Avian response to vegetative pattern in playa wetlands during winter

Loren M. Smith, David A. Haukos, and Robert M. Prather

Abstract Breeding-bird communities inhabiting northern prairie wetlands have been shown to have higher densities and diversities in wetlands with a well-interspersed 50:50 vegetative cover:water ratio than in those wetlands with a higher or lower proportion of cover. Potential reasons for such a response include increased food or visual isolation and spacing of breeding birds. We manipulated cover:water ratios (75:25, 50:50, 25:75) in Southern Great Plains playas and examined avian response (i.e., species richness, nonwaterfowl bird density, and waterfowl density) to these patterns in winter. We found the highest species richness and generally the highest waterfowl densities in the 50:50 cover:water treatment. Because the amount of vegetative food was similar among treatments and waterfowl inhabiting playas during winter are forming pair bonds, it is most likely that the optimal edge and visual isolation provided in the 50:50 cover:water treatment contributed to its high use and richness. Nonwaterfowl bird density was not different among the treatments. Many nonwaterfowl birds using playas in winter, such as McCown's longspur (*Calcarius mccownii*), occur as nonbreeding feeding flocks, are not forming pair bonds, and likely are not responding to particular cover:water treatments. Playa wetland biologists should create a well-interspersed 50:50 cover:water ratio to optimize waterfowl use and avian species richness.

Key words hemi-marsh, playas, Southern High Plains, waterfowl, wetlands

The ecological principle that species diversity increases with habitat diversity is well documented (see review in Rosenzweig 1995). In wetlands, emergent vegetation structure and interspersion (i.e., habitat diversity on a horizontal plane) have been demonstrated to be associated with diversity and abundance of breeding-bird species in the northern prairies (Weller and Spatcher 1965, Weller and Fredrickson 1974, Kaminski and Prince 1981, Murkin et al. 1982). Specifically, northern prairie wetlands with a 50:50 ratio of interspersed emergent vegetation and open water had a higher diversity and abundance of breeding wetland bird species than those wetlands containing more or less interspersed emergent vegetation (Kaminski and Prince 1981, Murkin et al. 1982). This association has been termed the "hemi-marsh" concept (Weller and Spatcher 1965, Weller and Fredrickson 1974) and is used in the management of wetlands for waterfowl and other birds. Various hypotheses have been proposed to account for greater avian abundance and diversity in the hemi-marsh setting versus other vegetative cover:open water ratios. These include increased food (e.g., seed and invertebrates), abundance or availability, and increased visual isolation and pair-spacing during breeding (e.g., Kaminski and Prince 1981, Murkin et al. 1982).

Response of wintering wetland birds to this relationship of vegetative cover:open water has not been tested. Tests of the relationship on wintering areas have important theoretical and conservation

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implications (e.g., Rosenzweig 1995). Understanding factors influencing avian use of wetlands with different vegetation structure during winter, which could be different from those important during the breeding season, will lead to a better understanding of why birds select certain wetland habitats (Smith 1990). Also, information on avian use of manipulated wetlands will provide biologists with information to better manage wintering wetland-dependent birds (Smith et al. 1989).

We tested the hypothesis that the density and diversity of birds using playa wetlands in the Southern Great Plains during winter would be highest in a hemi-marsh setting. These wetlands are known for potentially large numbers of wintering waterfowl and other nonwaterfowl birds (Smith 2003). We compared avian diversity and abundance in playas with the following water to vegetative cover ratios: 25:75, 50:50, and 75:25. We managed playas to have similar vegetative food levels to better determine whether behavioral isolation vs. food might be more important in selection of wetlands during winter.

Methods

We conducted the study on 9 playa wetlands in the Southern High Plains (SHP) of Texas. The SHP, the largest plateau in North America (Sabin and Holliday 1995), originally was short-grass prairie but now is one of the most intensively cultivated regions in the United States (Bolen et al. 1989). Primary crops were cotton, grain sorghum, winter wheat, and some vegetables. There were 25,000–30,000 playas in the SHP, and they constituted the major surface hydrological feature of the region (Osterkamp and Wood 1987). However, they made up <2% of the total land area (Haukos and Smith 1994). The SHP averaged 46 cm of precipitation per year, most of which fell from May–September from thunderstorms (National Oceanic and Atmospheric Administration 1998).

