DEER MOVEMENTS AND HABITAT USE OF IRRIGATED AGRICULTURAL LANDS IN CENTRAL WISCONSIN

by

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PREFACE

This thesis consists of 3 technical papers that present information that I collected while studying white-tailed deer (Odocoileus virginianus) in the Buena Vista Marsh area in southwestern Portage County, Wisconsin, during 1979-82. The first 2 papers, "White-tailed Deer Use of an Irrigated Agriculture-Grassland Complex in Central Wisconsin" and "Sedentary and Migratory White-tailed Deer on Adjacent Habitats in Central Wisconsin," were prepared for the Journal of Wildlife Management. The third paper (Appendix A), "Symbiotic Interaction Between Starlings and Deer," was published (1981) as a general note in the Wilson Bulletin (93:549).

I wish to acknowledge the landowners of the Buena Vista Marsh for their cooperation. I thank especially Don Dorr, Doug Hambach, Gary and Jess Higgins, Jere Kirst, Bob Konopacky, Joe and Al Okray, Louis Rozner, Ray Spielman, Myron Steinke, and Wallace Wasieleski. University of Wisconsin-Stevens Point students, especially Sue Babb, Tim Feavel, Scott Fredrickson, Dan Groebner, Greg Langlois, Jack Massopust, Dave McConnell, Dave Roeglin, Terry Simon, Joey Thanos, and Dave Thayer, provided valuable field assistance. For their support and encouragement, I thank colleagues Harv Halvorsen, Dennis Kent, Deb Jansen, Michael Johnson, Bob Rosenfield, and Jamie Tomasek. I am particularly grateful to John Cary of the University of Wisconsin-Madison and colleague Mike Gratson for guidance on data collection and analysis. Professors Ray Anderson, Neil Payne, and Orrin Rongstad developed the research proposal, acquired funding, and provided valuable guidance throughout the study.

Dr. Anderson also served as pilot when we radio-tracked deer from the air. I also thank Dr. Robert Miller for his input as a member of my graduate committee.

My deepest appreciation goes to my parents, Ann and Richard Murphy, and to my brother Mike. They have always nurtured my interest in wildlife, especially in white-tailed deer, and they provided moral support and field assistance during this study.

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WHITE-TAILED DEER USE OF AN IRRIGATED AGRICULTURE-GRASSLAND COMPLEX IN CENTRAL WISCONSIN

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Abstract: White-tailed deer (*Odocoileus virginianus*) use of irrigated croplands in southwestern Portage County, Wisconsin, was determined via radio-telemetry during November 1979-May 1981. Seasonal importance of non-irrigated cropland, grassland, pasture, shrub, and woods also was determined. Analysis of habitat use was based on 1,887 radio-locations of 17 deer. Deer infrequently used irrigated cropland (corn and cash crops) during fall, winter, and spring and avoided it during fawning season, summer, and deer hunting season ($P < 0.05$). Non-irrigated cropland (corn and hay) was used in proportion to its occurrence except during fawning. Pasture was used less than expected ($P < 0.05$) but attracted deer in early spring. Grassland and shrub were preferred during fawning and summer ($P < 0.05$), and woods were heavily used during deer hunting season and winter. Shifts in habitat use observed during spring and fall were associated with changes in forage availability. Spring-burned grasslands were selected during fawning and fall ($P < 0.01$) by deer within whose home ranges they occurred. Use of irrigated cropland and pasture was limited to the interfaces between these and other habitats, suggesting that irrigated cropland and pasture restrict deer distribution. Continued irrigation development may affect central Wisconsin deer herds by decreasing winter food and cover.

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Key words: white-tailed deer, *Odocoileus virginianus*, habitat use, land use, irrigated agriculture, grassland, pastureland, prescribed burn, radio-telemetry.

Midwest deer populations increased after an interspersion of woodlots, croplands, and abandoned farms was created during the 1930's-50's, but growing use of monotype crop systems may reverse this trend (Crawford 1968). An increase in irrigated agriculture, characterized by the loss of small farms and woodlots and widespread use of corporate farming techniques, has recently occurred in central Wisconsin (Butler 1978). The state's highest white-tailed deer densities (8-15/km^2) also occur in this region.

Wisconsin deer research has dealt mainly with northern forested regions (Dahlberg and Guettinger 1956, McCaffery and Creed 1969, McCaffery et al. 1974). Larson et al. (1978) described movements and habitat use of deer inhabiting an isolated tamarack (*Larix laricina*) swamp in southcentral Wisconsin. Hamerstrom and Blake (1939) studied winter habits of central Wisconsin deer in a primarily forested area that had little agricultural influence. This paper reports on seasonal habitat use by deer in an irrigated agriculture and grassland area in central Wisconsin.

We gratefully acknowledge all cooperating landowners. Field assistance was provided by several University of Wisconsin-Stevens Point students, especially D. McConnell. J. Cary designed computer programs and guided statistical analysis. Technical assistance was provided by M. Gratson and O. Rongstad throughout the project. R. Rosenfield critically reviewed the manuscript. This study was funded by the University of Wisconsin Cooperative Research Projects Consortium.

STUDY AREA

The Buena Vista Marsh, in southwestern Portage County, Wisconsin, is 200 km^2 of flat sand and peat soils drained by a series of ditches. Land use history is described by Westemeier (1971), Hamerstrom and Hamerstrom (1973), and Butler (1978). The 327-km^2 study area includes 2/3 of the Buena Vista Marsh (hereafter, marsh) and 190 km^2 of uplands around its boundary. About 28% of the study area is forested; mixed jackpine (*Pinus banksiana*) and oak (*Quercus* spp.) in the uplands make up 90% of the woodlot cover; some small (15-60 ha) trembling aspen (*Populus tremuloides*) woodlots are scattered throughout the marsh. Shrub (willow (*Salix* spp.) and shrub-stage aspen and oak) covers 8% of the area. Grassland comprises 20% of the study area; most (70%) is in the marsh and is managed by the Wisconsin Department of Natural Resources for prairie chickens (*Tympanuchus cupido*) by periodic burning, mowing, light grazing, and herbicide treatment. Large (65-200 ha) open pastures in the marsh (about 14% of the study area) are heavily grazed by beef cattle from early May through September. Irrigated croplands (corn and cash crops, mainly potatoes) comprise 18% of the study area; these large (65-260 ha) tracts are nearly always fall-plowed, but rye is used as a cover crop on 1/3-2/3 of the cash crop fields. In contrast, non-irrigated croplands (corn and hay, 12% of the study area) are smaller (16-32 ha) and are rarely fall-plowed. Mean annual precipitation is 75 cm, including 110 cm of snow; mean annual temperature is 6 C with extremes of -42 to 42 C.

