SEASONAL AVIAN USE OF FARMED KANSAS WETLANDS

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SEASONAL AVIAN USE OF FARMED KANSAS WETLANDS[1]

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ABSTRACT

In Kansas, farmed wetlands make up an important part of the landscape, yet few studies have documented seasonal use of these habitats by wildlife. We examined 12 farmed playa wetlands and 12 farmed floodplain wetlands during 1998 and 1999 to document seasonal use by birds. Avian surveys were conducted using a total count method twice each spring, summer, and autumn, and habitat variables were quantified to examine bird-habitat relationships. Fifty-one bird species were found on farmed wetlands: 39 on farmed playas and 31 on farmed floodplain wetlands. The two most abundant wetland-dependent groups were shorebirds (Charadriiformes) comprising 14 species and dabbling ducks (Anseriformes) represented by 6 species. Migrant shorebirds were most abundant during the spring and autumn periods in playa wetlands, whereas ducks used floodplain wetlands mostly in the autumn and early winter. On floodplain sites, but not on playas, bird indices (i.e., avian diversity and richness) showed significant correlations with plant diversity and richness. Permutation tests revealed significant positive correlations between bird indices and the area inundated by water in both wetland types. Because habitat variables were not correlated positively with avian indices, avian use of farmed wetlands appears to be dependent on other factors such as food resources (e.g., plant seeds, aquatic invertebrates). Our results suggest that cultivation practices can be compatible with management for wetland-dependent birds (e.g., shorebirds, ducks). Farming operations can reduce vegetation cover and bury plant matter, which benefits shorebirds, while promoting moist-soil plants that are used by ducks for food and cover. To maximize use of farmed wetlands by shorebirds and ducks in Kansas, a management plan that incorporates a mosaic of disturbance classes (e.g., farmed at intervals of 1 year, 2 years, and 4 years) would be best.

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INTRODUCTION

Wetlands are found throughout the world and are perhaps the most important of all habitats because of the variety of functions they perform. They recharge groundwater, provide flood protection, purify water, and serve as habitat for many wildlife species (Tiner 1998). Wetlands in the Great Plains often are small and ephemeral, but they provide critical habitat for many amphibians, reptiles, mammals, and birds (Bolen et al 1989a, Haukos and Smith 1994, Laubhan and Frederickson 1997). For example, nearly 40 species of shorebirds use wetlands in the Great Plains during seasonal migrations between breeding grounds in Arctic regions and wintering grounds in Central and South America (Helmers 1992, Skagen and Knopf 1993). Other waterbirds, including 2 million ducks and nearly 400,000 sandhill cranes (*Grus canadensis*) use playa wetlands in the southern Great Plains in a typical winter (Iverson et al. 1985, Bolen et al. 1989b). Because numerous taxa depend on these critical habitats, wetlands in this region are important components in the conservation and management of continental populations of ducks, shorebirds, and other wetland-dependent species.

Since the onset of European settlement, more than 47 million hectares (ca. 53%) of wetlands in the conterminous United States have been destroyed through human activities (Dahl 1990, Tiner 1998). In the Great Plains, technological advances in mechanized agriculture led to large-scale drainage of wetlands in an attempt to expand the amount of arable land from the late 1940s through the mid-1980s (U.S. Department of Interior 1994, National Research Council 1995). Currently, many wetlands in the Great Plains are modified through farming practices. A recent estimate by the National Research Council (1995) estimated that 2.8 million hectares of wetlands continue to be farmed legally under current legislation. In Kansas, two wetland types are cultivated if conditions allow: playa wetlands in the southwest and floodplain wetlands in southeast. These wetlands are seasonal in nature and often go dry for extended periods because their small, closed watersheds depend on localized and highly variable patterns of precipitation for hydrologic input (Bolen et al. 1989a). If the soil in a farmed wetland is able to support equipment during planting, that wetland may be cultivated, and if the wetland basin remains dry throughout the growing season, a crop can be harvested.

Although farmed wetlands appear to be important habitats for wildlife in Kansas, little is known about the influence of farming in these areas, and their current management is based on scant data. To better understand these habitats, we investigated seasonal wildlife use in farmed playa and floodplain wetlands using birds as a representative taxon. Our specific objectives were to: 1) survey farmed wetlands during three seasons (i.e., spring, summer, and autumn) and document seasonal avian use and 2) examine the relationship between habitat correlates and the number of species (i.e., species richness) that use farmed wetlands. We limited our investigation to small (<6 ha), recently farmed (since 1990) wetlands that were cropped under natural conditions (i.e., they had not been tiled or drained), which are those in most need of conservation.

Study Area and Methods

Twelve playa wetlands and 12 floodplain wetlands served as study sites during the 1998-99 field seasons. Playa wetlands are characterized by shallow, circular basins consisting primarily of Randall clay soils that collect and hold water for extended periods of time (Guthery and Stormer 1984, Bolen et al. 1989a). During wet periods, playas harbor a wide variety of animals including crustaceans, larval dipterans, aquatic coleopterans, amphibians, reptiles, and a host of birds and mammals (Bolen et al. 1989, Davis and Smith 1998). Over 99% of playas are located on private lands, and many continue to be farmed legally (Haukos and Smith 1997). In this study, playa wetlands located on private agricultural lands in Meade County, Kansas were selected with assistance from personnel of the Meade County National Resource Conservation Service. All playa wetlands were planted to winter wheat in one or both years of this study.

Floodplain wetlands are found in the southeastern part of Kansas, where higher precipitation levels and less cultivation are characteristic. Like playas, floodplains are typically small, shallow wetlands that support many wetland-dependent species when they hold water. Floodplain wetlands in this study were located adjacent to the Neosho River on the Flint Hills National Wildlife Refuge in Lyon and Coffey counties. They were planted to soybeans, corn, alfalfa, sorghum, and winter wheat during this study.

Bird Surveys

Bird surveys were conducted twice during the spring, summer, and autumn seasons of 1998-99. We used a modification of the consecutive flush method (Verner 1985) to count all individuals present on a study site. Species observed flying over sites were not counted except for aerial insectivores (i.e., swallows) or raptors that were hunting on the wing. Each survey was terminated when all birds had been detected and recorded. Because we wanted to have a complete list of the maximum number of species known to use each wetland, all surveys were combined to a create a cumulative species list for each farmed wetland. The cumulative number of species then was used to examine relationships between total avian richness (i.e., the minimum number of species observed on each wetland) and habitat characteristics of each wetland. Almost all individuals were identified to species (i.e., 99%); the few whose identity was not clear (i.e., 37 combined individuals from each of three groups: unidentified sparrow, *Sturnella* spp., or *Calidris* spp.) were excluded from analyses. The seventh edition of the AOU checklist (AOU 1998) was used for avian nomenclature and classification.

