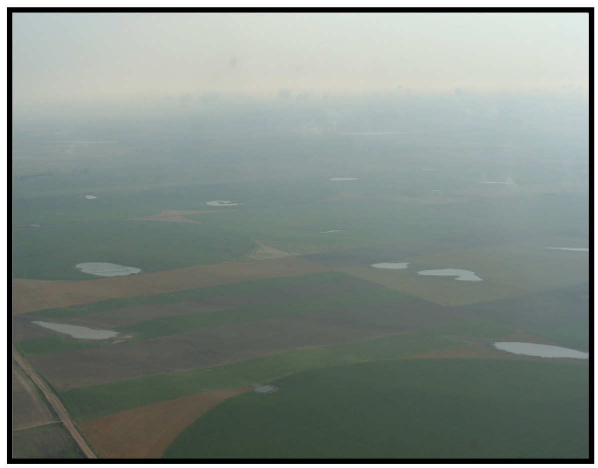
Biological Inventory and Evaluation of Conservation Strategies in Southwest Playa Wetlands

Final Report to the Nebraska Game and Parks Commission and the Playa Lakes Joint Venture



August 2007

Alison Banks Cariveau, Research Division Director
Lacrecia Johnson, Playa Survey Project Leader
Robert Sparks, Research Biologist

Rocky Mountain Bird Observatory
14500 Lark Bunting Lane
Brighton, CO 80603
303.659.4348
www.rmbo.org

Rocky Mountain Bird Observatory

The mission of the Rocky Mountain Bird Observatory (RMBO) is to conserve birds of the Rocky Mountains, Great Plains, and Intermountain West and the habitats on which they depend through research, monitoring, education, and outreach. *RMBO practices a multi-faceted approach to bird conservation that integrates scientific research and monitoring studies with education and outreach programs to bring bird conservation issues to the public and other conservation partners. RMBO works closely with state and federal natural resource agencies, private landowners, schools, and other nonprofit organizations. RMBO accomplishes its mission by working in four areas:*

***Research**: RMBO studies avian responses to habitat conditions, ecological processes, and management actions to provide scientific information that guides bird conservation actions.*

***Monitoring**: RMBO monitors the distribution and abundance of birds through long-term, broad-scale monitoring programs that track population trends for birds of the region.*

***Education**: RMBO provides active, experiential, education programs for K-12 students in order to create an awareness and appreciation for birds, with the goal of understanding the need for bird conservation.*

***Outreach**: RMBO shares the latest information in land management and bird conservation practices with private landowners, land managers, and resource professionals at natural resource agencies. RMBO develops voluntary, working partnerships with these individuals and groups for habitat conservation throughout the region.*

Suggested Citation:

Cariveau, A. B., L. A. Johnson and R. A. Sparks. 2007. *Biological Inventory and Evaluation of Conservation Strategies in Southwest Playa Wetlands: Final Report to the Nebraska Game and Parks Commission and the Playa Lakes Joint Venture.* Rocky Mountain Bird Observatory, Brighton, CO, 39 pp.

***Cover Photos**:*

All photos courtesy of RMBO.

Contact Information:

Alison Banks Cariveau alison.cariveau@rmbo.org
RMBO Fort Collins Office
230 Cherry Street
Fort Collins, CO 80521
970.482.1707

ACKNOWLEDGEMENTS

Rocky Mountain Bird Observatory (RMBO) thanks the Nebraska Game and Parks Commission (NGPC) and the Playa Lakes Joint Venture (PLJV) for providing funding from Conoco-Phillips for this project. In addition, NGPC contributed field vehicles and personnel time for field surveys in spring of 2007. The United States Fish and Wildlife Service (USFWS) also contributed to this project with GIS analysis and flight services.

We want to thank all of the people who contributed to data collection in the spring of 2007: Douglas Ekberg, Tim Hermansen, Ted LaGrange, Emily Munter, and Sarah Rehme of NGPC and Kelsi Niederklein of Pheasants Forever. We thank Ted LaGrange for his guidance throughout the project. We also thank Mike Fritz of NGPC for consultation on amphibian surveys.

