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White-Tailed Deer Movement at Pilot Knob State Park, Iowa

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Range and movement of 12 marked deer (*Odocoileus virginianus*) were studied at Pilot Knob State Park and surrounding lands from December, 1969, through May, 1972. Winter ranges of all marked deer included timber inside and outside the park and cropland outside the park. Deer generally bedded in timber during daylight and fed or bedded in croplands at night. Mean range of all marked deer was 283 acres. Range size varied from 49 to 1,129 acres.

This paper is a continuation of a report by Zagata and Haugen (1972) concerning a study conducted from December, 1969, through May, 1972, to provide basic information for deer management in north-central Iowa. Data on deer movement, gathered since the formal completion of the intensive field work in 1972, is included where appropriate. The objectives were to: determine daily, seasonal and yearly geographical range and movement of deer in the vicinity of Pilot Knob State Park, Iowa; determine the effects of crop harvest, weather and hunting pressure on normal movement patterns; and secure data useful for effective deer management.

Thanks are due the Iowa State Conservation Commission and the U.S. Bureau of Sport Fisheries and Wildlife for funding the study and to Jerry Anderson of the Iowa State Conservation Commission for his field assistance. Special acknowledgment is given to Hazel Clausen and Lois Yerxa for their help in preparation of this manuscript.

STUDY AREA

Pilot Knob State Park (PKSP) lies in Ellington Township in Hancock County, Iowa. PKSP, as described by Zagata and Haugen (1972), is a forested tract within an intensively farmed portion of Iowa.

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°F, and the mean yearly precipitation is 29.99 inches (Shaw and Waite, 1964).

INDEX DESCRIPTORS: White-tailed deer, Deer movements.

METHODS

Deer were captured, marked with ear streamers and equipped with color-coded radio collars and radio transmitters, each with a separate frequency. The materials, radios and triangulation techniques used are described in an earlier paper (Zagata and Haugen, 1972).

Seasonal ranges of marked deer were approximated by connecting the outermost locations to enclose the area of known activity (HR) and by plotting the major (longest) axis (MA) 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. Locations were determined for each deer while it bedded during the day, moved out into croplands to feed at night and then returned to timber to bed at dawn. These locations were connected and measured each day, thereby giving an estimate of the minimum daily movement (MDM) for each deer. Halving this figure yields a one-way movement (OWM) between bedding and feeding sites.

RESULTS

Thirteen individual deer, one of which died during handling, were captured (10 by trap and three with nicotine) between January 27, 1970, and February 22, 1972.

Movement Data for Marked Deer, 1969-70

Three female deer (one fawn and two adults) were marked and equipped with radio channels 2, 3 and 4 during the winter of 1969-70 (Zagata and Haugen, 1972). Movement data obtained for these deer include estimates of HR size, MA length and MDM (Table 1).

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TABLE 1. 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	1.1	0.9	32	1/27/70- 3/ 1/70
	4	snow	3.5	F	200	1.1	1.4	33	2/ 5/70- 4/ 1/70
	3	snow	1.5	F	215	1.1	1.2	29	2/ 6/70- 4/ 1/70
2	7	snow	fawn	F	307	1.2	1.5	50	11/22/70- 3/ 6/71
	10	snow	fawn	F	145	1.0	1.2	46	1/ 4/71- 3/ 6/71
	12	snow	fawn	M	49	0.6	0.6	17	2/27/71- 3/ 6/71
	8	snow	1.5	F	198	1.0	1.4	13	3/ 2/71- 3/ 6/71
3	2 ^a	snow	2.5	F	147	1.0	0.9	8	12/13/71- 3/19/72
		no snow			190	1.1	0.9	24	3/20/72- 4/25/72
	11	snow	fawn	M	504	1.9	1.2	1	12/12/71- 3/19/71
		no snow			435	1.7	1.8	86	3/20/71- 4/25/71
	5	snow	2.5	M	456	1.6	—	9	1/18/71- 1/31/71
		no snow			—	—	—	—	—
	5A	snow	fawn	M	253	1.6	1.0	44	2/ 3/72- 3/19/72
		no snow			176	1.2	0.8	79	3/20/72- 4/25/72
	6	snow	fawn	F	210	1.2	1.0	22	2/17/72- 3/19/72
		no snow			155	1.6	—	28	3/20/72- 4/25/72
1	snow	1.5	M	85	1.0	1.0	19	2/23/72- 3/19/72	
	no snow			1129	2.9	1.6	70	3/20/72- 4/25/72	

^a Same deer.

