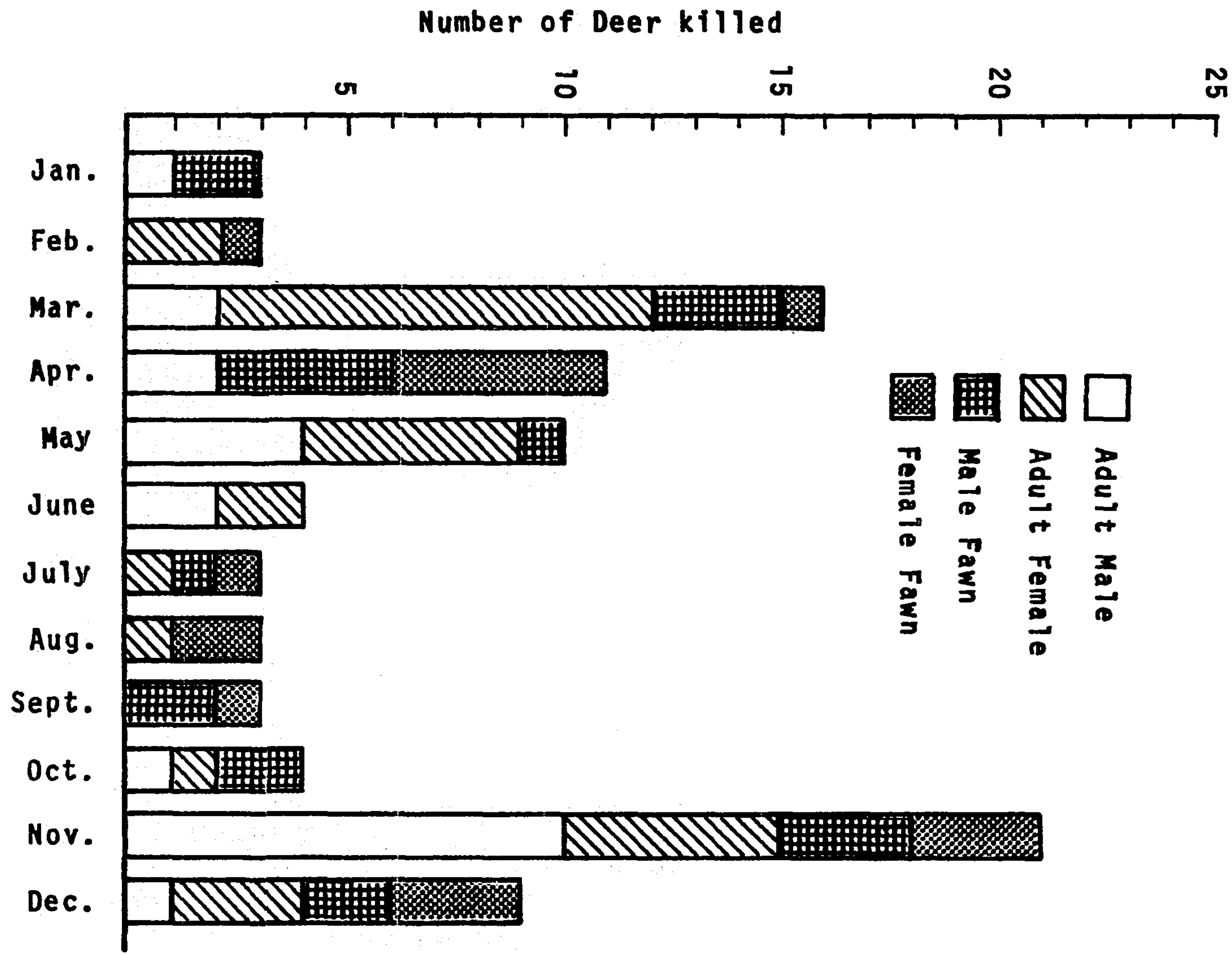


Fig. 37. Summary of highway mortality for deer killed in Winnebago and Worth Counties during 1970 and 1971

females in spring as the fawning period approaches and the increased movement of males in fall during the rut. Juveniles appeared equally vulnerable during both periods.

Generally, for the state as a whole, the fall kill exceeds that for spring (Gladfelter 1972). The fact that this does not appear so in the Pilot Knob area suggests that deer may be concentrated in the park during winter and suffer higher mortality as they disperse in spring.

3. Life table

Lower jaws were collected from 51 deer killed by hunters or by car during the 1969-72 period and aged according to Severinghaus (1949). Aged deer from all 3 years were then placed in appropriate age classes and included in a time-specific life table according to Quick (1963) (Table 28).

The fact that jaws from deer in the 3-1/2 and 4-1/2 year old age classes were collected indicates that deer in the study area were not as vulnerable as in some regions of Iowa. Life expectancy of a fawn was 1.78 years. For Iowa as a whole it is 1.40 years and for zone 5, which includes the park, 1.52 years. Sample size was small but indicates a greater life expectancy for deer in the fawn through 3-1/2 years old age classes in the vicinity of the park.

The mortality rate for fawns was 43 per cent and death was evenly distributed between male and female fawns.

Table 28. Time specific life table for deer killed in the vicinity of the Pilot Knob State Park study area (Quick 1963)

Age class	Deer killed	Deer killed per 1000	Deer surviving per 1000 at beginning of age class	Mortality rate	Mean number alive between age classes	Mean life expectancy
x	d'x	dx	lx	qx	Lx	ex
Fawns	15	429.0	1000.0	0.429	785.5	1.78
1-1/2	6	171.0	571.0	0.299	485.5	1.75
2-1/2	6	171.0	400.0	0.427	314.5	1.04
3-1/2	5	143.0	229.0	0.624	157.5	0.87
4-1/2	3	86.0	86.0	1.000	43.0	0.50

Therefore 22.0 per cent of the female fawns died during the period. It is generally accepted that 75 per cent of Iowa's fawns breed. Thus the 21.5 per cent mortality rate among fawns has significant impact on the ability of the population to increase.

For yearlings the mortality rate was lower, 30 per cent, but increased for all subsequent ages. No animals older than 4-1/2 years were aged.

R. Frequency of Occurrence of Group Sizes

Seven categories were established to represent the numbers of deer sighted together. They ranged from one deer to over six deer in a group. In all three winters single deer were sighted most frequently (Table 29). For all three periods groups of two or three deer were sighted about the same number of times (247 and 207 respectively). The frequency of sightings decreased steadily as group size increased until the category for over six deer in a group was reached. The increase at this level can be explained by considering when these large groups were sighted. Generally over six deer were sighted together while feeding in the open croplands at night. They were not found bedded together during the day.

A chi-square test was performed to see if there was a significant interaction between the frequency of occurrence for group size and period. The results were significant

Table 29. Frequency of occurrence of deer in 7 categories of group size by period

Group size (No. of deer)	1969-70 frequency	1970-71 frequency	1971-72 frequency	Total 1969-72
1	181	240	426	847
2	63	92	92	247
3	47	51	109	207
4	25	21	53	99
5	6	14	22	42
6	3	3	17	23
over 6	9	26	72	107
Total	334	447	791	1572

indicating that the frequency of sightings by group size was not consistent during the three periods (X^2 = 39.1, 12df, Prob. $X^2 < 0.05$). A nearly equal ratio would be expected in a closed system or more realistically in a situation where deer were endemic to an area. In this situation an influx of deer occurred during each winter. Deer outside the park are very vulnerable to hunting and as a result the composition of the herd inhabiting the park each winter is subject to broad fluctuation.

S. Aerial Census

Aerial censuses to count deer in the park and on land immediately surrounding it were taken during early and late winter in 1969-70, 1970-71, and 1971-72. Results of the counts are shown in Table 30. In each year, more deer were observed in and around the park during late winter than during early winter. This suggests that deer are forced to leave less suitable habitat as winter progresses in favor of better habitat provided by the park. This was especially evident in the winter of 1971-72. An aerial count was made on December 3, 1971; one day before the opening of the shotgun season for deer. Thirty-five deer were counted in and around the park. Five deer were subsequently killed by shotgun hunters and one by a bowhunter leaving 29 deer remaining in the area. An aerial count taken on February 15, 1972, revealed 69 deer in and around the park.