We thank the dedicated RMBO field staff of Crystal Bechaver, Cliff Cordy, Derek Hill, and Marie-Melissa Kalamaras for their hard work on this project. Luke Caldwell assisted with data entry and quality assurance. Carmen Blumberg, Sarah Manor and Jennifer Thieme assisted with report preparation. Don Hazlett, an expert botanist for the region, assisted with plant identification.

We thank Andy Bishop and Jacob Erdman at the USFWS Great Plains GIS Partnership office for their assistance with aerial photography interpretation and GIS data analysis.

We appreciate the aerial photos of playas in our study area provided by Rich Walters and Tim Hermansen, NGPC.

Playa ringed with smartweed, in the study area, fall 2006.

EXECUTIVE SUMMARY

This document is the Final Report for the Nebraska Game and Parks Commission State Wildlife Grant (SWG) entitled *Biological Inventory and Evaluation of Conservation Strategies in Southwest Playa Wetlands* (T-41 Segment 1). This is also the Final Report for a Playa Lakes Joint Venture (PLJV) Conoco-Phillips grant entitled *Biological Inventory and Buffer Evaluation of Nebraska's Southwest Playas,* which provided matching funds to the SWG.

This project investigates playa wetland hydroperiods, habitat availability, and use by anurans and migrating birds in southwestern Nebraska. In the fall of 2006, we combined radar rainfall data, aerial infrared photography, and 576 on-the-ground surveys to 43 playas to document habitat conditions and bird use following a heavy precipitation event. We also collected vegetation cover data for twelve playas. This represents the most comprehensive dataset of vegetation and avian use for playas in this part of Nebraska. In the spring of 2007, we conducted field surveys on over 50 playas that received heavy precipitation over the winter.

In this report we outline our findings in relation to our primary study objectives, as follows:

1. Quantify playa hydroperiod responses to precipitation events, playa size, watershed size and condition, buffers, dominant land use, and mapped soil types (PLJV Objective 1; SWG Objective 5).

2. Quantify the diversity and abundance of bird species using wet playas during migration, beginning with fall of 2006, with the addition of spring migration and/or breeding season surveys if funding levels are sufficient (PLJV Objective 2, SWG Objective 1).

3. Describe amphibian species composition and frequency of occurrence in playas, if seasonally appropriate (SWG Objective 2).

4. Coordinate with the Nebraska Natural Heritage Program to document other species of plants and animals using playas (SWG Objective 4).

5. Analyze the relationship between bird and amphibian use and habitat variables within the wetland and landscape attributes of the surrounding watershed (PLJV Objective 3; SWG Objective 3).

6. Correlate various Geographic Information System (GIS) data layers, including satellite imagery from PLJV, National Wetland Inventory (NWI), Soil Survey Geographic (SSURGO), and aerial photography from USFWS to create a comprehensive map of playas in the region (PLJV Objective 4, SWG Objective 6).

In this report we fully report the data collected in the fall of 2006. We report preliminary on findings from the data collected in the spring of 2007 because some of the data are still undergoing quality assurance

Key findings include:

1. A new estimate of 16,793 playas in the Southwest Playa Complex of Nebraska. This represents an 8% increase over the 15,530 originally predicted.

2. Field visits confirmed playas at more than 58% of the predicted locations.

3. Playas in Nebraska's Southwest Playa Complex are on average smaller than playas found in the Southern High Plains.

4. Tilling of playas and their watersheds is the most commonly encountered modification in the study area, documented at 80% of the playas we sampled.

5. Playas within the study area provide water depths and seed-producing annual plants that meet the needs of foraging waterfowl and shorebirds throughout the migratory season.

6. Four frog or toad species were documented in high numbers on playas; an additional four species were documented two or fewer times each. Anurans were found at 94% of playas surveyed. Night surveys were most effective for determining anuran presence.

7. When receiving similar rainfall, playas surrounded by cropland or shortgrass prairie are more likely to become wet than playas surrounded by CRP.

