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SYNOPSIS: Winter movement and home range of white-tailed deer at Pilot Knob State Park, Iowa. *Proc. Iowa Acad. Sci.*, 79(2):74-78, 1972. Home ranges of nine radio-equipped white-tailed deer (*Odocoileus virginianus*) were determined during the winters of 1969-70 through 1971-72. For does and female fawns, the winter ranges varied from 145 to 307 acres, the major (longest) axes from 1.00 to 1.19 miles, and minimum daily movement from 0.78 to 1.00 mile. Home range sizes of adult does were more consistent than those of female fawns or bucks, varying from 198 to 215 acres. Their major (longest) axes ranged from 1.00 to 1.12 miles and minimum daily movement varied from 0.78 to 0.88 mile. Bucks exhibited the greatest variation in movement, with home ranges varying from 49 to 504 acres, major axes from 0.62 to 1.90 miles, and minimum daily movement, from 0.50 to 1.25 miles. Most major axes of movement led from the southeastern corner of the park, where deer bedded during daylight hours, to the croplands north of the western half of the park, where deer fed during nocturnal hours. The park provides one of few large stands of timber in a 4-county area. This timber serves as permanent cover and is used by deer for bedding during daylight. The park also serves as a refuge for deer which are highly vulnerable to hunting in the intensively farmed regions of Iowa.

The winter movement habits of nine radio-equipped white-tailed deer inhabiting Pilot Knob State Park and adjacent cropland and timber were determined during the winters of 1969-70 through 1971-72. Principal objectives of the study included:

1). Determining daily and seasonal home range of deer in the immediate vicinity of Pilot Knob State Park, Iowa.
2). Securing data which might indicate the value of a State Park (refuge) in the management of deer in a predominantly agricultural area.

Past investigations into the annual home range of white-tailed deer have led to the acceptance of a general figure of 1 to 1½ square miles as a home range (Hahn, 1945; Hahn and Taylor, 1950; Heezen and Tester, 1967; Hunt and Mangus, 1954; Progulske, 1960; Severinghaus and Tanck, 1950; Taylor, 1956; Tester et al., 1964; and Thomas et al., 1964). Publications on the home range of mule deer (*Odocoileus hemionus*) indicate a seasonal home range of approximately 1.5 square miles (Leopold et al., 1951; Clark, 1953; Dasmann and Taber, 1956; Julander et al., 1961; and Zwickel et al., 1953).

Techniques for calculating the "minimum area" of the home range for mammals were proposed by Burt (1943), Lay (1942), Stickel (1946), Hayne (1949) and Harvey and Barbour (1965). Marchinton and Jeter (1966) applied Harvey and Barbour's (1965) method while determining the home range of white-tailed deer.

Winter ranges of marked deer were approximated by connecting the outermost locations to enclose the area of known activity (Harvey and Barbour, 1965) and by plotting the major (longest) axis of the polygon enclosing the outermost known points of occurrence (Marchinton and Jeter, 1966). The polygon's area was measured with a planimeter to arrive at the acreage occupied.

Terminology employed to describe the home range is taken from Marchinton and Jeter (1966) and includes:

1. Minimum home range—the area included within a line connecting the outermost 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 best approximation of home range acreage. The technique is similar to the modified minimum-area method described by Harvey and Barbour (1965), but differs somewhat because a knowledge of habitat and overall deer movement rather than a mechanical procedure was used in determining the minimum home range boundaries.
2. Home range major (longest) axis—the line segment formed by connecting the two radio locations of the deer that are the greatest distance apart.
3. Minimum daily movement—the distance obtained by measuring the lines connecting successive radio-locations established for an animal during any 24-hour tracking period.

Pilot Knob State Park, the core of the study area, is within Ellington Township being legally described as the NW¼ Sec. 3 and the NE¼ Sec. 4, with two adjacent strips in T.97N., R.23W. Approximately 70% of the park's 368.8 acres is timbered. Cropland borders the western half of the northern boundary and grazed timber borders the eastern half. The eastern boundary is bordered by grazed timber and cropland; the eastern half of the southern boundary by cropland and the western half by grazed timber; and pasture and timber border the western boundary (Fig. 2). Since its dedication in 1924, the park has not been grazed by livestock. Surrounding lands, however, have been subjected to various agricultural practices, including grazing of the timber and intensive row cropping with corn and soybeans.