METHODS

Deer were captured with Clover traps (Clover 1956), rocket nets (Hawkins et al. 1968), and a Cap-Chur gun (Palmer Chemical and Equipment Co., Inc., Douglasville, Ga.) with xylazine hydrochloride (Rompun®, Cutter Laboratories, Inc., Shawnee, Kans.) as an immobilizing agent. Deer were ear-tagged and fitted with solar-powered radio-transmitter collars that contained Ni-Cad batteries (Telemetry Systems, Inc., Mequon, Wis.). Radio-collared deer were located with a vehicle-mounted

Yagi antenna at an average distance of 0.8 km; the maximum receiving range was 1.5-2.0 km. Location accuracy varied from 0.5 ha in open areas to 2.5 ha in wooded areas. A Cessna 150 aircraft, with "H" antennas (Telonics, Inc., Mesa, Ariz.) mounted on the wing struts, was used to locate deer that could not be found from the ground. We attempted to locate each radio-collared deer every 28 hours; multiple daily locations were collected during the deer hunting season.

Radio-locations were pooled and analyzed for 6 seasons: spring (16 Feb-15 May), fawning (16 May-15 Jul), summer (16 Jul-15 Sep), fall (16 Sep-21 Nov), gun (deer hunting) season (22-30 Nov), and winter (1 Dec-15 Feb). Seasonal data sets for individual deer were not used if $<$ 20 radio-locations were available for analysis; a 10-location minimum was used for gun season.

Trapping was conducted over a 245-km^2 area that was arbitrarily defined by Township lines. Sections (2.6 km^2) outside this initial study area were included (75 km^2 total) when radio-locations occurred within them. We used chi-square goodness-of-fit tests to determine if habitats were used in proportion to their availability; the proportion of radio-locations in each habitat (observed frequencies) were compared with the proportion of occurrence of the respective habitat types in the study area (expected frequencies); if significant, preference for, or avoidance of, individual habitat types was determined (Neu et al. 1974). Use by individual deer of 2 grassland areas burned in mid-April 1980 was analyzed similarly, except that expected frequencies were based on habitat available within the minimum area home range (Mohr 1947). We used chi-square contingency tests to determine if use of habitats differed among seasons. Tests were considered significant at $\underline{P} < 0.05$.

RESULTS

We analyzed 1,887 radio-locations that were collected from 17 deer during 1 November 1979-15 May 1981, of which 56% were obtained at night (1 hour before sunset to 1 hour after sunrise). Habitat use differed among seasons ($\underline{P} < 0.001$) and was not in proportion to its occurrence ($\underline{P} < 0.001$).

Seasonal Habitat Use

Spring.--Deer from the marsh moved from wintering areas in mixed upland woods and began using grassland areas in the marsh. Non-irrigated cropland and grassland were used in proportion to their availability (Table 1). Irrigated cropland and pasture received their greatest use during this season but were used in proportions less than their availability ($\underline{P} < 0.05$). Irrigated croplands were used only if rye or waste corn were available. Use of pasture by deer in the marsh was high during April but decreased thereafter.

Fawning and summer.--Use of woods decreased and grassland was strongly preferred ($\underline{P} < 0.05$) (Table 1). Willow-aspen shrub was used as daytime cover in the marsh and was heavily selected by 2 parturient does. Deer made little use of pasture and avoided irrigated cropland ($\underline{P} < 0.05$). Hay was used during fawning season while other crops were being planted

Table 1. Seasonal habitat use by radio-collared deer in the Buena Vista Marsh area, Wisconsin, 1 November 1979-15 May 1981.

Habitat type	Percent of study area	Percent of radio-locations					
		Spring	Fawning	Summer	Fall	Gun season	Winter
Irrigated cropland	18.2	4.7[a]	0.6[a]	0.3[a]	1.2[a]	0.0[a]	3.0[a]
Non-irrigated cropland	12.0	10.1	7.4[a]	9.3	13.0	9.7	12.7
Grassland	20.4	20.4	48.7[b]	48.6[b]	30.8[b]	13.4	5.5[a]
Pasture	14.0	7.4[a]	4.5[a]	3.3[a]	5.6[a]	4.5[a]	2.4[a]
Shrub	7.9	13.6[b]	12.8[b]	14.6[b]	7.0	6.7	12.7
Woods	27.5	43.8[b]	26.0	23.9	42.4[b]	65.7[b]	63.7[b]
Total number of deer tracked		13	12	12	12	8	6
Total number of radio-locations		338	337	397	516	134	165

[a]Habitat use less than expected (avoidance), $P < 0.05$.

[b]Habitat use greater than expected (preference), $P < 0.05$.

or were in early growth stages; use of hay increased during summer after it was mowed.

Fall.--Deer begin moving back to uplands and increased their use of woods (Table 1). Use of grassland and shrub decreased. Waste corn became available during harvest and cropland use increased slightly. Pasture continued to be used less than expected ($P < 0.05$).

Gun season.--Irrigated cropland was not used (Table 1). Use of non-irrigated cropland was proportional to its occurrence, and consisted of night forays to hay and to cornfields. One deer used standing corn as refuge cover during daytime. Use of grassland decreased sharply and upland woods were strongly selected ($P < 0.05$) as deer were driven from the marsh by hunters.