8. Over 86,003 individual birds of 125 avian species use playas or adjacent uplands, including 19 Tier 1 and Tier 2 avian species of interest to Nebraska Natural Legacy Project. We also documented species rare for the area.

9. Playa area and percent of playa with open water correspond to higher numbers of fall waterfowl and shorebirds. The percent of playa in wet mud was also significant in explaining shorebird use.

In addition to the research work outlined above, we conducted outreach as part of the project. We presented information about playas, conservation practices and opportunities, and our research at six venues, including the Nebraska Game and Parks Annual Wildlife Division Meeting, Natural Resource Conservation Service Leadership Meeting, Natural Resource Conservation Service Area Two Meeting, two Nebraska landowner workshops, and the 125th American Ornithologists' Union Meeting.

The study is ongoing, with Phase II support from NGPC and PLJV.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

Playas are shallow seasonal wetlands that are filled following heavy rainfall events in the short- and mid-grass regions of the Great Plains. Characteristic wet-dry cycles produce rich vegetative and insect resources that form critical migration habitat for waterfowl, shorebirds, and other wetland-dependent species (Skagen and Knopf 1993, Smith 2003). In the Southwest Playa Complex of Nebraska (Figure 1) there are estimated to be over 16,000 playas totaling 21,680 acres (LaGrange 2005). However, due to localized and unpredictable rainfall events, not all playas are wet during an average year (Bolen et al. 1989). Information relating rainfall history to wet playa conditions is lacking, thereby hampering efforts to estimate habitat availability for migratory species (Hands 2005).

An estimated 70% of playas have been degraded due to sedimentation from agricultural landscapes (Smith 2003). Buffer programs and other conservation tillage practices may be effective in reducing sedimentation in playas but the effects of such programs on playa hydrology are unknown. Conservation programs have been made available for buffer implementation, pit removal, and other practices, but there has not yet been an opportunity to monitor the hydrological and wildlife responses to these programs. Understanding the relationship between local and landscape features of playas and habitat use by amphibians and birds will enable managers, conservation partners, and others to engage in biological and conservation planning and implementation to secure such habitats for wetland-dependent wildlife species of interest into the future.

Playa affected by agriculture

Playas provide many other important wetland functions, including flood mitigation, capturing and filtering surface runoff, recharging the Ogallala aquifer, and enhancing biodiversity on a landscape scale (Pezzolesi et al. 1998, Haukos and Smith 1994). Understanding the relationship between rainfall events, the capture of surface runoff, and the storage of surface water may assist other conservation partners in water resource planning, including evaluating the possibility of using playa restoration and conservation as an offset to water depletions in western Nebraska.

Painted lady butterfly in front of a playa

The *Nebraska Natural Legacy Project* specifically articulates the need to conserve and restore Southwest playas and further states that due to a lack of knowledge about these communities, “there is a need to conduct an analysis of these and other similar types of communities to identify priority sites for conservation action” (Nebraska Game and Parks Commission 2005). This project addresses this information need by generating abundance and species lists for birds, amphibians, and other species using Playa Wetland and Wheatgrass Playa Grassland communities in the Shortgrass region of Nebraska.

Playas within the study area, August 2007

This project similarly contributes to several high priority research needs of the Playa Lakes Joint Venture, including increasing our understanding of the function of playa buffers, the highest priority research topic for the PLJV. The project also addresses other priority topics identified by the JV, including the monitoring of priority species during migration (high priority), the landscape-scale comparison of well-utilized and non well-utilized wetlands (high), documenting the duration of inundation of individual playas (medium), and comparing the rate of inundation and hydroperiod of playas in different land uses and landscape contexts (medium).

Our primary study objectives are as follows:

1. Quantify playa hydroperiod responses to precipitation events, playa size, watershed size and condition, buffers, dominant land use, and mapped soil types (PLJV Objective 1; SWG Objective 5).

2. Quantify the diversity and abundance of bird species using wet playas during migration, beginning with fall of 2006, with the addition of spring migration and/or breeding season surveys if funding levels are sufficient (PLJV Objective 2, SWG Objective 1).