Habitat Measurements

Vegetation surveys were conducted during late summer of 1998 and 1999 to examine the relationship between total avian richness and the plant communities on farmed wetlands. Data were collected on all farmed wetlands except for those sites that had been tilled recently and were devoid of live vegetation or on sites dominated by agricultural crops. The latter category was not included because vegetation measurements were inaccurate in cropland and virtually no vegetation other than crops was present. On surveyed farmed wetlands, plant species composition, frequency, maximum plant height, and percent live cover were measured using two perpendicular transects. Both transects originated in the center of the wetland and extended to the outer boundary. The bearing of the first transect was selected randomly, and the second transect was situated 90° in a clockwise direction from the first. In 1999, new transects were used to measure vegetation in farmed wetlands. For analyses, data from both transects were combined to provide an overall index of vegetation characteristics for each site.

After transects were established, they were measured for length and divided into 50 equidistant points. Next, species composition and frequency were measured using a point-intercept method (Brower et al. 1998). After this was completed, each transect then was divided into 25 equidistant points, and a 20 x 50 cm sampling quadrat was used to measure maximum vegetation height and percent live cover. Quadrats were placed on alternating sides of a transect at each of 25 points; the side of the first quadrat was determined by a coin toss. The height of the tallest live plant that fell within a vertical column above each sampling quadrat was measured. In addition, the amount of live cover within the quadrat was scored as one of the following categories: 0%, 1-5%, 6-10%, 11-25%, 26-50%, 51-75%, and 76-100%. Cover class midpoints were used to compute cover estimates for each wetland. Plants were identified to genus, and when possible, to species following the nomenclature and classification of the Great Plains Flora Association (1986). Wetland size was measured using ArcView 3.2 software (1999) with digitized aerial photos of study sites. In addition, the percent water present in each wetland relative to its typical size was recorded (hereafter called wet hectares) during each field visit. After wetland sizes had been measured, the number of wet hectares for each site was estimated by multiplying the wetland size by the percent of the wetland covered by water.

Data Analysis

Avian and plant diversity estimates were calculated using Shannon's diversity index (H', Magurran 1988), and species richness estimates were determined by counting the total number of avian and plant species present on an individual site over the time period under examination (i.e., one year, both years). Strengths of relationships between avian and plant indices were examined with Spearman's rank test for 1998, 1999, and both years combined using PROC CORR in SAS (SAS Institute Inc. 1997). Additionally, data resampling software (Resampling Stats 1995) was used to construct permutation tests on the correlation coefficients obtained by resampling the data. These tests were implemented by permuting the ranks of the original data, calculating a correlation coefficient on the permuted ranks, and then repeating this process 999 times. All computed correlation coefficients were placed into a frequency distribution, and the correlation coefficient from the observed data was used as the test statistic. The P-values from the Spearman's rank test are reported, but permutation P-values were used to test differences because of limited sample sizes. The P-values for all tests were considered significant at $P < 0.10$ because of small sample sizes; all reported values are means (± SE) unless otherwise specified.

RESULTS

For all site visits from 1998-99 combined, 3050 individuals belonging to 51 bird species were observed on farmed wetlands (Table 1). The mallard was the most abundant species with 994 individuals observed, followed by the northern pintail (795), red-winged blackbird (334), killdeer (117), and horned lark (82). See Appendix A for scientific names of birds observed on study sites. The majority of species recorded on farmed wetland sites were found alone or in groups of less than five individuals (78.9% of all observations). Flocks of greater than 20 individuals were very rare, and only on seven occasions did the number of individuals reach or exceed 60 for any species. Over both years, 65% of species (36/55) were represented by 20 individuals or fewer, and 16% (9/55) of all species were represented by a single individual. The final floodplain wetland survey of 1998, conducted in late November because of extensive flooding of the Neosho River, counted 1840 individuals of five species of dabbling ducks on only three study sites. During this visit, the most abundant species was the mallard (935 individuals) followed by northern pintail (795), green-winged teal (70), northern shoveler (30), and American wigeon (10). This one visit alone accounted for 60% of all individuals observed throughout the entire study and underscores the variation that existed among surveys.

Distinct differences were found between the avifauna in playas and floodplain wetlands. We observed 39 species on playa wetlands and 31 species on floodplain sites. Sixteen species were found on both wetland types, and 23 species were exclusive to playas. Floodplain wetlands had 15 species that were not found on playas, but most of these were represented by a small number of individuals. Mean species diversities averaged over both years were 1.89 (± 0.19) for 12 playa wetlands and 0.82 (± 0.17) for 12 floodplain wetlands (Table 2). Similarly, playa wetlands, which generally were larger, also had a higher mean species richness averaged over the 2 years: 12.1(± 1.6, n=12 sites) versus 4.5 (± 0.8, n = 12 sites) for floodplain sites (Table 2).

Temporal variations in species present between 1998 and 1999 also occurred on farmed wetlands. In 1998, playa wetlands had a combined overall richness of 23 species; floodplain wetlands had a similar measure of 24 species when all sites were combined. In 1999, however, richness increased to 31 species in playas, whereas floodplain richness declined to 9 species. Species richness for each paired site visit (e.g., 1998 playa spring survey #1 vs. 1998 floodplain spring survey #1) was higher on playa sites than on floodplain sites for 11 of 12 visits (Fig. 1). For both wetland types, the number of new species added at each visit showed no consistent pattern (Fig. 2), yet species were added over the course of the study.

Over both years and wetland types, 54 species of plants were found on farmed wetlands (see Appendix B). However, plant sampling on several wetlands was hindered because disturbance by mechanical farming equipment destroyed vegetation prior to sampling. Dominant species were distinct between playa and floodplain wetlands. In playas, pink smartweed (*Polygonum bicorne*), junglerice (*Echinochloa colonum*), and bearded sprangletop (*Leptochloa fascicularis*) were the dominant plant species. In contrast, floodplain sites were dominated by bulrush (*Scirpus* spp.), barnyardgrass (*E. crus-galli*), and cocklebur (*Xanthium strumarium*).