Winter.--Deer decreased their movements and remained in uplands during winter. Grassland and pasture were little-used (Table 1) and woods were strongly preferred ($P < 0.05$). Irrigated cropland was used slightly, when corn stubble was available. Non-irrigated cropland continued to be used in proportion to its availability.

Use of Burned Grasslands

Two grassland areas (65 and 134 ha) were burned in mid-April 1980. These burns were within the home ranges of 4 radio-tagged deer (3 bucks and 1 doe). Deer began using these sites within 2 weeks after burning, when new growth (forbs and grasses) was evident; use increased thereafter. Burned grasslands were preferred during fawning and fall ($P < 0.01$) and were used in proportion to their availability during summer (Table 2).

Table 2. Observed (OBS) and expected (EXP)[a] use of burned grasslands[b] by 4 radio-collared yearling deer in the Buena Vista Marsh, Wisconsin, during fawning season through fall 1980.

		Number of radio-locations in burned grasslands		
		Fawning	Summer	Fall
Male 16	OBS	19	20	10
	EXP	10	10	2
Male 19	OBS	4	20	8
	EXP	1	22	1
Male 20	OBS	4	2	[c]
	EXP	1	1	[c]
Female 23	OBS	11	23	27
	EXP	5	12	14

[a]Expected values are based on proportions of burned grassland available within seasonal (minimum area) home ranges (Mohr 1947).

[b]Burned in mid-April 1980.

[c]Burned grassland was not available within the fall home range of Male 20.

The doe was monitored through 1982; she continued using the 1980 burn.

Deer Distribution and Land Use Patterns

Radio-collared deer distributed their activity over non-irrigated cropland, grassland, shrub and wooded types, but used irrigated cropland and pasture only near cover provided by other habitats (Fig. 1). In fall, deer sometimes ventured into unharvested irrigated cornfields and remained there throughout the day. Deer crossed pastures when traveling to feeding sites and occasionally grazed and bedded in pasture on spring nights. We also observed unmarked deer crossing plowed irrigated cropland and pasture after hunters forced them from cover during gun season.

DISCUSSION

Seasonal variation in habitat use by deer in the Buena Vista Marsh area was influenced mainly by agricultural practices and changes in availability of natural food and cover. Preference for grassland and shrub during fawning season and summer was due to the availability of forbs and grasses. Woods were preferred in winter when grassland, pasture, and irrigated cropland were windswept and offered little food and cover. Spring and fall were transitional periods when deer used the greatest number of habitat types. Habitat use shifted to grassland and pasture in spring when green forage became available in these areas. A preference for woods was evident again in fall when frost killed herbaceous vegetation. The increase in number of habitats used in fall

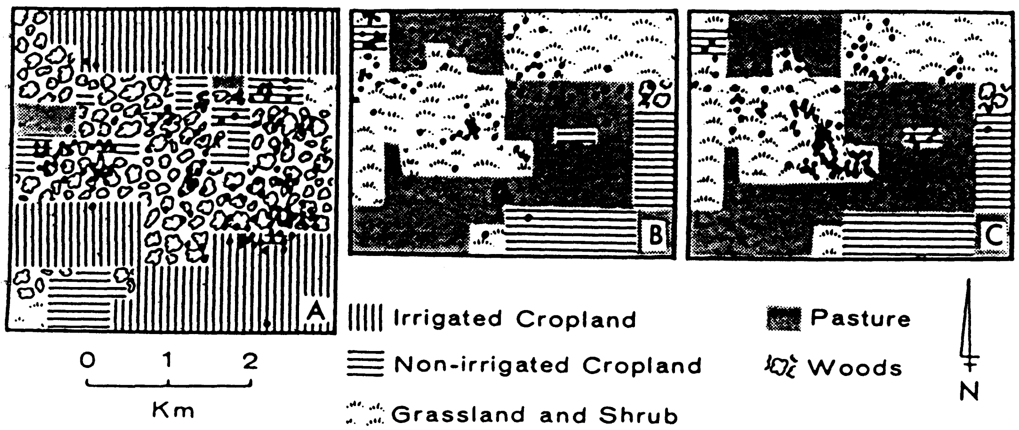

Figure 1. Distribution of deer radio-locations in relation to land use in central Wisconsin. A. Winter and spring radio-locations of 5 deer, 1 km northwest of the Buena Vista Marsh, 1980-81. B and C. Spring radio-locations, and fawning season and summer radio-locations, respectively, of 3 deer on the central Buena Vista Marsh, 1980.

may have been influenced by rut activity.

Irrigated cropland was little-used during fall, winter, and spring and was avoided the rest of the year. Potato and other cash crop fields attracted deer in spring if covered with rye, but were otherwise rarely used. Rye provides the 1st green food for deer after snowmelt in eastcentral Minnesota (Rongstad and Tester 1969). About 1/2 of all cash crop fields were covered with rye during this study, but the extent of rye planting may vary in other years depending in part on time available to farmers in late summer and fall. Similarly, early ground-freeze or delayed harvest may preclude the plowing of irrigated cornfields, thereby leaving waste corn available. However, irrigated cornfields are typically fall-plowed as they were during this study.

Waste corn is a key winter food throughout the non-yarding deer range of the midwest (Mustard and Wright 1964, Nixon et al. 1970, Sparrowe and Springer 1970, Pils et al. 1980). Winter shelter requirements are not as important to southern, non-yarding deer as they are to northern deer (Boer 1978) and winter cover needs may be less critical if high quality forage is available. Deer in western Minnesota agricultural areas do not always seek cover during extremely cold weather because a diet of waste corn, soybeans, and dry sweet clover supplies adequate energy (Moen 1968). We noted that non-irrigated croplands provide waste corn in winter and appear to be an important deer range component during the rest of the year. The conversion of small dairy farms to irrigated agriculture in central

Wisconsin will result in decreased waste corn availability in winter if irrigated cornfields continue to be fall-plowed. Deer depend on woody browse when crop residues are not available, but natural winter foods will be lost when woodlots are removed.