The four counties surrounding the park consist of approximately 97% cropland, 2% urban and 1% timber. Of the 1%

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TABLE 1. TRAPPING AND HOME RANGE RECORDS FOR DEER CAPTURED DURING THE WINTERS OF 1969-70 THROUGH 1971-72 AT PILOT KNOB STATE PARK, IOWA

Deer (radio channel)	Date of capture	Sex	Age (years)	Winter range (acres)	Major axis (miles)	Diel movement (miles)	Telemetric study period
2	1/27/70	F	Fawn	243	1.06	1.00	1/27/70-3/1/70
4	2/5/70	F	3.5	200	1.12	0.88	2/5/70-3/1/70
3	2/6/70	F	1.5	215	1.12	0.88	2/6/70-3/1/70
7	11/22/70	F	Fawn	307	1.19	0.81	11/22/70-3/6/71
–*	12/20/70	M	Fawn	–	–	–	–
10	1/14/71	F	Fawn	145	1.00	0.88	1/4/71-3/6/71
12	2/27/71	M	Fawn	49	0.62	0.50	2/27/71-3/6/71
8	3/2/71	F	1.5	198	1.00	0.78	3/2/71-3/6/71
11	12/12/71	M	Fawn	504	1.90	1.13	12/12/71-2/1/72
5	1/18/72	M	2.5	456	1.60	1.25	1/18/72-1/3/72
			Total area enclosed = 676				
				$\bar{X} = 258$	$\bar{X} = 1.18$	$\bar{X} = 0.90$	

*Died in the process of handling (after being live-trapped).

timber, 80% is privately owned, 75% of which is grazed.

METHODS

Deer marked at Pilot Knob State Park were captured in a "Stephenson" type box trap (Siglin, 1965) or immobilized with 1.5 to 2.5 mg nicotine salicylate per pound estimated body weight. Traps were baited with corn, apples, alfalfa or various combinations of the baits.

Captured deer were marked with a numbered metal tag in each ear; a colored polyvinyl streamer was affixed to the right ear of bucks, to the left ear of does. Each animal also was equipped with a color-coded collar, consisting of 6-ply rubberized 2-inch-wide machine belting joined into a ring with alligator clamps. Attached to each collar was a crystal-controlled transmitter with a separate frequency channel between 150 and 152 megacycles. The radios emitted a continuous signal while operational.

Locations of radio-equipped deer were determined by triangulation (Jeter and Marchinton, 1964; Marshall and Kupa, 1963) and by actually following the directional signal until the animal was sighted. Directional bearings were obtained with a Leupold compass and a directional hand-held antenna or one attached to a vehicle roof. Initial bearings on a newly captured deer were obtained by triangulation while the animal was bedded and then checked by the investigator moving along the azimuth bearing for a visual check of the animal. Directional bearings checked in the above manner proved accurate to within 0.5 acre. An effort was made to approach to within 0.25 mile in order to secure accurate bearings. The small size of the study area and the system of roads around and through the park made this possible.

All telemetric and visual locations were recorded and plotted on a 4-inch/mile map of the area reduced from an aerial photo-mosaic and divided into a 10-acre/square grid (Fig. 1). Directional bearings were determined at intervals throughout the day on a 7-day/week basis and also at night if temperature conditions permitted operation of the receiver and transmitter. Temperatures below 20° F slowed down battery reactions and reduced the transmission-reception distance to 50 yards or less. There is no evidence to indicate that deer, which were repeatedly exposed to human activity by park recreationists the year round, were unduly disturbed by the investigator's activities.

RESULTS AND DISCUSSION

Three deer were live-trapped in the winter of 1969-70, 5 in the winter of 1970-71, and in the winter of 1971-72, one deer was live-trapped and another immobilized by nicotine (Table 1). All captured deer, with the exception of a live-trapped buck fawn that died from shock or suffocation during handling, were marked with numbered ear tags, a colored streamer, collar and telemetry radio. All radios remained operational throughout the winter of capture. The home range of each animal (in acres) and the length and direction of the major axis were plotted (Figs. 3a-j), and telemetric bearing, home range, length of major axis, minimum daily movement, and duration of observation are shown for each animal (Table 1).