Although landscape factors such as wetland diversity, density, and area also can influence diversity and abundance of wetland birds (Brown and Dinsmore 1986, Naugle et al. 2000), we selected a region of the Southern High Plains of Texas where playa density was high and relatively uniform (Haukos and Smith 1994) and applied cover-pattern treatments (see next paragraph) randomly to avoid these influences. The 9 playas we selected for study were in Lubbock and Floyd counties within the central SHP. All 9 playas had both a groundwater well for irrigation and a surface pump to draw down the wetland as part of the surrounding irrigation system. These playa attributes permitted moist-soil management designed to improve playa seed and invertebrate production for migrating birds (Haukos and Smith 1993, Anderson and Smith 1999). We started moist-soil management of all 9 playas by creating moist-soil conditions (saturated soil) to promote mud-flat species in early April, with 2 additional periods of moist-soil created into early August as needed (Haukos and Smith 1993). We moist-soil managed all 9 playas similarly during the 1992 and 1993 growing seasons to ensure that similar food resources were available in all playas. The 9 playas were dominated by barnyard grass (*Echinochloa crusgalli*), smartweed (*Polygonum* spp.), and curly dock (*Rumex crispus*), common species in playas surrounded by cropland (Smith and Haukos 2002).

During September of each year after seed set and when all 9 playas had similar vegetative biomass, we cut cover patterns in all 9 playas using a tractor and a 2.5-m-wide single-blade shredder. We randomly assigned 1 of 3 cover patterns (3 playas with 25:75, 3 playas with 50:50, and 3 playas with 75:25 cover:water) to each playa in each year. Therefore, playas received different cover-pattern treatments between years. We cut cover patterns in a checkerboard fashion, starting in the center of each playa, in the following cover:water ratios: 25:75 paths were cut every 2.5 m; 50:50 paths every 7.3 m; and 75:25 paths every 14.9 m. We cut vegetation from the playa but did not remove it, to ensure that vegetative food resources remained similar among all playas. We flooded playas to a depth of 16–25 cm for optimal foraging by dabbling ducks (Fredrickson and Taylor 1982) from 15 November to 15 January during each year of study.

Vegetation sampling

To evaluate potential production differences among mowed treatments in moist-soil managed playas, we established 5 200-m transects during August of each year to determine plant species frequency and vertical vegetative cover. We used a 10-cm-diameter circular plot at each 5-m interval along the transect and recorded species presence to determine frequency (Smith and Kadlec 1983). We estimated area of each moist-soil species (barnyard grass, pink smartweed [*P. pensylvanicum*], willow smartweed [*P. lapathifolium*], curly dock, and spikerush [*Eleocharis palustris*]; Haukos and Smith 1993) by multiplying playa area by percent occurrence. We used a profile board (Nudds 1977) 2.4 m high, and 15 cm wide, divided into 6 40-cm × 15-cm sections to determine vertical cover. A single observer estimated percent cover in each section of the profile board at a distance of 5 m from each of the 4 cardinal directions (Haukos et al. 1998).

We determined seed production by clipping 25 0.5 × 0.5-m quadrats in monotypic stands of moist-soil species in each playa (Haukos and Smith 1993). We separated seed and vegetation of each species in the field and then dried it in the laboratory at 40°C to a constant mass. Weighed samples of each species were converted to kg/ha and multiplied by the estimated area of each species to estimate total production of each species in each playa. We then transformed seed biomass data to duck-use days (DUD) (Reinecke et al. 1989, Haukos and Smith 1993) as an index of carrying capacity for each playa.