Table 30. Results of aerial counts of deer made during early and late winter during 1969-1972 at the Pilot Knob study area, Iowa

	Early winter			Late winter		
Winter	Inside park	Near park	Total	Inside park	Near park	Total
1969	32	9	41	30	16	46
1970	30	9	39			49[a]
1971	24	11	35[b]	34	35	69

[a]Count made by a conservation officer.

[b]Count made prior to the shotgun season for deer.

VI. DISCUSSION

A. Daily Range and Movement of Deer in Relation to Pilot Knob

Each of the 12 deer equipped with radio-telemetry devices used the timber within and immediately surrounding the park for bedding during daylight hours. The use of timber by non-yarding deer in agricultural areas was discussed by Murphy (1968). He felt the lack of timber limited potential for population increase. Lack of timber is a problem in the four counties surrounding the park because, at present, less than 1 per cent of their land is timbered.

During the dusk period deer moved out of the timber and into the surrounding croplands to feed on waste corn and soybeans. Buxton (1951), Erickson et al. (1961), Korschgen (1962), Mustard and Wright (1964), Nixon and McClain (1968), Nixon et al. (1971) and Watt et al. (1967) found corn a staple in the diet of midwestern deer. Of the 851 telemetrically determined locations for deer, 80 were in corn or soybeans. This number may not reflect the usage of croplands by marked deer because cold temperatures often prevented the investigator from obtaining readings at night when deer would be expected to be in crops.

During the years 1969-72, 4262 deer were located by direct observation or radio-telemetry. Of these, 2710 were outside and 1552 were inside the park. The frequency of occurrence per 10-acre grid decreased the further the grid was located from the park. Further emphasis on the role of the park as a nucleus of deer activity was given by known minimum daily movements of marked deer. The means for known minimum daily movements for the four periods studied were 1.11, 1.19, 1.11 and 1.35 miles respectively. This indicates a movement distance of approximately 0.60 mile from a bedding area like the park to feeding areas. Byford (1969) described daily centers of activity which had a radius of 0.78 mile.

Track surveys made along gravel or paved section roads also indicated that movement was restricted to a short distance from the park. During winter, roads located more than one-half mile from the park were rarely crossed by deer. This was not true of the other seasons.

B. Seasonal Range and Movement

Ten of the twelve deer marked at Pilot Knob during winter are known to have shifted their range when spring came. During the winter period the range of each deer remained quite constant but there was considerable variation in the range sizes of the group. Range size varied from 49 to 504 acres during the period of snow cover and from 155 to 1129 acres after the spring thaw. Home range sizes agreed with those found for white-tailed deer by Byford (1969), Kohn and Mooty (1971), Progulske (1960) and Sparrowe and Springer (1970). No significant effect on the size of the home range was found for period, age, period by age interaction or sex. This agrees with Sparrowe and Springer (1970) who found no difference in home range size by age or sex. The effect of age by sex interaction on range size was not significant at the 0.05 level but indicated a trend. Male fawns and adults tended to have larger ranges than female fawns and adults respectively.

Five deer were studied intensively during the winter of 1971-72 and subsequent spring period. One deer, a female fawn, shifted its range completely. Six deer studied in previous winters were also known to shift ranges completely. This agrees with Dahlberg and Guettinger (1956) and Pietsch (1954) who found their deer had distinct summer and winter ranges.

Another deer, an adult male, expanded its range by a factor of 13 plus when spring came. The new range included some of the winter range and grazed timber and cropland to the south (Fig. 25).

The remaining three deer shifted their ranges somewhat when spring came (Figs. 26, 27, 29). Channel 2, an adult doe, expanded her range slightly and two male fawns, channels 5A and 11, decreased theirs.

During both seasons, home ranges included both timber or brush for bedding and cover during daylight and croplands for feeding at night.

C. Yearly Range and Movement

Three types of movement involving a yearly change in range occurred at Pilot Knob; emigration (dispersal), immigration, and migration.

1. Emigration

Five marked deer were known to have emigrated from the park between 1969 and 1972. They included 1 male fawn, 2 female fawns and 2 adult females. Distances moved varied from 1 to 110 miles and occurred in each of the directions except north (Fig. 38). These results are in disagreement with Carlsen and Farnes (1957), Hahn and Taylor (1950), Progulske and Baskett (1958) and Thomas et al. (1964) who found that deer generally do not move more than 2 miles from their capture site. It is in agreement with Hawkins and Montgomery (1969), Hawkins et al. (1971), Pietsch (1954) and Sparrowe and Springer (1970) who found that subadult males moved farthest.

It appears from records of marked deer sightings in spring that dispersal is occurring along the waterways which provide the only cover in spring. Pietsch (1954) and Sparrowe and Springer (1970) found this to be true in areas where land practices are similar to those practiced on the study area.

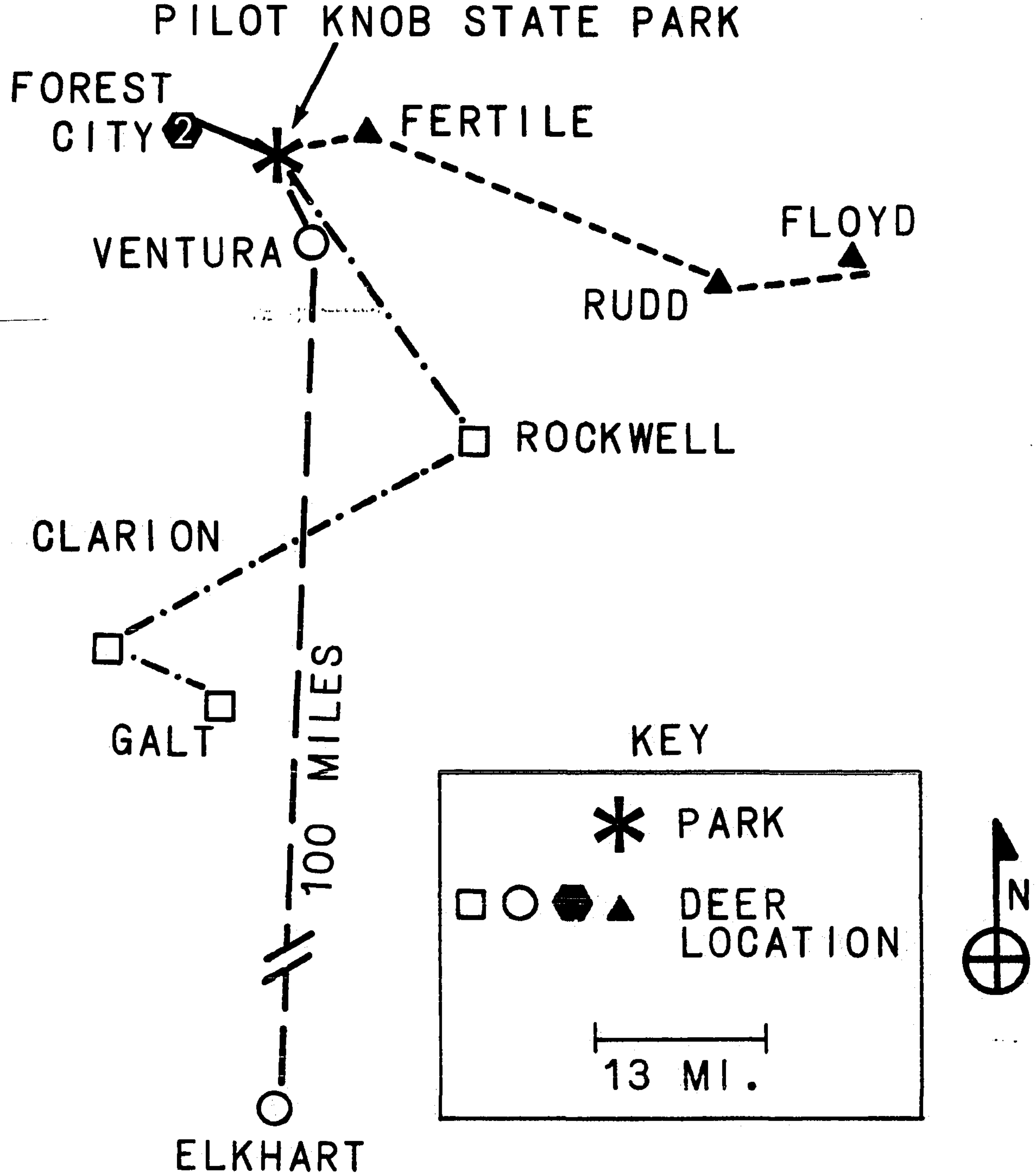


Fig. 38. Map showing dispersal of five deer from Pilot Knob State Park, Iowa

(Two marked deer were located at the Forest City site.)