Mean plant diversity estimates for 1998 were lower on playa wetlands (0.86 ± 0.06, n = 9 sites) than on floodplain sites (1.25 ± 0.20, n = 9 sites). In the following year, however, mean diversity estimates in playas (1.18 ± 0.14, n = 6 sites) were similar to those on floodplain sites (1.18 ± 0.20, n = 8 sites). Measurements of richness showed a similar trend as diversity estimates, but differences in 1999 were more pronounced between playa and floodplain sites. For both years combined, the total species richness of playa wetlands (19 species) was less than half that of floodplain sites (41 species). Other measured vegetative characteristics showed no distinct patterns between wetland sites. Maximum vegetation heights in playas averaged 28.3 cm (± 4.4, n = 9) in 1998 and 46.0 cm (± 6.9, n = 6) in 1999, whereas those in floodplain sites averaged 45.2 cm (± 6.7, n=9) in 1998 and 51.8 cm (± 8.7, n = 8 sites) in 1999. Mean percents live cover in playa wetlands were 31.2% (± 5.2, n = 9) in 1998 and 32.1% (± 5.0, n = 6) in 1999, whereas those in floodplain wetlands averaged 48.6% (± 7.0, n = 9) in 1998 and 57.2% (± 8.7, n = 8) in 1999.

Overall, no significant correlations were detected between avian indices and vegetation features in playa wetlands, but negative correlations occurred between these measures in floodplain sites. In farmed playas, no significant correlations were found when avian indices (i.e., avian diversity and richness) were plotted against plant indices (i.e., plant diversity and richness) or when they were plotted against maximum vegetation height (Tables 3, 4). However, significant negative correlations were found in floodplain wetlands when the same comparisons were made for combined 1998 and 1999 data (Tables 3, 4). Correlations of avian indices and mean percent live cover showed different patterns in playa and floodplain wetlands, but the results were mixed (Table 5).

Two additional features, total wetland size and wet hectares, showed distinct patterns between the two wetland types. In playa wetlands, avian indices had significant, positive correlations with wetland size over both years combined; however, such a relationship was not observed in floodplain sites (Table 6). Similar outcomes were found when avian indices were tested against wet hectares (Table 7). Although avian indices appeared to be correlated strongly and positively with size of playa wetlands, this relationship was largely the effect of one datum (Figs. 3,5). Size did not appear to influence bird diversity or richness in floodplain sites (Figs. 4,6).

DISCUSSION

Both obligate and facultative wetland users were observed on farmed wetlands, despite frequent disturbances from agricultural practices. Observed species were placed into three general groups: migrant shorebirds, dabbling ducks, and facultative wetlands users (i.e., those species that use wetlands but do not require them for habitat; see Table 1). Although these groups were observed in both wetland types during all seasons, the timing and wetland selection among the three groups differed seasonally. Shorebirds were observed in farmed wetlands during the spring and autumn migration periods and were more abundant in playa wetlands. Dabbling ducks, in contrast, were more common in floodplain wetlands and were found more often in the autumn and early winter. Facultative wetland users were found in both wetland types across all seasons and usually were there when little or no water was present. Because facultative wetland users typically were found in low numbers and often were more abundant in habitats other than farmed wetlands, they are not considered further.

Shorebird use of playa wetlands as stopover sites during migration is well known in Texas (Baldassarre and Fischer 1984, Bolen et al. 1989a, Davis and Smith 1998), but little is known about species use of Kansas playas. Flowers (1996) documented the occurrence of 26 species of shorebirds in playa wetlands in Meade County, Kansas based on 13 years of observations. However, only 11 of those 26 shorebirds were observed over the course of this study, suggesting that our sampling effort was not sufficient to detect all species that are known to use these habitats. Indeed, playa wetlands can be extremely variable on a yearly basis (Bolen et al. 1989a), which may bias the results of studies that are conducted over a relatively short time period or when conditions are atypical.

Dabbling duck use of Kansas farmed wetlands was not restricted to either type, but five of six species observed were more abundant in floodplain wetlands than in playas. Mallards were observed in both farmed wetlands in all seasons. They used playa wetlands on a limited basis for brooding habitat and perhaps nesting sites. Northern pintail and American wigeon were found only during the late November visit, whereas northern shovelers were present during spring and autumn. Blue-winged and green-winged teals usually were observed during early autumn migration periods and were present on both wetlands. Several species of ducks were found in floodplain wetlands, but no consistent patterns of waterfowl use were observed. This may be explained by other available habitats that were proximal to floodplain sites (e.g., Neosho River, John Redmond reservoir).

In this study, habitat characteristics were not correlated positively to the number of species using farmed wetlands. Instead, other factors may have influenced seasonal avian use. For example, migrant shorebirds use stopover wetland habitats to forage on seasonally abundant food resources (e.g., annelids, cladocerans, larval dipterans) that replenish energy reserves depleted by seasonal movements between breeding and wintering areas (Baldassarre and Fischer 1984, Davis and Smith 1998). In Texas, shorebird use of playa wetlands appears to be based largely on food availability (Davis and Smith 1998), and Kansas wetlands apparently provide similar resources to migrant shorebirds. Although not quantified, several species of shorebirds collected in Kansas playas contained aquatic invertebrates in their digestive tracts (Rivers, personal observation) similar to those found in Texas playas by Davis and Smith (1998). It is not surprising that the aquatic invertebrates used by migrant shorebirds in Kansas and Texas playas are similar given the generalist nature and dispersal patterns of many taxa found in these ephemeral habitats (Maguire 1963, Hall et al. 1999). Thus, use of wetland habitats by migrant shorebirds in Kansas probably is based on available food resources, but this remains to be demonstrated empirically.

In contrast to shorebirds, habitat characteristics may be more important for migrant and wintering dabbling ducks that use farmed wetlands. Ducks often select wetlands that contain moderate to extensive amounts of vegetation (Bolen et al. 1989a). Vegetation provides protection from predators and reduces thermal stress from high velocity winds during cold weather (Bennett and Bolen 1978), which can augment fat reserves and reduce winter mortality (Smith and Sheeley 1993). Vegetation also provides important food resources to dabbling ducks during the autumn and winter months (Bolen et al. 1989b). Several moist-soil plants provide food for migrating and overwintering ducks in wetland habitats in the Great Plains and in particular, *Polygonum* spp., *Echinochloa* spp., *Scirpus*, spp., and *Leptochloa* spp. produce seeds that are consumed by dabbling ducks during the nonbreeding season (Guthery and Stormer 1984, Bolen et al. 1989b, Haukos and Smith 1993). Although seed production was not quantified in this study, these plants dominated playa and floodplain wetlands and probably were important food sources for migrating and wintering ducks.