3. Describe amphibian species composition and frequency of occurrence in playas, if seasonally appropriate (SWG Objective 2).

4. Coordinate with the Nebraska Natural Heritage Program to document other species of plants and animals using playas (SWG Objective 4).

5. Analyze the relationship between bird and amphibian use and habitat variables within the wetland and landscape attributes of the surrounding watershed (PLJV Objective 3; SWG Objective 3).

6. Correlate various Geographic Information System (GIS) data layers, including satellite imagery from PLJV, National Wetland Inventory (NWI), Soil Survey Geographic (SSURGO), and aerial photography from USFWS to create a comprehensive map of playas in the region (PLJV Objective 4, SWG Objective 6).

In this report we fully report the data collected in the fall of 2006. We report preliminary findings only from the data collected in the spring of 2007 because some of the data is still undergoing data analysis.

2 METHODS

2.1 Study Approach

Our study region is the Southwest Playa Wetland Complex (LaGrange 2005), located mostly in the Shortgrass Prairie Ecoregion of Nebraska and encompassing the Kimball Grasslands, Sandsage North, and Sandsage South Biologically Unique Landscapes (Nebraska Game and Parks Commission 2005, Figure 1). This also corresponds to most of the Playa Lakes Joint Venture area within southwestern Nebraska (Figure 1). We studied playas within this region in specific study areas as delineated by heavy rainfall.

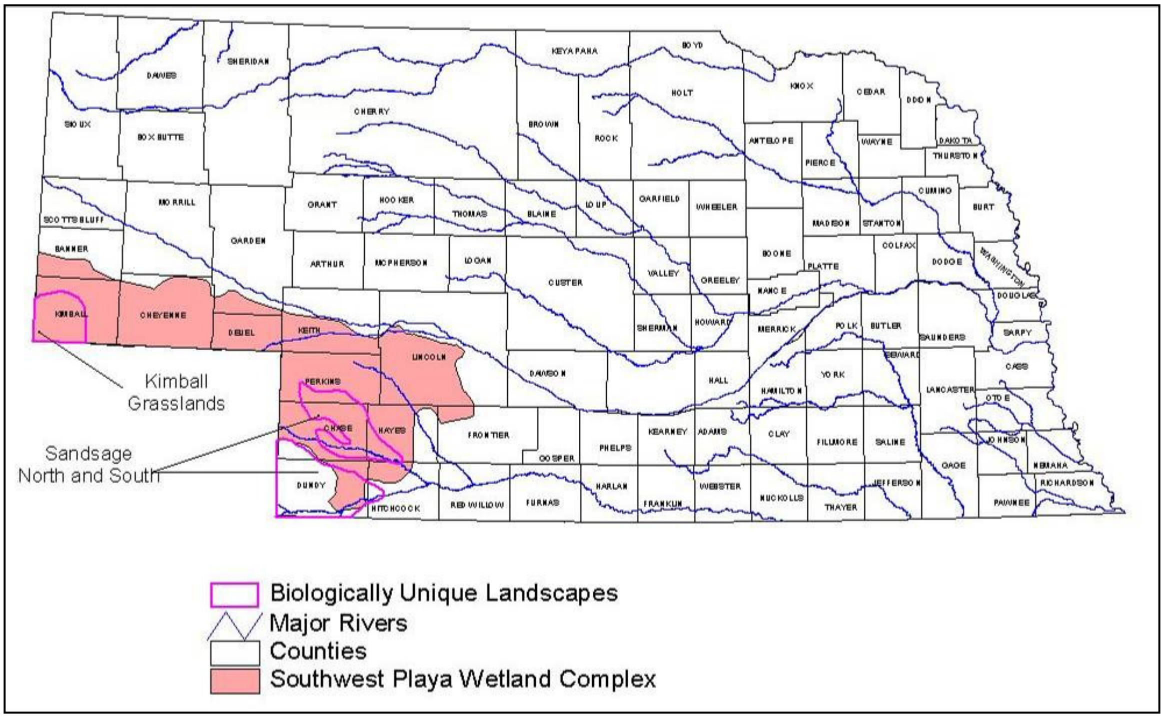


Figure 1. Southwest Playa Wetland Complex and Biologically Unique Landscapes that comprise our study area.

