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Agricultural Land Use and Mourning Doves in Eastern Colorado: Implications for Nesting and Production in the Great Plains

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ABSTRACT — Mourning dove (*Zenaida macroura*) nesting and production were studied in four agricultural habitats and in shelterbelts in eastern Colorado in 1978-80. Although success did not differ ($P > 0.70$) between ground nests (46.7%) and nests in trees (43.7%), nesting densities and production were greatest ($P < 0.05$) in shelterbelts. The outlook for mourning dove production in treeless areas of the Great Plains is poor if the trend of shelterbelt removal without replacement continues into the 1990s.

Mourning doves nest throughout North America on a diversity of substrates including trees, shrubs, vines, buildings, and the ground. Substantial numbers of mourning dove nests on the ground have been reported in relatively treeless areas (Cowan 1952, Hon 1956, Downing 1959).

On the Great Plains, agricultural practices have changed tremendously during the past three decades, potentially affecting nesting mourning doves and other wildlife. Van Deusen (1978) reported considerable removal of shelterbelts and farmstead groves that had been planted primarily in the 1930s and 1940s. Field observations by the authors and other agency personnel indicate that shelterbelt removal continued in eastern Colorado in the 1980s. Many of the removed shelterbelts have not been replanted, or have been replaced with a single row of trees that are less useful to migrating and breeding birds, including mourning doves (Martin 1978).

Additional trends in agricultural land use have included increased field size, conversion of native prairie to dryland and irrigated agriculture, and production of irrigated crops on land previously planted to non-irrigated crops. Increases in irrigated cropland during the 1970s and 1980s resulted from the advent of center-pivot irrigation systems. Analyses of trends indicate that, in the United States, the Great Plains will be the agricultural

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region with the greatest impacts on wildlife habitats due to changes in agricultural practices (National Academy of Sciences 1982).

These changes in agricultural land use in the Great Plains have been apparent in eastern Colorado, particularly in wheat- and corn-producing counties. For example, area planted to dryland wheat in Weld County increased from about 61,000 ha in 1950 to 95,000 ha in 1980 (Colorado Agricultural Statistics 1952, 1982). Similarly, in Yuma County (the leading corn-producing county in Colorado) corn production increased during the same period from about 45,000 to 84,000 ha (Colorado Agricultural Statistics 1952, 1982). A dramatic rise in the use of irrigation systems facilitated the increase in corn production; the percentage of area planted to grain corn in Yuma County that was irrigated increased from 0.2 in 1950 to 98.5 in 1980. Our objectives were to examine mourning dove nesting densities, nesting success, and production in habitats representative of those undergoing changes in agricultural land use in the Great Plains.

STUDY AREAS AND METHODS

Four study areas containing representative samples of native prairie, dryland agriculture, irrigated row crops, and shelterbelts (windrows and groves of trees near farm buildings were collectively referred to as shelterbelts) were searched for mourning dove nests in 1978-80 (Fig. 1).

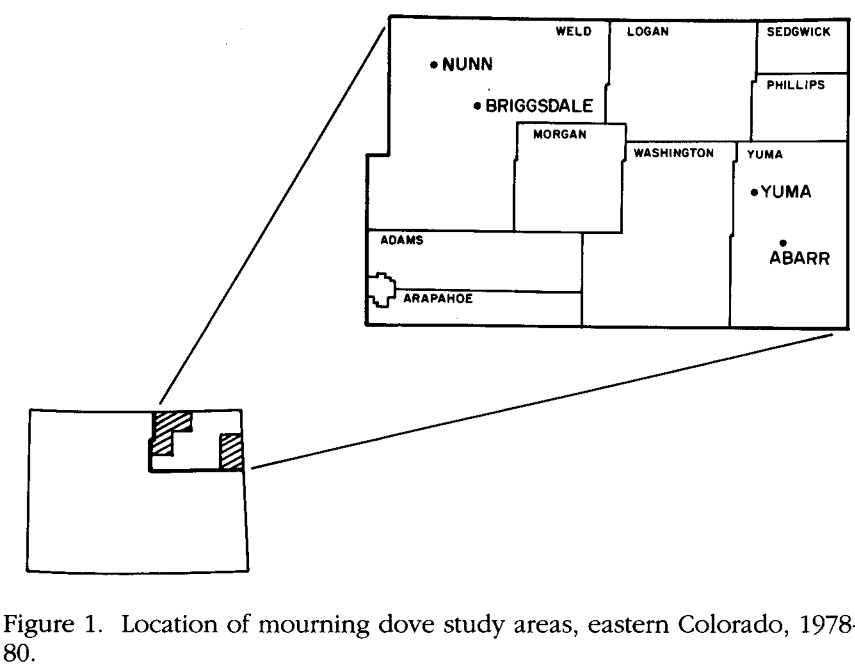

Figure 1. Location of mourning dove study areas, eastern Colorado, 1978-80.

The Nunn study area was 12 km north of Nunn, Weld County, and within the Pawnee National Grassland at 1640 m elevation. Eight short-grass prairie plots totaling 70 ha (range: 5-10 ha) and three shelterbelts totaling 0.9 ha (range: 0.2-0.4 ha) were searched for nests. Dominant plant species in the short-grass prairie plots were blue grama (*Bouteloua gracilis*), common buffalograss (*Buchloe dactyloides*), and fourwing salt-bush (*Atriplex canescens*). Shelterbelts included primarily Siberian elm (*Ulmus pumila*) and eastern juniper (*Juniperus virginiana*), as well as rows of fragrant sumac (*Rhus trilobata*) and Siberian peashrub (*Caragana arborescens*).

The Briggsdale study area was 12 km east-southeast of Briggsdale in southeastern Weld and northwestern Morgan counties at about 1500 m elevation. Nest searches were conducted in two dryland winter wheat and two fallow plots totaling 20 ha (10 ha/plot) each during the three years. Three shelterbelts searched for nests in 1978 totalled 1.5 ha (range: 0.2-0.9 ha). Two shelterbelts (0.2 and 0.4 ha in size) were searched in 1979 and 1980. Because nesting densities and productivity were examined on a per ha basis, rather than as absolute numbers, the decrease in area of shelterbelts searched did not affect interpretation of results. Dominant tree species in the shelterbelts were Siberian elm and common honeylocust (*Gleditsia triacanthos*).

The Yuma study area was in the sandhill region of Yuma County, 9 km south of Yuma at about 1260 m elevation. Three irrigated corn study plots totaling 60 ha (20 ha/plot) and three mixed prairie plots totaling 30 ha (10 ha/plot) were searched. Mixed prairie plots contained a variety of short-, mid-, and tall-grasses, including prairie sandreed (*Calamovilfa longifolia*), needle-and-thread (*Stipa comata*), and sand dropseed (*Sporobolus cryptandrus*). Dominant shrubs were sand sagebrush (*Artemisia filifolia*) and small soapweed (*Yucca glauca*). Three shelterbelts totaling 0.6 ha (0.1, 0.1, and 0.4 in ha in size) were searched for nests during the three years. All three shelterbelts were composed entirely of Siberian elm.

The Abarr study area was also in Yuma County, 32 km southeast of Yuma at 1306 m elevation. Two shelterbelts (0.8 and 0.5 ha) were searched for nests. The dominant tree species within the shelterbelts was Siberian elm, with occasional plains cottonwood (*Populus sargentii*) and Russian-olive (*Elaeagnus angustifolia*).

Study plots and shelterbelts in all study areas were searched weekly for mourning dove nests from May through October 1978 and March through October in 1979 and 1980. No active nests were observed in March or April during the latter two years. Nests in trees at heights greater than 2 m above the ground were observed using a 6.5-m telescoping mirror pole. During the initial year of study, trees that appeared to be completely dead (snags) were noted, as were those with crowns that appeared to contain at least 50% dead material.

Study plots in ground-nesting habitats were searched by walking parallel transects that varied in width with height of vegetation. Transect widths in fallow study plots were 10 m, whereas in shortgrass and mixed prairie they were generally 4-7 m wide. Width of transects in wheat decreased during the growing season from 8 to 3 m at harvest in mid-July, then increased in the remnant stubble to 5 m. As vegetation height and density increased in irrigated corn plots, transect width decreased from 8 to 3 m. Due to height and density of corn plants, nest searches were discontinued in those plots when plants exceeded 2 m in height. We believe it unlikely that doves or nests could be located if present among corn plants of that height. In contrast, the difficulty of finding nests in other ground-nesting habitats did not substantially increase during the nesting season. For example, height and density of plants in native prairie and fallow changed little throughout the nesting seasons. Vegetative cover in wheat increased in height to a maximum of 0.6-1.0 m in mid-July. At that time, wheat was harvested, leaving stubble of about 10-25 cm in height.

Each active dove nest was observed weekly until it failed or until young fledged. Although some previous investigators believed that fledging can occur as early as 10-11 days after hatching (Cowan 1952, Swank 1955, Hanson and Kossack 1963, Geissler et al. 1987), results of recent research have indicated that young doves may be dependent on adults up to 18 days after hatching (Hitchcock and Mirarchi 1984). Therefore, we considered nests successful only if young disappeared more than 13 days after hatching and the nest was intact. This nestling period followed more conservative times to fledging used by others, such as Hanson and Kossack (1963). Age of nestlings was estimated by comparing them to photographs and descriptions of known-age nestlings (Hanson and Kossack 1963). To accurately assess the outcome of nesting attempts, efforts were made to observe nests containing young as close to the 13th day after hatching as possible.

Because of the variable and protracted length of time that young doves are dependent on adults, we calculated nesting success by traditional percentages, rather than the Mayfield (1961, 1975) method. The latter is based on days of nest exposure and requires a known, consistent nesting period. In addition to an inconsistent nestling period, other factors could cause difficulties in using the Mayfield method for mourning doves, including potential differences in daily mortality rates within the incubation period (as reported by Woolfenden and Rohwer 1969) and between ground nests and nests in trees. Green (1977) suggested that if this method is used on groups of nests with different degrees of risk (such as ground nests vs. nests in trees), a biased estimate will result. Although Johnson (1979) proposed a technique to minimize the bias, we opted to use traditional percentages due to the potential confounding effects of differences in nesting period and susceptibility to nest loss.

Chi-square analysis was used to compare expected and observed results. Expected results were based on equal proportions among habitats for nesting success, number of nests found, and number of young produced. Contingency tables were used to compare the above three nesting parameters among the six habitats (short-grass prairie, mixed prairie, irrigated corn, dryland wheat, fallow wheat, shelterbelt), as well as to compare within-habitat differences among years.

RESULTS

Nesting densities of mourning doves differed ($P < 0.01$) by habitat (Table 1). Densities were consistently high in shelterbelts, ranging from 21.5 nests/ha in 1979 (range among individual shelterbelts: 0.0-32.5) to 60.9 nests/ha in 1980 (range among shelterbelts: 20.0-155.0). Of 449 nests observed in shelterbelt areas, all but 2 were in trees. Most shelterbelt nests were in Siberian elm trees (83% of all shelterbelt nests), typically at heights of 3-8 m. Nesting densities in shelterbelts differed ($P < 0.01$) among years. High and low years were 1980 (60.9 nests/ha) and 1979 (21.5 nests/ha), respectively. Intermediate to those years was 1979 (41.2).

In contrast to shelterbelts, few nests were found in ground-nesting habitats (Table 1). Overall densities, including all study plots in native prairie and cropland, were less than 0.1 nest/ha (0.02-0.07). Short-grass and mixed prairie habitats accounted for 15 of 17 ground nests located in 1978, 6 of 8 in 1979, and 3 of 5 in 1980. During 1978-80, few nests were found in cropland (five in wheat, one in corn, and none in fallow). Despite the somewhat higher densities in prairie habitats, all ground-nesting habitats contained low densities of less than 0.2 nests/ha in each of the three study years.

Nesting in shelterbelts began in early to mid-May and continued into September 1978-80. The last active nest either failed or had young fledge from it during the first (1978), second (1979), or third (1980) week of September. Nesting activity in shelterbelts peaked (highest number of simultaneously active nests) in mid-July in 1978 and 1979, and late July-early August in 1980. Based on small sample sizes, the nesting season (time from initiation of first nest to completion or failure of last nest) of ground-nesting doves was shorter than for those nesting in trees. During 1978-80, the lengths of nesting seasons (from first nest initiation to date of last fledgling/failure) in shelterbelts were 99, 111, and 84 days in length. In each year, active ground tests were observed from mid-May to mid-August, with a peak in early June.