2. Immigration

Aerial census counts taken in February were higher than those taken during January. This indicates that deer move into the study area as winter becomes more severe and habitat in outlying regions deteriorates.

Several deer were observed moving through croplands headed in the direction of the park during the shotgun hunting season. Deer outside the park were very vulnerable to hunting as indicated by the 50 per cent success rate for shotgun hunters. Once sighted, deer were often driven across the fields for miles. The only sanctuary from harassment was the park.

Movement involving immigration and emigration is indicated by road kill data. Road kill figures are low for summer and winter and high for spring and fall. Two possible explanations exist to this phenomena; a shift in range and the breeding season or fawning seasons.

The spring kill has a higher percentage of females than the fall kill. Both sexes are hunted in Iowa. Therefore, theoretically both sexes should be present in nearly equal numbers. The change in road kill percentages must therefore reflect a behavior pattern among adults. Females are looking for fawning areas in spring and males are searching for females in fall. In both cases deer are moving about more than usual and often through unfamiliar territory. Both facts enhance their chance of being struck by a car.

3. Migration

Two deer, both adult females, were known to have left the park in spring and returned the following winter. Channel 3, a yearling female when marked in the winter of 1969-70, left the park in spring. She and a fawn spent the summer west of the park. In late winter she and a fawn were observed feeding immediately north of the park. She was sighted west of the park the following summer and returned in late fall.

Channel 2 remained in the park as a yearling. In the summer of 1971 she was observed west of the park. When fall came, she was back in the park.

For deer that disperse short distances from the park in spring it seems logical that they would return in winter because of the scarcity of suitable habitat in the four-county area.

D. Crop Harvest

Crawford (1968) stated what effect the harvesting of crops has on midwestern deer by saying that there is a wealth of food and cover in summer but once crops are harvested little food or cover remains for deer. When only timber having an understory of brush is considered there are only 8 acres in 1000 of deer habitat in Cerro Gordo, Hancock, Winnebago and Worth counties. Little more needs to be said about the effect of crop harvest on the cover available for winter use by deer.

Nixon *et al.* (1971) adds to the seriousness of the winter habitat situation by prophesizing on the effects of fall plowing on available winter deer food.

E. Effects of Light and Weather on Movement

1. Sunrise and sunset

The number of deer sighted during the crepuscular periods was affected by sunrise and sunset times. For all deer, fewer animals were seen the farther one observed from the time of sunrise or sunset. In the morning it was too dark to see much before sunrise and shortly after sunrise deer were no longer visible because they had moved into the timber to bed. This did not hold for adult males. Apparently they returned to cover earlier than adult females and fawns and were, therefore, nearly absent from the sample.

During the period from shortly before until after sunset, more deer were seen after than before sunset. Again this effect was not significant for males which apparently moved after it is too dark to be observed.

Track counts made along the routes taken by deer while going to and from feeding indicate that the majority of deer moved too early in the morning and too late in the evening to be observed.

2. Wind velocity

Dasmann (1954) and Loveless (1964) stated that deer move out of strong winds for protection. Results in this study indicated that at dusk more deer were observed moving into the exposed croplands when the wind velocity increased. At dusk deer moved out to feed earlier when temperatures were colder. However, they did not return to the timber later in the morning due to cold.

3. Wind direction

Wind direction affected movement in the morning but not at night. More deer were sighted in the morning moving south past the investigator when the wind was from the north. At night deer were apparently not affected by the wind direction as they moved north to feed.

Wind did not appear to affect the selection of nocturnal bedding sites in the exposed cropland. The deer on this study area are in excellent health as indicated by the lack of adult males with "spike" antlers (French *et al*. 1955 and Murphy 1968) and the high reproductive rate of fawn and adult females (Cheatum and Severinghaus 1950). Moen (personal communication 1971) felt that cold had very little influence on midwestern deer because of their high nutritional plane.

4. Lunar phase

Lunar phase did not affect the number of deer sighted. This is in contradiction to results obtained by Buss and Harbert (1950) who sighted more deer at a salt lick when the moon was full. Possibly the ability to see and not the influence on the deer is being measured here.

F. Management

If the policy of Iowa's Conservation Commission is to increase the present herd and sustain the increase while allowing hunting, deer must be made less vulnerable. This could be accomplished by increasing the number of refuges in the state and by protecting the functional ability of existing ones in some instances.

It has been established that deer occupy a mean home range size of 283 acres in winter with a standard deviation of 244 acres. This mean range must include both timber and cropland. Deer occupying the park in winter tend to disperse in spring and repopulate the surrounding land. It would seem essential that additional tracts be set aside across the state to serve as buffers during critical periods, especially in areas of intensive agriculture and sparse woodland cover.

Deer are more active and thus more vulnerable at sunrise, sunset and, to some extent, at noon. The current gunning hours eliminate legal harassment of deer during these periods and thereby increase the chances of survival for deer.

Snow cover increases the chances of sighting a deer. On the average, 1.79 more deer were observed per sighting with snow than without it. Here the issue becomes, should the season be set earlier to attempt to avoid snow cover in the northern zones, or later to increase the chance of snow and therefore the recovery of crippled animals.

On the average, more deer were observed per sighting in open cover as opposed to dense cover. More dense cover is available before the crops are harvested. Therefore a decrease in the deer kill could be anticipated with an earlier season. Timing would be critical because farmers would not appreciate having shotgun hunters using rifled-slugs in the field while harvesting corn or soybeans.

Adult bucks were the most difficult deer to see and would probably be equally difficult to bag. A possible solution to eliminating the high percentage of fawns in the kill (45%) and low life expectancy of fawns (1.40 for the state, 1.78 for the study area) would be to institute a bucks only season, in conjunction with other protective measures, on a temporary basis.

Deer exhibited a preference for the cropland north of the western half of the park. This may have been due to less harassment, more fertile soil or some unknown factor. Their freedom of choice is currently in jeopardy, however. The Forest City Development Company has purchased an option on the land one-half mile north of the park and intends to develop two 18-hole golf courses and construct 200 housing units. The externalities associated with their proposal in combination with the completion of highway I-35, the mobility of an increasing number of recreationists and the expansion of the park's lake are difficult to access. One thing is certain, however; the man-days use of the park will increase. This does not pose the threat to the deer that the appreciated property values of the croplands peripheral to the park does. Commercial development of those lands could truly render the park an island and as an island its capacity to serve as a wintering area for deer will be greatly reduced.

VII. SUMMARY

The over-riding objective of the study was to provide information on home range size and daily, seasonal and yearly movement of white-tailed deer in relation to Pilot Knob State Park, Iowa. Field work on the 368.8-acre park and surrounding land was conducted primarily during the winters 1969-70 through 1971-72 and the spring of 1972.

A. Marked Deer

A total of 13 individual deer was captured, 10 by trap and 3 with nicotine salicylate. One deer, a male fawn, died during the process of handling. Fawns required 109 trap nights per capture and adults 255 trap nights. No adult males were trapped. The most successful trap was located in a remote area of the park seldom visited by man during winter.

Ten deer were darted with nicotine; three were immobilized. Nicotine dosages of 2.1 to 2.5 mg per pound estimated body weight completely immobilized 2 deer while 5 others failed to go down with similar dosages.

Metal and rubber ear tags were used to mark deer. Rubber tags were quicker to attach in the field, and none had been lost when field studies were terminated. Collars were the most durable of the markers used. The effective broadcasting life of batteries used to power the transmitters increased from a mean of 71 days to one of 130 days when batteries with tabs were used to reduce heat damage while soldering.

Ranges of all marked deer included timber inside and outside the park and cropland outside the park. Deer were generally located bedded in timber during daylight and feeding or bedded in the cropland at night. Eighty locations for marked deer were in cropland and 771 were in brush or timber.