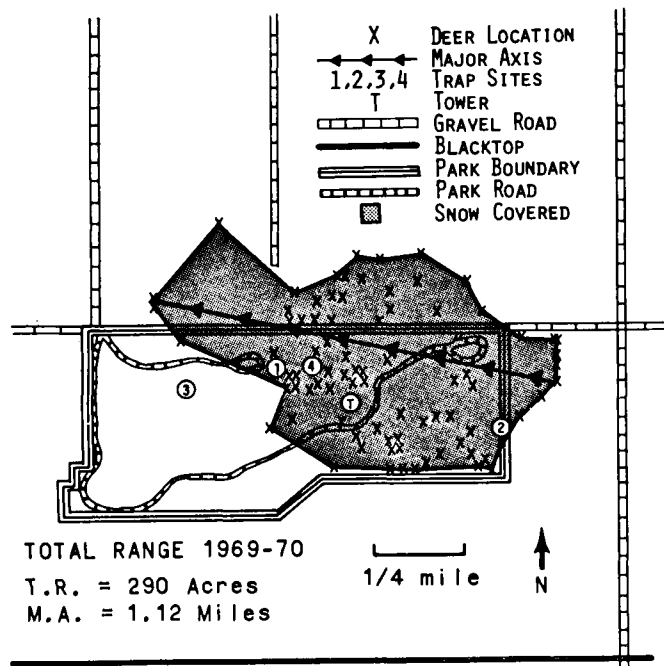


Figure 1. Estimated combined total range (TR) and major axis length (MA) for three female deer (one fawn and two adults), marked in winter, 1969-70, from January 27-April 1, 1970.

The total combined range occupied by all three marked deer during the winter of 1969-70 was estimated at 290 acres with an MA length of 1.1 miles (Figure 1). 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 1.1 miles long. The average orientation of the three major axes extended from timber used for bedding in the eastern half of the park to cropland for feeding north of the western half of the park. Average MDM for the three deer was 1.2 miles (round trip). Halving this figure indicates an OWM of 0.6 mile.

Two of the three marked deer were known to have left the area in the spring following their capture (Table 2). Because these deer were captured randomly, it is possible that this percentage of dispersal may be indicative for the herd occupying PKSP during winter.

Movement Data for Marked Deer, 1970-71

Four deer (one male fawn, two female fawns and one adult female) were marked and equipped with radios broadcasting on channels 7, 8, 10 and 12. Movement data for individual deer are recorded in Table 1. The total combined range occupied by all four deer marked in the winter of 1970-71 was estimated at 448 acres with an MA length of 1.5 miles (Figure 2).

Average estimated winter range for the four deer was 175 acres with an average MA length of 1.0 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 MDM for the four deer was 1.2 miles with an OWM of 0.6 mile between feeding and bedding sites.

TABLE 2. DISPERSAL DATA FOR DEER MARKED IN PILOT KNOB STATE PARK, IOWA, FROM DECEMBER, 1969, THROUGH MAY, 1972

Channel	Age (years)	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			
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	0.0	—			
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	?	—			
			1972	Fall	36.0	NE			
6	fawn	F	1971-72	Winter	0.0	—			
			1972	Spring	1.0	S			
			1972	Summer	1.0	S			
			1974	Winter	0.0	—			
11	fawn	M	1971-72	Winter	0.0	—			
			1972	Spring	0.0	—			
			1972	Summer	35.0	SW			

* Summer records indicate single sightings.

Three of the four deer marked in 1970-71 (one male fawn, one female fawn and one adult female) and two deer (adult females) marked in 1969-70 left the park in spring

(Table 2). Thus 71 percent of the marked deer left the park and dispersed into surrounding lands. Average dispersal distance from the park for these five deer was 43.3 miles.