Overall nesting success did not differ between ground nests and those in shelterbelts. During 1978-80, 46.7% (14 of 30) of mourning dove nests observed in ground-nesting habitats were successful (at least one young fledged), compared to 43.7% (196 of 449) of those in shelterbelts ($P > 0.70$) (Table 2). Success rates of ground nests during individual years ranged from 40.0% in 1980 to 50.0% in 1979. Success rates for nests in shelterbelts ranged from 28.2% in 1979 to 47.8% in 1980.

Table 1. Mourning dove nesting densities (nests/ha) by year and habitat, eastern Colorado, 1978-80.

	1978			1979			1980		
Habitat	n Nests	Density	Range of Densities	n Nests	Density	Range of Densities	n Nests	Density	Range of Densities
Short-grass prairie	8	0.1	0.0-0.5	4	0.1	0.0-0.4	3	<0.1	0.0-0.2
Mixed prairie	7	0.2	0.1-0.4	2	0.1	0.0-0.1	0	0.0	—
Dryland wheat	1	<0.1	0.0-0.1	2	0.1	0.0-0.1	2	0.1	0.0-0.1
Irrigated corn	1	<0.1	0.0-0.1	0	0.0	—	0	0.0	—
Fallow wheat	0	0.0	—	0	0.0	—	0	0.0	—
All ground-nesting habitats	17	0.1	0.0-0.5	8	<0.1	0.0-0.4	5	<0.1	0.0-0.2
Shelterbelts	177	41.2	0.0-440.0	71	21.5	0.0-32.5	201	60.9	20.0-155.0

Table 2. Nesting success and productivity of mourning doves by year and habitat, eastern Colorado, 1978-80.

	1978			1979			1980		
Habitat	Percent nests successful	Young fledged per ha	Range in young fledged per ha	Percent nests successful	Young fledged per ha	Range in young fledged per ha	Percent nests successful	Young fledged per ha	Range in young fledged per ha
Short-grass prairie	50.0	0.1	0.0-0.8	50.0	< 0.1	0.0-0.6	33.3	<0.1	0.0-0.2
Mixed prairie	57.1	0.3	0.0-0.6	50.0	<0.1	0.0-0.1	—	—	—
Dryland wheat	0.0	0.0	—	50.0	0.1	0.0-0.1	50.0	<0.1	0.0-0.1
Irrigated corn	0.0	0.0	—	—	—	—	—	—	—
Fallow wheat	—	—	—	—	—	—	—	—	—
All ground-nesting habitats	47.0	0.1	0.0-0.8	50.0	<0.1	0.0-0.6	40.0	<0.1	0.0-0.2
Shelterbelts	45.2	34.6	0.0-420.0	28.2	11.5	0.0-35.0	47.8	53.8	7.5-205.0

Due to the high density of nests in limited tree-nesting habitats, mourning doves were much more productive in shelterbelts. Of 397 young fledged during 1978-80, 371 were from nests in shelterbelts (Table 2). Production of young in shelterbelts on a per-ha basis differed among years, ranging from 11.8 in 1979 to 55.4 in 1980 ($P < 0.05$).

Twenty-six young fledged from ground nests, including 22 from nests in native prairie, whereas only four fledged from nests in cropland. Overall, however, the greatest numbers of young produced/ha in short-grass (0.11 in 1978) and mixed (0.27 in 1978) prairie were substantially less than that produced in shelterbelts (53.8 in 1980).

Causes of failure differed ($P < 0.01$) between ground nests and nests in shelterbelts. Of those that could be determined, 43.2% (112 of 259) of nest failures in shelterbelts were caused by inclement weather, primarily strong winds. In contrast, the leading cause of definitely attributable failure of ground nests was predation (6 of 16 = 37.5%).

DISCUSSION

Shelterbelts provide valuable nesting habitat for mourning doves throughout eastern Colorado. Densities of nesting attempts were higher ($P < 0.05$) in that habitat than in any ground-nesting habitat. In addition, despite greater susceptibility to weather-related failures and lower nesting success, mourning dove production was highest ($P < 0.05$) in shelterbelts.

Among treeless habitats, native prairie contained the highest densities of mourning dove nests and produced the most young/ha. Nesting densities and production of young were lowest in cropland. Previous investigators suggested that, despite low nesting densities, ground-nesting doves in native prairie contribute substantially to overall production in eastern Colorado (Giezentanner 1970, Strong 1971, Ryder 1972). Cowan (1952) and Downing (1959) reported similar conclusions about relatively treeless areas of southern California and Oklahoma, respectively. Although young doves are produced at a much lower rate in these habitats, the contribution to overall production is substantial due to large areas involved.

Changes in agricultural land use that have taken place in eastern Colorado are representative of trends occurring throughout the Great Plains. Continuation of trends such as conversion of native prairie to cropland and removal of shelterbelts will substantially reduce the amount of relatively higher quality nesting habitat for mourning doves. This may result in decreased mourning dove production on a region-wide basis.

In our study areas in eastern Colorado, mourning dove production was highest in shelterbelts, followed by native prairie. Those two types of habitat, however, have been removed at a rapid rate from the 1960s to the present. Both types have been and are being converted to cropland. Although the area that shelterbelts comprise is comparatively small, trees are often removed because they have become decadent, and thus, no longer considered by private landowners to be useful or aesthetically acceptable. Tree species such as Siberian elm and Russian-olive that dominate in shelterbelts in eastern Colorado and throughout the Great Plains are early maturing and have a tendency to break apart near the top. Of the trees searched during this study, only 14% were completely dead. However, more than 50% of Siberian elm, Russian-olive, plains cottonwood, common honeylocust, and black locust (*Robinia pseudoacacia*) trees were estimated to be at least 25% dead.

Habitats replacing shelterbelts and native prairie are of limited value as nesting habitat to mourning doves. In addition to containing low nest densities, cropland habitats provide less suitable nest sites due to disturbances caused by agronomic practices. Potential disturbances caused by agronomic practices include flooding of nests in irrigated corn, mechanical destruction of nests in wheat during harvest, and lack of cover, as well as destruction of nests due to periodic cultivation of fallow fields. In eastern Colorado, wheat harvest coincides with the peak of mourning dove nesting activity in July. Despite the decreased value as nesting habitat, cropland may benefit mourning doves by providing a food source at certain times of the year.

Soutiere and Bolen (1976) studied mourning dove nesting in habitats undergoing land use changes in Texas. There data indicated that decreases in production due to conversion of tree-nesting sites to pasture were partially compensated by increases in ground nesting. Their study, however, did not address the potential effects of conversion to cultivated cropland. Results of Soutiere and Bolen's (1976) study suggest that mourning doves may be adaptable enough in nesting habitat use to offset some losses in production caused by conversion of high quality habitat to pasture. However, we believe that losses in dove production due to conversion of shelterbelts to cropland are not likely to be compensated by increased nesting in the cropland.

Unavailability of water, rising costs of electricity, and/or decreased market prices of grains could result in conversion of irrigated cropland to dryland agriculture, or of cropland to grassland (Conservation Reserve Program). However, economic incentives do not appear adequate to encourage private landowners to replace shelterbelts that have been removed during the past two decades. If trends of increased area in cropland and decreased area in native prairie and shelterbelts continues into the 1990s, the overall outlook for mourning doves in the Great Plains is potentially one of reduced abundance due to lower quality nesting habitat.

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Distribution of Sandhill Cranes in the North Platte River Valley 1980 and 1989

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ABSTRACT—We observed the abundance, diurnal distribution, and habitat use of sandhill cranes (*Grus canadensis*) in the North Platte River Valley (NPRV) in 1989 for comparisons to similar data from 1979-80. Sandhill cranes traveled farther from nocturnal roosts to diurnal feeding sites and use of the NPRV was lower in 1989 as compared to 1979-80. Observations of cranes in corn stubble and pasture increased from 1980 to 1989, while observations in alfalfa and palustrine wetlands decreased. Plowing of corn stubble fields and drought conditions in 1989 may have influenced crane distribution, abundance, and habitat use.

Sandhill cranes (*Grus canadensis*) of the midcontinent population depend on corn for assimilation of energy reserves during spring migration (Krapu et al. 1985, Tacha et al. 1987). Reduced acreages in corn or plowing of corn stubble fields in fall or early spring could negatively affect the distribution, movements, and physical condition of sandhill cranes (U.S. Fish and Wildlife Service 1981, Iverson et al. 1987). Optimal habitat complexes for sandhill cranes should include 35-70% corn stubble fields within 4 km of major roosts in the North Platte River Valley (NPRV) (Iverson et al. 1987).

Observations of diurnal crane distribution in the NPRV during spring 1988 appeared different from those reported for 1980 by Iverson et al. (1987). This prompted us to determine abundance, diurnal distribution, and habitat use of sandhill cranes in the NPRV in 1989 for comparisons to similar data from 1980 (Iverson et al. 1987).

METHODS

The study area included Iverson et al. 1987:Fig. 1 and outlying areas where cranes were observed in 1989 but not 1979-80. Six weekly survey routes were driven 9 March-13 April 1989 on roads (see Iverson et al. 1987:Fig. 1) of the 407-km^2 study area, and data for crane flocks were recorded as in Iverson et al. (1987). Locations of roads permitted visual inspection of each section (1 mi^2 = 259 ha) for crane flocks. Mean crane-use per section for the spring staging period was calculated by dividing the sum of cranes observed in each section by 6 (number of weekly surveys). An index called DIFF was created to represent the direction (+

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or –) and degree of change in mean crane-use per section in 1989 (our data) versus 1980 (Iverson et al. 1987), where DIFF = mean crane-use per section 1989 – mean crane-use per section 1980. Sections with no cranes observed in either 1980 or 1989 were excluded from analyses.

A t-test (SAS Institute, Inc. 1985) was used to test the null hypothesis (H_O) that DIFF = 0; a positive mean of all DIFF values reflected an overall increase in crane-use for 1989 over 1980, and a negative mean reflected decrease in crane-use. The H_O that DIFF = 0 was also tested within each of six Zones (representing distance from river) and five Roost areas (representing east-west distribution of upland habitats in relation to major roosts, see Fig. 1) to determine distributional differences for 1989 versus 1980. Use of habitats, reported as proportions of total, was compared between 1989 and 1979-80 using Z-tests with N = number of flocks (after Iverson et al. 1987).

RESULTS

Cranes were observed using 81 sections in the NPRV study area in 1989 and 71 in 1980. Overall crane use of the NPRV was lower ($\bar{x}$ of DIFF = -533, $t = -3.15$, df = 90, $P < 0.01$) in 1989 than in 1980. However, crane use of Zone 6 and Roost area 0 (Fig. 1) was greater in 1989 (Table 1). Use of Zones 3 and 4 decreased in 1989. Roost areas 3 and 4 (eastern) showed decreased crane use in 1989, while Roost areas 1 and 2 (western) did not differ between years.

Table 1. DIFF index comparing crane distribution in spring 1989 vs. 1980 within Zone and Roost areas of the North Platte River Valley of Nebraska. Positive and negative means with significant differences from 0 to reflect increases and decreases in crane use, respectively.

Location[a]		No. of Sections	$\bar{x}$ of DIFF[b]	t[c]	df	P
Zone						
	1	6	32	0.89	5	0.41
	2	14	-441	-2.07	13	0.06
	3	18	-423	-2.39	17	0.03
	4	17	-1894	-3.55	16	0.01
	5	16	-677	-1.22	15	0.24
	6	20	408	2.16	19	0.04
Roost						
	0	16	217	2.09	15	0.05
	1	22	-376	-1.78	21	0.09
	2	15	-90	-0.28	14	0.78
	3	19	-1178	-2.05	18	0.05
	4	19	-1049	-2.68	18	0.01

[a]See Fig. 1.
[b]DIFF = $\bar{x}$ number of cranes per section in 1989 - $\bar{x}$ number of cranes per section in 1980.
[c]H_O: DIFF = 0.