In Kansas, farming practices in farmed wetlands may benefit some wetland-dependent birds, particularly shorebirds and ducks. Cultivation operations (e.g., mowing, tilling) prevent successional patterns of vegetation on playa wetlands and result in little or no vegetation. Reduction of vegetation is important for shorebirds, because it allows them to see distant predators and increases their foraging efficiency (Helmers 1992, Davis and Smith 1998). In addition, shallow disking buries dead plant matter that provides a food base for the aquatic invertebrates that proliferate in wetlands after inundation (Davis and Smith 1998, Hall et al. 1999). Ducks also appear to benefit from cultivation because several moist-soil plants used as food (e.g., *Polygonum* spp., *Echinochloa* spp.) are favored by the conditions created by farming disturbances. Overall, disturbances from cultivation may mimic natural disturbances (e.g., fire, ungulate grazing) that "reset" wetland communities by reducing vegetation, burying plants in the soil, and conferring a competitive advantage to moist-soil plants.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Farmed wetlands in Kansas play major roles in providing habitat for many species of birds throughout the year and thus contributing to the biological diversity of the Great Plains region (Bolen et al. 1989b, Haukos and Smith 1994, Davis and Smith 1998, Hall et al. 1999). They also provide food resources that allow shorebirds and ducks to rest and replenish engrey reserves during migration and wintering periods. Farmed playa wetlands in Kansas appear to be similar to those examined in Texas, that is, they serve as stopover habitats for shorebirds during the spring and autumn migrations. Farmed floodplain wetlands, in contrast, are habitats for several species of dabbling ducks, but their use may be influenced strongly by an abundance of local, alternative wetlands.

Farming of playa and floodplain wetlands in Kansas may be compatible with habitat management for migrant shorebirds, a group of conservation importance (Helmers 1992). Continuing disturbance by mechanized farming equipment is an important component in maintaining wetland habitat for the many species of shorebirds that migrate through this homogenous, agriculturally dominated landscape. Unlike most farming practices, those conducted in wetlands can contribute to habitat improvement for this taxon by altering the physiognomy of the sites and contributing to the food resource base. The continued farming of Kansas wetlands also may be a suitable management practice for ducks. Many species of waterfowl forage on moist-soil plants that require the entire growing season to mature and produce the seeds that they use (Haukos and Smith 1993). In addition, spilled grains in farmed fields are alternative food sources for waterfowl during the autumn and winter months (Baldassarre et al. 1983, Bolen et al. 1989b). To maximize use of farmed wetland habitat for shorebirds and ducks in Kansas, a management plan that incorporates a mosaic of disturbance classes (e.g., farmed at intervals of 1 year, 2 years, and 4 years) is recommended. Although farming disturbances modify habitat in positive ways for these two groups, effects from other farming practices (e.g., application of herbicides or pesticides) may substantially impact wetland-dependent species and must be examined to provide a holistic perspective of the influence of agriculture on Kansas wetlands and the organisms that use these habitats.

In the effort to conserve Kansas farmed wetlands as wildlife habitat, we must recognize that nearly all of them are located on privately owned property. Any management plan developed for wildlife also must be accepted by landowners and recognized as a compatible land use. Because farmed wetlands are major habitats for numerous species of resident and migrant wildlife, educating landowners as to their importance and developing additional programs (e.g., conservation easements) for producers to conserve farmed wetlands will provide the most benefit.

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Table 1. Status and abundance of birds observed on farmed playa (n = 12) and farmed floodplain wetlands (n = 12) combined over the 1998 and 1999 seasons.

Species	Status	Season	Playa	Floodplain
American avocet*	C	Su	9	---
American crow	C	Yr	---	6
American pipit	U	Tr	12	---
American wigeon*	C-A	Tr	---	10
Baird's sandpiper*	C	Tr	---	1
Barn swallow	C	Tr	9	---
Barred owl	C	Yr	---	1
Black-bellied plover[1*]	U	Tr	4	---
Blue-winged teal*	C-A	Tr	53	25
Brown-headed cowbird	C	Su	---	1
Calidris spp. *	---	---	15	---
Cliff swallow	C	Tr	54	---
Common grackle	C	Su	18	5
Common snipe*	C	Tr	11	5
Dickcissel	C	Su	16	3
Eastern kingbird	C	Tr, Su	---	1
Eastern meadowlark	C	Su	---	1
Grasshopper sparrow	C	Su	39	---
Great blue heron*	C	Su	---	4
Greater yellowlegs*	C	Tr	---	1
Great-tailed grackle	C	---	12	---

(continued)

Table 1. Status and abundance of birds observed on farmed playa (n = 12) and farmed floodplain wetlands (n = 12) combined over the 1998 and 1999 seasons.

Species	Status	Season	Playa	Floodplain
Green-winged teal*	C	Tr	8	70
Harris's sparrow	C	Tr, W	36	---
Horned lark	C	Yr	82	---
Killdeer	C	Su	94	23
Lark bunting	C	Tr, Su	15	---
Lark sparrow	C	Tr, Su	18	2
Least sandpiper*	U	Tr	2	---
Lesser yellowlegs*	C	Tr	21	2
Long-billed dowitcher*	C	Tr	18	
Mallard*	C-A	Tr	55	939
Mourning dove	C-A	Tr, Su	20	---
Northern bobwhite	C	Yr	1	1
Northern harrier	C	Su, W	3	---
Northern pintail*	C-A	Tr	---	795
N. rough-winged swallow	C	Tr	---	2
Northern shoveler*	C-A	Tr	6	30
Pectoral sandpiper*	C	Tr	4	2
Prairie falcon	U	W	1	---
Red-tailed hawk	C	Yr	1	---
Red-winged blackbird	C	Su	281	53

(continued)

Table 1. Status and abundance of birds observed on farmed playa (n = 1 2) and farmed floodplain wetlands (n = 12) combined over the 1998 and 1999 seasons.

Species	Status	Season	Playa	Floodplain
Ring-necked pheasant	C	Yr	26	---
Savannah sparrow	C	Tr	54	---
Solitary sandpiper*	U	Tr	2	2
Sora*	C	Tr, Su	---	1
Sturnella spp.	---	---	14	---
Unidentified sparrow	---	---	6	2
Upland sandpiper	C	Su	---	4
Vesper sparrow	C	Tr	---	2
Western meadowlark	C	Su	23	---
Western sandpiper*	C	Tr	4	---
White-faced ibis*	R	Sp, Su, F	2	---
Wild turkey	C	Yr	---	4
Wilson's phalarope*	C	Tr	40	---

Status is based on the probability of occurrence in Kansas as determined by Thompson and Ely (1989, 1992): A=Abundant, C=Common, U=Uncommon, R = Rare. Season is based on the periods of occurrence in Kansas reported by Thompson and Ely (1989, 1992): Sp=Spring, Su=Summer, F=Fall, W=Winter, Yr=Year-round resident, Tr=Transient during migration periods. Wetland-dependent species are denoted by *.

Table 2. Wetland size, last year wetland was farmed, and measures of avian diversity and avian richness calculated for playa and floodplain wetlands.