In July of 2006, we began monitoring rainfall data within the study region daily at http://www.srh.noaa.gov/rfcshare/precip_download.php, a National Weather Service website that integrates radar and rain gauge data. The first rain event that met our criteria of encompassing at least 40 playas (based on our GIS model) with at least 2 inches of rain (what we estimated as necessary to pond water for several weeks) occurred on August 8. This rain event of up to 4 inches covered approximately 390 square miles in Chase and Perkins counties (Figure 2). A cursory ground survey accomplished by cooperators from Nebraska Game and Parks Commission confirmed the abundance of playas with ponded water in the area. Because of the prohibitive cost of flying the entire area, four smaller units totaling 83 square miles within the rain area were selected for an aerial flight. Flight units were selected to reflect a gradient from 1.5 inches to 4 inches of rainfall and contain cropland, grassland, and CRP landcover types (according to USFWS and PLJV landcover data). On August 14, with the cooperation of the U.S. Fish and Wildlife Service, the area was flown to collect infrared imagery of playa basins.

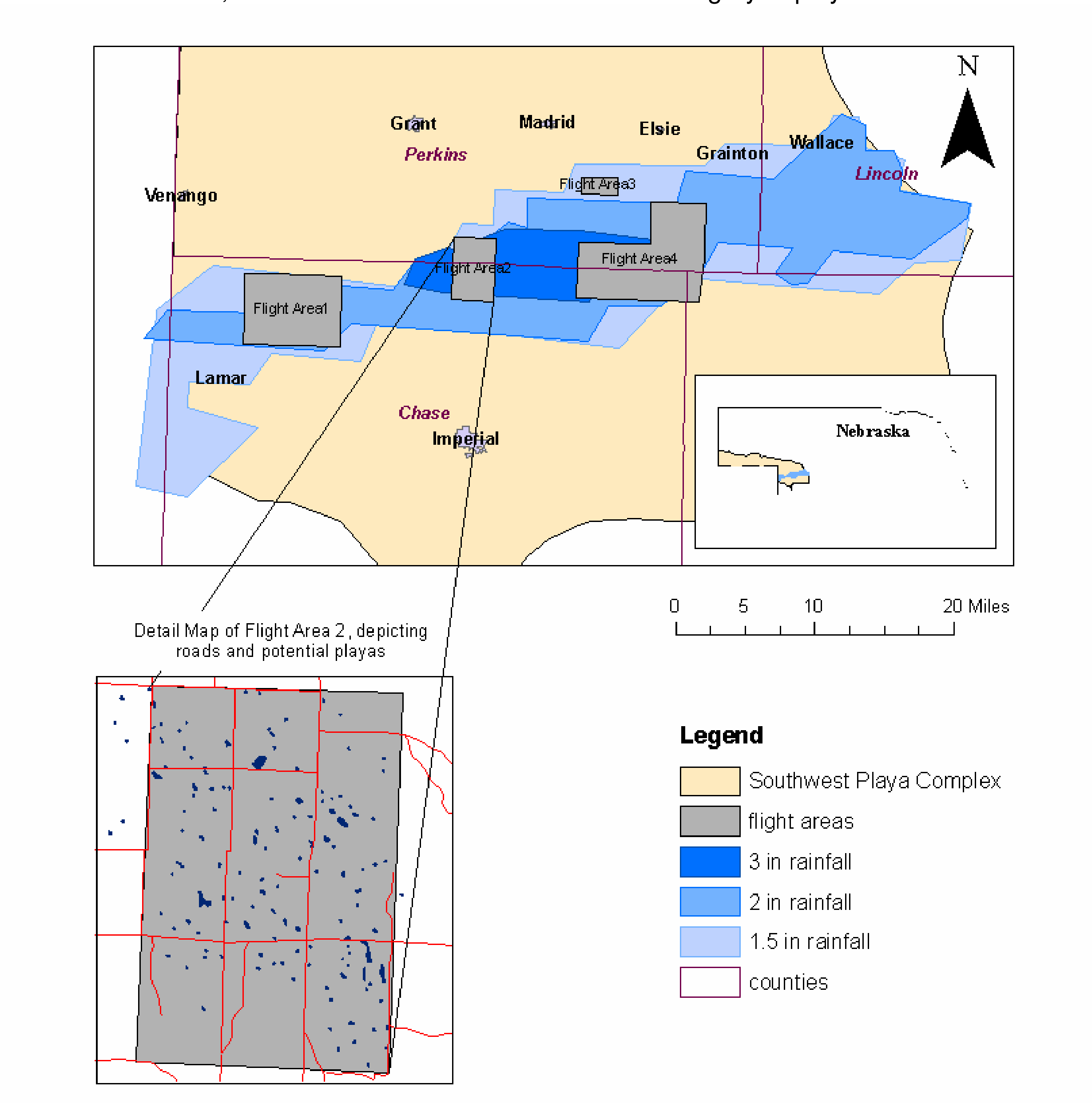


Figure 2. The fall 2006 focus area, showing levels of rainfall received August 8, 2006 and the areas flown August 14, 2006.

Our field survey sampling design focused on the area flown to maximize integration of the imagery and field data. An initial examination of the GIS database indicated that 70% of the 460 potential playas within the flight area were less than one acre in size. Because we expected small playas to have shorter hydroperiods than larger playas, we stratified our sampling based on size to maximize the number of repeat surveys per playa. We attempted to survey all potential playas in our GIS model that appeared to be within 100 m of the road and greater than one acre in size (n=48). We also randomly selected half of the 88 potential playas less than one acre in size and within 100 m of the road for sampling (n=44), for a total of 92 potential playa locations for roadside sampling. Because our initial selection did not yield many playas in non-cropland cover, we also added several potential playas that appeared to be associated with grassland or CRP cover that were within 250 m of roads.