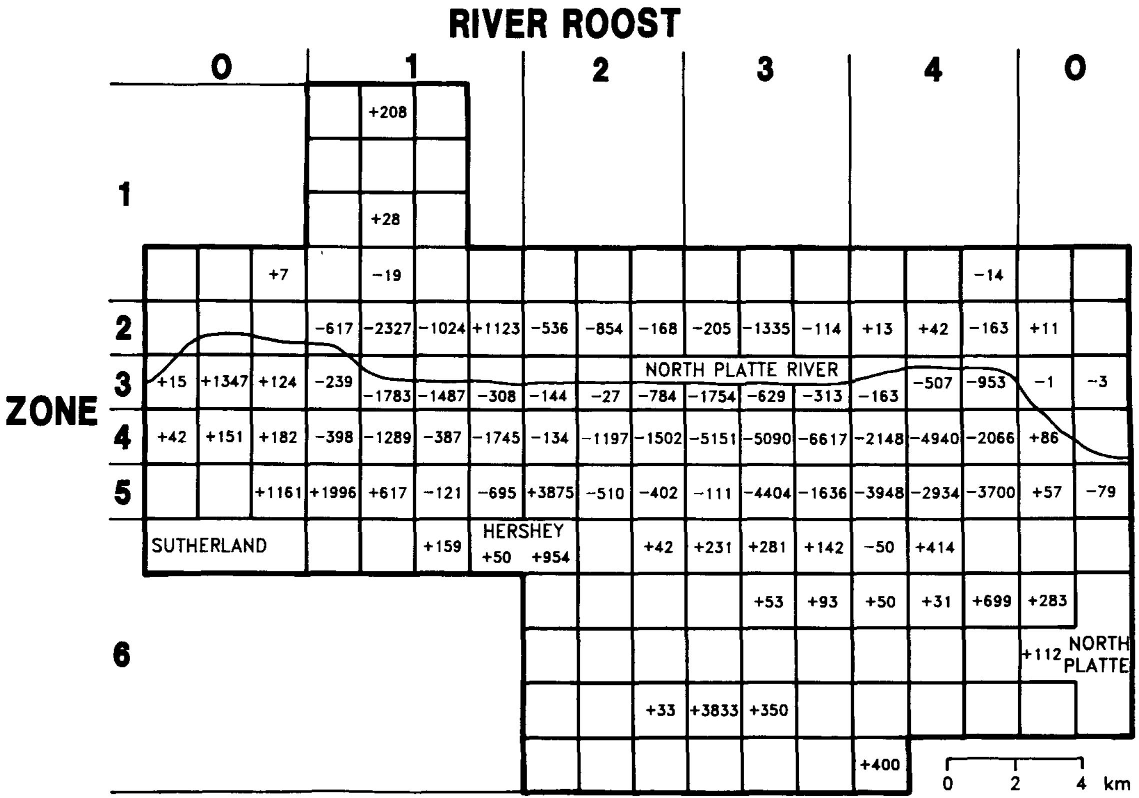

Figure 1. Study area in the North Platte River Valley showing differences in mean crane-use per section in spring 1989 compared with spring 1980 (from Iverson et al. 1987). Analyses by Zones and Roost areas allowed comparisons of crane distributions.

Use of all the major habitat types differed between 1989 and 1979-80 (Table 2). Pasture and corn stubble uses were higher and use of alfalfa and wetland lower in 1989.

Table 2. Comparisons of diurnal habitat use by sandhill cranes in 1989 vs. 1980 within the North Platte River Valley of Nebraska.

Habitat	% Use 1979-80[a]	% Use 1989[b]	Z-value[c]
Corn Stubble	45.6	57.2	+8.2
Alfalfa	20.2	0.2	-17.6
Pasture	27.1	40.4	+10.6
Wetland	7.1	2.2	-6.7

[a]From Iverson et al. 1987, based on observations of 5041 flocks of cranes.
[b]Based on observations of 389,707 cranes in 1246 flocks.
[c]All values significant ($P < 0.001$).

DISCUSSION AND MANAGEMENT IMPLICATIONS

Drought conditions prevailed in the NPRV in 1989; all temporary and some semipermanent palustrine wetlands were dry (Folk and Tacha 1990). Plowing of corn stubble fields in early spring 1989 and the previous fall may or may not have been associated with drought, and probably affected diurnal distribution of cranes. A subjective estimate is that 50% of corn stubble fields were plowed in 1989, versus less than 1% in 1980 (Iverson et al. 1987). Discing and plowing of corn stubble fields result in 77-97% loss of waste grain (Baldassarre et al. 1983) and minimal use by cranes (Krapu et al. 1984). The maximum distance cranes were observed from the North Platte River in 1979-80 was 3.2 km north and 4.8 km south (Iverson et al. 1987). In contrast, we observed cranes 8 km north and 11.2 km south in 1989. Cranes apparently made relatively longer flights north and south of the river in spring 1989 to reach untilled corn stubble fields. Longer flights from nocturnal roosting areas to diurnal feeding areas are energetically expensive and undesirable (Tacha et al. 1987).

Decreases in use of alfalfa and palustrine wetland habitats in 1989 occurred during drought. Krapu et al. (1984) suggested that crane-use of alfalfa habitat may be lower in dry years because of a lack of earthworms near the soil surface.

Consistent use in 1989 and 1979-80 suggests that Roost area 2 is important to migrant sandhill cranes. The first cranes to arrive in the NPRV during spring 1989 concentrated in Roost area 2. Nocturnal (Folk and Tacha 1990) and diurnal use of this area was high throughout the staging period. The Nebraska Game and Parks Commission property adjacent to the north side of the North Platte River within Roost area 2 is heavily vegetated and unsuitable for cranes. Property adjacent to and extending 0.8-4 km south of the river in Roost area 2 should be given priority for protection and management for migrant sandhill cranes.

Availability of nocturnal roosting habitat did not limit crane use of the NPRV (Folk and Tacha 1990). However, relatively low overall crane-use in 1989 may have resulted from availability and distribution of diurnal habitats negatively altered by spring plowing. Further monitoring of crane distribution and abundance, and habitat use and availability, is needed during years of differing moisture conditions to determine if our observations were unique to periodic drought conditions, or if upland habitat quality for cranes has declined in the NPRV.

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Nocturnal Behavior of Sandhill Cranes Roosting in the Platte River, Nebraska

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ABSTRACT — We studied nocturnal roosting behavior of sandhill cranes (*Grus canadensis*) roosting in the Platte River in Nebraska during March and April 1990. Individual cranes were most active from arrival in the roosting area to 2100 hr and from 0505 hr to departure. Resting was the predominant behavior, followed by standing. Preening, flying, walking, alert, courtship, and agonistic activities constituted the remainder of observed behaviors.

Roosting activities of sandhill cranes (*Grus canadensis*) have been described (Frith 1974, Lewis 1974, Iverson et al. 1987), but little is known regarding the nocturnal behavior of sandhill cranes while roosting. We studied temporal variation in behavior patterns of roosting sandhill cranes throughout the night during a portion of the spring staging period on the Platte River, Nebraska, and examined the influence of weather on behavior patterns.

STUDY AREA AND METHODS

The study site was located on the Platte River near Grand Island, NE, 1.8 km upstream from the Highway 281 bridge on the south channel. The site had a mean channel width of 246 m and relatively shallow water interspersed with numerous exposed sandbars. The site was bounded on the north by the Mormon Island Crane Meadows Area and on the south by private agricultural land.

We used scan sampling (Altmann 1974) to evaluate nocturnal behaviors of roosting sandhill cranes. Observations were made with a 2x Noctron IV night vision scope from a blind located on the river bank when the moon was between the first and last quarter stages. Flocks were observed on five evenings: 19, 22, and 28 March and 3 and 9 April. Flock size ranged from 350 to 3000 birds.

Observations began shortly after the last sandhill crane arrived at the roost and continued until departure began at dawn. Scans were con-

[1]The unit is jointly supported by the University of Wyoming, the Wyoming Game and Fish Department, and the U.S. Fish and Wildlife Service.

ducted at 5-min intervals, beginning at the right side of the flock and proceeding to the left until the entire flock was observed. Scans generally required less than 20 sec to complete.

Behavior was categorized as flying, walking, standing (stationary position with partially retracted head), preening (preening and bathing), alert (motionless stance with elevated head), resting (bill tucked under wing), agonistic (bill threats, biting, and chasing), or courtship (head pump and leap displays). Behaviors were ranked from 5 to 0 according to the frequency of occurrence from the most common (5=predominant behavior) to the least common (0=behavior absent).

Weather data were recorded at 5-min intervals concurrent with each scan. Weather variables included cloud cover, fog or precipitation, wind speed, wind direction, and air temperature. Cloud cover was classified into one of five classes: 0, 1-25, 26-50, 51-75, or >75% (overcast). Fog or precipitation was classified as either absent or present. Wind speed was described as 0, 1-16, 17-32, 33-48, or >48 km/hr. Wind direction was categorized into one of the eight cardinal directions or as calm.

Data were divided into four periods for analysis: early night (final arrival-2100 hr), midnight (2105-0100 hr), late night (0105-0500 hr), and early morning (0505 hr-departure). Differences in frequency of behaviors among periods were tested by 1-way analysis of variance (ANOVA). If significance was observed Duncan's multiple-range test was used to determine individual differences. Temporal variation of sandhill crane activities during the staging season was assessed by trend analysis. Spearman rank correlation procedures were used to determine relations between weather variables and behavior. Significance for all statistical inferences was $P \leq 0.05$.

RESULTS

During roosting, resting was the most prevalent behavior, standing next, followed by preening, flying, walking, alert, courtship, and agonistic behaviors (Fig. 1, Table 1). Analysis of variance indicated significant variation in standing ($P < 0.0001$), walking ($P < 0.005$), and preening (P 0.002) activities over the four periods. Sandhill cranes spent less time walking and standing and more time resting during the midnight and late night periods (2105-0500 hr) than during the early night and early morning periods. Courtship, flying, alert, and agonistic behaviors were observed infrequently, and no significant differences were found among the four periods. Behaviors of sandhill cranes did not vary significantly over five nights during the staging season. Significant correlations between weather variables and behavior were observed only between flying and wind speed ($r=0.51$, $P=0.02$) and between preening and air temperature ($r=0.51$, $P=0.02$).

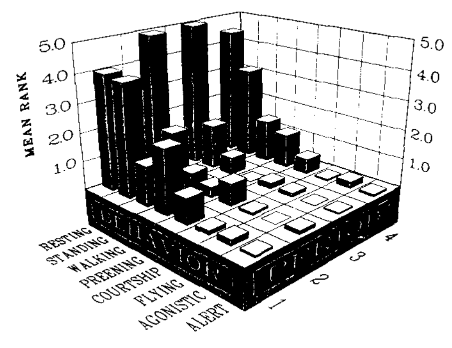

Figure 1. Relative frequency (mean rank) of nocturnal behaviors of five sandhill crane flocks observed during four periods of the night, 19 March – 9 April 1990, along the Platte River, Nebraska. Period 1 = final flock formation to 2100 hr (CST), period 2 = 2105-0100 hr, period 3 = 0105-0500 hr, and period 4 = 0505 hr to initial departure. Ranks varied from 5 (dominant activity) to zero (behavior absent).

Table 1. Percentage of time spent by sandhill cranes in various behaviors. Data are means for the five flocks observed between 19 March and 10 April 1990.

		Behavior							
Period[a]	Rank[b]	Resting	Standing	Walking	Preening	Courtship	Flying	Agonistic	Alert
1	5	57	29		14				
	4	13	56	1	27			2	1
	3	10	8	37	20	21	3	1	
	2	19		31	10	33	4		2
	1	6		55	9	6	18	3	3
2	5	98	1						1
	4	1	65	4	13	13	1		3
	3		24	33	6	30	4	1	2
	2		13	44	4	38	1		
	1			75		12	13		
3	5	100							
	4		88	8		4			
	3		5	68	2	7	14		4
	2			18		52	24		6
	1			25		38	12	12	13
4	5	75	11		9			3	2
	4	12	65	10	10	3			
	3	5	18	55	14	5	3		
	2	15		30	5	45		5	
	1			25		75			

[a]Period 1 = final flock formation to 2100 hr (CST), period 2 = 2105-0100 hr, period 3 = 0105-0500 hr, and period 4 = 0505 hr to initial departure.

[b]Rank 5 = most common behavior, 4 = second most common behavior, 3 = third most common behavior, 2 = fourth most common behavior, and 1= least common behavior.

DISCUSSION

Resting was the predominant behavior of sandhill cranes during the night throughout the staging season. Resting was also the dominant nocturnal activity of sandhill cranes in Texas (95%) and in Nebraska and Saskatchewan (100%; Tacha et al. 1987). Cranes were most active from arrival at the roost until 2100 hr. During this period, they moved about within the flock. As the night progressed, they became sedentary and inactive. (i.e., resting). At dawn, activity intensified again, and movement within the flock was common. Frith (1974) reported a more limited period of inactivity, suggesting sandhill cranes were active until midnight, with least activity occurring from midnight until 0200 hr.