Playa Wetlands					Floodplain Wetlands				
Site	Size (ha)	Last Year Farmed[1]	Avian Diversity[2]	Avian Richness[3]	Site	Size (ha)	Last Year Farmed[1]	Avian Diversity[2]	Avian Richness[3]
1	0.92	1998-99	2.58	19.00	1	0.22	1999-99	0.95	6.00
2	0.32	1998-99	0.76	4.00	2	0.19	1998-99	1.62	6.00
3	1.13	1998-99	2.40	15.00	3	0.08	1998-99	1.64	8.00
4	0.49	1998-99	2.27	14.00	4	0.13	1994	0.64	8.00
5	1.03	1998-99	1.71	7.00	5	0.20	1991	0.95	3.00
6	4.46	1998-99	2.69	22.00	6	0.18	1998	0.88	9.00
7	0.43	1998-99	2.32	18.00	7	0.28	1998-99	0.00	1.00
8	0.69	1998-99	1.02	8.00	8	0.09	1998-99	0.00	1.00
9	0.26	1998-99	1.72	10.00	9	0.14	1995*	0.00	1.00
10	1.02	1998-99	2.11	11.00	10	0.16	1994	0.82	4.00
11	1.36	1998-99	2.21	12.00	11	0.19	1994	0.69	2.00
12	0.76	1998-99	0.89	5.00	12	0.40	1994	1.61	5.00
Mean	1.07 (± 0.32)	---	1.89 (± 0.19)	12.1 (± 1.6)	Mean	0.19 (± 0.02)	---	0.82 (± 0.17)	4.5 (± 0.8)

[1] The last year wetland was tilled and planted.
[2] H’ following Magurran (1988).
[3] The total number of species observed on a site over the course of the study.
* Vegetation in wetland was mowed in the summer of 1999.

Table 3. Spearman's rank correlations of mean (± SE) avian diversity (Shannon's H') vs. mean (± SE) plant diversity (Shannon's H') and mean (± SE) avian richness vs. mean (± SE) plant richness showing significant correlations between avian and plant indices in farmed floodplain wetlands.

Year and Wetland	N	Avian Diversity	Plant Diversity	P^1	R	P^2	Avian Richness	Plant Richness	P^1	R	P^2
1998											
Playa	9	1.52 ± .25	0.86 ± .06	.332	-0.37	---	7.4 ± 1.5	5.0 ± 0.4	.740	-0.13	---
Floodplain	9	0.73 ± .19	1.25 ± .20	.168	-0.50	---	4.0 ± 0.8	10.4 ± 1.1	.179	-0.49	---
1999											
Playa	6	1.97 ± .17	1.18 ± .14	.623	-0.26	---	10.7 ± 1.7	7.3 ± 0.9	.734	0.18	---
Floodplain	6	0.36 ± .23	1.16 ± .24	.268	-0.54	---	1.7 ± 0.4	9.7 ± 1.5	.188	-0.62	---
Combined											
Playa	11	1.91 ± .21	1.08 ± .11	.750	-0.11	.376	12.5 ± 1.7	7.1 ± 0.8	.597	0.18	.307
Floodplain	9	0.98 ± .18	1.34 ± .21	.067	-0.63	.034	5.1 ± 0.9	15.1 ± 1.6	.094	-0.59	.045

[1] *P*-value from Spearman's rank correlation.
[2] *P*-value from permutation test.
Permutation tests were conducted only on combined data from 1998 and 1999 field seasons.

Table 4. Spearman's rank correlations of mean (± SE) avian diversity (Shannon's H') vs. maximum (± SE) plant height and mean (± SE) avian richness vs. maximum (± SE) plant height highlighting the significant correlation between avian indices and maximum plant height in farmed floodplain wetlands.

Year and Wetland	N	Avian Diversity	Max. Plant Height	*P*[1]	R	*P*[2]	Avian Richness	Max. Plant Height	*P*[1]	R	*P*[2]
1998											
Playa	9	1.52 ± 0.25	28.3 ± 4.4	.381	-0.33	---	7.4 ± 1.5	28.3 ± 4.4	.377	-0.34	---
Floodplain	9	0.73 ± 0.19	45.2 ± 6.7	.005	-0.84	---	4.0 ± 0.8	45.2 ± 6.7	.076	-0.62	---
1999											
Playa	6	1.97 ± 0.17	46.0 ± 6.9	.872	0.09	---	10.7 ± 1.7	46.0 ± 6.9	.742	0.17	---
Floodplain	6	0.36 ± 0.23	52.8 ± 11.4	.034	-0.85	---	1.7 ± 0.4	52.8 ± 11.4	.042	-0.83	---
Combined											
Playa	11	1.91 ± .21	31.8 ± 4.4	.894	0.05	.473	12.5 ± 1.7	31.8 ± 4.4	.730	0.12	.370
Floodplain	9	0.98 ± .18	46.2 ± 6.9	.030	-0.72	.015	5.1 ± 0.9	46.2 ± 6.9	.024	-0.74	.008

[1] *P*-value from Spearman's rank correlation.
[2] *P*-value from permutation test.
Permutation tests were conducted only on combined data from 1998 and 1999 field seasons.

Table 5. Spearman's rank correlations of mean (± SE) avian diversity (Shannon's H') vs. mean (± SE) plant live cover and mean (± SE) avian richness vs. mean (± SE) plant live cover.

Year and Wetland	N	Avian Diversity	Plant Live Cover	P^1	R	P^2	Avian Richness	Plant Live Cover	P^1	R	P^2
1998											
Playa	9	1.52 ± 0.25	31.2 ± 5.2	.406	-0.32	---	7.4 ± 1.5	31.2 ± 5.2	.484	-0.27	---
Floodplain	9	0.73 ± 0.19	48.6 ± 7.0	.075	-0.62	---	4.0 ± 0.8	48.6 ± 7.0	.385	-0.33	---
1999											
Playa	6	1.97 ± 0.17	32.1 ± 5.0	.208	0.60	---	10.7 ± 1.7	32.1 ± 5.0	.148	0.67	---
Floodplain	6	0.36 ± 0.23	57.6 ± 9.9	.034	-0.85	---	1.7 ± 0.4	57.6 ± 9.9	.042	-0.83	---
Combined											
Playa	11	1.91 ± .21	29.2 ± 4.6	.631	0.16	.335	12.5 ± 1.7	29.2 ± 4.6	.484	0.24	.234
Floodplain	9	0.98 ± .18	50.7 ± 7.8	.042	-0.68	.027	5.1 ± 0.9	50.7 ± 7.8	.116	-0.56	.068

[1] *P*-value from Spearman's rank correlation.
[2] *P*-value from permutation test.
Permutation tests were conducted only on combined data from 1998 and 1999 field seasons.