To complement the roadside surveys, we also selected a set of playas that would represent conditions distant from roads; these were within a flight unit, at least 300 m from a road, greater than 1 acre, and had received at least 3 inches of rain. We imposed the latter two conditions to increase the probability that these playas would maintain standing water long enough to provide a rigorous comparison of bird use with playas near the road throughout the fall migration season. This process generated a list of 23 potential playas for contacting landowners for access. We gained access to eight of these playas that were suitable for surveys (contained standing water that was not obscured by standing corn). We opportunistically added to the sample 5 playas that were wet, not obscured by corn, at least 1 acre, and at least 200 m from the road. These 13 playas were surveyed weekly for water depths, vegetation frequency and height class, and bird use, for a total of 5 repeat surveys per playa.

In the spring of 2007, we tracked over-winter precipitation to target areas for playa sampling in March, where wet playas might provide migratory habitat for waterfowl. We selected several locations within the study area that represented a precipitation gradient and conducted field visits to potential playas in those areas (Figure 3).

2.2 Initial Visits to Potential Playa Locations

On initial visits to potential playa locations, we assigned each potential playa a status: playa, possible playa, other waterbody, no access, or no visible playa. For this study, we define a playa as a depressional wetland fed by rainfall and runoff that is hydrologically isolated from other natural water bodies in the landscape, particularly stream beds and creeks. Possible playas could not be confirmed at the time of visit, usually due to heavy anthropogenic modification or a tall standing crop. Other waterbodies included reservoirs, feedlot ponds, or stock dams within creek drainages. No access indicated that the road was not passable, was private, or for some other reasons the surveyor was not able to view the potential playa location. No visible playa was reserved for cases when the surveyor was able to view the appropriate location and determined that a playa was not present. Potential playas with unconfirmed status may be investigated further in subsequent seasons and/or by examining aerial photography to attempt to classify these into one of the other categories (i.e., other waterbody, playa, no visible playa).