Weather had little influence on the nocturnal behavior of sandhill cranes. Amount of flying increased with wind speed. Frith (1974) reported that during wind speeds in excess of 32 km/hr, short flights within flocks were common. Preening increased with air temperature; such a relationship has not been reported previously.

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Lead Poisoning of a Marbled Godwit

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ABSTRACT — A thin adult female marbled godwit (*Limosa fedoa*) found dead at Benton Lake National Wildlife Refuge, Montana, was found to have 17 ingested lead shot in its gizzard. Its liver contained 51.7 ppm lead (wet weight). Based on these necropsy findings a diagnosis of lead poisoning was made.

Lead poisoning is common in numerous waterfowl species and has been reported in some upland game bird species, but reports of lead shot ingestion or toxicity in shorebirds are few (Duncan and Jensen 1976, Hall and Fisher 1985, Anonymous 1986). In Italy, lead was detected in bones of three black-tailed godwits (*Limosa limosa*) (Sivieri Buggiani and Rindi 1972); however, none of these godwits was intoxicated from lead. Wetmore (1919) had observed lead poisoning in a singled marbled godwit (*L. fedoa*) but provided no details. White et al. (1980) reported concentrations of lead in the livers and kidneys of 75 shorebirds, not including godwits, wintering at Corpus Christi, TX. They reported 3 of 15 western sandpipers (*Calidris mauri*) examined had liver lead concentrations greater than 6 ppm (wet weight), a concentration which is considered to indicate toxic exposure for waterfowl, raptors, and cranes.

Godwits feed in upland fields as well as in wetlands. These feeding habits expose them to lead in areas where lead shot is still used in hunting upland game birds. Godwits also may ingest lead pellets while feeding in or near wetlands where lead shot is still legally used, where nontoxic shot is required but lead shot is illegally used, or where large residues of lead pellets remain from previous years.

The only documented lead poisoning die-off of waterbirds at Benton Lake National Wildlife Refuge (NWR) was in 1970 when an estimated 200 goldeneyes (*Bucephela* spp.) died. This note reports on a case of lead toxicosis in a marbled godwit (*Limosa fedoa*) found during an avian botulism outbreak at Benton Lake NWR in Montana.

STUDY AREA AND METHODS

Benton Lake NWR includes 12,389 acres (5014 ha) of prairie marsh and associated grasslands in north central Montana. It is an important

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staging area for waterbirds during migration. Shorebirds using the refuge include dowitchers (*Limnodromus* spp.), yellowlegs (*Tringa* spp.), American avocets (*Recurvirostra americana*), western sandpiper, and marbled godwits.

Refuge staff picked up 2206 waterbird carcasses at Benton Lake NWR during an avian botulism outbreak between 13 June and 26 September 1989. The carcasses were disposed of in an effort to control losses of waterbirds using these wetlands.

A few of these carcasses were submitted on 17 August to the National Wildlife Health Research Center (NWHR) in Madison, WI, for necropsy and laboratory evaluation as avian botulism type C suspects. The shipment included an American avocet, a marbled godwit, a northern shoveler (*Anas clypeata*), a gadwall (*A. strepera*), and three blue-winged teal (*A. discors*).

Frozen livers were prepared for lead analysis by grinding with a hand grinder and thoroughly mixed with a spatula. A 5-g sample was weighed into a tared crucible, dried for 24 hr at 110° C, and ashed in a muffle furnace at 500° C for 16-18 hr. One ml of concentrated nitric acid and 25 ml of 6N hydrochloric acid were added to the ashed sample and the mixture reduced to 3-5 ml by boiling on a hot plate. The sample was quantitatively transferred to a graduated centrifuge tube, then distilled water was added to obtain a volume of 12.0 ml. Standards, containing 1.0, 2.5, and 5.0 micrograms of lead per ml, were prepared and the samples analyzed at the 217-nm line on a Perkin-Elmer flame spectrophotometer (Model 2380). The average recovery of the standard (spiked) samples was 94%. Lead amounts are presented as ppm wet weight, unless otherwise noted.

Tissues were collected for routine bacteriological studies. Heart blood was submitted for the type C botulism mouse toxicity test and a cloacal swab was submitted for virus isolation.

RESULTS

The marbled godwit reported on here was found on 21 July 1989 during a routine carcass pickup effort during the avian botulism outbreak on Unit 4C of Benton Lake NWR. Nothing unusual about the godwit carcass was noted when it was found.

A provisional diagnosis of lead poisoning in waterbirds is based on observation of some or all the following necropsy findings: enlarged gallbladder filled with dark green bile, green-stained gizzard, atrophy of body fat, muscle, liver, and heart, and finding of ingested lead shot among the gizzard contents.

Gross necropsy findings showed the godwit carcass to be somewhat thinner than normal. The pectoral muscles were atrophied, and subcutaneous fat was present but limited to deposits at the thoracic inlet and the medial surface of the upper legs adjacent to the patella. The carcass weight was 290 g. This specimen was a non-breeding, adult female with all follicles less than 0.5 mm in diameter.

The gallbladder was enlarged (17 x 5 x 4 mm) and distended with dark green bile. The gizzard lining was stained dark green and the gizzard contained 17 moderately worn lead shot (Fig. 1), along with stones. No steel shot was found. Spleen, liver, heart, lungs, esophagus, and kidneys were all grossly normal. Coronary fat was present on the heart. Several of these observations (distended gallbladder, bile-stained gizzard lining, atrophy of pectoral muscles, and presence of lead shot among the gizzard contents) supported a provisional diagnosis of lead poisoning.

Figure 1. Ingested lead shot (17) and grit found in gizzard of marbled godwit that died from lead poisoning at Benton Lake NWR in July of 1989.

Lead concentration in the liver of the marbled godwit was 51.7 ppm wet weight. Heart blood from the godwit used for the mouse toxicity test was negative for avian botulism. No pathogenic bacteria were isolated from the blood or the liver. The cloacal swab taken at necropsy did not yield any viruses.

DISCUSSION

The source of lead shot found in the marbled godwit is unknown. Although the wetland in which this dead bird was found has been closed to hunting with lead shot since 1986, illegal use of lead shot could have occurred. Alternately the length of the godwit's bill may have allowed it to probe deeper into the sediment where lead shot from earlier years was still present. Because godwits are also upland feeders, we believe that it was most likely that the godwit picked up the lead shot on an upland field off the refuge where upland game hunting with lead shot is permitted. Although a total of six marbled godwits was recovered, the number of godwits succumbing to lead poisoning is unknown because only one was submitted for examination.

The only other marbled godwit for which we have data on the concentration of lead in its liver was a godwit that died of type C botulism at Long Lake National Wildlife Refuge, North Dakota, in 1986. The liver of this godwit contained 0.12 ppm lead (wet weight).

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Geographic Affinity of Bird Species Associated with Rocky Mountain Juniper Woodlands and Adjacent Grasslands in Southwestern South Dakota

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ABSTRACT — Bird populations were sampled monthly for two years in Rocky Mountain juniper (*Juniperus scopulorum*) stands and adjacent grasslands in Badlands National Park. In spite of the generally western distribution of Rocky Mountain juniper, the majority of the 62 species of birds observed are pandemic to the Great Plains. The preponderance of pandemic species was attributed to the small area of the juniper stands, limited deciduous cover, and relative isolation from other large forests. The domination by tree canopy nesters and limited number of cavity nesters was attributed to the low shrub cover and near absence of snags in the juniper stands.

On the generally treeless grasslands of the northern Great Plains, small, interspersed woodlands such as riparian stands and woody draws provide critical bird habitat (Faanes 1983, 1984; Hopkins et al. 1986; Hodorff et al. 1988). However, little published information exists on bird species associated with Rocky Mountain juniper stands found scattered along the river breaks of major rivers in western South Dakota. The purpose of this paper is to provide baseline data on year-round avian use of Rocky Mountain juniper (*Juniperus scopulorum*) stands and adjacent grasslands in Badlands National Park. Given the generally westerly distribution of Rocky Mountain juniper (Fowells 1965), I hypothesized that these stands would tend to attract many avian species with a western geographic affinity. Further, I hypothesized that the limited shrub cover and absence of large decadent trees in the juniper study sites (Sieg 1988) would tend to favor canopy nesting species over shrub nesters or cavity nesters.

STUDY AREA AND METHODS

The study area is in Pennington County, approximately 15 km south of the town of Wall, in Sage Creek Basin. Eight 60- x 400-m study sites were established: four in Rocky Mountain juniper woodlands in draws, and four on adjacent grasslands. The juniper stands were essentially monocultures of Rocky Mountain juniper, with sparse understories dominated by yellow sweetclover (*Melilotus officinalis*), stoneyhills muhly (*Muhlenbergia cuspidata*), and littleseed ricegrass (*Oryzopsis micrantha*)

(Sieg 1988). Western wheatgrass (*Agropyron smithii*) and needle-and-thread grass (*Stipa comata*) were the most common plants on the grasslands, followed by blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*). Shrub cover averaged less than 5%.

Bird populations were sampled year-round for two consecutive years (1981-1983) along 400-m transects. The surveyor slowly walked the transect and recorded the number and species of birds seen and/or heard within 30 m of the transect. If an individual crossed into the transect more than once, only the first observation was recorded. The surveys were conducted monthly beginning in June. Surveys were started within 30 minutes of sunrise and were conducted for four consecutive days unless unfavorable weather (eg. winds > 15 kph or heavy rain) precluded sampling. It is unlikely that many birds were not detected, because of the narrow widths of the juniper stands (Emlen 1971, Conner and Dickson 1980, Yahner 1983) and the high degree of visibility on grassland sites. Nests were located by conducting systematic searches each spring. If males were observed singing on two or more occasions during the breeding season, the species was considered a probable breeding species.

Species were categorized into general geographic affinities, similar to Johnsgard's (1979) classification: (1) **pandemic:** distribution pattern not clearly associated with specific major vegetation types; (2) **endemic:** largely limited to grasslands or marshes of the Great Plains; (3) **eastern:** generally associated with deciduous forest areas to the east or southeast; (4) **northern:** generally associated with boreal forests to the north or northeast; (5) **southern:** generally associated with deserts or scrublands to the south or southwest; (6) **western:** generally associated with montane forests to the west or northwest. Breeding species were categorized according to substrates where they commonly nest (Ehrlich et al. 1988).

RESULTS

Juniper

A total of 62 species of birds were observed in juniper stands: 47% were pandemic, 18% northern, 16% western, 13% eastern, 5% endemic, and 1% southern. Pandemic species predominated in all seasons, constituting between 51 and 58% of the total observations (Fig. 1). The highest percentage of northern species in juniper stands occurred in the winter (35%), followed by the fall (20%) and spring (15%); northern species were not present in juniper stands in the summer. Western species comprised 15% of the observations in the winter, approximately 20% in the spring and fall, and 30% in the summer months. Eastern species were absent from juniper stands in the winter; they constituted approximately 6% of the spring and fall observations and 12% of the summer observations.