Irrigated croplands also are avoided probably because of their size, just as use of forest clear-cuts by deer is inversely related to the size of the cut (Drolet 1978). The limited use of irrigated croplands that occurred was on field edges. Similarly, Suring and Vohs (1979) found that habitats with food and cover were heavily used by Columbian white-tailed deer (O. v. leucurus) and those with forage only were used only near adjacent cover.

Pastures were little-used, also probably because they lacked cover. However, deer may avoid cattle (Suring and Vohs 1979). Pastures were used in April apparently because they provided green forage earlier than surrounding grasslands. Corn food plots (2 ha) planted for prairie chickens were heavily used in spring. Deer crossed pastures to reach these and sometimes remained in food plots for 1-3 days, bedding in unharvested portions during the day. Use of standing corn as daytime bedding cover also has been observed in southern Wisconsin (Larson et al. 1978).

Deer abundance in central Wisconsin depends in part on fawn production and survival. Grasslands in the marsh provide undisturbed fawning habitat; lack of disturbance is critical to fawn survival (Ozoga et al. 1982). Grasslands also provide abundant forbs and grasses; these are generally high in protein and digestible energy (Verme and Ozoga 1980). Julander et al. (1961) related mule deer (O. hemionus) productivity to quality of summer range. Nutritional quality in summer is also important to winter survival (Boer 1978, Mautz 1978). Aspen suckers that occur in shrub and grassland areas provide succulent leaves through early fall. McCaffery et al. (1974) reported that grasses and aspen leaves are the most important summer foods of deer in northern Wisconsin.

Our results support those of Hamerstrom and Blake (1939) that central Wisconsin deer prefer young grasses in burned areas and use aspen-willow flats extensively during summer. Deer in the marsh used aspen shrub and willow for bedding and fawning cover. Interspersed shrub may increase the value of grassland as summer range. South Dakota deer prefer meadows in summer because both herbaceous growth and shrub cover are present (Progulske and Duerre 1964). Selection for burned grasslands during fawning and fall in this study probably was related to the availability of succulent, nutritious vegetation. Moisture and protein content of vegetation increases after burning (Vogl 1965, Lay 1967). Selected use of burned areas by deer also has been reported by Dasmann and Taber (1956), Lay (1967), Vogl and Beck (1970), and Pledger (1975).

Deer continued using grasslands in fall but began shifting their use to upland woods, probably in search of acorns which are a preferred fall food (McCaffery et al. 1974). During gun season and winter, woods (mixed oak-jackpine-aspen) were the only preferred habitat. Winters were mild during this study and we expect that use by deer of open areas would be even less in winters with heavy snow. Hamerstrom and Blake (1939) likewise observed preference for mixed oak-pine and complete avoidance of open marsh and aspen-willow flats during winter. Deer in an intensive agricultural area in Iowa rely on a timbered state park for cover during hunting season and winter (Zagata and Haugen 1972). Swenson (1982) observed an increase in use of timbered areas by prairie mule deer during hunting season and found that these deer are more vulnerable to hunters than those in wooded areas. The proximity of upland woods to the marsh is likely critical for the survival of deer from grasslands during gun season.

Use of habitats also varied among individual deer. Social experience, learning, and tradition may be more important than innate abilities in selecting the best habitat (Nelson 1979). We noted different preferences for grasslands and woods during spring through fall but woods were heavily used by all deer during gun season and winter.

MANAGEMENT IMPLICATIONS

During 1972-77, irrigated croplands increased from 650 to 22,250 ha in Portage County and this trend will likely continue (Butler 1978). Irrigation development initially may have increased diversity of central Wisconsin deer range by breaking up extensive forest cover, but now it appears that irrigated agriculture is of little value to deer. Our data suggest the continued irrigation development will restrict deer distribution and reduce winter range carrying capacity. The upland woods area west of the marsh, used by deer as wintering habitat during this study, is destined for irrigation development (Butler 1978). Reduced crop residues and loss of hayfields associated with replacement of small dairy farms by cash crop farming, combined with decreased mast and browse associated with woodlot removal, will likely result in lowered productivity of central Wisconsin deer. Weights and antler beam diameters of Illinois deer from a cash crop area were less than those from a beef and dairy farming area, suggesting lower quality nutrition associated with cash crop farming (Richie 1970). The relationship between deer productivity and nutrition is well known (Cheatum and Severinghaus 1950, Severinghaus and Tanck 1964, Verme 1963, 1965, 1969).

Landowners must be encouraged to maintain wildlife habitat if continued deer abundance is desirable in central Wisconsin. Windbreaks (grass-shrub strips on irrigated fields and tree windbreaks on field edges and corners), minimum tillage systems on cornfields, and increased rye-cover planting on cash crop fields will improve irrigated croplands for deer. Unless woodlots remain, winter cover will become the major limiting factor for deer as it has in other midwest agricultural areas (Mustard and Wright 1964, Crawford 1968, Nixon et al. 1970).

Deer benefit from existing grassland management practices in the marsh. Although control of aspen shrub invasion is a major aim of this management, present shrub distribution on grasslands appears favorable to deer. Continued practice of spring burning and establishing corn food plots also will enhance the value of grasslands for deer.

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SEDENTARY AND MIGRATORY WHITE-TAILED DEER ON ADJACENT HABITATS IN CENTRAL WISCONSIN

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Abstract: Intensive row cropping is replacing other land uses in a central Wisconsin area of open grassland-agriculture surrounded by mixed upland woods-agriculture. There we investigated seasonal movements, home ranges, and wintering areas of white-tailed deer (*Odocoileus virginianus*). We radio-tracked 19 deer during November 1979-November 1982; about 2,500 radio-locations were collected of which 1,887 were used for home range analysis. Additional data were collected from 10 ear-tagged deer. Our data indicate that 2 populations exist in the study area. Sedentary deer occupied year round home ranges in the upland woods-agricultural area. Migratory deer summered in the open grassland-agricultural area and moved to separate home ranges in the uplands mainly in early to mid-October after the 1st frosts occurred; they returned to the open area during mid-February through March when successive daily temperatures reached 8-15 C; winter and summer ranges of 7 of these deer were separated by an average of 10.2 km. Core area home ranges that contained 67% of a season's radio-locations varied from 4 ha for an adult doe in upland woods during winter to 1,932 ha for a yearling buck in open grassland during fall. Home ranges appeared to be smallest during fawning, summer, and winter periods, largest during fall, and intermediate during spring and deer hunting season. Deer in open grassland appeared to use the largest areas while those with woodlot in their home ranges appeared to use the smallest. Both sedentary and migratory deer in the study area may be negatively affected if their common winter (upland woods) habitat continues to be diminished.