During the winter of 1969-70, three deer occupied a total range of 290 acres having a major axis length of 1.12 miles. Average known minimum daily movement for this period was 1.17 miles. Two of three marked deer dispersed from the study area in spring.

Four deer marked during the winter of 1970-71 occupied a seasonal range of 448 acres with a major axis length of 1.52 miles. Average known minimum daily movement for this period was 1.15 miles. In spring, five of six marked deer known to have been on the study area during winter left.

During the winter of 1971-72, six marked deer occupied a total winter range of 562 acres having a major axis length of 1.87 miles.

During the period of snow (winter 1971-72) the average range size for six deer was 276 acres with a major axis 1.37 miles long. Minimum daily movement for that period was estimated at 1.02 miles. After the snow had melted, the average range size was 348 acres with a major axis 1.71 miles in length. Estimated minimum daily movement was 1.28 miles.

Two of six marked deer known to have utilized the park during winter left in spring. Dispersal over the 3-year period ranged from 1 to 110 miles. Spring dispersal was also indicated by the increase in highway mortality experienced by deer during March, April and May.

A regression analysis was performed to determine if the unique effect of certain independent variables had a significant effect on the size of home range, length of major axis or minimum daily distance traveled by marked deer. Variables were considered to have a significant effect if the probability of getting a larger F-value was less than 0.05. Home range size and length of major axis were highly correlated (0.92). Therefore, results are only reported here for effects on home range.

The mean range size of 12 marked deer taken over the four study periods was 283 acres; standard deviation 244 acres. Range size varied from 49 to 1129 acres.

Variables tested for their effect on home range size, major axis length and minimum daily movement included: period, age, period by age interaction, sex and age by sex interaction. None of these variables were found to have a significant effect on home range size or major axis length.

The mean known minimum daily movement (round trip) for 12 marked deer over the four periods was 1.20 miles; standard deviation 0.57 mile. Known daily movement ranged from 0.60 to 1.76 miles.

For all periods, age and sex of the deer had no significant effect on daily movement. There was a significant relationship between the distance moved and the effect of period, period by age interaction and age by sex interaction.

When only periods three (snow) and four (no snow) were considered, age and age by sex interaction effects were not found to be significant. Effects of period, period by age interaction and sex were found to significantly affect minimum daily movement.

B. All Deer

During the period extending from December 1969 through April 1972, 4262 deer were sighted in 1552 observations for an average of 2.7 deer per observation (standard deviation 4.2). Of all deer sighted or located by telemetry, 1899 were adults and 2336 were known to be fawns. Eight-hundred fifty-seven sightings were recorded for antlered deer and 3376 for antlerless deer. There were 1478 sightings of bedded and 2783 sightings of active deer.

Of the 4262 deer sighted, 2710 were outside the park and 1552 were inside its borders. In the winter of 1971-72 more deer were located outside than inside the park. Increased use of the park during winter by snowmobilers and free running dogs may have been the causative factor in this phenomena. Deer were sighted more frequently in the 10-acre zones located close to the park than in more distant ones. Zones north of the park were used more frequently by deer than those south of the park. More zones were used during the winter of 1971-72 than in either of the two previous winters. Milder weather and a substantial increase in the deer population during late winter may have contributed to this expansion.

A regression analysis was performed to determine effects of various light and weather conditions on the numbers of deer sighted. A significant relationship to the number of deer sighted was found to exist with the effects of the following variables; time of sunrise, time of sunset, maximum temperature, minimum temperature, wind direction, wind velocity, and ground cover. These effects were not the same for all sex and age classes, and, in some instances different effects were observed for the dawn and dusk periods.

Deer exhibited three major periods of activity; dawn, mid-day, and dusk. A higher percentage of deer observed was found bedded, as opposed to active, during periods prior to and following peak periods of activity.

Animals observed during the study demonstrated a preference for ungrazed over grazed timber for bedding. They avoided open pasture and used sumac, an edge species, for cover while moving to and from exposed feeding areas during crepuscular periods. Major trails used by deer while traveling between bedding and feeding areas were shifted slightly each winter in response to changes in the crop pattern.

Deer living in the vicinity of the park were apparently less vulnerable to hunting and other mortality factors than deer in other areas of Iowa. Fawns on the study area were found to have a life expectancy of 1.78 years. For the state of Iowa their life expectancy is 1.4 years (Gladfelter 1972). This is true in spite of heavy hunting pressure adjacent to the park. Deer were found to move into the study area during winter resulting in an increase in herd size. The frequency of observation of deer in various group sizes differed significantly by period. This indicated that deer were not occurring as often in structured family groups as would be expected in a closed system. Possibly the influx of deer from surrounding areas during winter contributed to this. Many of the immigrating deer no longer belong to family groups following the hunting season.

Deer have demonstrated a need for timber and cropland. At present, the cropland surrounding the park is adequate for their needs. Changing economic conditions in the area and increased emphasis on recreation via camping pose a threat to the status quo, however. Land bordering the park has already caught the eye of the speculator and is being developed for residential and recreational purposes. The remaining timber and cropland bordering the northern boundary of the park should be secured by the state to serve as a buffer to development peripheral to and within the park.

This land could be devoted to meeting the food and cover needs of wildlife and at the same time insure Eugene Secor's dream of 1924: "May the Knob never be tarnished by artificiality" (Iowa State Board of Conservation 1925).

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X. APPENDIX I: LIST OF PERSONS CONTRIBUTING TO THE PURCHASE OF LAND FOR PILOT KNOB STATE PARK, IOWA[1]

For the purpose of creating a Park area I hereby give my check for $____, which is for the purpose of purchasing ___ acres of the Pilot Knob quarter at $70.00 per acre. It being understood that this subscription is void and the amount to be returned to me if a sufficient amount is not raised to insure the establishment of a Park.

1 acre - $70.00 Pd.

Emory J. Oleson
M. M. Thompson
M. J. Wolfs
Throwald Thorson
Oliver Gordon
O. E. Gunderson
R. R. Jacobs
T. Jacobs
G. M. Whiteis
D. C. Keasey
A. C. Hanson
R. C. Plummer
Nina Secor
O. N. Gjellefald
H. R. Irish
Tom Boynton
Thos. Lucast
Fertile Sav. Bank
W. A. Olson
O. B. Anderson
H. L. Taylor
O. Rislow
Paul L. Thompson
H. M. Ehred
R. B. Gunn
A. A. Lein
Burt J. Thompson
C. J. Anderson
Larson-Charlson
Jasper Thompson
R. M. Clark
M. C. Wheeler
Geo. M. Dickson
Kloster & Branstad

1 acre - $70.00 Pd.

A. E. Clauson
L. R. Perry
H. R. Cleophas
G. I. Koto
H. K. Nelson
A. A. Sanden
E. F. Guendling
W. C. Haugland
A. M. Clauson
Roy Wisely
L. T. Thompson
Halvor Haagenson
J. F. Thompson
N. T. Thurston
N. I. Gas & Elec. Co.
Isaac Sweigard
G. E. Kloster
L. E. Peterson
J. L. Wheeler
F. M. Hanson - Garner
O. J. Rusley
Alan Loth
O. K. Olson
F. W. Russell
Thompson & Anderson
Richard Beckman
E. L. Anderson
Ora J. Peterson
Fred Katter
Nathan Brones
M. C. Wheeler
Thompson Yards
B. A. Plummer

[1]Copied from a list provided by Ray Turner, custodian at Pilot Knob State Park (1969).