Table 6. Spearman's rank correlations of mean (± SE) avian diversity vs. mean (± SE) wetland size (ha) and mean (± SE) avian richness vs. mean (± SE) wetland size (ha).

Year and Wetland	N	Avian Diversity	Wetland Size (ha)	*P*-value	R	Avian Richness	Wetland Size (ha)	*P*-value	R
1998									
Playa	12	1.26 ± 0.23	1.07 ± 0.32	.353	0.29	6.3 ± 1.3	1.07 ± 0.32	.285	0.34
Floodplain	11	0.66 ± 0.16	0.19 ± 0.03	.429	-0.27	3.7 ± 0.7	0.19 ± 0.03	.186	-0.43
1999									
Playa	12	1.68 ± 0.17	1.07 ± 0.32	.557	0.19	8.8 ± 1.4	1.07 ± 0.32	.616	0.16
Floodplain	9	0.41 ± 0.17	0.18 ± 0.03	.416	0.31	1.9 ± 0.4	0.18 ± 0.03	.888	0.06
Combined									
Playa	12	1.89 ± 0.19	1.07 ± 0.32	.118	0.48	12.1 ± 1.6	1.07 ± 0.32	.200	0.40
Floodplain	12	0.82 ± 0.17	0.19 ± 0.02	.539	0.20	4.5 ± 0.8	0.19 ± 0.02	.677	-0.13

Permutation tests were conducted only on combined data from 1998 and 1999 field seasons.

Table 7. Spearman's rank correlations of mean (± SE) avian diversity vs. mean (± SE) wet hectares (i.e., total hectares x percent inundated) and mean (± SE) avian richness vs. mean (± SE) wet hectares (i.e., total hectares x percent inundated).

Year and Wetland	N	Avian Diversity	Wet Hectares	*P*[1]	R	*P*[2]	Avian Richness	Wet Hectares	*P*[1]	R	*P*[2]
1998											
Playa	12	1.26 ± 0.23	0.11 ± 0.04	.244	0.36	---	6.3 ± 1.3	0.11 ± 0.04	.341	0.30	---
Floodplain	12	0.81 ± 0.21	0.06 ± 0.01	.214	0.39	---	4.8 ± 1.3	0.06 ± 0.01	.075	0.53	---
1999											
Playa	12	1.53 ± 0.18	0.43 ± 0.15	.779	0.09	---	7.6 ± 1.3	0.43 ± 0.15	.570	0.18	---
Floodplain	8	0.38 ± 0.19	0.04 ± 0.01	.389	-0.35	---	1.9 ± 0.4	0.04 ± 0.01	.532	-0.26	---
Combined											
Playa	12	1.89 ± 0.19	0.27 ± 0.07	.138	0.45	.070	12.1 ± 1.6	0.27 ± 0.07	.175	0.42	.083
Floodplain	12	0.82 ± 0.17	0.05 ± 0.01	.053	0.57	.028	4.5 ± 0.8	0.05 ± 0.01	.045	0.59	.020

[1] *P*-value from Spearman's rank correlation.
[2] *P*-value from permutation test.
Permutation tests were conducted only on combined data from 1998 and 1999 field seasons.

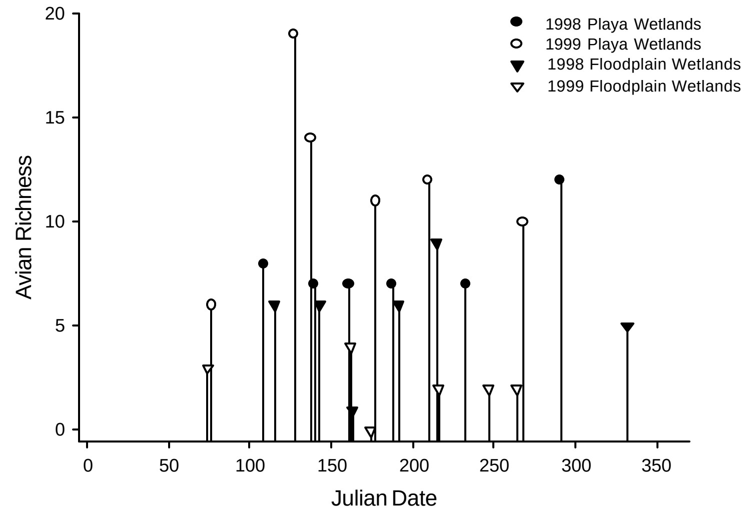

Figure 1. Julian date plotted against avian richness for all wetland visits.

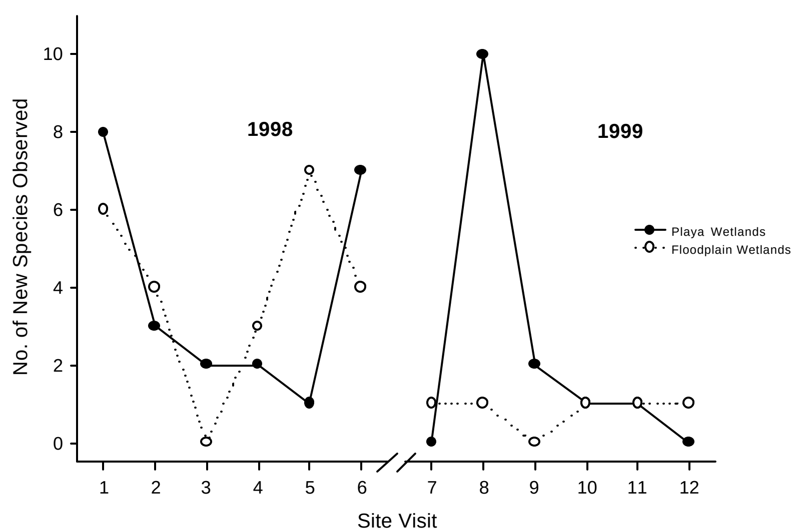

Figure 2. New avian species added to the total pool of species in playa and floodplain wetlands over the entire course of the study.