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Key words: white-tailed deer, *Ococoileus virginianus*, Wisconsin, movements, home range, sedentary, migratory, dispersal, behavior, land use, radio-telemetry, harmonic mean activity center.

Deer in heavily forested northern Wisconsin move to traditional yarding areas for the winter (Dahlberg and Guettinger 1956, Christiansen 1959, O'Brien 1976) while those in agricultural southern Wisconsin have overlapping summer and winter ranges (O'Brien 1976, Larson et al. 1978, Wozencraft 1978). In a forested part of central Wisconsin with little agricultural influence, deer move to winter "concentration areas" (Hamerstrom and Blake 1939) that are similar to yards used by northern deer.

Little is known about seasonal movements of deer in the mixed agriculture and forest region of central Wisconsin where the state's highest deer densities (8-15/km^2) exist. The 200-km^2 Buena Vista Marsh, a unique grassland area in this region, harbors deer from late spring through fall. Wintering areas of deer from the marsh are unknown; adjacent woodlots that may serve as winter cover are being converted to irrigated croplands (Butler 1978). The objective of this study was to examine seasonal movements and home ranges of white-tailed deer in and adjacent to the Buena Vista Marsh.

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STUDY AREA

The 327-km^2 study area includes all but the southeastern 1/3 of the drained Buena Vista Marsh in southwestern Portage County, Wisconsin and 190 km^2 of adjacent uplands. That part of the study area (137 km^2) in the marsh consists of 38% grassland and grass-shrub types (Kentucky bluegrass (Poa pratensis), quackgrass (Agropyron repens), goldenrod (Solidago spp.), willow (Salix spp.), and shrub-stage trembling aspen (Populus tremuloides)), 31% open pasture, 23% cropland (corn, cash crops, and hay), and 8% small (15-60 ha) woodlots (aspen). The uplands consist of 42% woodlots and 10% shrub (both dominated by mixed oak (Quercus spp.), jackpine (Pinus banksiana), and aspen), 35% cropland (corn, cash crops, and hay), and 13% idle fields and pasture. Soils are primarily flat sands from glacial outwash. Mean annual precipitation is 75 cm, including 110 cm of snow; mean annual temperature is 6 C with extremes of -42 and 42 C.

METHODS

Deer were captured with Clover traps (Clover 1956), rocket nets (Hawkins et al. 1968), and a Cap-Chur gun (Palmer Chemical and Equipment Co., Inc., Douglasville, Ga.) with xylazine hydrochloride (Rompun®, Cutter Laboratories, Inc., Shawnee, Kans.) as an immobilizing agent. Fawns (1-2 weeks old) were captured by hand (Downing and McGinnes 1969). Deer were marked with cattle ear-tags and most were fitted with solar-powered radio-transmitter collars that contained Ni-Cad batteries (Telemetry Systems, Inc., Mequon, Wis.). Deer were located with a vehicle-mounted Yagi antenna. A Cessna 150 aircraft, with "H" antennas (Telonics, Inc., Mesa, Ariz.) mounted on the wing struts, was used to locate deer that could not be found from the ground. During November

1979-December 1980, we attempted to locate each radio-collared deer every 28 hours; deer were tracked infrequently (1-3 times weekly) thereafter. Multiple daily locations were collected during the 9-day Wisconsin deer hunting season in 1980.

For home range analysis, we recognized 6 seasons: spring (16 Feb-15 May), fawning (16 May-15 Jul), summer (16 Jul-15 Sep), fall (16 Sep-21 Nov), gun (deer hunting) season (22-30 Nov), and winter (1 Dec-15 Feb). Seasonal data sets for individual deer were not used for home range analysis if $<$ 20 radio-locations were available; a 10-location minimum was used for gun season.

Home ranges were determined by constructing a convex polygon with the smallest perimeter (i.e., minimum perimeter polygon, MPP) that encompassed the outermost radio-locations. The most frequented parts of an animal's home range have been termed "core areas" (Ewer 1968:65). Isopleths that contained 67% of a season's radio-locations and that were defined by harmonic mean activity centers (Dixon and Chapman 1980) were used to determine core areas in this study. Deer with exclusive summer and winter core areas were considered migratory. Bucks that moved from their summer core areas and that were shot during gun season were considered migratory based on our knowledge of movements of migratory does that survived gun season.

RESULTS AND DISCUSSION

We captured 29 deer during June 1979-February 1981; 10 were ear-tagged, and 19 were radio-collared and followed 2-30 months each during November 1979-November 1982. About 2,500 radio-locations were collected; 56% of 1,887 locations used for home range analysis were obtained at night (1 hour before sunset to 1 hour after sunrise).

Deer that used the marsh during summer (hereafter, "marsh deer") had separate home ranges in the uplands during winter. Marsh deer moved to and from these areas mainly in spring and fall. Deer that used uplands as summer habitat (hereafter, "woods deer") maintained year round home ranges, except when they dispersed.

Migration

Migration data are from 10 marsh deer (4 yearling bucks, 4 yearling does, and 2 adult does) that were tracked in 1980; 2 of these continued to provide data in 1981, and 1 was tracked through 1982.

Timing and Causes of Fall Migration.--Marsh deer moved to uplands mainly in early to mid-October after the 1st frosts occurred (23 and 25 Sep, 2-5 Oct). Decreasing temperatures also trigger migration to winter yards by northern deer (Verme and Ozoga 1971, Nelson and Mech 1981). However, northern deer may not migrate in winters of relatively little snow (Drolet 1976). Deer migrated from the Buena Vista Marsh before snow accumulated; those that were still in the marsh during gun season were either shot or were driven from their home ranges. One deer moved to her wintering area on the last day of gun season when tracked as a yearling, on the 1st day of gun season the next year, and was shot while moving toward her wintering area on the 1st day of gun season when tracked a 3rd year. If deer in open habitats suffer greater mortality than those in wooded habitats (Picton and Mackie 1980), early fall migration from the marsh would have survival value.