1/2 acre - $35.00 Pd.
I. W. Dahley
W. R. Prewitt
F. E. Hussong
L. T. Skrivseth
J. P. Neist
W. K. Skinner
Albert Field
Arne Sogard
Sheimo & Jones - Fertile
Isabelle Aaumodt
Mrs. G. W. Beadle
Julia Beadle
Andrew Christenson
L. F. Nelson
V. J. Babbitt
C. K. Nelson
John E. Anderson
Draper & Jenson
A. A. Johnson - Fertile
Matt Olson
Charles Drugg
Nels Miller
Emil Hawkinson
Clarence Halverson - Fertile
A. O. Johnson - Fertile
Carl Gustafson
C. E. Robinson
Edw. Pinckney
B. C. Conner
Otto Beckjorden
A. M. Thurston
Osmund Hylen
P. H. Vesterborg
Geo. Lundberg
Albert Lundberg
Mary Lundberg
Wm. Watson
John A. Olson
Frank Lundberg
M. E. Terry
N. P. Hanson
F. P. Oleson
Thov. Thovson
A. B. Berhow
S. B. Durant
John A. Johnson
Andrew Teigen
A. K. Felland - Joice

1/2 acre - $35.00 Pd.
Martin Samuelson
J. V. Vrba - Garner
J. W. Surball
A. R. Butler
Thomas Olson
H. J. Olson
P. J. McGuire
Adolph Groves
R. W. Foge
Ole L. Halvorson
H. F. Thompson
H. M. Jensen
H. H. Eichoren
T. A. Haugen
Amil Johnson
Geo. Osmundson
F. R. Lackore
R. E. Hanson
J. S. Akeson
O. K. Maben
Bick Conner
R. E. Burman
K. J. Hanson
C. H. Kelley
Wm. C. Hanson
P. H. Olson
Ole Thompson
J. S. Gettis
B. G. Gunhus
Phil Kirch
W. G. Hallett
A. L. Lunstrum
Oscar Roalson
Ola Kingland
J. G. Field
E. J. Indvik
Oscar Indvik
J. J. Sowr
Al Taylor & Waldeck
John Holst
A. A. Elthon
Wm. Lindberg
Edd Elias

XI. APPENDIX II: LIST OF MAMMALS ENCOUNTERED ON THE AREA

Nomenclature based on Miller and Kellogg (1955)

Common name	Scientific name
Chipmunk	*Tamias striatus*
Deer, white-tailed	*Olocoileus virginianus*
Deermouse, prairie	*Peromyscus maniculatus*
Dog	*Canis familiaris*
Fox, red	*Vulpes fulva*
Fox, grey	*Urooyon* cinereoargenteus
Mouse, House	*Mus musculus*
Opossum	*Didelphis marsupialis*
Rabbit, cottontail	*Sylvilagus floridanus*
Raccoon	*Procyon lotor*
Skunk, prairie spotted	*Spilogale interrupta*
Squirrel, fox	*Sciurus niger*

XII. APPENDIX III: LIST OF TREES AND SHRUBS FOUND AT THE PILOT KNOB STUDY AREA, IOWA

Nomenclature based on Fernald (1950)

Common name	Scientific name
Ash, black	Fraxinus nigra
Ash, green	Fraxinus pennsylvanica
Ash, prickly	Xanthoxylem americanum
Basswood	Tilia americana
Bitternut hickory	Carya cordiformis
Bittersweet	Celastrus scandens
Box elder	Acer negundo
Butternut	Juglans cinerea
Cherry, black	Prunus serotina
Cherry, choke	Prunus virginiana
Corn	Zea mays
Cottonwood	Populus deltoides
Dogwood	Cornus racemosa
Elm, American	Ulmus americana
Elm, slippery	Ulmus rubra
Hackberry	Celtis occidentalis
Hawthorn	Crataegus sp.
Hazelnut	Corylus americana
Ironwood	Ostrya virginiana
Lead plant	Amorpha fruticosa
Meadowsweet	Spirdea latifolia
Oak, bur	Quercus macrocarpa
Oak, northern pin	Quercus ellipsoidalis
Oak, red	Quercus rubra
Oak, white	Quercus alba
Plum	Prunus americana
Poison ivy	Rhus radicans

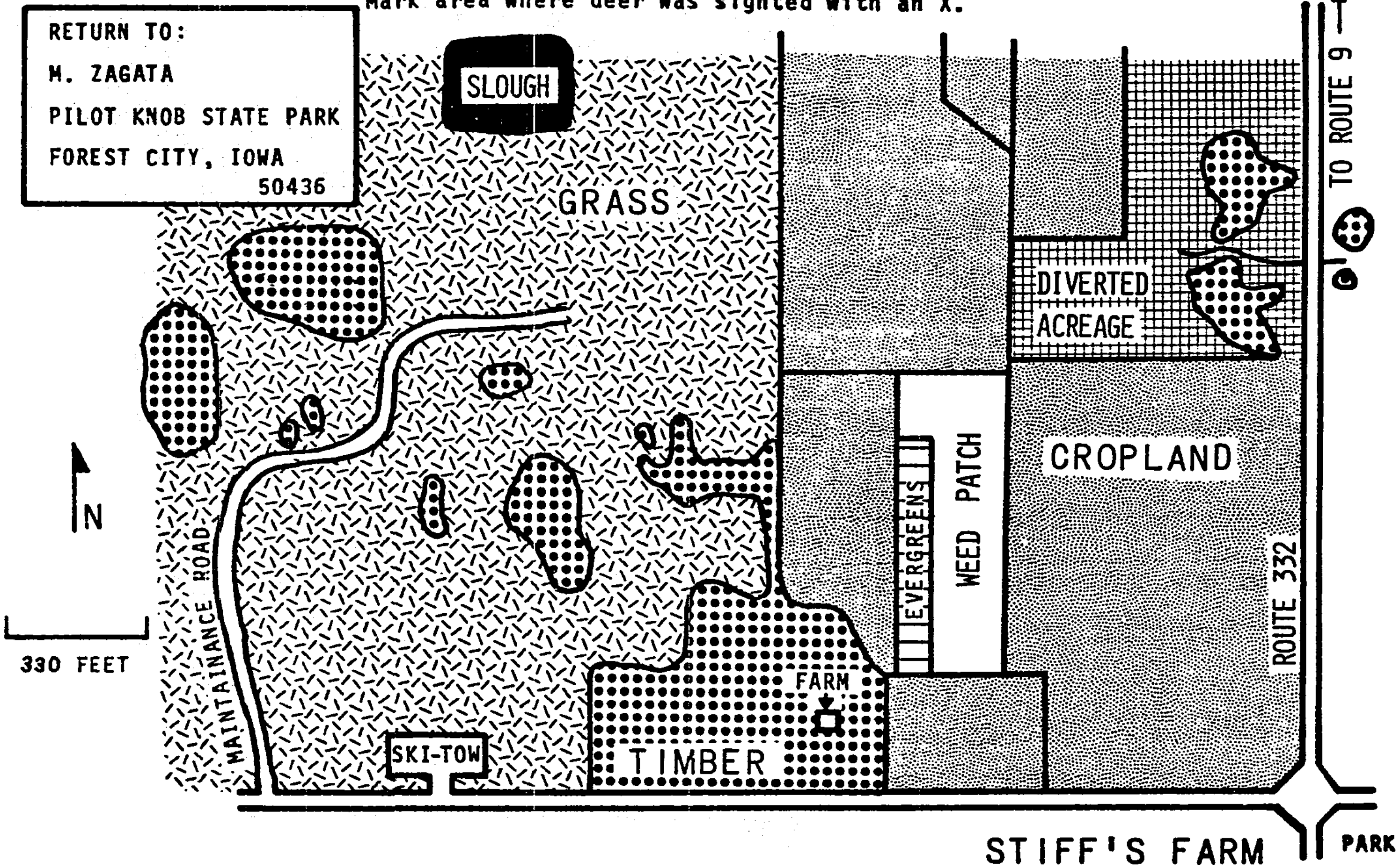
Nomenclature based on Fernald (1950)	
Quaking aspen	*Populus tremuloides*
Rose	*Rosa sp.*
Service berry	*Amelanchier canadensis*
Soybeans	*Glycine sp.*
Sumac	*Rhus, typhina*
Walnut	*Juglans nigra*
Wild grape	*Vitis vulpina*

XIII. APPENDIX IV. MAPS WITH QUESTIONNAIRES GIVEN TO BOWHUNTERS HUNTING IN THE VICINITY OF PILOT KNOB STATE PARK, IOWA (a, b, c)