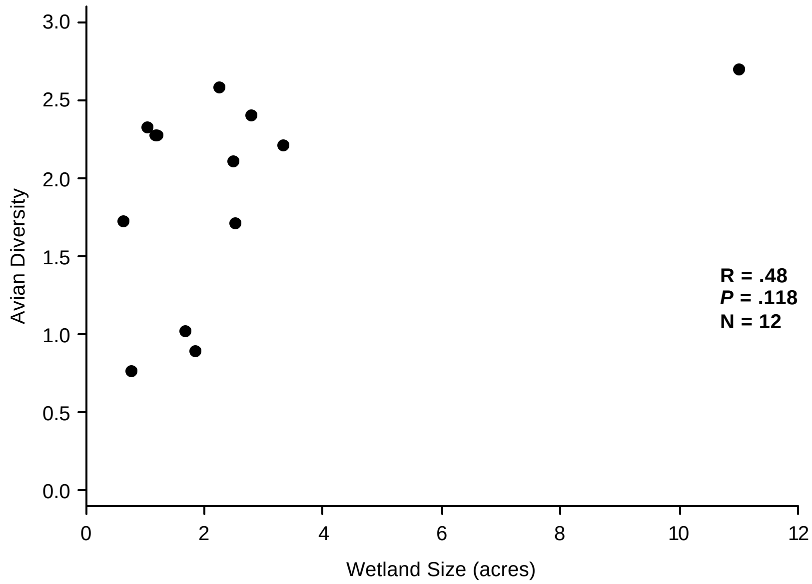

Figure 3. Total wetland size plotted against avian diversity (H') in playa wetlands; strength of relationship based on Spearman's rank correlation test.

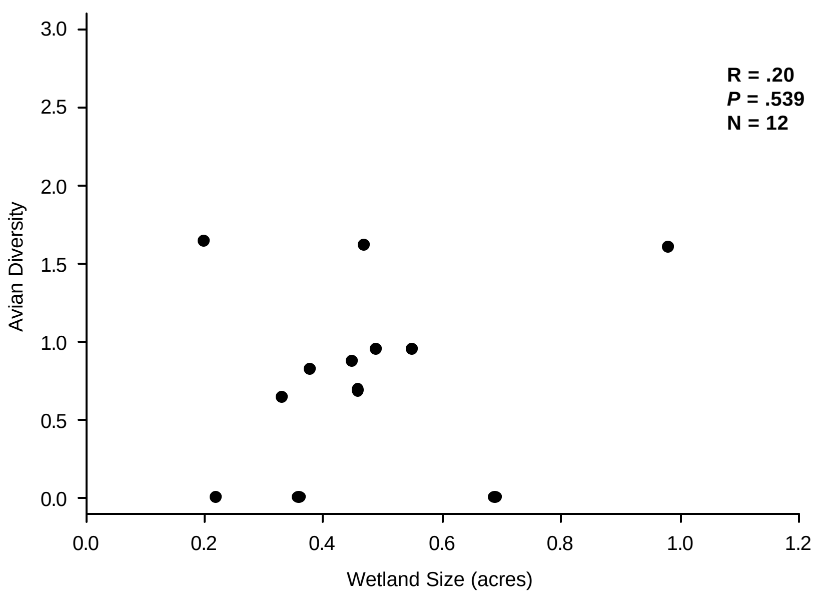

Figure 4. Total wetland size plotted against avian diversity (H') in floodplain wetlands; strength of relationship based on Spearman's rank correlation test.

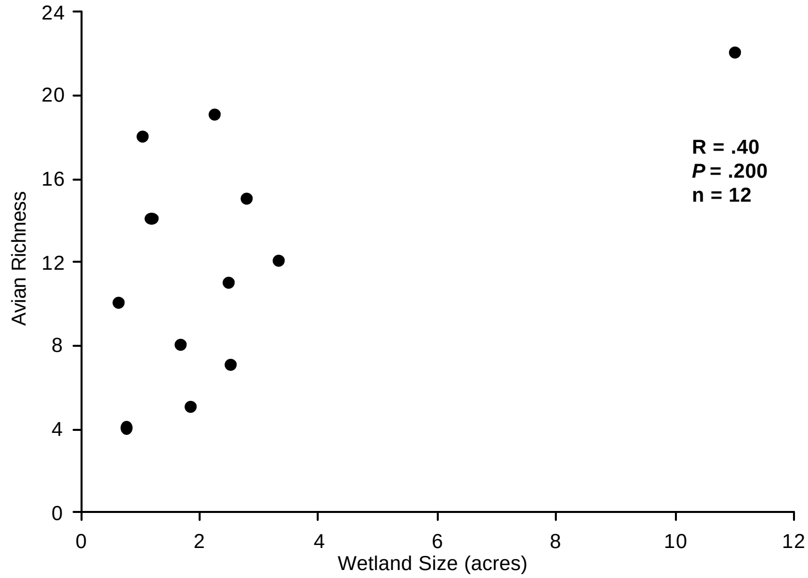

Figure 5. Total wetland size plotted against avian richness in playa wetlands; strength of relationship based on Spearman's rank correlation test.

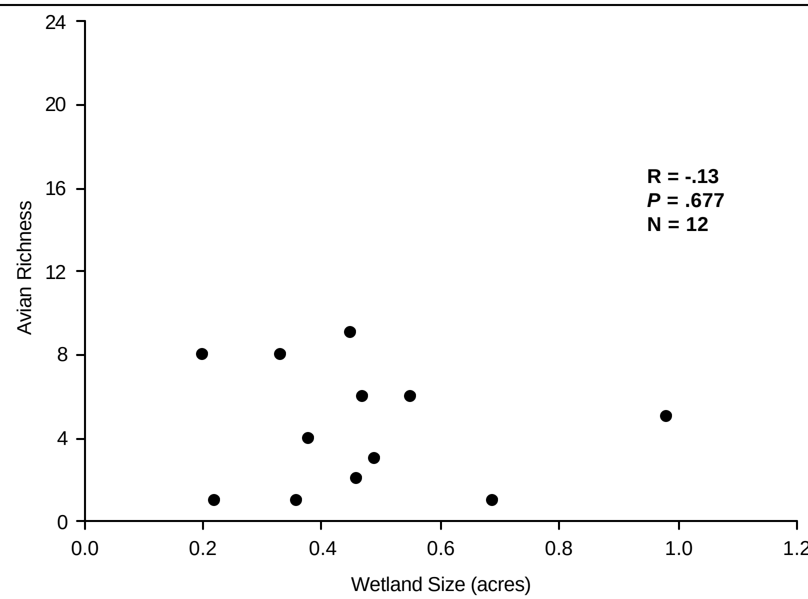

Figure 6. Total wetland size plotted against avian richness in floodplain wetlands; strength of relationship based on Spearman's rank correlation test.

Appendix A. Birds observed during 1998-99 farmed wetland surveys.