American robins (see scientific names in Table 1) and black-capped chickadees were common pandemic species observed in juniper stands

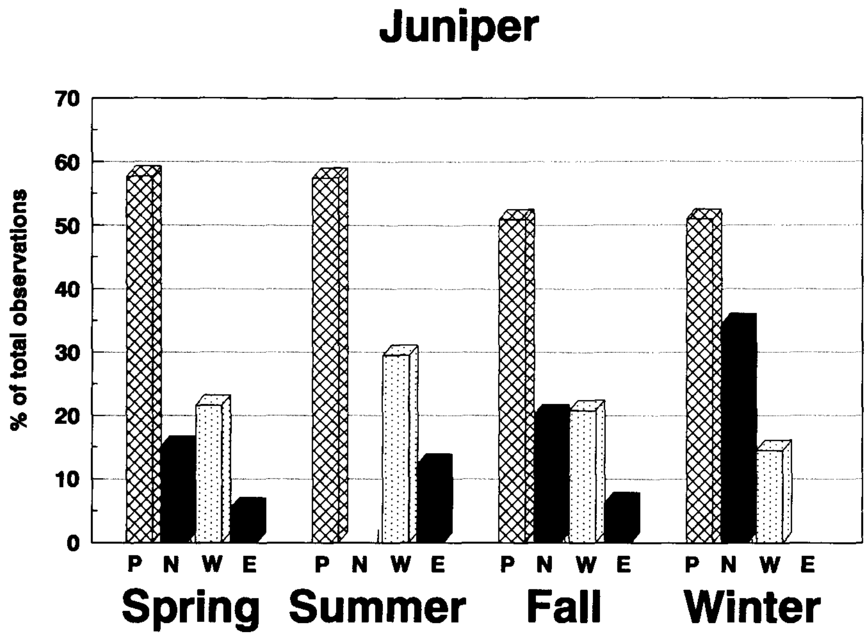

Figure 1. Percentage of total bird observations, by season and geographic affinity, in Rocky Mountain juniper woodlands in western South Dakota. (P = pandemic, N = northern; W = western; E = eastern).

throughout the year; mourning doves, rufous-sided towhees, and chipping sparrows were present in all seasons except winter (Table 1). Dark-eyed juncos, American tree sparrows, and Bohemian waxwings were the most abundant northern species observed in juniper stands; increasing numbers of these three species accounted for the large percentage of northern species in the winter. Townsend's solitaires, lark sparrows, western meadowlarks, and black-billed magpies were the most common western species observed in juniper stands. Lark sparrows and meadowlarks predominated during the growing season; Townsend's solitaires were present in every season except summer, and black-billed magpies were present year around. Field sparrows constituted the largest percentage of eastern species observed in juniper stands; brown thrashers and eastern kingbirds were other less common species with an eastern geographic affinity. The only endemic species observed in juniper stands were upland sandpipers, clay-colored sparrows, and chestnut-collared longspurs; blue grosbeaks were the only southern species observed in juniper stands.

At least eight species nested in juniper stands, and three others were probable breeding species, of which the majority (mourning doves, long-eared owls [see also Paulson and Sieg 1984], American crows, American

Table 1. Number of individual birds, by species and season, observed on Rocky Mountain juniper (*Juniperus scopulorum*) and grassland study sites in southwestern South Dakota.

		No. individuals							
		Juniper				Grassland			
Common name	Scientific name	SP[1]	SU	FA	WI	SP	SU	FA	WI
Pandemic species:									
Canada goose	*Branta canadensis*	—	—	—	—	2	—	—	—
Mallard	*Anas platyrhynchos*	5	—	—	—	—	1	—	—
Turkey vulture	*Cathartes aura*	—	3	2	—	—	4	—	—
Sharp-shinned hawk	*Accipiter striatus*	1	—	—	—	—	—	—	—
Red-tailed hawk	*Buteo jamaicensis*	—	—	2	—	—	1	—	—
Northern harrier	*Circus cyaneus*	6	2	4	5	12	6	3	4
Killdeer	*Charadrius vociferus*	—	—	—	—	—	1	—	—
Mourning dove[2,3]	*Zenaida macroura*	58	198	48	—	30	70	20	—
Great-horned owl	*Bubo virginianus*	—	—	—	3	—	—	—	—
Long-eared owl[2,3]	*Asio otus*	32	16	17	9	1	—	—	—
Short-eared owl[2]	*Asio flammeus*	1	2	1	—	2	—	—	—
Common nighthawk	*Chordeiles minor*	—	4	—	—	—	1	—	—
Northern flicker	*Colaptes auratus*	5	1	11	—	1	1	1	—
Downy woodpecker	*Picoides pubescens*	2	4	2	1	—	—	—	—
Horned lark	*Eremophila alpestris*	—	2	2	10	37	21	99	47
Barn swallow	*Hirundo rustica*	—	6	1	—	—	18	2	—
Cliff swallow	*Hirundo pyrrhonota*	—	13	—	—	—	123	—	—
American crow[2]	*Corvus brachyrhynchos*	51	35	1	2	19	13	2	2
Black-capped chickadee	*Parus atricapillus*	42	82	85	79	—	—	—	—
American robin[4]	*Turdus mitratorius*	118	37	148	293	13	—	39	—
Cedar Waxwing	*Bombycilla cedrorum*	—	—	1	—	—	—	—	—
Loggerhead shrike	*Lanius ludovicianus*	2	14	—	—	1	—	—	—
Yellow-breasted chat	*Icteria virens*	—	6	—	—	—	—	—	—
Red-winged blackbird	*Agelaius phoeniceus*	16	1	—	—	—	9	—	—
Northern oriole	*Icterus galbula*	—	3	—	—	—	—	—	—
Brown-headed cowbird[4]	*Molothrus ater*	29	35	—	—	2	1	—	—
American goldfinch	*Carduelis tristis*	—	11	19	—	—	3	2	—
Rufous-sided towhee[3]	*Pipilo erythrophthalmus*	25	119	17	—	—	—	—	—
Grasshopper sparrow	*Ammodramus savannarum*	—	2	—	—	12	82	11	—
Vesper sparrow	*Pooecetes gramineus*	—	—	—	—	2	—	2	—
Chipping sparrow[3]	*Spizella passerina*	41	101	65	—	20	4	—	—
Song sparrow	*Melospiza melodia*	—	—	1	—	—	—	—	—
Northern species:									
Rough-legged hawk	*Buteo lagopus*	—	—	—	—	—	—	1	—
Golden eagle	*Aquila chrysaetos*	—	—	—	1	—	—	—	1
Sharp-tailed grouse	*Tympanuchus phasianellus*	—	—	2	6	22	18	4	43
Brown creeper	*Certhia americana*	1	—	—	2	—	—	—	—
Swainson's thrush	*Catharus ustulatus*	—	—	19	—	—	—	—	—
Golden-crowned kinglet	*Regulus satrapa*	5	—	—	4	—	—	—	—
Ruby-crowned kinglet	*Regulus calendula*	—	—	1	—	—	—	—	—
Bohemian waxwing	*Bombycilla garrulus*	63	—	—	61	—	—	—	—
Yellow-rumped warbler	*Dendroica coronata*	1	—	12	—	—	—	—	—
Pine siskin	*Carduelis pinus*	—	—	28	—	—	—	—	—
Dark-eyed junco	*Junco hyemalis*	39	—	97	129	—	—	—	—
American tree sparrow	*Spizella arborea*	5	—	10	69	13	—	—	4
Lapland longspur	*Calcarius lapponicus*	—	—	—	—	—	—	—	2

Table 1. (continued)

Common name	Scientific name	Juniper SP[1]	Juniper SU	Juniper FA	Juniper WI	Grassland SP	Grassland SU	Grassland FA	Grassland WI
Western species:									
Swainson's hawk	*Buteo swainsoni*	12	—	—	—	1	4	—	—
Prairie falcon	*Falco mexicanus*	—	—	—	—	—	—	2	—
Western kingbird	*Tyrannus verticalis*	—	—	—	—	1	11	—	—
Black-billed magpie[2]	*Pica pica*	19	18	35	46	1	1	5	4
Red-breasted nuthatch	*Sitta canadensis*	1	—	6	—	—	—	—	—
Townsend's solitaire	*Myadestes townsendi*	49	—	104	69	—	—	1	—
Orange-crowned warbler	*Vermivora celata*	5	—	6	—	—	—	—	—
Western meadowlark[3]	*Sturnella neglecta*	57	88	18	—	238	167	98	—
Brewer's blackbird	*Euphagus cyanocephalus*	2	10	—	—	—	—	—	—
Black-headed grosbeak	*Pheucticus melanochephalus*	—	1	2	—	—	—	—	—
Lark sparrow[4]	*Chondestes grammacus*	17	237	3	—	4	16	—	—
White-crowned sparrow	*Zonotrichia leucophrys*	11	—	—	—	—	—	—	—
Eastern species:									
American kestrel	*Falco sparverius*	—	1	1	—	2	8	—	—
Red-headed woodpecker	*Melanerpes erythrocephalus*	—	—	—	—	—	—	1	—
Eastern kingbird	*Tyrannus tyrannus*	—	11	—	—	—	14	2	—
Blue jay	*Cyanocitta cristats*	1	—	2	—	—	—	—	—
Brown thrasher	*Toxostoma rufum*	4	22	12	—	—	—	—	—
Black-and-white warbler	*Mniotilta varia*	—	1	—	—	—	—	—	—
Ovenbird	*Seiurus aurocapillus*	1	—	—	—	—	—	—	—
Common grackle	*Quiscalus quiscula*	4	—	—	—	5	1	—	—
Field sparrow[3]	*Spizella pusilla*	31	114	38	—	2	—	—	—
Endemic species:									
Upland sandpiper	*Bartramia longicauda*	1	1	—	—	7	3	—	—
Lark bunting	*Calamospiza melanocorys*	—	—	—	—	—	6	—	—
Clay-colored sparrow	*Spizella pallida*	—	—	8	—	—	1	—	—
Chestnut-collared longspur	*Calcarius ornatus*	—	—	5	—	—	1	14	—
Introduced species:									
Ring-necked pheasant	*Phasianus colchicus*	—	—	—	—	—	—	2	—
European starling	*Sturnus vulgaris*	—	—	—	—	1	—	9	—
Southern species:									
Blue grosbeak	*Guiraca caerulea*	—	2	—	—	—	—	—	—

No. individuals: Juniper / Grassland.

[1]Season: SP = spring (March-May); SU = summer (June-August); FA = fall (September-November); WI = winter (December-February).
[2]Nest observed.
[3]Fledglings observed.
[4]Probable breeding species, as indicated by song on two or more occasions during the breeding season.

robins, rufous-sided towhees, chipping sparrows, and brown-headed cowbirds) were pandemic species (Table 1). Two species, the black-billed magpie and lark sparrow, showed a western geographic affinity; the field sparrow was the only breeding species in juniper stands with an eastern geographic affinity. Further, the majority of the breeding birds in juniper stands nested in the tree canopy; the black-capped chickadee was the only cavity nester observed in juniper stands.

Grasslands

Forty-six species of birds were observed on grassland study sites. Of these, 50% were pandemic, 11% northern, 15% western, 11% eastern, 9% endemic, and 4% introduced. Pandemic species predominated in all seasons except spring and constituted between 34 and 59% of the total observations on grasslands (Fig. 2). Northern species constituted less than 8% of the observations on grasslands in the spring, summer, and fall, but made up 47% of the winter observations. The proportion of the total grassland observations that were western species ranged from a low of 4% in the winter to a high of 54% in the spring. The percentage of eastern birds on grasslands varied from 0% in the winter to only 4% in the summer.

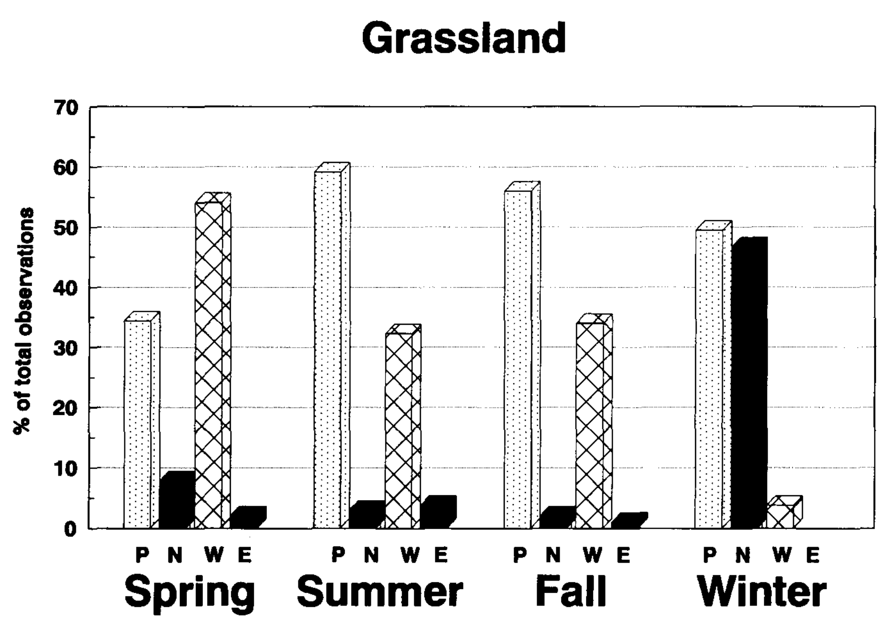

Figure 2. Percentage of total bird observations, by season and geographic affinity, on grassland study sites in western South Dakota. (P = pandemic; N = northern; W = western; E = eastern).