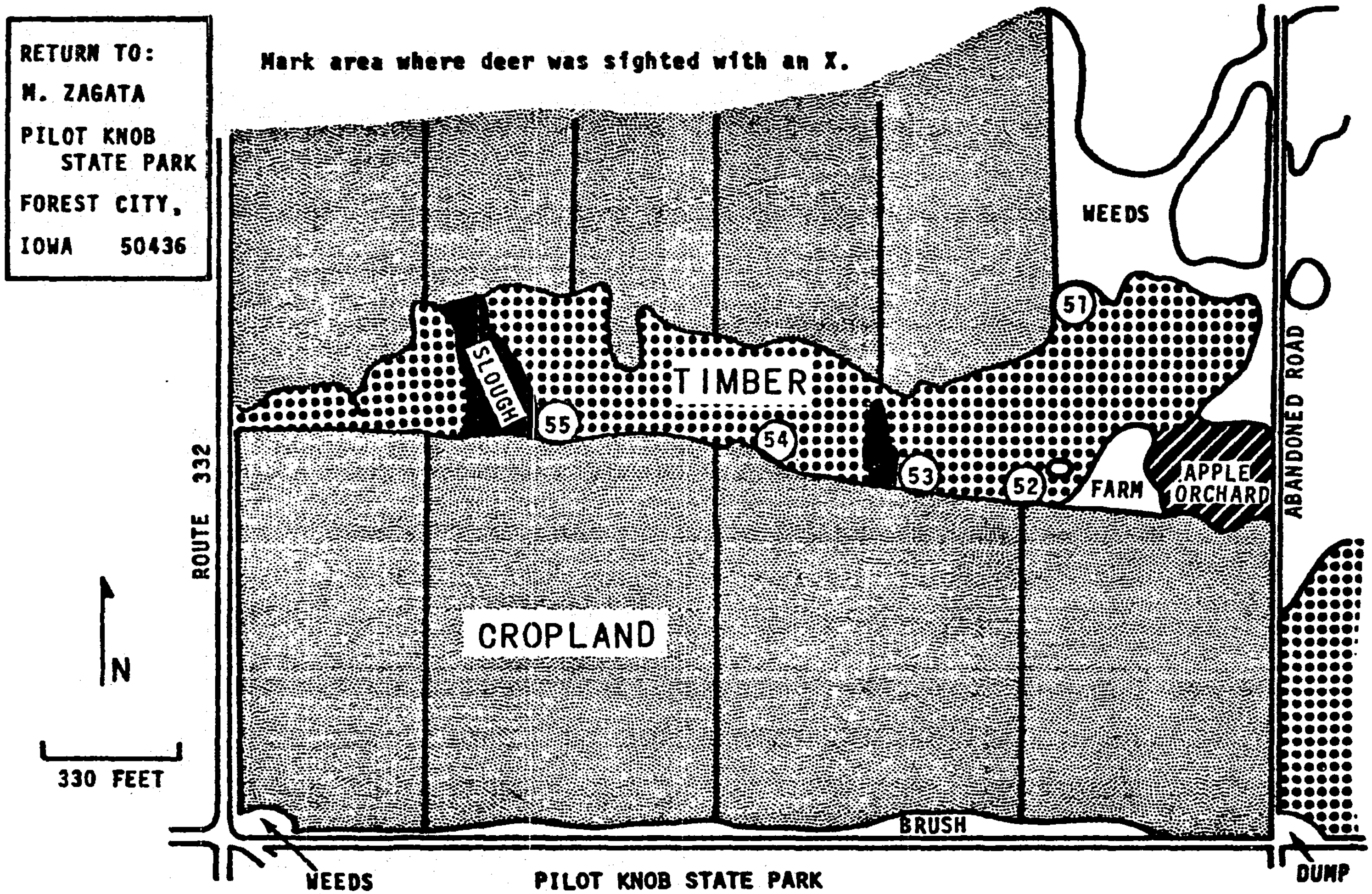
NAME ______ NO. DEER SIGHTED ______ ANTLERED ______ ANTLERLESS ______ UNKNOWN ______

TIME SIGHTED ______ DATE ______ ADULT DEER ______ JUVENILE ______ TIME SPENT IN FIELD ______
CENTRAL STANDARD (even if no deer sighted)

Mark area where deer was sighted with an X.



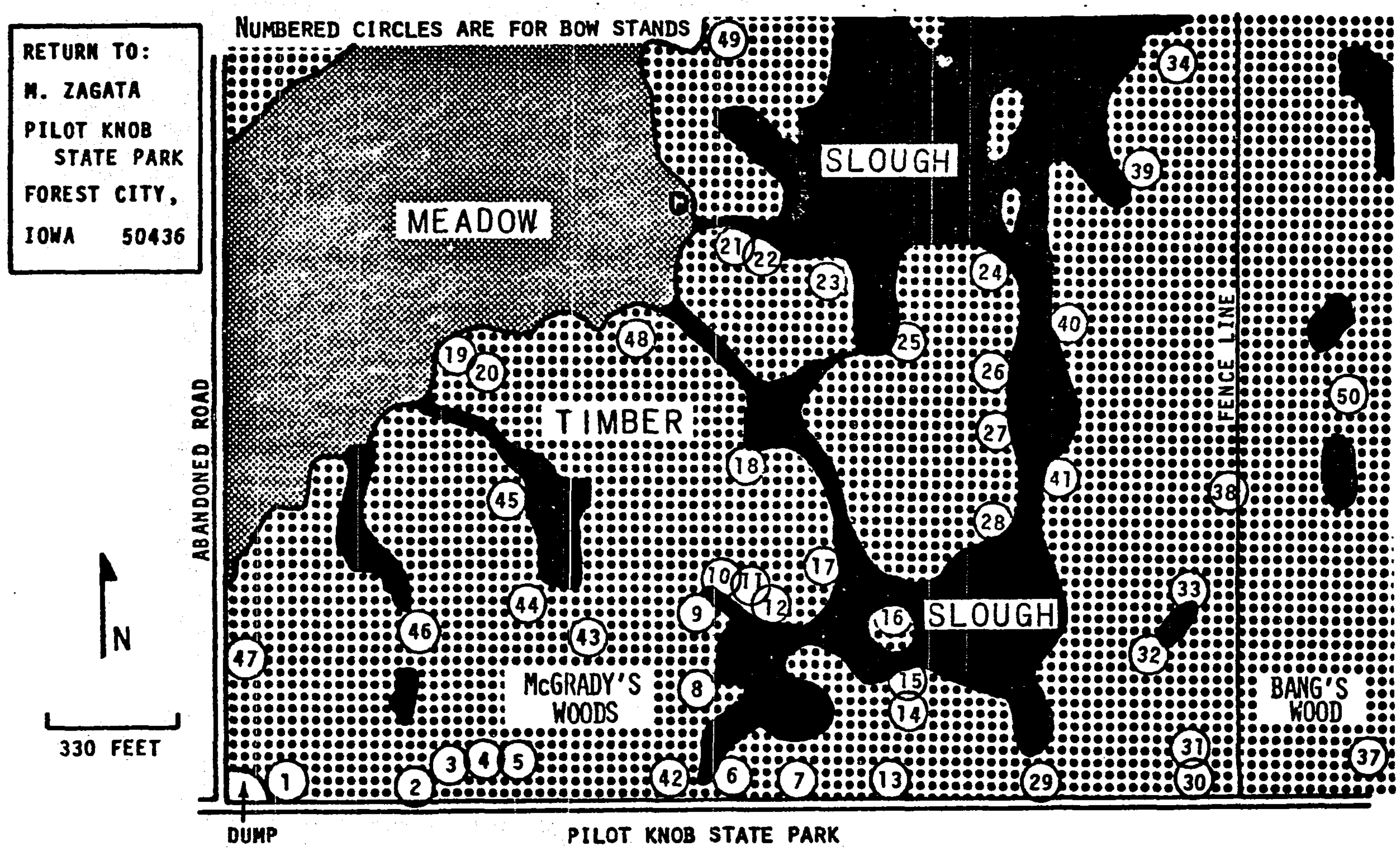
Map a



NAME ____________ NO. DEER SIGHTED ______ ANTLERED _____ ANTLERLESS ______ UNKNOWN ________

TIME SIGHTED __________ DATE __________ ADULT DEER _____ JUVENILE _____ TIME SPENT IN FIELD ______
CENTRAL STANDARD (even if no deer sighted)

Map b



NAME ______________ NO. DEER SIGHTED _____ ANTLERED _____ ANTLERLESS _____ UNKNOWN _____

TIME SIGHTED __________ DATE __________ ADULT DEER _____ JUVENILE _____ TIME SPENT IN FIELD _____
CENTRAL STANDARD (even if no deer sighted)

Mark area where deer was sighted with an X.