Order	Family	Species
Anseriformes	Anatidae	American wigeon (*Anas americana*)
		Blue-winged teal (*Anas discors*)
		Green-winged teal (*Anas crecca*)
		Mallard (*Anas platyrhynchos*)
		Northern pintail (*Anas acuta*)
		Northern shoveler (*Anas clypeata*)
Charadriiformes	Charadriidae	Black-bellied plover (*Pluvialis squatarola*)
		Killdeer (*Charadrius vociferus*)
	Recurvirostridae	American avocet (*Recurvirostra americana*)
	Scolopacidae	Baird's sandpiper (*Calidris bairdii*)
		Common snipe (*Gallinago gallinago*)
		Greater yellowlegs (*Tringa melanoleuca*)
		Least sandpiper (*Calidris minutilla*)
		Lesser yellowlegs (*Tringa flavipes*)
		Long-billed dowitcher (*Limnodromus scolopaceus*)
		Pectoral sandpiper (*Calidris melanotos*)
		Solitary sandpiper (*Tringa solitaria*)
		Upland sandpiper (*Bartramia longicauda*)
		Western sandpiper (*Calidris mauri*)
		Wilson's phalarope (*Phalaropus tricolor*)
Ciconiiformes	Ardeidae	Great blue heron (*Ardea herodias*)
	Threskiornithidae	White-faced ibis (*Plegadis chihi*)
Columbiformes	Columbidae	Mourning dove (*Zenaida macroura*)
Falconiformes	Accipitridae	Northern harrier (*Circus cyaneus*)
		Red-tailed hawk (*Buteo jamaicensis*)
	Falconidae	Prairie falcon (*Falco mexicanus*)

(continued)

Appendix A. Birds observed during 1998-99 farmed wetland surveys.

Order	Family	Species
Galliformes	Odontophoridae	Northern bobwhite (*Colinus virginianus*)
	Phasianidae	Ring-necked pheasant (*Phasianus colchicus*)
		Wild turkey (*Meleagris gallopavo*)
Gruiformes	Rallidae	Sora (*Porzana carolina*)
Passeriformes	Alaudidae	Horned lark (*Eremophila alpestris*)
	Cardinalidae	Dickcissel (*Spiza americana*)
	Corvidae	American crow (*Corvus brachyrhynchos*)
	Emberizidae	Grasshopper sparrow (*Ammodramus savannarum*)
		Harris's sparrow (*Zonotrichia querula*)
		Lark bunting (*Calamospiza melanocorys*)
		Lark sparrow (*Chondestes grammacus*)
		Savannah sparrow (*Passerculus sandwichensis*)
		Vesper sparrow (*Pooecetes gramineus*)
	Hirundinidae	Barn swallow (*Hirundo rustica*)
		Cliff swallow (*Petrochelidon pyrrhonota*)
		N. rough-winged swallow (*Stelgidopteryx serripennis*)
	Icteridae	Brown-headed cowbird (*Molothrus ater*)
		Common grackle (*Quiscalus quiscula*)
		Eastern meadowlark (*Sturnella magna*)
		Great-tailed grackle (*Quiscalus mexicanus*)
		Red-winged blackbird (*Agelaius phoeniceus*)
		Western meadowlark (*Sturnella neglecta*)
	Motacillidae	American pipit (*Anthus rubescens*)
	Tyrannidae	Eastern kingbird (*Tyrannus tyrannus*)
Strigiformes	Strigidae	Barred owl (*Strix varia*)

Classification follows AOU (1998).

Appendix B. Plants found on playa (n = 12) and floodplain (n=12) wetlands combined for 1998 and 1999 seasons.

Family	Species	Playa	Floodplain
Aceraceae	Boxelder (*Acer negundo*)		+
Alismataceae	Arrowhead (*Sagittaria* spp.)		+
	Longbarb arrowhead (*Sagittaria longiloba*)	+	
Amaranthaceae	Pigweed (*Amaranthus* spp.)		+
Apocynaceae	Dogbane (*Apocynum* spp.)		+
	Hemp dogbane (*Apocynum cannabinum*)		+
Asteraceae	Bur ragweed (*Ambrosia grayi*)	+	+
	Cocklebur (*Xanthium strumarium*)		+
	Fleabane (*Erigeron* spp.)		+
	Giant ragweed (*Ambrosia trifida*)		+
	Sunflower (*Helianthus annuus*)	+	+
	Unknown Asteraceae I		+
Brassicaceae	Tansy mustard (*Descurainia pinnata*)		+
Caesalpiniaceae	Showy partridge pea (*Cassia chamaecrista*)		+
Caryophyllaceae	Giant chickweed (*Stellaria aquatica*)		+
Chenopodiaceae	Kochia (*Kochia scoparia*)	+	
	Russian thistle (*Salsola iberica*)	+	
Convolvulaceae	Field bindweed (*Convolvulus arvensis*)		+
	Morning glory (*Ipomoea* spp.)		+
Cyperaceae	Bulrush (*Scirpus* spp. I)	+	+
	Bulrush (*Scirpus* spp. II)		+
	Sedge (*Carex* spp.)		+
	Umbrella sedge (*Cyperus* spp.)	+	
Fabaceae	Alfalfa (*Medicago sativa*)		+
	Soybean (*Glycine max*)		+
Lamiaceae	Ground ivy (*Glecoma hederacea*)		+
Lythraceae	Toothcup (*Ammannia coccinea*)	+	+

(continued)

Appendix B. Plants found on playa (n = 12) and floodplain (n=12) wetlands combined for 1998 and 1999 seasons.

Family	Species	Playa	Floodplain
Malvaceae	Flower-of-an-hour (*Hibiscus trionum*)		+
	Velvetleaf (*Abutilon theophrasti*)		+
Molluginaceae	Carpetweed (*Mollugo verticillata*)		+
Onagraceae	Spotted evening primrose (*Oenothera canescens*)	+	
Poaceae	Barnyard grass (*Echinochloa crus-galli*)		
	Bearded sprangletop (*Leptochloa fascicularis*)	+	+
	Green foxtail (*Setaria viridis*)		+
	Johnson grass (*Sorghum halepense*)		+
	Junglerice (*Echinochloa colonum*)	+	
	Red sprangletop (*Leptochloa filiformis*)		+
	Reed canary grass (*Phalaris arundinacea*)		+
	Yellow foxtail (*Setaria glauca*)	+	
Polygonaceae	Knotweed (*Polygonum aviculare*)		+
	Pink smartweed (*Polygonum bicorne*)	+	+
	Knotweed (*Polygonum ramosissimum*)	+	
Potamogetonaceae	Variable pondweed (*Potamogeton gramineus*)	+	
Salicaceae	Cottonwood (*Populus deltoides*)		+
	Willow (*Salix* spp.)		+
Scrophulariaceae	Water hyssop (*Bacopa rotundifolia*)	+	
Solanaceae	Virginia ground cherry (*Physalis virginiana*)		+
Unknown	Unknown I	+	
	Unknown II	+	
	Unknown III		+
	Unknown IV	+	
	Unknown V		+
	Unknown VI		+
	Unknown VII		+

Classification follows Great Plains Flora Association (1986).

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