Horned larks, mourning doves, grasshopper sparrows, and American crows were the predominant grassland pandemic species; the horned lark was among the few species present in the winter (Table 1). Sharp-tailed grouse constituted the largest portion of the northern species, although American tree sparrows were present in low numbers in the winter and spring months. Black-billed magpies were the only western species to be observed on grasslands in the winter. Western meadowlarks were the predominant western species on grasslands between March and November, and their high numbers in the spring accounted for the high percentage of western species during that season. Only five species with an eastern geographic affinity were observed on grasslands: eastern kingbird, American kestrel, common grackle, field sparrow, and red-headed woodpecker. Species endemic to the Great Plains that were observed on grasslands included chestnut-collared longspurs, upland sandpipers, lark buntings, and clay-colored sparrows. The ring-necked pheasant and European starling were introduced species observed on grasslands; no southern species were observed. Four species nested on grasslands: three pandemic species (short-eared owls, mourning doves, and grasshopper sparrows) and one western species, the western meadowlark.

DISCUSSION

In the entire Great Plains area, the geographic affinities are 27% eastern, 23% pandemic, 20% western, 16% northern, 7% southern, and 5% endemic (Johnsgard 1979). In this study, pandemic species made up a higher proportion of the total number of species, and western and eastern made up lower proportions of the total number of species, compared to the Great Plains as a whole. The smaller percentage of western birds in juniper stands compared to the Great Plains overall may be attributed to the small area of the juniper woodlands and long distance from large tracts of juniper. Several other authors (e.g., Whitcomb 1977, Robbins 1979, Blake and Karr 1984) have reported bird species disappearances associated with forest fragmentation and isolation. Although the percentage of western species on grasslands was also lower than on the Great Plains overall, the percentage of the total numbers of birds contributed by western species was higher on grasslands than in juniper stands. Western grassland birds were not as limited in geographic range, compared to western juniper species, due to the continuity of grasslands extending westward into Wyoming.

Limited deciduous cover in the juniper stands and the long distance from large tracts of deciduous woodlands likely resulted in lower numbers of eastern species, compared to the Great Plains as a whole. Several other species with eastern geographic affinities, including eastern bluebirds (*Sialia sialis*), red-eyed vireos (*Vireo olivaceus*), American redstarts (*Setophaga ruticilla*), and Indigo buntings (*Passerina cyanea*) were observed in green ash (*Fraxinus pennsylvanica*)/ chokecherry (*Prunus virginiana*) woodlands in northwestern South Dakota (Hordorff and Sieg 1986). However, the larger number of eastern species in juniper stands compared to grasslands indicates that juniper stands apparently provide some of the structural attributes attractive to eastern avian species.

The slightly higher percentage of northern species in this study, compared to the Great Plains overall, is probably due to the slightly northern location of the study site in the Great Plains area. Northern species became more prevalent in the winter in both juniper stands and on grasslands, as these species migrated southward. Based on the large number of birds observed in juniper stands in the winter, these woodlands are likely important sources of food (especially juniper berries) and shelter in the winter (Sieg 1991), but well-vegetated grasslands near the juniper stands provide winter habitat for northern species such as sharp-tailed grouse.

The high proportion of pandemic breeding species associated with juniper communities is consistent with breeding bird surveys in Rocky mountain juniper woodlands in western North Dakota (Hopkins et al. 1986), and can likely be attributed to the same factors that limit eastern and western species during the remainder of the year: the isolation of these stands. The domination of breeding bird species in juniper stands by tree canopy nesters and the limited number of cavity nesters was attributed to the low shrub cover and near absence of snags in juniper stands (Sieg 1988). Hopkins et al. (1986) reported similar results, with the majority of the breeding species nesting in the tree canopy, on the ground, or in the shrub-sapling layer; cavity nesters were absent from juniper stands.

Although I speculated that juniper stands would support a large percentage of western bird species due to the generally westerly distribution of Rocky Mountain juniper, these stands are apparently too isolated from large forested tracts, both deciduous forests to the east and coniferous communities to the west, and too poorly connected with adequate corridors for dispersal of many bird species. Only well-distributed bird species, not strongly associated with specific vegetation types, are well-suited to take advantage of the year-round habitat provided by juniper stands.

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Implanting Radio Transmitters in Plains Pocket Gophers

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ABSTRACT — Implantation and removal of transmitters in pocket gopher peritoneal cavities under field conditions proved successful in 25 of 27 experimental surgeries. Weight loss in the first days following surgery never exceeded 11% of total body weight. Females tended to show greater losses than males, but recovery times were equivalent. Gophers were mobile within two hours after surgery, and healing was completed in two to three days. Gophers in captivity were capable of constructing one mound per hour within 12 hours after surgery. Gophers survived multiple surgeries, and some showed long-term weight gain while carrying transmitters. Overall, peritoneal implantation is a satisfactory method of attaching transmitters to pocket gophers.

Plains pocket gophers (*Geomys bursarius*) dig extensive underground burrow systems for shelter and access to food. These three-dimensional tunnel systems allow gophers to forage on both above- and below-ground vegetation. Conventional observation techniques have produced few data on behavior of pocket gophers; however, radio telemetry has potential for non-intrusive monitoring of subterranean movements.

Gophers have short necks without constriction (Chase et al. 1982), which precludes attachment of transmitter collars. Andersen and MacMahon (1981) used transmitter collars on gophers for 2-8 days and felt that the collars may have affected normal use of the cheek pouches. A harness-mounted transmitter would probably inhibit digging and might interfere with travel through burrows.

Artmann (1967) found that gophers expelled transmitters sewn into cheek pouches within 48 hours and our preliminary experiments confirmed these results. Even if gophers left the transmitters in place, this technique could possibly reduce gopher foraging efficiency.

Successful transmitter implantations with mink (*Mustela vision*) and Franklin's ground squirrels (*Citellus franklini*) (Eagle et al. 1984) suggested that implantation might have fewer adverse effects on pocket gophers than other methods. This study was conducted to determine a suitable size and shape of transmitters and method of attachment for pocket gophers. We initiated trials to evaluate transmitter implantation and replacement techniques for use in the field, to determine acceptable transmitter dimensions, and to determine if implanted transmitters inhibited freedom of movement required for digging or gathering food.

METHODS

Between 9 December 1982 and 10 July 1983, 27 surgeries were performed on 11 gophers (five females, six males) trapped on the Cedar Creek Natural History Area in east central Minnesota. Body mass was determined at time of implantation and at time of removal of transmitters. Since gophers were supplied with food and did not have to maintain burrow systems, mass loss was assumed to be related to surgical trauma.

Gophers were placed in a plexiglass chamber, anesthetized with methoxyflurane (Metofane), and then weighed and sexed.. A 15x25 mm patch parallel to the last rib was shaved with dog clippers halfway between the diaphragm and the forward arch of the pelvis. Fur removal kept the incision clean and allowed easier viewing of the sutures while closing. A layer of subcutaneous fat extending from around the base of the tail into the sacral region was found to extend into the incision area in some gophers. Because sutures in this type of tissue sometimes tore loose, subsequent incisions on "fat" gophers were situated more anteriorly and ventrally. Betadine antiseptic solution was used to swab the incision area before and after surgery.

Scissors were used to cut each of the three tissue layers: skin, muscle, and peritoneum. Forceps with locking teeth were used to lift fragile tissues away from the body cavity so that scissor cuts could be made safely and precisely. Incisions were enlarged to the diameter of the transmitter, usually about 12 mm. Three to five interrupted sutures were used to close the muscle and peritoneum as a single layer. Next the skin was closed in a similar manner. Of four suture types tested, 4-0 chromic gut was superior to both 3-0 or 5-0 monofilament nylon and 5-0 polypropylene. Although reverse cutting suture needles worked better for suturing skin, tapered point suture needles were satisfactory for both muscle and skin. One 68-cm filament with a tapered needle was sufficient for all the suturing required for two surgeries. Implantation required about 20 minutes.

Transmitter removal and/or replacement took about 25 minutes and required an incision about 15 mm long. Because of the cylindrical shape of the transmitter and the usual lack of encapsulation by tissue, the abdomen of the gopher was manipulated to slide one end of the transmitter under the incision. By squeezing the gopher's abdomen gently with one hand, we caused the transmitter to protrude from the opening enough to be grasped by the thumb and forefinger of the other hand and gently drawn from the body cavity. On the one occasion when encapsulation occurred, retractors were used to spread the incision and hold back the intestine so a scalpel could be used to scrape away the tissue holding the transmitter in place. Replacements were inserted into the same position as the previous transmitters. After repositioning the intestine that had been shifted during removal of the old transmitter, the incision was sutured.

Two transmitter styles, constructed by the Cedar Creek BioElectronics Laboratory, were used in the implantation trials. Both were cylindrical with smooth rounded ends, weighed approximately 12 g, and measured 12x57 mm and 14x40 mm. Slight variations in transmitter size and weight were due to the coating of inert electrical resin (Scotchcast, 3M Co., St. Paul, MN). To create a smooth impermeable surface, the final stage of transmitter preparation involved repeated dipping of transmitters into hot resin and curing the surface in a drying oven. Before surgery, transmitters were disinfected in methyl alcohol for at least 15 minutes. Transmitters were then placed in 38°C salt water while the gopher was anesthetized and the incision made. To ensure that each transmitter would be functional after surgery, the transmitter pitch, pulse interval, and duration were checked while the transmitter was immersed in salt water.

Usually two surgeries, implantation and removal, were performed on each gopher with subsequent incisions placed parallel to the first. Reported mass changes reflect results of the initial surgery only. Exceptions were one male gopher who was operated on five times and another male who experienced four surgeries.

The ability of each gopher to dig was evaluated to determine how this behavior was affected by surgical trauma and by carrying an internal transmitter package. Each gopher was tested three times by placing it in a 92x38x20 cm aquarium filled with 40 liters of sand obtained from the Cedar Creek Natural History Area. Each trial lasted 1 hr; trials were conducted approximately 12, 24, and 48 hr after surgery. All loads of sand pushed up into a mound were counted as well as other behaviors such as grooming or exploratory bulldozing. The sand was moistened and packed down before each trial; no burrows existed at the time each gopher was placed in the test arena.

RESULTS AND DISCUSSIONS

Average body mass (with standard deviation) at the time of implantation surgery was 271 ± 55 g for six males and 186 ± 25 g for five females. Average mass change from time of implantation to time of removal of transmitters, which ranged from 3 to 13 days, was -1.5 ± 2.1% of original weight for six males and -2.6 ± 3.2% of original weight for five females (Fig. 1).

The most striking demonstration of the acceptability of this method of transmitter attachment was the long-term observation of a male gopher (not included in Fig. 1) who carried a transmitter internally for a total of 159 days. This gopher weighed 202 g when the transmitter was first implanted and 258 g after 159 days, a 21% gain. Based on observation of mound building activity, this gopher also survived after being returned to its original burrow system following transmitter removal.

Two of 27 surgeries resulted in death. We believe the first fatality occurred because the 57-mm transmitter was too long to easily fit inside the small (155 g) female. The transmitter had lodged against the sternum

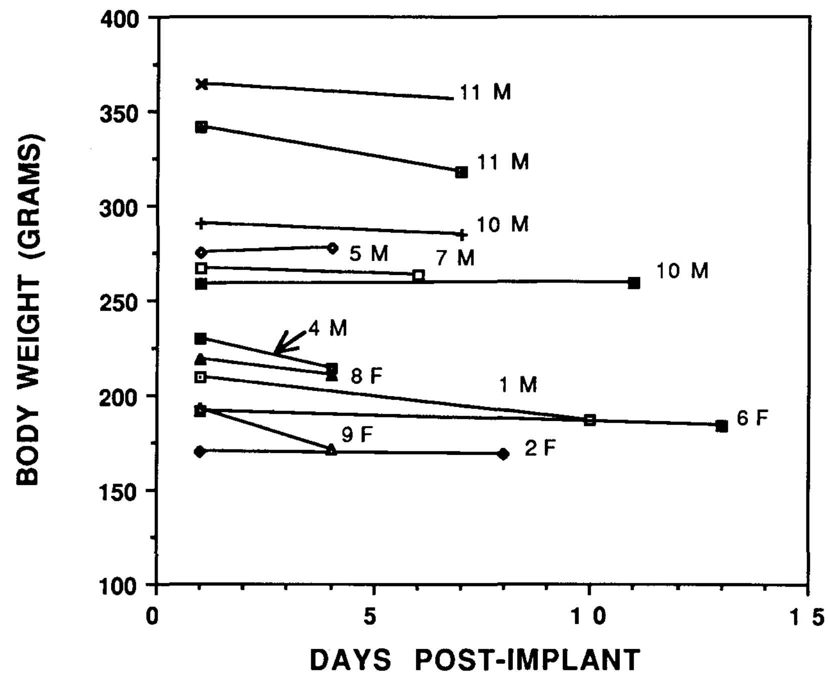

Figure 1. Mass change of pocket gophers following surgery to implant radio transmitters. Gopher identification number and sex are shown for each surgery.

and appeared to have bruised the heart and lungs, causing death in 12 hours. The other mortality was not due to the transmitter per se, but occurred after the fourth surgery in 45 days for a very large (364 g) male. This gopher opened the incision with its claws. A second large male also tore out its stitches with its claws immediately following surgery, but was re-anesthetized and resutured.