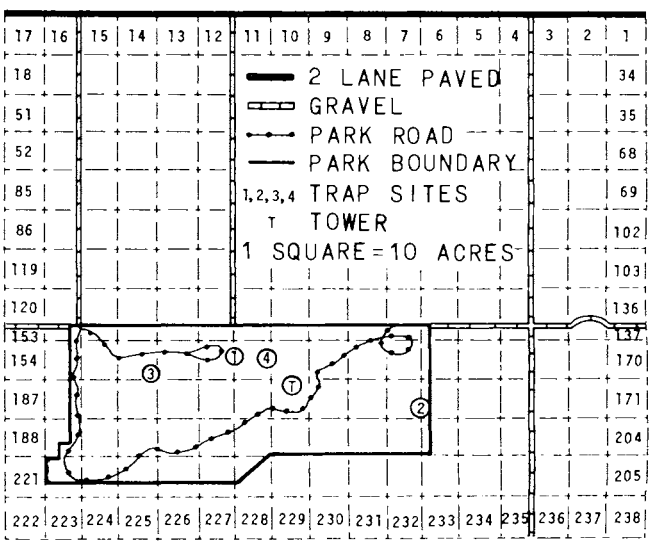

FIG. 1. NUMBERED-10 ACRE GRID OF THE PILOT KNOB STATE PARK STUDY AREA.

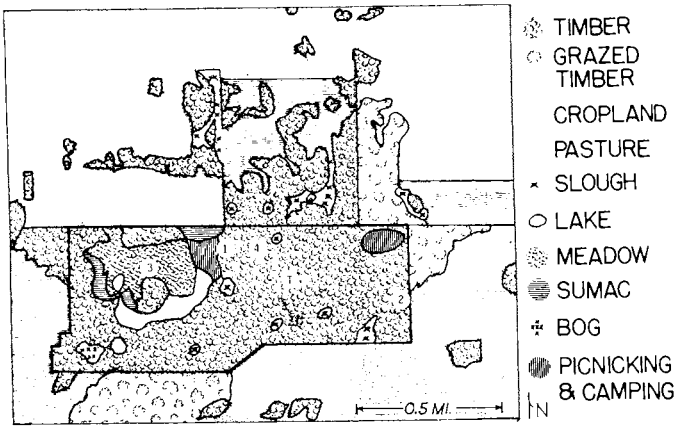

Figure 2. Cover map of the Pilot Knob State Park Study Area.

TABLE 2. FREQUENCY OF OCCURRENCE OF RADIO-EQUIPPED DEER IN THE COVER TYPES MAPPED AT PILOT KNOB STATE PARK, IOWA

Cover type	Acres	Number of times deer were sighted	Occurrence of deer per 10 acres
1. Timber—ungrazed	434	233	5.4
—grazed	113	9	0.8
2. Cropland	728	64	0.9
3. Pasture	156	1	0.1
4. Slough	25	6	2.4
5. Lake	24	0	0.0
6. Bog	4	0	0.0
7. Meadow (prairie)	28	17*	6.0
8. Sumac	19	8	4.2
9. Picnicking and camping	13	0	0.0
Total	1540	338	

*"Bait addicted" deer captured 14 times at same site in 25 days.