Avian surveys

We conducted migratory-bird surveys in managed playas weekly from 15 November to 15 January each year. We counted all wetland-dependent birds in small flocks ($n<300$) by species using a spotting scope. When large flocks ($n \geq 300$) were present, we estimated number within species by counting number of like birds in 5 fields of a spotting scope and extrapolating to total number of fields observed (Obenberger 1982). We divided observations into 5 species or class groupings: mallard (*Anas platyrhynchos*), northern pintail (*A. acuta*), green-winged teal (*A. crecca*), nonwaterfowl birds, and total species richness (Table 1). Species groupings were made on the basis of their abundance.

Table 1. Avian species observed in moist-soil managed playas from 15 November through 15 January of 1992–1994 in the Southern Great Plains of Texas.

Common name	Scientific name
American wigeon	*Anas americana*
Bald eagle	*Haliaeetus leucocephalus*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Cooper's hawk	*Accipiter cooperii*
Dark-eyed junco	*Junco hyemalis*
Eastern meadowlark	*Sturnella magna*
Ferruginous hawk	*Buteo regalis*
Great blue heron	*Ardea herodias*
Green-winged teal	*Anas crecca*
Harris' sparrow	*Zonotrichia querula*
House finch	*Carpodacus mexicanus*
House sparrow	*Passer domesticus*
Killdeer	*Charadrius vociferus*
Lark bunting	*Calamospiza melanocorys*
Long-billed curlew	*Numenius americanus*
Mallard	*Anas platyrhynchos*
McCown's longspur	*Calcarius mccownii*
Mourning dove	*Zenaida macroura*
Northern bobwhite	*Colinus virginianus*
Northern harrier	*Circus cyaneus*
Northern pintail	*Anas acuta*
Northern shoveler	*Anas clypeata*
Peregrine falcon	*Falco peregrinus*
Prairie falcon	*Falco mexicanus*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-necked pheasant	*Phasianus colchicus*
Rough-legged hawk	*Buteo lagopus*
Sandhill crane	*Grus canadensis*
Swainson's hawk	*Buteo swainsoni*

Statistical analyses

We used a completely randomized design (CRD) factorial multivariate analysis of variance (MANOVA) with sampling error to compare vertical cover among treatments (Haukos et al. 1998). Percentages from the 6 strata of the profile board were dependent variables, with treatment (cover:water ratios) and year (1992 and 1993) as independent variables. Because moist-soil managed playas are dominated by annuals (Haukos and Smith 1993), dominant playa vegetation typically changes within and among years (Haukos and Smith 1997, Smith and Haukos 2002), and we randomly applied cover:water treatments each year to playas; treatments were therefore independent between years. We compared seed production (DUD) among cover:water treatments using an analysis of variance (ANOVA) on the ranks (Conover and Iman 1981). We rank-transformed these data because the variance assumption for standard parametric tests was not met.

We analyzed survey data for the 5 avian groups using a CRD factorial ANOVA. Dependent factors in the ANOVA were cover:water treatment, survey week, and year. Because of the extensive movement of birds wintering in playas caused by food availability, weather, migration, and other physiological needs (Baldassarre et al. 1983, Bergan 1990, Haukos and Smith 1993), we assumed that bird surveys were independent. We considered F tests significant at $P<0.10$. Following a significant ANOVA result, we separated treatment means of groups using Fisher's least significant difference (LSD) test.

Table 2. Mean percent cover for each strata (1–6; 1 is the bottom strata on a profile board and 6 is the top strata) of the profile board for 9 moist-soil managed playas, 1992–1993, in the Southern High Plains of Texas.