WHITE-TAILED DEER MOVEMENT

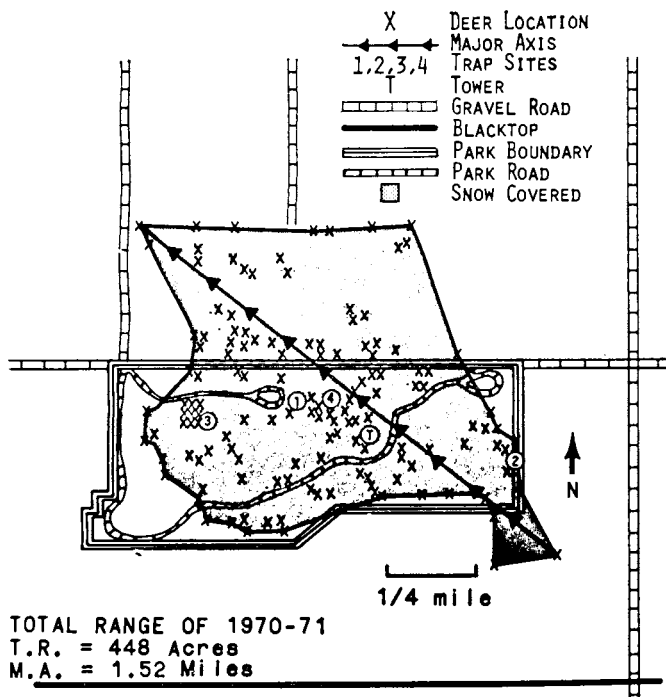


Figure 2. Estimated combined total range (TR) and major axis length (MA) for four deer (one male fawn, two female fawns and one adult female) marked in winter, 1970-71, from November 22, 1970-March 6, 1971.

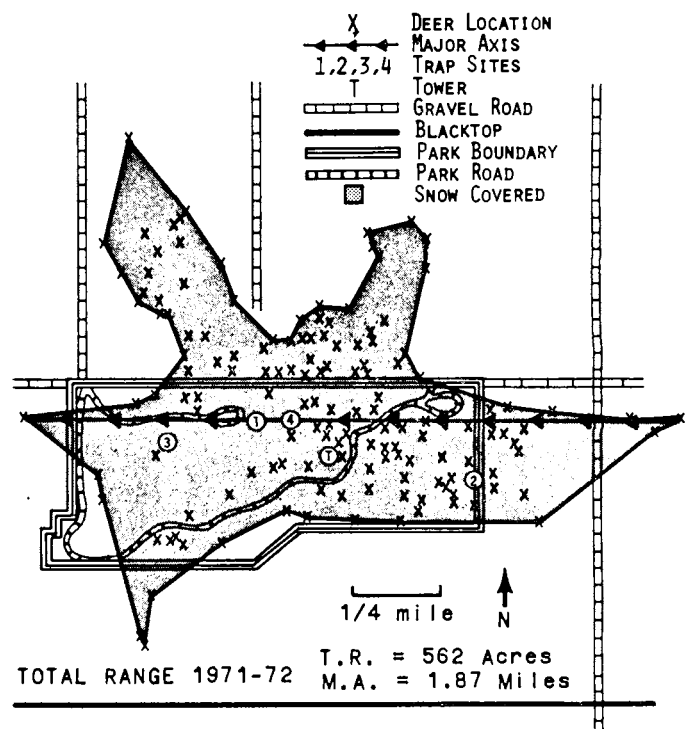


Figure 3. Estimated combined total range (TR) and major axis length (MA) of six deer (two male fawns, two adult males, one female fawn and one adult female) in winter, 1971-72, from December 12, 1971-March 19, 1972.

Movement Data for Marked Deer, 1971-72

Five deer (two male fawns, two adult males and one female fawn) were marked and monitored during the winter of 1971-72 (snow cover) and spring of 1972 (no snow cover). In addition, movement data were recorded for an adult female (channel 2) marked in 1969-70; she was traveling with a newly "radioed" deer. Size of estimated HR, length of MA and estimated MDM were compared for the period with snow cover versus the period lacking snow cover (Table 1).

The six marked deer occupied a total range of 562 acres during the winter of 1971-72 (Figure 3). The MA of that range was 1.9 miles long. In spring this range expanded greatly; one deer occupied a range of 1,129 acres.

During the period with snow cover, the average range size for these six deer (channels 1, 2, 5, 5A, 6, 11) was 276 acres, with a major axis length of 1.4 miles. The estimated MDM for five deer (channel 5 was killed before enough data were secured to measure his MDM) during that period was 1.0 mile.

Later, after the snow melted, the average range size for the five deer increased to 348 acres with an MA length of 1.7 miles. Minimum daily movement for four deer (MDM could not be determined for channel 6) was 1.3 miles. There was a slight increase in each movement descriptor after the snow had melted. Deer expanded their range into grazed timber and brush which they had avoided during severe winter months. Two of these six deer known to utilize the park during the winter of 1971-72 left the park in the spring of 1972 (Table 2).