Rut activity does not appear to influence fall migration as deer moved to uplands at least 1 month before the peak of the rut in mid-November. However, 2 of 3 radio-collared deer that were still in the marsh in mid-November were breeding bucks; they may have been showing fidelity to their home ranges because of the rut. Adult bucks are the last to leave the fall breeding grounds in Upper Michigan (Verme 1973).

Timing and Causes of Spring Migration.--Deer returned to the marsh when successive daily temperatures reached 8-15 C, during mid-February through March following a mild winter (average Feb and Mar snow depths in 1981 were 8.0 and 0.0 cm, compared to 22.4 and 19.4 cm for 1961-77), and during April following a severe winter (average Feb and Mar snow depths in 1982 were 47.6 and 20.8 cm). Similarly, Hamerstrom and Blake (1939) reported that central Wisconsin deer move from their wintering areas during March and April, and move earlier after short, mild winters. Deer in the prairie-agricultural region of eastern South Dakota also move to their summer ranges during March-April thaws (Sparrowe and Springer 1970), and northern deer move from their winter yards when temperatures rise above freezing and snow depths permit travel (Rongstad and Tester 1969, Verme and Ozoga 1971, Drolet 1976, Hoskinson and Mech 1976, Nelson and Mech 1981).

Migration Distance and Visits.--Winter and summer ranges of 7 marsh deer were 4.8-21.0 km apart ($\bar{x}$ = 10.2, SE = 2.2), slightly less than distances reported for northern yarding deer (4-40 km) (Hoskinson and Mech 1976, Nelson and Mech 1981) and deer in prairie-agricultural regions (20-48 km) (Sparrowe and Springer 1970, Harmoning 1976).

Marsh deer occasionally returned to their summer ranges after migrating in fall. These visits lasted 1-4 days and were associated mainly with hunter pressure during gun season, and with periods of warm (8-15 C) weather during early spring; spring visits ended when cold ($<$ 0 C) weather resumed. Northern deer make similar temporary visits that also are associated with increasing temperatures (Ozoga 1968, Rongstad and Tester 1969, Nelson and Mech 1981). In this study, 1 doe that was tracked during 2 consecutive fall and spring migrations and whose winter and summer ranges were farther apart (21.0 km) than those of other deer, did not make any visits; perhaps visits are made only by deer with winter and summer ranges relatively close to each other.

Migration and Home Range Tradition.--Marsh deer apparently use their wintering areas year after year as has been reported for white-tailed deer throughout northern parts of their range (Olson 1938, Verme 1973, Drolet 1976, Hoskinson and Mech 1976, Nelson and Mech 1981); those that were tracked $>$ 1 year moved to the same respective wintering areas during consecutive fall migrations. This migration tradition may be learned through mother-offspring association (Nelson and Mech 1981); adult does were accompanied by their fawns when they moved from the marsh.

Wintering Area Location vs. Land Use.--The conversion of woodlots around the Buena Vista Marsh to irrigated cropland could negatively affect area deer by reducing winter cover. Marsh deer winter home ranges in uplands apparently overlapped those of year round residents and were mainly west of the marsh (Fig. 1); this area has high potential for continued irrigation development (Butler 1978).

Seasonal Home Range Dynamics

Spring.--MPP home ranges were determined for comparison with other studies, but they generally overestimated the size of the area that was used. For example, spring MPP home ranges (Table 1) of marsh deer that migrated included the "unused" areas between their respective winter and summer ranges, and those of other deer included forays (0.7-2.9 km) to rye and to cornfields. One deer made a brief (1 night) 3.0-km trip from her core area that was presumably caused by the onset of territorial behavior by her dam before fawning (Hirth 1977, Ozoga et al. 1982).

Fawning and Summer.--MPP and core sizes decreased from spring to fawning and summer for nearly all deer (Tables 1, 2) probably because habitat needs were well met during these periods and, except for agricultural activity, deer were free from disturbance. Relatively small home range size during fawning-summer periods has been reported by others (Behrend 1966, Sparrowe and Springer 1970, Gladfelter 1978, Wozencraft 1978, Nelson and Mech 1981).

Fall and Gun Season.--MPP and core sizes increased from summer to fall (Table 2, 3). Early fall movements that increased MPP sizes appeared to be food-related while those in late fall were associated with the rut. For example, a yearling buck moved (28 Sep and 6 Oct) 4.0 km

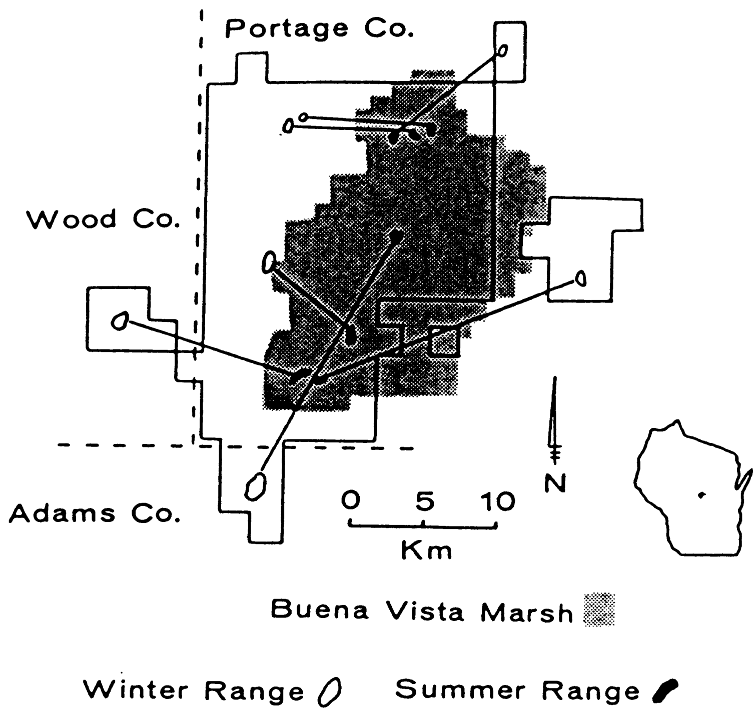

Fig. 1. Winter and summer ranges of 7 deer from the Buena Vista Marsh, Wisconsin, 1980-82.