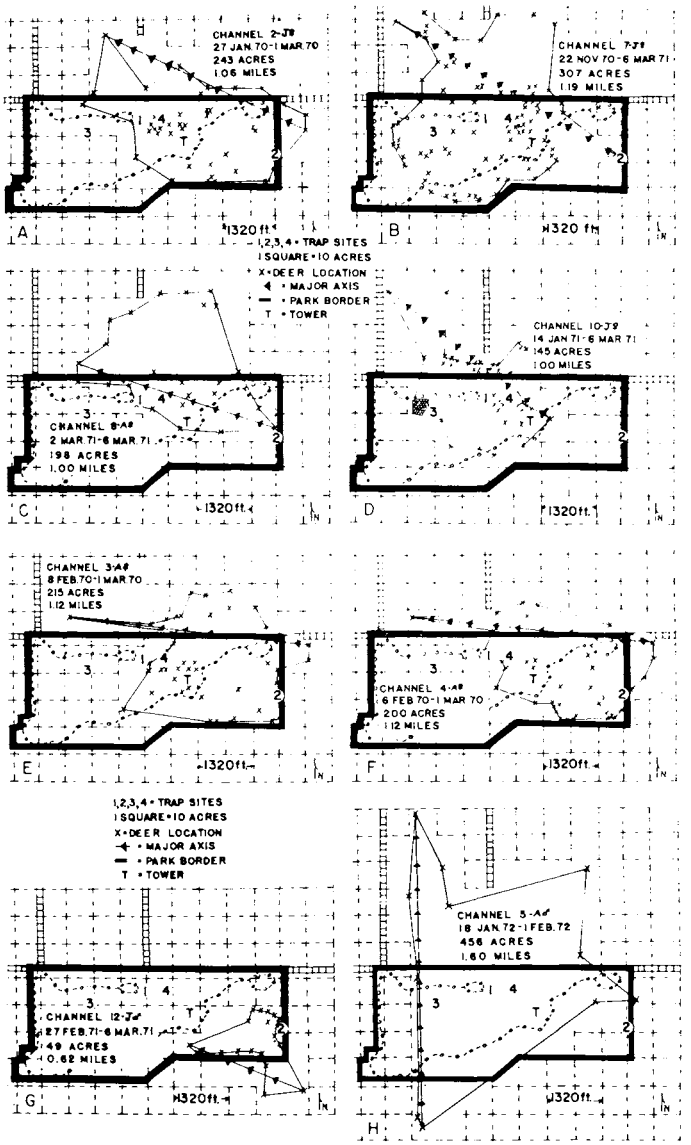

Figure 3. Home range of marked deer at Pilot Knob State Park, Iowa (A-F, females, G-I, males).

For does, the minimum winter home range varied from 198 to 215 acres, the major axis ranged from 1.00 to 1.19 miles, and minimum daily movement varied from 1.00 to 1.78 miles.

For female fawns, the home range varied from 145 to 307 acres, the major axis ranged from 1.00 to 1.19 miles, and minimum daily movement varied from 0.81 to 1.00 mile. The size of home ranges of adult does were more consistent than those of female fawns or bucks; their home ranges varied from 198 to 215 acres; major axes, from 1.00 to 1.12 miles; and minimum daily movements, from 0.88 to 1.78 miles.

Bucks showed the greatest variation in all three categories. For two buck fawns, the home range varied from 49 to 504 acres, the major axis ranged from 0.62 to 1.90 miles, and minimum daily movement from 0.50 to 1.13 miles. The home range of an adult buck consisted of 456 acres, the major axis was 1.60 miles and minimum daily movement was 1.25 miles. Data on type of home range, length of major axis and minimum daily movement are in agreement with those of Marchinton and Jeter (1966) and Progulske (1960).

The northwesterly-southeasterly orientation of most recorded major axes is reflective of a movement pattern which involves the use of the dense timber in the eastern half of the park for bedding and the croplands north of the western half of the northern boundary for feeding. Both marked and unmarked deer usually could be located bedding in the timber in the eastern half of the park during the day, either feeding or bedding in row crops north of the western half of the park at night, or moving between these areas during crepuscular periods.

The two most important cover types in the winter ranges of deer at Pilot Knob State Park were timber and cropland. This is illustrated by the fact that of 338 radio contacts and