Map c

XIV. APPENDIX V. PUNCH CARD FORMAT FOR DATA ON THE EFFECT OF SUNRISE-SUNSET TIME, LUNAR PHASE AND WEATHER VARIABLES ON TIME OF DEER MOVEMENT DURING CREPUSCULAR PERIODS

1. Date

   Day: 1 2 — Month: 3 4 — Year: 5 6

2. Sunrise-sunset time

   7 8 9 10

3. Observation time

   11 12 13 14

4. Site

   15

   1. Camp area
   2. Orchard
   3. Grid 10

5. Location

   16 17 18

6. Number of deer observed

   19 20

7. Number of adults

   21 22

8. Number of juveniles

   23 24

9. Antlered

   25 26

10. Antlerless

    27 28

11. Unknown

    29 30

12. Lunar phase

    31 32

13. Temperature

    Maximum: 33 34 35 — Minimum: 36 37 38

14. Wind

    Direction: 39 — Velocity: 40 41

    1. N
    2. NE
    3. E
    4. SE
    5. S
    6. SW
    7. W
    8. NW

15. Nebulosity

<u>42</u> <u>43</u> <u>44</u>

16. Precipitation

Type	Amount
45	46
0 - none	0 = 0.0
1 - rain	1 = 0.0-0.245
2 - snow	2 = 0.25-0.495
3 - fog	3 = 0.50-0.745
	4 = 0.75-0.995
	5 = 1.00-1.245
	6 = 1.25-1.495
	7 = 1.50-2.995
	8 = 2.00-3.995
	9 = 4.00 on

17. Ground cover

Type Amount

<u>47</u> <u>48</u> <u>49</u>

1 = bare

2 = snow

18. P.M. or A.M.

<u>80</u>

1. A.M.
2. P.M.

XV. APPENDIX VI. FORM USED TO RECORD DAILY WEATHER INFORMATION

WEATHER DATA FROM MASON CITY AIRPORT

Month ______ Year ______

Date	Temp. Max.	Temp. Min.	Barometric pressure	Wind vel. & direc.	Precipitation	Total snow	Nebulosity
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

XVI. APPENDIX VII. FORMAT USED TO RECORD DATA REGARDING MINIMUM DAILY MOVEMENT ONTO PUNCH CARDS

1. Card number

   1 2 3

2. Blank

   4

3. Study period

   5

   1. Winter 1969-70
   2. Winter 1970-71
   3. Winter 1971-72
   4. Spring 1972

4. Blank

   6

5. Channel

   7 8

6. Blank

   9

7. Age

   10

   1. fawn
   2. adult

8. Blank

   11

9. Sex

   12

   1. male
   2. female

10. Blank

    13

11. Movement (inches)

    14 15 16

XVII. APPENDIX VIII. FORMAT USED TO RECORD DATA PERTAINING TO ACTIVITY, AGE, SEX, LOCATION AND BEDDING AREAS ON PUNCH CARDS

1. Card number

   1 2 3 4

2. Blank

   5 6

3. Sheet number

   7 8 9

4. Blank

   10

5. Date

   Day Month Year

   11 12 13 14 15 16

6. Study period

   17

   1. 1969-70
   2. 1970-71
   3. 1971-72

7. Hour

   18 19

   1 through 24

8. Number of deer

   20 21

9. Blank

   22

10. Marked or unmarked

    23

    1. marked
    2. unmarked

11. With other marked deer

    24

    0. no
    1. yes

12. Channel

    25 26

13. Age

Adult Juvenile

<u>27</u> <u>28</u> <u>29</u> <u>30</u>

14. Blank

<u>31</u>

15. Sex

Antlered Antlerless

<u>32</u> <u>33</u> <u>34</u> <u>35</u>

16. Blank

<u>36</u>

17. Sighted by

<u>37</u>

1. investigator
2. hunter

18. Blank

<u>38</u>

19. Activity

Bedded Active

<u>39</u> <u>40</u> <u>41</u> <u>42</u>

20. Zone

<u>43</u> <u>44</u> <u>45</u>

21. Inside or outside park

<u>46</u>

0. outside
1. inside

22. Topography

<u>47</u> <u>48</u>

1.	flat	7.	E slope
2.	knoll	8.	SE slope
3.	N-S ridge	9.	S slope
4.	E-W ridge	10.	SW slope
5.	N slope	11.	W slope
6.	NE slope	12.	NW slope
		13.	Valley

23. Blank

<u>49</u>

24. Cover type

<u>50</u> <u>51</u>

1.	ungrazed timber	6.	lake
2.	grazed timber	7.	meadow
3.	cropland	8.	sumach
4.	pasture	9.	bog
5.	slough	10.	camping & picnicking

25. Blank

52

26. Temperature

Maximum			Minimum		
53	54	55	56	57	58

27. Wind

Direction	Velocity	
58	60	61

1. N
2. NE
3. E
4. SE
5. S
6. SW
7. W
8. NW

28. Nebulosity

62 63 64

29. Precipitation

Type	Amount
65	66

0. none
1. rain
2. snow
3. fog

0 = 0.0
1 = 0.0-0.245
2 = 0.25-0.495
3 = 0.50-0.745
4 = 0.75-0.995
5 = 1.00-1.245
6 = 1.25-1.495
7 = 1.50-1.995
8 = 2.0-3.995
9 = 4.0 on

30. Ground cover

Type	Amount	
67	68	69

1. bare
2. snow

XVIII. APPENDIX IX. HOME RANGE SIZE, MAJOR AXIS LENGTH AND MEAN MINIMUM DAILY MOVEMENT OF MARKED DEER OVER FOUR PERIODS: WINTER 1969-70, WINTER 1970-71, WINTER 1971-72, SPRING 1972

	1969-70 Snow						1970-71 Snow					
	Fawn			Adult			Fawn			Adult		
	HR[a]	MA[b]	MDM[c]	HR	MA	MDM	HR	MA	MDM	HR	MA	MDM
Male							49	0.62	0.60			
Female	243	1.06	0.90	215	1.12	1.22	307	1.19	1.48	198	1.00	1.38
				200	1.12	1.39	145	1.00	1.15			

	1971-72 Snow						1972 No snow					
	Fawn			Adult			Fawn			Adult		
	HR	MA	MDM	HR	MA	MDM	HR	MA	MDM	HR	MA	MDM
Male	253	1.62	0.97	85	0.95	0.98	176	1.22	0.84	1129	2.85	1.62
	504	1.87	1.22	456	1.60		435	1.72	1.76			
Female	210	1.22	1.03	147	0.95	0.90	155	1.62		190	1.12	0.91

[a] HR = home range (acres).

[b] MA = major axis length (miles).

[c] MDM = minimum daily movement (miles).

XIX. APPENDIX X. DEER ACTIVITY FOR THE WINTERS 1969-1972 AS INDICATED BY FREQUENCY OF OCCURRENCE PER ZONE (Blank space indicates no deer sighted)

Zone[a]	1969-70 Active	1969-70 Bedded	1969-70 Total	1970-71 Active	1970-71 Bedded	1970-71 Total	1971-72 Active	1971-72 Bedded	1971-72 Total	1969-72 Total
8									1	1
10	14	5	19	3	1	4	0	2	2	25
11					1	1	1		1	2
19								1	1	1
20							4		4	4
21								1	1	1
22							1		1	1
25	1		1				1	1	2	3
26	1		1				5	3	8	8
27				1	1	2			2	4
40							1	2	3	3
41							1	2	3	3
42							4	1	5	5
43	3		3				1	2	3	6
48							2	3	5	5
49							1	2	3	3
51				1	1	2				2
52				5		5		1	1	6
53				1		1		5	5	6
54				1		1				1
55								1	1	1
56				1		1	2		2	3
61				1		1	1	2	3	4
62				1		1	6		6	7
63							1		1	1
74							1		1	1
75							1		1	1
76							7	6	13	13

[a]Refer to Fig. 4 for the location of the zone number with respect to the study area. Only zones where deer were sighted have been included.