Table 1. Spring (16 Feb-15 May) core area[a] and minimum perimeter polygon (MPP) home range sizes (ha) for radio-collared deer from the Buena Vista Marsh (marsh deer) and from adjacent uplands (woods deer), 1980.

	Deer no.	Core	MPP
Marsh deer			
Fawn male	16[b]	122	231
	19[b]	262	700
	20[b]	80	313
Fawn female	22	116	160
Yearling female	02[c]	90, 33[d]	598
	23[c]	269	2,408
Adult female	26[c]	278, 30[d]	813
Woods deer			
Fawn male	05	74	396
	09	47	63
	11	64	100
Yearling male	06	310	550
Fawn female	08	57	83
	13	55	192

[a]Core areas are defined by isopleths that contain 67% of a season's radio-locations, and that are based on harmonic mean activity centers (Dixon and Chapman 1980).

[b]Males 16, 19, and 20 were captured on their summer ranges in the Buena Vista Marsh during mid-spring (16 Mar-4 Apr).

[c]Data were collected in 1981.

[d]Females 02 and 26 had 2 core areas during spring; the 1st figure is the uplands (winter range) core area size and the 2nd figure is the marsh (summer range) core area size.

Table 2. Fawning (16 May-15 Jul) and summer (16 Jul-15 Sep) core area[a] and minimum perimeter polygon (MPP) home range sizes (ha) for radio-collared deer from the Buena Vista Marsh (marsh deer) and from adjacent uplands (woods deer), 1980.

		Fawning		Summer	
	Deer no.	Core	MPP	Core	MPP
Marsh deer					
Yearling male	12	19	71	74	213
	16	67	323	53	440
	19	215	458	50	131
	20	76	163	98	415
Yearling female	02	16	42	6	25
	10	15	37	8	35
	23	81	260	46	165
Adult female	26	16	23	15	54
	27	20	77	153	813
Woods deer					
Yearling male	05	232	1,694	56	148
Adult male	06	56	162	51	125
Yearling female	13	61	571	12	92

[a]Core areas are defined by isopleths that contain 67% of a season's radio-locations, and that are based on harmonic mean activity centers (Dixon and Chapman 1980).

Table 3. Fall (16 Sep-21 Nov) and gun season (22-30 Nov) core area[a] and minimum perimeter polygon (MPP) home range sizes (ha) for radio-collared deer from the Buena Vista Marsh (marsh deer) and from adjacent uplands (woods deer), 1980.

		Fall		Gun Season	
	Deer no.	Core	MPP	Core	MPP
Marsh deer					
Yearling male	12	345, 147[b]	2,213	---	---
	16	1,932	4,033	---	---
	19	501	3,592	---	---
	20	450, 148[b]	3,215	170	296
Yearling female	02	115, 167[b]	2,190	107	548
	10	65	640	---	---
	23	108	358	864	4,046
Adult female	26	134	452	89	910
Woods deer					
Fawn male	04[c]	---	---	5	27
Yearling male	05	53	327	---	---
Adult male	06	270	635	47	102
Fawn female	03[c]	5	25	14	27
Yearling female	13	27	58	41	390

[a]Core areas are defined by isopleths that contain 67% of a season's radio-locations, and that are based on harmonic mean activity centers (Dixon and Chapman 1980).

[b]Males 12 and 20, and Female 02 had 2 core areas during fall; the 1st figure is the uplands (winter range) core area size and the 2nd figure is the marsh (summer range) core area size.

[c]Data were collected in 1979.

from his core area in the marsh to a 65-ha cornfield where he remained for 3-4 days. Two other yearling bucks wandered extensively over the marsh during late fall and had MPP home ranges that exceeded 3,500 ha. Home ranges of southern Wisconsin does decrease during fall while those of bucks increase (Wozencraft 1978). Both bucks and does in the Buena Vista Marsh area made irregular movements during rut, but those of bucks seemed more frequent and extensive, as Downing and McGinnes (1975) also noted for white-tails in Virginia.

Deer responses to hunter pressure during gun season varied. One adult and 1 yearling buck reduced their activity to within small, heavily wooded core areas (Table 3) and survived 5 and 7 days, respectively, of the 9-day gun season. The adult remained inactive (bedded) while hunters made organized drives through his home range; on 1 occasion he was bedded on the edge of a small (8 ha) field of standing corn while 2 hunters passed within 8-10 m. Other yearling bucks were shot on the 1st day of gun season; all responded to drives by crossing open areas (grass-shrub or hayfields). Yearling male black-tailed deer (O. hemionus columbianus) likewise run across open areas during hunting season; older males seek shelter and allow hunters to pass (Dasmann and Taber 1956). Southern Wisconsin deer behave similarly (Wozencraft 1978).

Does and fawns exhibited strong home range fidelity during gun season; hunters drove them 0.5-9.0 km from their core areas, but they returned at night. Dasmann (1953) noted similar behavior in black-tailed deer. Female deer in Texas also show strong home range fidelity after being driven out during cattle round-ups (Hood and Inglis 1974).

Winter.--MPP and core sizes during winter (Table 4) were similar to those during fawning and summer periods (Table 2). All deer made regular feeding trips (0.4-1.0 km) to hay and to cornfields. The winters of 1979-80 and 1980-81 were mild (average Dec, Jan, and Feb snow depths were 1.5, 3.8, and 7.9 cm compared to the 1961-77 averages 9.1, 24.3, and 22.4 cm) and deer home ranges probably would be smaller in more severe winters. Winter home ranges of northern deer decrease as snow depth increases (Rongstad and Tester 1969, Drolet 1976), reflecting decreased mobility (Telfer 1970).