Movement Data for All Marked Deer, 1969-72

The average HR for all periods for all marked deer was 283 acres, with an MA length of 1.3 miles. Minimum daily movement average for all deer over the four periods was 1.2 miles (round trip). The total combined winter HR for the 12 marked deer from 1969-72 was 684 acres with an MA 1.9 miles long. All deer exhibited a preference for timber during daylight hours and croplands at night. Timber probably was used to fulfill a behavioral rather than a physiological need because deer commonly bedded in exposed areas at night, the coldest part of the day.

A multiple regression analysis was performed to measure unique effects on certain variables on movement parameters by using the model:

$$HR, MA, MDM = P A PxA S AxS$$

$$P = \text{Period} \quad A = \text{Age} \quad S = \text{Sex}$$

Raw data used in the analysis are given in Tables 3 and 4.

A high correlation coefficient (0.92) existed between HR size and MA length when taken over all four periods; it was 0.94 for winter and spring of 1971-72. The major axis is one component of range size. Correlations with other variables will most likely be similar for both HR size and MA length.

Unique effects of each variable on home range size were determined and F-tests made to determine if the independent variable effects and variable interaction effects were significant at the 0.05 level (Table 5). Home range size and MA length were not found to be significantly affected by any of the variables or their interactions used in the model.

TABLE 3. 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
<i>Male</i>											
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
<i>Female</i>											
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			248	
MA	1.10		0.95		1.37		1.71			1.31	
MDM	1.11		1.19		1.11		1.35			1.15	
N	3		4		6		5			18	

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

TABLE 4. 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		Both Periods Mean by Sex	Both Periods Mean by Age and Sex	
	Fawn	Adult	Fawn	Adult		Fawn	Adult
<i>Male</i>							
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
<i>Female</i>							
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	
MA	1.32		1.71		1.51	1.55	
MDM	1.11		1.35		1.23	1.20	
N	5		5		10	6	

^a See footnotes to Table 3.

Minimum daily movement was influenced by the effects of period, period by age interaction and age by sex interaction when taken over all four periods and by period and sex effects during winter and spring 1972.

DISCUSSION

Daily Range and Movement of Deer in Relation to Pilot Knob State Park

Each of the 12 deer equipped with radio-telemetry de-

TABLE 5. 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		Period Age x Age		Sex F	Age x Sex F	Percent Total Variation Explained by the Model
	F	F	F	F			
<i>All periods</i>							
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 ^a	2.25*	3.09*	2.34	3.69*	1.80	8.05*	12
df ^a	9	3	1	3	1	1	
<i>Periods 3 and 4</i>							
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 See footnote to Table 3.

* Probability F < 0.05.

uses 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), who stated that 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 one percent of the land is timbered.

During the evening twilight period, deer moved out of the timber and onto 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.* (1970) and Watt *et al.* (1967) found corn to be a staple in the diet of mid-western deer. Of the 851 telemetrically determined locations for deer, 80 were in corn or soybeans. This number may not reflect accurately the use of croplands by marked deer because cold temperatures often prevented obtaining readings at night when deer commonly could be spotlighted in crops (Zagata and Haugen, 1973).

Seasonal Range and Movement

Ten of the 12 deer marked at PKSP during winter are known to have shifted their range during spring. In 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 1,129 acres after the spring thaw. Home range sizes correspond to 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 HR was found for period, age, period by age interaction or sex. This agrees with Sparrowe and Springer (1970), who found no difference in HR size by age or sex. The effect of age by sex interaction on range size was not significant at the 0.05 level but did indicate that male fawns and adults tended to have larger ranges than female fawns and adults, respectively.

Movements of five deer were studied intensively during the winter of 1971-72 and the subsequent spring period. One female fawn shifted its range completely. Six deer studied

in previous winters also shifted their ranges completely. Dahlberg and Guettinger (1956) and Pietsch (1954) also found that deer had distinct summer and winter ranges.

An adult male expanded its range by a factor > 13 when spring came. The expanded range included some of the winter range and grazed timber and cropland to the south. The other three deer shifted their ranges somewhat when snow cover disappeared in spring. Channel 2, an adult doe, expanded her range slightly, but two male fawns, channels 5A and 11, showed a decrease in range size. During both seasons home ranges included both timber or brush for bedding and cover during daylight and croplands for feeding at night.