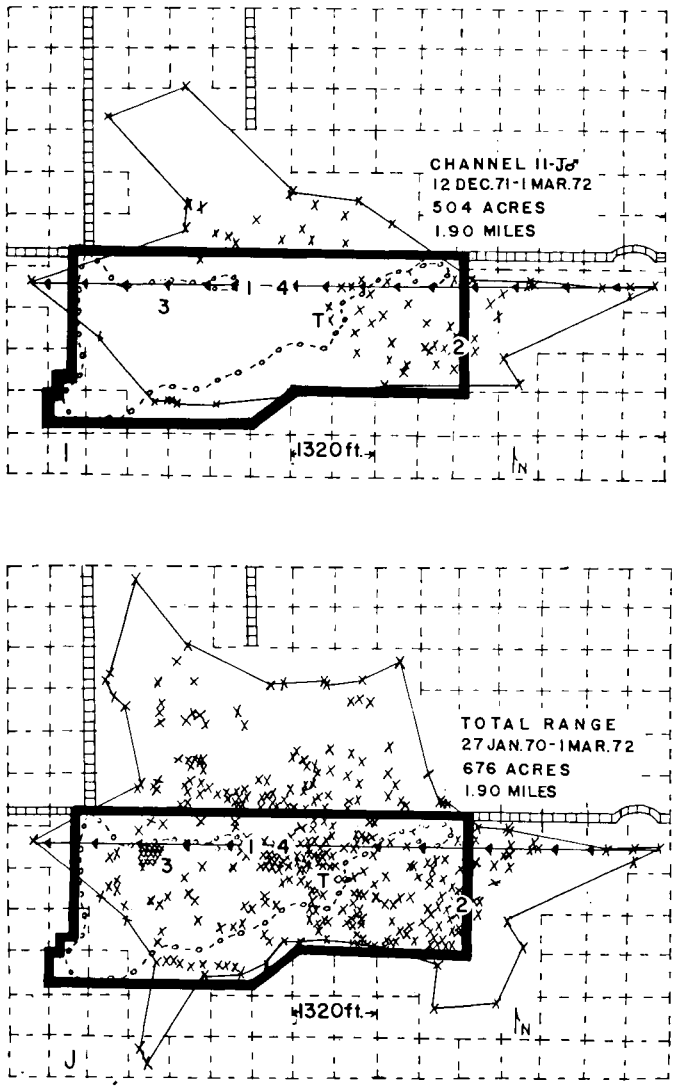

Figure 3. Continued.

sightings, 233 were made within the ungrazed timber in and adjacent to the park and 64 were in cropland adjacent to the park (Table 2).

For bedding, deer seemed to select ungrazed timber with a dense understory of woody plants in preference to overgrazed, open timber. Mapping of trails and sightings of both marked and unmarked deer supported this conclusion. With the exception of cropland areas used for feeding during crepuscular periods, deer avoided areas having little cover and/or high human activity.

When cover types were ranked on the basis of occurrence of deer per 10 acres, the value of edge cover became apparent (Table 2). Although sumac provided only 19 acres (1%) of habitat, it ranked third behind meadow and ungrazed timber (Table 2). Channel 10, a doe fawn, became "bait addicted" and was captured 14 times in a trap located in meadow habitat. This undoubtedly biased the occurrence per 10 acres for meadow. Sumac afforded cover for movement to and from bedding and feeding areas during crepuscular periods.

Escape movement varied with topographic and vegetative conditions. During the day, if deer were disturbed in timber patches outside the park, they usually fled into open cropland where they could more easily observe their surroundings. Although they demonstrated a reluctance to return to timber, they eventually did.

At night, deer were spotlighted as they fed or bedded in harvested row crops. They generally paid little attention to the light and, if a response was evoked, they simply moved out of sight over a ridge.

When disturbed along the fence within the park's boundary, deer have been observed to run parallel to the fence; bolt back inside the park; or jump the fence and move into the timber or cropland outside. It is difficult to determine what evokes a particular flight pattern as deer in similar situations react differently.

CONCLUSIONS

Deer on the study area depend on permanent cover afforded by the park in winter when the crops on 97% of the surrounding land in the 4-county area are harvested. As a result of the crop harvest, winter habitat shrinks to 1% of that available during summer.

Once on the study area, deer established a seasonal home range. The size of the range varied from 49 to 504 acres. Each home range consisted in part of the dense woody cover of the park which deer used for bedding and in part of the cropland adjacent to the park which was used for feeding. Any interruption in this pattern of bedding in timber and feeding in adjacent agricultural lands could lower the park's carrying capacity during critical winter months.

If the policy of a conservation commission in a predominantly agricultural state is to increase the present deer 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 intensively farmed regions of the state, by protecting the functional ability of existing refuges and by setting the shooting hours to avoid hunter harassment while deer are feeding in croplands outside a refuge.

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