Since gophers double up their bodies to reverse direction while pushing a load of dirt, the style determined to be optimal was a short, fat cylinder 30-35 mm long and 10-14 mm in diameter. Minimum size (30x10 mm) was determined by the linear alignment of a 1/2 amp, 3.6 v, lithium battery with a 53 mhz crystal oscillator and copper antenna coil.

Gophers dug as readily during the initial trial at 12 hr post-surgery as during the third trial after 48 hr. Tunnels long enough to fit the body of the gopher were constructed in 4-6 minutes (n=30). After choosing a site to begin excavation, the first mound was completed (burrow opening plugged) within 6-34 minutes (n=30). At least one mound was constructed per hour; multiple mounds were constructed in 40% of the trials.

Observed digging activity demonstrated that gophers can function normally 12 hr after surgery. Observed mound building activity was at least 1.66 mounds per day long term, and often greater than 1 mound per hour, short term. Mohr and Mohr (1936) reported *Geomys bursarius* in Minnesota produced 1.88 mounds per day. In Sherburne County, Minnesota, Bailey (1929) observed three pocket gophers for 14 days and found a daily average of 2.86 mounds per gopher per day. Kennerly (1964) reported the production of five mounds in 2.75 hr following the release of a subadult *Geomys bursarius*; this constitutes 1.88 mounds per hour which is comparable to what we observed.

CONCLUSION

No animals died from post-operative infections, and incisions were closed and healing within 2-3 days. Mass loss in the first week following surgery never exceeded 11% of total body mass (Fig. 1). Females tended to show greater short-term weight losses than males, but recovery times were equivalent. Because transmitters were free-floating in the body cavity, they did not appear to impair digging behavior or foraging efficiency. Similar implantations in marmots (*Marmota flaviventris*) did not appear to affect survival or reproduction (Van Vuren 1989). Gophers were mobile within 2 hours after surgery, and were capable of constructing mounds 12 hours after surgery.

Implantation appears to be a viable technique for field studies of movements and behavior of pocket gophers, and has also been shown to be appropriate for much smaller species (Koehler et al. 1987).

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Courtship, Eggs, and Development of the Plains Topminnow in Nebraska (Actinopterygii: Fundulidae)

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ABSTRACT — Captive specimens of the plains topminnow, *Fundulus sciadicus*, carried out courtship and egg deposition in aquaria provided with filamentous algae. Eggs were attached to algae by means of thin filaments, and the hatching occurred in 13-14 days at 21-23° C. Newly hatched larvae were small (6.2-7.7 mm total length) and did not feed. Eggs laid in the laboratory were the same size as eggs collected from streams and did not change size during development (1.6-2.2 mm diameter).

The plains topminnow is discontinuously distributed over the northern Great Plains and Missouri (Lee et al. 1980, O'Hare 1985). In most states where it occurs, it is found near an edge of its distribution and the species is poorly known. Authors of the fish accounts for these regions either report that nothing is known about the reproductive biology of the species (Baxter and Simon 1970, Cross and Collins 1975, Miller and Robison 1973) or cite Pflieger's (1975) brief account for Missouri. Pflieger (1975) had some personal observations (spawning occurs in May and June) but largely repeated the very general comments of Mayer (1931), who had bred the species in captivity and reported the results in an obscure aquarium journal (eggs attached to vegetation, hatch in 8-10 days at 70° F). *Fundulus sciadicus* occurs across most of Nebraska and is rather abundant at most localities in lentic microhabitats with considerable aquatic vegetation (Stribley and Stasiak 1982).

Out interest in the reproductive biology of this species was an outgrowth of the junior author's study of the dispersing western mosquitofish (*Gambusia affinis*) in Nebraska (Lynch 1988, 1989) and the coincidental disappearance of plains topminnows. Those observations led us to ask which stages in the life cycle of the plains topminnow might be most at risk from the invading mosquito fish and to attempt to document aspects of its breeding biology.

MATERIALS AND METHODS

Adult topminnows were captured with seines and dipnets in a small stream near Columbus, Platte County, and Clear Creek, near Mead, Saunders County, Nebraska, and returned to the laboratory where they

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were maintained in environmental chambers at 18° and 21° C in aquaria of 40-200 liter capacities, with gravel substrates and abundant vegetation (*Elodea* and filamentous algae). Freshly caught fish were acclimated to the warmer water conditions in the laboratory; within a few days they took on brighter colors (intense red on fins of males and black border on median fins in both sexes). The fish from Columbus were captured in October and November 1989, and those from Clear Creek in February and March 1990. Early in their captivity, the fish were very wary and retreated to cover whenever the tank was approached. They were fed commercial flake food twice daily but beginning in March, in an effort to stimulate reproduction, the diet was changed to live brine shrimp until the fish were "trained" to swim toward the keeper and accept food rapidly. They were then shifted to a diet of frozen brine shrimp and commercial flake food and were fed every few hours during the day. Within a week under this feeding regimen (March 15), some courtship behavior was noted.

When eggs (embryos) appeared in algal mats in the aquaria, they were separated from the algae and removed to petri dishes filled with aged water and partially covered to minimize evaporation. Water was added to the dishes during development to compensate for evaporation. Eggs attacked by fungi were discarded and the water in the dishes was changed. Eggs were maintained at 21-23° C under 12-14 hr light/day. The aquaria containing adult fish were searched daily for eggs in the algae and once eggs were found, they were removed from the aquaria, placed in petri dishes, and labeled with that date and allowed to develop (they may have been deposited as much as 20 hr previously). Using the date found as the deposition time, eggs were preserved at various times in order to secure a relatively complete sequence of development. Three lots of eggs were allowed to hatch in petri dishes and the larvae were preserved at various ages up to four days post-hatching.

RESULTS

Courtship

Courtship began almost as soon as the fish were provided a mixed brine shrimp/flake food diet. Interactions between males consisted of two males aligning head to tail and circling. One male attempted to turn perpendicular to the other, and if successful, bit the other on the dorsal fin or just anterior to the dorsal fin. Such combats lasted up to 90 minutes and preceded the establishment of a few dominant males in the aquarium. The combats resulted in injuries to some males (shredding of the dorsal fin and wounds in front of the fin).

Interactions between males and females included two behaviors which are probably connected. What we take to be the first behavior consists of the male lowering his lower jaw and enlarging his gular region. (He appears to have filled his mouth with water.) Following this "signal," the female swims to the male and they assume a head to tail posture followed by vigorous wiggling on the part of each individual. This wiggle behavior was most often observed in open areas (away from vegetation) within the tank but was seen in vegetated areas as well. Sometimes, both individuals would tilt laterally so that their abdomena were more closely approximated. This "tilt" behavior was not seen in every encounter but was seen often enough to suggest that it may be part of courtship (and see below). What we take to be oviposition behavior is as follows: A pair of individuals (male and female) swims together into filamentous algae and then vigorously wiggles. We assume that this event represented release of eggs and sperm but cannot confirm this supposition. It was only after this behavior was observed that we began to find eggs attached to algal filaments.

On five occasions, a female was observed to rotate her body laterally to between 45 and 90 degrees (when first noted, we thought she was dying) so that her swollen abdomen was "aimed" toward the male. She held this position for 10-15 sec and wiggled before righting herself. This posturing behavior is somewhat like the tilting behavior sometimes seen between a courting pair.

Eggs and Embryos

Swollen females from the University of Nebraska State Museum were dissected in order to learn about the sizes of the eggs. Dissected eggs are approximately 1.6-1.8 mm in diameter, yellow to orange in color, and contain many small oil droplets (Univ. Nebraska State Mus. ZM 1043, Holt Creek, Keya Paha Co., Nebraska, 17 May 1977 and ZM 1467, unnamed tributary to Clear Creek, Saunders Co., Nebraska, 5 June 1985).

Preserved specimens in the museum collection have minute eggs (0.1-0.3 mm diameter) in collections made in August, October, and April. Preserved specimens taken during the breeding season have large eggs in the ovary. We do not know how long it takes for the female to move reserves to the eggs but suspect that it occurs rapidly, based on finding females in early April with only minute eggs and our observation of how rapidly fish in aquaria begin to show abdominal swelling after a rich food supply is provided.

The first eggs of captive fish (Columbus fish, held through winter) were found March 22. The eggs of plains topminnows had thin filaments on the chorion and the filaments became entangled on algal filaments. Fish from Clear Creek (collected in February and March) began to deposit eggs in algae on April 18. The eggs held at 21-23° C hatched in 13.5-14.0 days. The sequence of development followed closely that of the diamond killifish, *Adinia xenica*, (Koenig and Livingston 1976) except that the development of the plains topminnow was slower (at a slightly lower temperature). *Adinia xenica* required 9.0-11.0 days at 27° C. Koenig and Livingston (1976) reported delayed hatching in *Adinia* but we see no evidence of a delay in the plains topminnow (nor did we manipulate the developing stocks in search of diapause). At hatching, plains topminnows were 6.2-7.7 ($\bar{x}$ = 6.7) mm in total length (5.0-6.2 mm SL). No fin rays in the dorsal or anal fin folds were evident in larvae 0-96 hr posthatch. Yolk depletion was obvious, but we saw no evidence of the newly hatched fish attempting to feed. The larvae hung at the water's edge, but if molested (by the observer tapping the side of the petri dish), they swam in short, jerky movements on the first day after hatching. Two to four days posthatch, the larvae would swim away from an observer even when the side of the dish was not tapped.

Over the course of the 13-14 day development, there was no change in the size of the egg. The chorion (containing the embryo) of laboratory-produced embryos ranged from 1.6 to 2.2 mm in diameter ($\bar{x}$ = 1.83 ± 0.01 [1 SE], N = 107); only two were larger than 2.0 mm.

Algal mats collected at Clear Creek on May 22 and June 14 contained embryos of *Fundulus sciadicus.* Eggs there were of identical size to the laboratory eggs (114 natural eggs, $\bar{x}$ = 1.84 ± 0.01 mm in diameter) and differed only in that they were more often discolored (presumably stained by substances in the water). Eggs collected in May were in water 18° C and those from June were at 25° C. On each occasion, a 1-l jar was filled with algae and preserved in 10% formaldehyde. The May sample contained 112 eggs and the June sample only four. The eggs from May were in developmental days (stages) 1, 5, 6, and 8 (some appeared to be less than six hours old), whereas those from June were in stages 8 and 11-12 (these stages correspond to terminology of Koenig and Livingston 1976). Based on these two field collections and the observations of development in the laboratory, breeding in Clear Creek extended minimally from May 15 to June 21.

DISCUSSION

The eggs of plains topminnows resemble those of other species in the family (see Able 1984). The breeding season of this species appears to be short and is probably controlled by temperature. Mayer (1931) implied that fish held at 65° F did not breed, but that as soon as the temperature was raised to 70° F they bred. In our experience, the plains topminnow breeds over a temperature range of 18-22° C. We suspect that at temperatures much above that, egg deposition ceases and eggs in the ovaries regress (at Clear Creek, few eggs were found in the algal mats when water temperatures had reached 25° C).

Several fish were maintained through the summer at 18° C on diets limited to flake food once per day. In these fish, there was no evidence of reproduction. The females appeared to be post-reproductive but the males maintained breeding colors. In September, the diet was changed to daily feedings of frozen brine shrimp and ten fish were moved to 21° C. In those ten fish, courtship began in three weeks but the females never appeared "obviously gravid." Nevertheless, three to four weeks later, two fertilized eggs were found on filamentous algae. Five more eggs were found between mid-October and late November.