	Cover Pattern (cover:water)											
	25:75				50:50				75:25			
	1992		1993		1992		1993		1992		1993	
Strata	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
1	77.0	12.1	89.0	17.3	88.6	5.3	90.5	6.7	91.5	4.6	97.2	4.4
2	18.8	5.2	53.6	42.8	42.2	17.5	55.1	21.5	34.6	17.8	70.9	29.8
3	2.7	2.0	9.0	8.0	4.6	1.6	7.1	5.8	2.9	2.3	20.1	16.7
4	1.2	1.2	0.3	0.5	0.7	1.1	0.7	1.1	0.1	0.0	0.5	0.8
5	1.0	1.7	0.0	0.0	0.5	0.9	0.1	0.2	0.0	0.0	0.0	0.0
6	0.7	1.2	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0

Results

Vegetation and carrying capacity

Mean percent vertical cover for each treatment (across years) and 6 strata of the profile board ranged from 77–97% for stratum 1, 19–71% for stratum 2, 3–20% for stratum 3, and generally <1% for the remaining strata (Table 2). Vertical cover did not differ between years (Wilks' lambda=0.54, $P=0.50$) or among cover:water treatments (Wilks' lambda=0.29, $P=0.48$). All playas had similar vertical structure.

Seed production of moist-soil managed playas in both years was high. Mean carrying capacity across years for the 25:75 (cover:water) treatment was 6,743 DUD/ha (SE=3,456), 5,366 DUD/ha (SE=1,052) for the 50:50 treatment, and 7,180 DUD/ha (SE=2,496) for the 75:25 treatment. There was no difference ($F_{2,12}=0.44, P=0.65$) in carrying capacity among treatments. Therefore, in terms of vegetative cover and carrying capacity, treatments were similar and avian response should be mainly attributed to the change in cover:water ratios.

Avian response to cover:water treatment

Survey week had little ($F\leq1.52$, $P\geq0.47$) influence on avian density or richness in the overall analyses; however, response varied by year for each avian group ($F\geq4.95$, $P<0.028$). Generally, more individual birds were present in the second year of study.

There were either year × survey or year × treatment interactions ($P<0.10$) for all avian groups; therefore, data were analyzed separately by year. Mallard density ($F_{2,60}=2.46, P=0.09$) was greater in the 25:75 and 50:50 treatments than the 75:25 treatment in 1992 (Table 3). In 1993 mallard density was highest ($F_{2,60}=4.47, P=0.016$) in the 50:50 treatment. In 1992 northern pintail density ($F_{2,60}=4.04$, $P=0.023$) did not differ between 25:75 and 50:50, but densities in these treatments were higher than in the 75:25 treatment. In 1993 pintail densities ($F_{2,60}=3.02$, $P=0.056$) were highest in the 50:50 treatment. Green-winged teal densities ($F_{2,60}=2.22$, $P=0.117$) in 1992 did not differ among cover:water treatments. In 1993 green-winged teal densities ($F_{2,60}=3.93, P=0.025$) were similar in the 50:50 and 75:25 treatments, both of which were greater than the 25:75 treatment (Table 3).

Nonwaterfowl bird density was not different among cover:water treatments in 1992 ($F_{2,60}=$

Table 3. Mean density (per ha) of avian species or groups in playas with manipulated cover:water patterns in winters of 1992–1993 (year 1) and 1993–1994 (year 2), Southern High Plains, Texas. Species richness is average number of species per playa.

	Cover Pattern (cover:water)											
	25:75				50:50				75:25			
	Year 1		Year 2		Year 1		Year 2		Year 1		Year 2	
Group	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Mallard	2.33AB[a]	0.82	7.54B	1.74	3.09A	0.85	25.11A	4.65	1.07B	0.41	17.81A	4.34
Northern pintail	1.43A	0.60	0.02B	0.02	1.11A	0.36	5.18A	1.84	0.04B	0.04	3.34AB	1.52
Green-winged teal	0.27A	0.13	0.42B	0.16	0.39A	0.16	4.62A	1.29	0.06A	0.03	4.96A	1.62
Nonwaterfowl birds	11.42A	1.96	24.62A	4.05	9.43A	1.39	27.18A	6.45	14.61A	3.72	26.82A	4.82
Species richness	3.60B	0.18	5.37A	0.29	4.83A	0.45	6.53B	0.46	3.03B	0.18	4.23C	0.27

[a] Within a year, means followed by the same letter within a species or group are not different ($P > 0.10$).