Zone[a]	1969-70 Active	1969-70 Bedded	1969-70 Total	1970-71 Active	1970-71 Bedded	1970-71 Total	1971-72 Active	1971-72 Bedded	1971-72 Total	1969-72 total
77	4		4	2		2		1	1	7
78							2		2	2
80							1	1	2	2
81					1	1	2	5	7	8
82				2	2	4	9	9	18	22
83		1	1	2	4	6	4	1	5	12
84				1	5	6	1	5	6	12
85							4		4	4
86					1	1	1		1	2
87				4	3	7	3	3	6	13
88					2	2	6	2	8	10
89				2	3	5	2	4	6	11
90	1		1	1		1	6		6	8
91	4		4	1		1	2	3	5	10
92							2		2	2
93			2				14	1	15	17
94	1		1	1		1	1		1	3
95							2		2	2
96							3	4	7	7
97							1		1	1
109	3	1	4				1	2	3	7
110	1		1	1		1	8	5	13	15
111	2		2	4		4	7	5	12	18
112				1	3	4	5	5	10	14
113	4		4	4		4	16	3	19	27
114	6		6	4		4	6	1	7	17
115				13		13	6	2	8	21
116				12	1	13	3	3	6	19
117				5	1	6	3		3	9
118				2	1	3		1	1	4
119		1	1	1		1	1		1	3
120				41	2	43	10	2	12	55

Zone[a]	1969-70 Active	1969-70 Bedded	1969-70 Total	1970-71 Active	1970-71 Bedded	1970-71 Total	1971-72 Active	1971-72 Bedded	1971-72 Total	1969-72 Total
121				7		7	2		2	9
122		3	1	4	4	4	5		5	13
123	5	3	8	7		7	16		16	31
124	3		3	16		16	12	2	14	33
125				11		11	14		14	25
126	14	1	15	17	2	19	13	5	18	52
127	3	4	7	9		9	16	9	25	41
128	1		1	10		10	6	4	10	21
129	1	1	2	4		4	5	5	10	16
130				1		1	1		1	2
131				2		2				2
139							1		1	1
141	1		1							1
144	1		1	1		1				2
145	2		2	1		1	1	3	4	7
146	1		1	2		2				3
147	1		1				1		1	2
148	3		3	1		1	4	1	5	9
149				3		3	22		22	25
150	3	2	5	6	1	7	1	1	2	14
151							1		1	1
153				1	1	2	1		1	3
154							1	6	7	7
155					1	1	5	3	8	9
156	1		1	1	1	2		1	1	4
157	3	1	4	18	1	19	4		4	27
158	3		3				3		3	6
159	10		10	8		8				18
160	7	8	15	7	3	10	4	3	7	32
161	10	10	20	8	6	14	3	8	11	45
162	13	7	20	8	2	10	6	14	20	50
163	5	2	7	4	2	6	10	8	18	31

Zone[a]	1969-70 Active	1969-70 Bedded	1969-70 Total	1970-71 Active	1970-71 Bedded	1970-71 Total	1971-72 Active	1971-72 Bedded	1971-72 Total	1969-72 Total
164	7	5	12	2		2	2	2	4	18
165	1		1				8	9	17	18
166							5	4	9	9
167							3		3	3
168							1		1	1
169							5	8	13	13
172							1		1	1
174	2		2							2
175							2		2	2
176	2		2	13	2	15	18	5	23	40
177	5	4	9	3	3	6	6	1	7	22
178	4	2	6	3	2	5	5	5	10	21
179	6	5	11	5	5	10	3	7	10	31
180	8	6	14	5	6	11	7	4	11	36
181	2	1	3	3	1	4	3	4	7	14
182	7		7	1		1		3	3	11
183					2	2		1	1	3
184				2	2	4	3	1	4	8
185				2	1	3				3
186							1	2	3	3
187								1	1	1
188							2		2	2
189							1		1	1
190					1	1	1		1	2
191	1		1				2		2	3
192	1	1	2				1		1	3
193	3	1	4	1		1	2	3	5	10
194	2	3	5	1	2	3	1	1	2	10
195	4		4	5	3	8	5	4	9	21
196	7	10	17	3	2	5	3	4	7	29
197	8	5	13	2	5	7	3	14	17	37
198	10	9	19	4	5	9	3	8	11	39

Zone[a]	1969-70 Active	1969-70 Bedded	1969-70 Total	1970-71 Active	1970-71 Bedded	1970-71 Total	1971-72 Active	1971-72 Bedded	1971-72 Total	1969-72 Total
199	1	1	2	3	1	4	3	3	6	12
200							2		2	2
210							2		2	2
211					1	1				1
212							1		1	1
215	1		1				2	4	6	7
216	1		1	2		2		2	2	5
217	1	2	3	6		6	3	11	14	23
218	4	3	7	2		2	2	3	5	14
219							1	3	4	4
220							1	2	3	3
223							5		5	5
224							6		6	6
225							2	2	4	4
226								2	2	2
227							1		1	1
233				2		2	1		1	3
234				3		3	1		1	4
300[b]						1	9	19	28	29
Total grids with deer			61			85			133	

[b]Number used for any deer located within one mile of the study area.

XX. APPENDIX XI. AGE, SEX AND ACTIVITY OF DEER SIGHTED FOR EACH HOUR DURING THE WINTER OF 1969-70

Hour	Age		Antlered	Antlerless	Bedded	Active
	Adult	Juvenile				
0100	0	0	0	0	0	0
0200	0	0	0	0	0	0
0300	0	0	0	0	0	0
0400	0	0	0	0	0	0
0500	0	0	0	0	0	0
0600	1	0	0	1	0	1
0700	13	10	2	21	5	17
0800	20	15	2	33	9	26
0900	21	19	4	36	14	26
1000	26	20	6	40	30	16
1100	35	38	13	59	36	37
1200	38	33	5	66	26	45
1300	27	23	9	41	20	30
1400	41	61	10	92	70	32
1500	26	20	3	45	10	38
1600	15	5	4	16	5	15
1700	49	50	14	86	0	100
1800	42	41	14	69	6	77
1900	3	6	0	9	0	9
2000	5	9	0	14	4	10
2100	19	25	6	38	30	14
2200	6	3	2	7	8	1
2300	3	3	0	6	2	4
2400	0	0	0	0	0	0

XXI. APPENDIX XII. AGE, SEX AND ACTIVITY OF DEER SIGHTED FOR EACH HOUR DURING THE WINTER OF 1970-71

	Age					
Hour	Adult	Juvenile	Antlered	Antlerless	Bedded	Active
0100	8	8	3	13	0	16
0200	0	0	0	0	0	0
0300	11	16	4	23	26	1
0400	0	0	0	0	0	0
0500	21	18	3	36	8	31
0600	64	63	17	111	1	127
0700	44	65	17	92	9	100
0800	18	28	12	34	6	40
0900	33	37	14	56	40	30
1000	10	20	2	28	24	6
1100	17	23	3	37	19	21
1200	6	5	4	7	3	8
1300	13	14	3	24	13	14
1400	16	21	3	34	13	24
1500	7	16	4	19	12	11
1600	21	19	6	34	0	40
1700	58	47	20	85	5	101
1800	68	92	13	144	3	157
1900	16	13	12	17	0	29
2000	7	8	5	10	2	13
2100	61	86	14	133	117	30
2200	10	12	5	17	19	3
2300	1	3	0	4	1	3
2400	0	0	0	0	0	0

XXII. APPENDIX XIII. AGE, SEX AND ACTIVITY OF DEER SIGHTED FOR EACH HOUR DURING THE WINTER OF 1971-72

	Age					
Hour	Adult	Juvenile	Antlered	Antlerless	Bedded	Active
0100	2	2	2	2	4	0
0200	0	0	0	0	0	0
0300	1	0	1	0	1	0
0400	0	0	0	0	0	0
0500	6	7	1	12	0	13
0600	60	85	25	120	0	145
0700	71	108	50	128	5	173
0800	54	83	47	90	50	88
0900	35	61	26	70	40	58
1000	27	39	28	38	50	16
1100	84	108	49	143	140	52
1200	21	29	7	43	24	26
1300	43	56	27	72	66	33
1400	98	113	53	157	171	39
1500	87	116	46	157	112	93
1600	77	110	46	141	49	138
1700	166	203	70	297	4	368
1800	24	40	18	46	0	73
1900	15	21	21	15	9	30
2000	32	45	23	56	32	47
2100	33	40	14	59	46	27
2200	36	46	27	55	41	41
2300	27	29	18	38	38	20
2400	0	0	0	0	0	0