ACKNOWLEDGMENTS

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Book Reviews

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NATURE TELEVISION IN A BOOK

The Survival Factor. Mike and Tim Birkhead. 1990. Facts on File Inc., New York. 208 pages. $24.95 (cloth).

Viewers of the British television series *Survival Anglia* and other quality nature programs will find much of familiarity in content and style of this book. It is essentially a "nature flick" in book form. The senior editor is indeed a television producer of natural history programs, and the junior author is a well-known zoologist. Both hold doctorates in zoology so one would expect this book to be attractive, interesting, and authoritative. It is, to some degree, all of those things, and should find some appeal among literate natural history buffs. However, as essentially a coffee table book, it has little value to either a professional or a college library.

From the standpoint of a professional, the book is lacking in three critical ways. First, it is not a comprehensive treatment of adaptations for survival. The topics are miscellaneous and probably selected on the basis of what the senior author had gained familiarity with via his television productions. The chapters in sequence are: The Cuckoo; Tool Users; Bigamy Birds; The Spadefoot Toad; Venomous Animals; Life on the Edge (about Mountain Goats); White Water, Blue Duck; Underwater Mammals; Woodpeckers; and Eagles. Such significant adaptations for survival as speed, crypsis, mimicry, burrowing, and social behavior are given only scattered and cursory treatment.

Second, while generally accurate in natural history details, some errors and careless writing could lead one to believe, for example, that (a) whales and dugongs are closely related, (b) male European cuckoos watch for nest-building by potential hosts, (c) frogs and toads copulate, (d) ant-lions occur only in the tropics, and (e) some lizards are the only vertebrates known to reproduce asexually.

The third deficiency is the complete lack of literature citations. One is, therefore, unable to check on such interesting but dubious bits of information as (a) whales are so well-insulated by their blubber that their meat cooks after they are dead and blood can no longer carry heat away, (b) "...there is more than one record of a grizzly bear being fatally wounded by a goat," (p. 120), (c) worldwide there are 100,000 deaths a year caused by snake bites, and (d) the gaboon viper has the longest fangs (1 inch) of any venomous snake.

Based on an appraisal of the subjects with which I have some knowledge, the information appears for the most part accurate. I would therefore guess that overall accuracy is high, but it is frustrating not to have references to follow up topics for verification or expanded treatment.

If you are fond of good television nature programs, you probably will find this book both enjoyable and educational.—*Norman L. Ford, Department of Biology, St. John's University, Collegeville, MN 56321.*

Prairie Nat. 23(1): 47-48. 1991.

A NATURAL HISTORY IMPERATIVE

The Island Within. Richard Nelson. 1989. North Point Press, San Francisco, CA. $18.95 (hardcover).

The Island Within is a natural history journal of natural history journals by Richard Nelson, a cultural anthropologist. The author originally embarks on exploration of a place called Kluska Island off the Pacific Coast of Alaska, and arrives at "an exploration of the meaning of place itself... how we all live in our surroundings not only as visitors and observers but as participants."

Overt and covert references to prairie habitat and species are woven into the journal, recommending it to readers in the Midwest and Great Plains, but the text is metered in the wind speeds, tides, clouds, and light of the Alaskan coast. The author affirms that "...the particular place I'd chosen was less important than the fact that I'd chosen a place and focused my life around it... What makes a place special is the way it buries itself inside the heart, not whether it's flat or rugged, rich or austere, wet or arid, gentle or harsh, warm or cold, wild or tame. Every place, like every person, is elevated by the love and respect shown toward it, and by the way its bounty is received... My hope is to acclaim the rewards of exploring the place in which a person lives..."

This acclamation resonates from the tradition of other authors with Midwestern ties: Aldo Leopold, John Muir, and John Madson. Nelson cites these authors among the literary influences from which he draws. It is given breadth by Nelson in demonstrating the *necessity* of wonder and gratitude. Nelson, the anthropologist, turns anthropomorphism inside-out: hence "the island within."

The book is written with an epistemological fluency that draws from both the western empirical tradition in which Nelson was schooled, and the teachings of Koyukon Native American elders with whom he lived for many years. It is also given depth in his keen powers of observation that take in a diversity of lifeforms, perception of process, and sensitivity to magnificence at all scales, qualified by acknowledging the limitations to human powers of observation.

A plethora of natural history information on animal life is conveyed, in a manner filled with immediacy. Adventures, encounters, and musings are populated by whales, deer, bears, ravens, seals, sea lions, martens, otters, albatrosses, auklets, oystercatchers, halibut, salmon, jellyfish, sea urchins, dragonflies, timber slugs and a host of others, conveying a sense of the natural communities of Kluska Island.

Nelson's natural history insight is typified in his reflection on a varied thrush and on a particularly inaccessible wave-beaten shore. He writes about the thrush song: "The varied thrush is a shy bird, and this is the first time I've ever heard one sing at such close range. His nasal voice is curiously ventriloquial and his beak never opens, so it seems like the sound exudes through his skin. The only way I can tell the notes emanate from this bird is by a slight compression of his chest and puffing of his throat; otherwise it could be coming from anywhere. Between the clear, strong, chiming notes are softer ones, filling the spaces I'd always thought were silent, making an almost continuous song. Each delicate phrase falls on its own pitch, thin and ethereal...like wisp of fog, a filament of spider web, a colored cellophane ribbon afloat on the breeze. For years I've listened to the varied thrush's voice, and now I realize the notes I so loved were less than half its song, not even the most beautiful part." This revelation in a bird song reflects a level of consciousness that is maintained throughout the book.

Similarly, as Nelson reaches a rugged shore of Kluska Island in abnormally calm conditions, he notes: "However fascinating and unusual it is to be here, we can scarcely forget that the true, living force of the place is missing. We're only able to walk this shore because the ocean is asleep today so it's like visiting a stadium when no game is being played."

The 10 chapters of the book are simply and eloquently built around nine trips to the island and a counterpoint chapter written about a set of experiences at home nearby on the mainland. The chapters begin with central trip objectives such as a deer hunt, an ascent to the highest point on the island, and an exploration of a nearby islet rookery. The chapters are more than explorations or escapist experiences. They delve into the antagonism of contemporary western society between people as they might live in concert with nature and as they need to live in concert with family, community and careers. They are written with a philosophical style that begs interjection of the readers' personal experiences.

This book offers a refreshing exuberance and exhilaration that might jump-start the capacity for wonder in even the most weary cynic. Direct reference is made to hunting, fishing, bird-watching, and many facets of biology, but its intended audience extends beyond that of hunting, fishing, and bird-watching enthusiasts or biologists.

In short, *The Island Within* is among the most substantial selections on the literary natural history menu in recent years. It is to be savored, and interfused with the personal experiences of its readers.—*Bonnie Heidel, North Dakota Parks and Recreation Department, Bismarck, ND 58501*

Note

Prairie Nat. 23(1):49-50. 1991.

TWO INCUBATING MALLARDS MOVE EGGS TO DRIER NEST SITES–While studying waterfowl reproduction at Union Slough National Wildlife Refuge in northern Iowa (Fleskes, 1986, M.S. Thesis, Iowa State University, Ames), I found evidence of entire clutch transfer to new nests by two incubating mallards (*Anas platyrhynchos*). One hen also moved her down from the initial nest site.

On 9 May 1985, I flushed a mallard hen from a heavily down-lined nest with 11 eggs that had been incubated for 17 days (Weller, 1956, J. Wildl. Manage. 20:111-113). The nest was in bulrush (*Scirpus* sp.) at the edge of an impounded wetland. The down and nest bowl under the eggs were wet. During the next five days 3.5 cm of rain fell, raising the water level of the wetland. On 15 May, I found the nest bowl flooded and empty except for a small amount of water-soaked down in its bottom. The hen was incubating 11 eggs (incubated 23 days) in a new, heavily down-lined dry nest, 55 cm from the initial nest site. The slope of the site was 15°, and the new nest was 15 cm above the initial nest. The expected hatching date was 18 May. On 23 May, I found 11 membranes from hatched eggs in the new nest; by then an additional 1 cm of rain had fallen and the new nest was also flooded.

On 6 June 1985, after a week of rain totaling 3 cm, I flushed another mallard hen off a heavily down-lined nest with 10 eggs that had been incubated 20 days. The nest was in a low area of a smooth brome (*Bromus inermis*) field. The bottoms of the eggs were wet, and the soil substrate, the nest bowl, and the down were all water-soaked. The expected hatch date was 12 June. On 18 June, I found the nest bowl empty except for some nearly dry down. However, just 30 cm away at about the same level, I found a new nest bowl with eight membranes from hatched eggs, one unhatched egg with a dead embryo, and one infertile egg. The new nest bowl had very little down.

The adaptive reproductive advantage for an incubating bird to retrieve eggs displaced from her nest is obvious and all waterfowl do so by rolling the eggs with their bills (Poulsen, 1953, Videns. Medd. Dansk Naturh. Foren. 115:1-131; Sowls, 1955, Prairie ducks, Stackpole Co., Harrisburg, PA; Prevett and Prevett, 1973, Auk 90:202-204). However, incidents of ducks moving eggs to a new nest bowl have only been reported when man-made obstacles such as a nest-trap (Oring, 1964, Auk 81:88-89; Blohm, 1981, Wilson Bull. 93:276-277) or fence (Johnson and Kirsch, 1977, Wilson Bull. 89:331-332) seemingly disturbed the hen or prevented her from returning to her initial nest from the same direction. Natural circumstances that elicit egg-moving have not been reported.

Mallards commonly select nest sites in dense vegetation in or adjacent to wetlands (Krapu et al., 1979, Wildl. Soc. Bull. 7:104-110). However, these sites are also prone to periodic flooding, so by moving her eggs a hen can save her clutch from floodwaters or excessively high nest humidity (Baerends, 1959, Ibis 101:347-368).

Managers should consider egg-moving behavior when controlling water levels of wetlands. Hens can move their entire clutch in a day, will move it repeatedly (Johnson and Kirsch, 1977, Wilson Bull. 89:331-332), and some clutches may be saved if water levels are raised slowly. However, further research is needed to determine the prevalence of egg-moving and specific conditions that elicit egg-moving before managers can assume that most clutches will be saved if nesting habitats are flooded slowly.

I found that one hen saved her clutch from waters rising about 2 cm per day. However, the rate at which the water level in a wetland can be raised safely will depend upon the time until hatching for clutches in danger of flooding and the slopes of the wetland edges. For instance, early in the nesting season any clutch that is being incubated must survive many days before hatching. Also, all incomplete clutches in or adjacent to wetlands will flood because laying hens do not move eggs (Oring, 1964, Auk 81:88-89; Johnson and Kirsch, 1977, Wilson Bull. 89:331-332; Blohm, 1981, Wilson Bull. 93:276-277). Water levels can probably be increased faster in wetlands with steep edges than in wetlands with more gradually sloping edges, because clutches moved a short distance gain more elevation in a steep than on a gradual slope. However, a severe slope may prevent hens from rolling eggs uphill.

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1. Manuscripts on any aspect of the biology of the North American Great Plains and the organisms living in this region will be considered for publication. Studies on grassland habitats in areas outside this region will also be considered.
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Article: Kantrud, H. A., and R. E. Stewart. 1977. Use of natural basin wetlands by breeding waterfowl in North Dakota. J. Wildl. Manage. 41:243-253.

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Article in Book: Lack, D. 1964. Population dynamics. Pp. 659-661 in A new dictionary of birds (A. L. Thompson, ed.). McGraw-Hill Book Co., New York.

Thesis or Dissertation: Zumbaugh, D. M. 1984. Natural history of foxes in Kansas. M.S. Thesis. Fort Hays State University, Hays, KS.

In Notes the references are inserted in parentheses into the body of the text. Give author's last name, year, journal title, volume, and pages. For a book, include the author's last name, year, title, publisher, and city.

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THE COVER AND ITS ARTIST

The sharp-tailed sparrow (*Ammospiza caudacuta*) is found in marsh habitat in much of the northern prairie region. Here it sits atop prairie cordgrass (*Spartina pectinata*) while singing its insect-like "gasping" song.

Ross H. Hier is an Assistant Wildlife Manager for the Minnesota Department of Natural Resources. Ross enjoys working with watercolors and pen-inks of various natural subjects. He and his wife, Leela, reside in Crookston, MN.