0.95, $P=0.391$) or 1993 ($F_{2,60}=0.08$, $P=0.96$; Table 3). Species richness, however, was greatest in the 50:50 treatment in both years ($F_{2,60}=9.53$, $P<0.001$; $F_{2,60}=10.50$, $P<0.001$, respectively) (Table 3). More than 30 avian species used playas during winter (Table 1).

Production of moist-soil plants prior to cutting of cover:water ratios in playa wetlands.

Discussion

Vegetation

Vegetative and seed production were similar among cover:water treatments. Seed production was high, and carrying capacity based on this production alone was higher than reported for most other moist-soil managed wetlands in the United States (Haukos and Smith 1993). Because there were no differences in vegetative cover and carrying capacity based on seed production among treatments, avian response should be primarily attributable to differences in cover:water ratios within the moist-soil managed playas.

Avian response

Highest overall bird richness and waterfowl numbers—primarily northern pintail, green-winged teal, and mallard—were in the 50:50 cover:open water treatment. Therefore, overall data for wetland birds wintering in playas support the hemi-marsh hypothesis. Although the hypothesis was developed for breeding wetland birds in prairie potholes, it also is supported for wintering wetland birds in the southern prairies. Kaminski and Prince (1981) initially hypothesized that invertebrate production may be higher in 50:50 cover to water ratios than in areas with less or more open water, and this production may be responsible for selection of hemi-marsh sites by breeding waterfowl. However, their data did not support the hypothesis, because aquatic invertebrate biomass, abundance, and number of families were similar among various cover:water configurations. Murkin et al. (1982) also found few differences in invertebrate production among similar cover:water treatments.

We did not sample invertebrates in our moist-soil wetlands, but Anderson and Smith (2000) found substantial invertebrate production in moist-soil managed playas flooded during fall and winter. Anderson et al. (2000) further found that moist-soil wetlands with higher invertebrate production were selected by feeding green-winged teal more often than moist-soil managed playas that had lower invertebrate production. However, because plant biomass was a primary influence on invertebrate production (Anderson and Smith 2000), and standing vegetative biomass was similar among cover:water treatments, we hypothesize it is unlikely that invertebrate production varied among cover:water treatments.

Murkin et al. (1982) hypothesized that a 50:50 cover:water ratio may have provided the optimum configuration for waterfowl pairs to remain visually isolated from each other when they were territorial during the breeding season. Because most dabbling ducks are forming pair bonds during winter (Weller 1965), this hypothesis also may explain why we observed highest waterfowl numbers in the 50:50 treatment. However, many nonwaterfowl bird species are not territorial during winter, and they form large flocks. Therefore, this group of birds would not be influenced as much by breeding behavior and the need for visual isolation at this time of year. We hypothesize that overall avian diversity and waterfowl abundance are likely in response to the increased edge and habitat diversity (e.g., Rosenzweig 1995) provided in the hemi-marsh treatment created within the moist-soil managed playas.

Anderson and Smith (1999) compared avian use of moist-soil managed playas with 100% cover between diurnal and nocturnal periods. They found higher nocturnal use (by wetland dependent birds) of playas with 100% cover than during diurnal periods. They attributed higher nocturnal use of playas by waterfowl to a survival strategy used by ducks to avoid potential raptor predation. The vast majority of raptors inhabiting the region are diurnally active. Accordingly, birds feeding in water with dense vegetation, which permits close approach of predators, are more susceptible to predation. As wetland vegetative cover becomes less dense, higher use of wetlands by waterfowl occurs during diurnal periods.

Management implications

Moist-soil management greatly increases the carrying capacity of playas for waterfowl over simply applying water to unmanaged playas (Haukos and Smith 1993). Because far fewer wetlands are available to birds during winter than occurred historically (Dahl 2000), conservation typically is aimed at increasing use and carrying capacity of remaining wetlands (Smith 1990). We suggest that biologists provide a well-interspersed 50:50 ratio of vegetative cover:open water in moist-soil managed playas to maintain large numbers of waterfowl and optimal wetland bird diversity during winter.

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