Yearly Range and Movement

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

Emigration

Nine marked deer were known to have emigrated from the park between 1969 and 1972. They included three male fawns, two female fawns, three adult females and one adult male. Distances moved varied from 1.0 to 110 miles and occurred in each of the directions except north (Figure 4; Table 2). 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. They are 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 seems from records of marked deer sightings in spring that dispersal occurs 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 on the study area.

Immigration

Aerial census counts taken in late winter were higher than those taken in early winter (Table 6), indicating that deer move into the study area as winter weather becomes more severe and farmland habitat in outlying regions deteriorates.

During the December shotgun hunting season, several deer were observed moving through croplands in the direction of the park. Deer outside PKSP may have been vulnerable to hunting, since 50 percent of the shotgun hunters were successful (Gladfelter, 1971). Once observed by hunters,

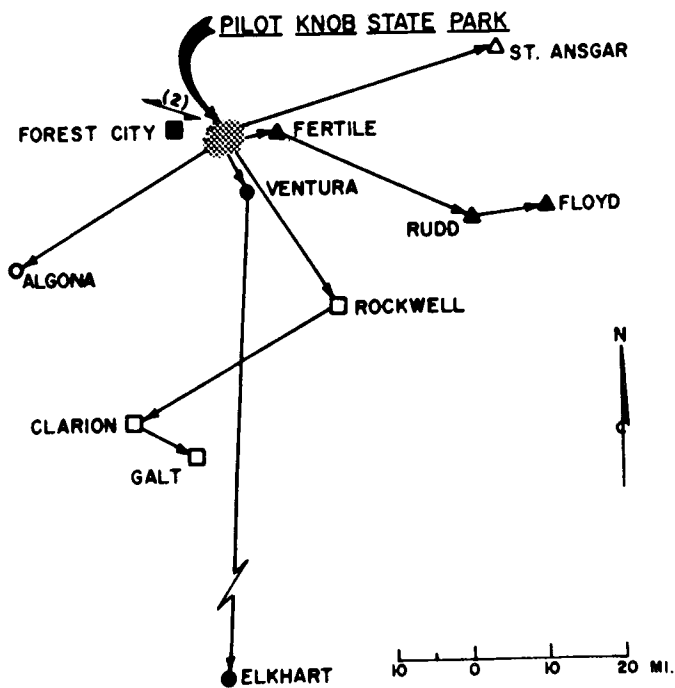


Figure 4. Known dispersal of seven deer from Pilot Knob State Park, Iowa. The number 2 indicates that two deer moved to that location.

TABLE 6. RESULTS OF AERIAL COUNTS OF DEER MADE DURING EARLY AND LATE WINTER DURING 1969-1972 AT THE PILOT KNOB STUDY AREA, IOWA

Year	Early Winter			Late Winter		
	Inside Park	Near Park	Total	Inside Park	Near Park	Total
1969	32	9	41	30	16	46
1970	30	9	39	34	35	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.

deer were often pursued across the open fields for miles. Sanctuary from harassment was provided by PKSP.

Movement involving immigration and emigration is also indicated by roadkill data (Gladfelter, 1971). Roadkill figures are low for summer and winter and high during spring and fall. Two possible explanations for this phenomenon exist: a shift in range, and the breeding season or fawning seasons.

The spring kill has a higher percentage of females than the fall kill (Gladfelter, 1971). Both sexes are hunted in Iowa and both should therefore be present in nearly equal numbers. The seasonal change in roadkill percentages most likely reflects a behavior pattern change among adults. Females are moving to fawning areas in spring and males are searching for females in the fall rut. In both seasons deer are moving about more than usual, often through unfamiliar territory, thus increasing their chance of being struck by a car.

Migration

Three deer (two adult females and one adult male) 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 seen west of the park the following summer and returned in late fall. During the fall of 1972, she was again observed immediately north of the park.

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. Channel 1, an adult male, shifted his range to a wooded tract one mile south of the park. The following fall he was observed several times and shot during the 1973 archery season immediately north of the park.

It seems logical that deer dispersing only short distances from the park in spring would return in winter because of the scarcity of suitable habitat in the four-county area.

Management

If the goal of management 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 refuge areas in the intensively cropped areas of the state. Such refuges could then be managed to provide protection from hunting and other harassment, and to provide cover and food necessary for winter deer habitat.

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 seems practical to set aside additional tracts across the intensively farmed portions of the state to serve as buffers during critical periods.

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