Other Factors Influencing Movements and Home Range

Habitat Interactions.--Home range size appeared to increase as cover availability decreased. Marsh deer in an open grassland area generally had the largest core areas of all deer except during summer when they intensively used a 134-ha area that was burned in mid-April. Their core areas ranged from 67 ha during fawning (Table 2) to 1,932 ha during fall (Table 3). Marsh deer that used grass-shrub-woodlot on the marsh boundary had intermediate (76-450 ha) core sizes, and those that used aspen woodlot in the marsh had the smallest (67-167 ha) core areas. Except for an adult buck, core sizes of woods deer were comparable to those of marsh deer that used woodlots.

Behavior of Parturient Does.--Adult does decreased their movements, and used smaller areas than nearly all other deer during the fawning

Table 4. Winter (1 Dec-15 Feb) core area[a] and minimum perimeter polygon (MPP) home range sizes (ha) for radio-collared deer from the Buena Vista Marsh (marsh deer) and from adjacent uplands (woods deer), 1980-81.

	Deer no.	Core	MPP
Marsh deer			
Yearling female	02	35	81
	23	263	425
Adult female	26	4	27
Woods deer			
Fawn male	04[b]	137	521
Fawn female	13	9	33

[a]Core areas are defined by isopleths that contain 67% of a season's radio-locations, and that are based on harmonic mean activity centers (Dixon and Chapman 1980).

[b]Data were collected during winter 1979-80.

period (Table 2), but they increased their MPP size during summer as fawns became more mobile and social intolerance toward other deer presumably decreased; 1 doe moved 7.5 km with her twin fawns to an oak woodlot in late August. Ozoga et al. (1982) also reported that parturient does sharply decrease their home range size during fawning and aggressively defend their territories, but begin to associate with other deer about 4-6 weeks postpartum. Others also have noted relatively small home range size for parturient does (Hawkins and Klimstra 1970, Gladfelter 1978, Bartush and Lewis 1979, Nelson and Mech 1981). Michael (1965) found that fawning season movements of female white-tails in Texas were no different from movements in other seasons.

Dispersal of Yearlings.--Our data suggest that central Wisconsin deer disperse greater distances than do southern Wisconsin deer, and they disperse when about 1 year old to habitats similar to those from which they move. Five yearlings dispersed an average of 20.8 km (SE = 1.5); the farthest yearling dispersal in southern Wisconsin was 6.4 km (Larson et al. 1978). Two radio-collared yearlings dispersed at fawning, presumably during the break-up of the family group (Hawkins and Klimstra 1970, Ozoga et al. 1982). This is also the major dispersal period for Iowa deer (Gladfelter 1978). Four woods deer dispersed to the side of the marsh opposite where they were marked, to upland areas similar to those from which they moved. Nelson (1979) stated that habitat selection may be expressed best by dispersing yearlings; our data support his conclusion that familiarity and learning may be more important than innate abilities in selecting the "best" habitat.

CONCLUSIONS

Two behaviorally different populations exist in the Buena Vista Marsh area: sedentary deer fulfill their needs on year round home ranges in uplands adjacent to the marsh; migratory deer fulfill their food and cover needs in the marsh during spring through fall, but move to uplands to fulfill these needs during winter. Movements of marsh deer are roughly similar to those of deer in prairie-agricultural and northern forested regions, and year round home ranges used by woods deer resemble those of deer in agricultural areas.

Home ranges were largest in fall, intermediate during spring and gun season, and smallest during winter, fawning, and summer. Deer in grasslands used larger areas than did deer that included woodlot in their home ranges, probably because feeding areas in grasslands are far from cover while those in wooded areas coincide with, or are adjacent to, cover.

Deer that migrate from the marsh supplement fall populations, and thus the hunting harvest, of deer in adjacent uplands. Similarly, movement of deer from some refuges is important to the deer harvest in surrounding areas (Hawkins et al. 1971, Kammermeyer and Marchinton 1976). Deer harvests in the Buena Vista Marsh and in surrounding uplands will decrease if winter (upland woods) habitat continues to be removed.

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APPENDIX A. SYMBIOTIC INTERACTION BETWEEN STARLINGS AND DEER

The symbiotic relationship between oxpeckers (Buphagus spp.) and large African mammals is well documented (Rice, Auk 80:196-197, 1963). A few North American birds have been observed on large mammals eating ectoparasites. Most of these associations involve ungulates and corvids (Rice and Mockford, Wilson Bull. 66:272-273, 1954; Dixon, Condor 46:204, 1944); a recent note describes interactions between Scrub Jays (Aphelocoma coerulescens) and feral hogs (Sus scrofa) (Baber and Morris, Auk 97:202, 1980). I observed two similar interactions between Starlings (Sturnus vulgaris) and white-tailed deer (Odocoileus virginianus) in central Wisconsin where Starlings commonly feed on insects flushed by grazing cattle. Observations were made with a 15 x 60 spotting scope.

On 8 July 1979 at 20:50 CST I saw an adult female deer walking through a grass-shrub area; an adult Starling was perched on its nose. The bird moved up to the crown of the deer's head, down the neck and back, and returned to the head, ostensibly probing for ectoparasites; the deer showed no reaction. The observation lasted 10 minutes while the deer moved over 200 m and then out of view.

On 16 July 1979 at 09:15 CST I saw an adult Starling on the head of an adult deer of unknown sex. The deer was on a little-used road which bisected a pasture area interspersed with oak (Quercus spp.) woodlots. The deer was visible for only 15 seconds before it disappeared into cover and was apparently oblivious to the presence of the Starling. Riney (Condor 53:178-185, 1957) noted similar complacency in Scrub Jay-mule deer (O. hemionus) interactions. That advanced feeding behavior is extensive in another sturnid, the oxpecker, suggests that family-related learning traits may be developing within local Starling social groups as Baber and Morris (op. cit.) speculated for Florida Scrub Jays.

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