Photo taken from the roadside on initial visit

For each playa or possible playa, we collected the following information using a standardized field form:

- We marked the location with a handheld Garmin eTrex® Global Positioning System (GPS) unit and recorded the Universal Transverse Mercator (UTM) coordinates;
- We estimated the distance and bearing from the observer to the center of the playa, using a Bushnell Yardage Pro 500 laser rangefinder;
- We took at least one photograph and recorded the location, direction, and a written description for each photograph;
- We estimated playa size by using the rangefinder to measure distance from the observer to the near and far edges of the playa and converting diameter to area (assuming playas were circular) to classify playas into one of the three size classes (<2 ac, 2-12 ac, or >12 ac);
- We documented the relative wetness of playas by classifying the extent of standing water within the playa basin (> 100% full; 50-100% areal extent covered by standing water, 1-50% areal extent covered by standing water), documenting indicators of past wetness (dry with hydrophytes present, dry with cracks visible), or noting if the playa was dry (no hydrophytes or cracks visible);
- We recorded the surrounding land use as dryland agriculture (cropland), irrigated cropland, USDA Conservation Reserve Program (CRP), grassland, or other;
- We noted the following agricultural uses in the playa: farmed, grazed, or hayed;
- We noted hydrologic modifications to the playa: pit/excavation, constructed inlet or outlet, impoundment/berm/terrace, and whether a well was present;

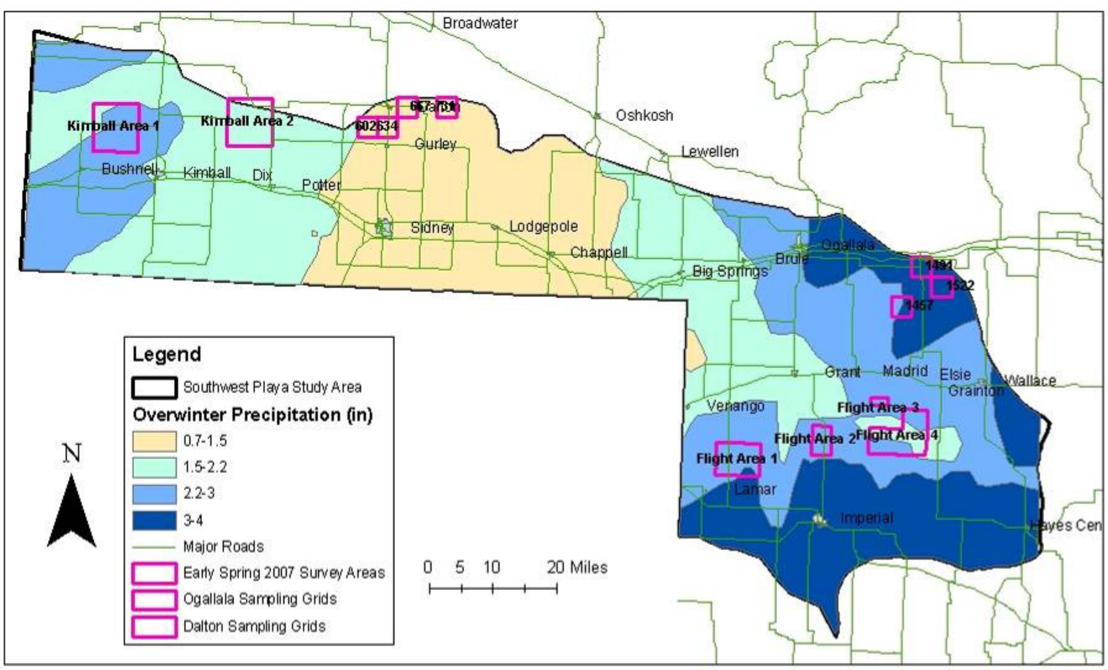


Figure 3. Spring 2007 playa survey locations in relation to total overwinter precipitation.

- We noted if the playa basin was bisected by a road;
- We estimated the average height of vegetation within the playa (<0.1 m, 0.1- <0.5 m, 0.5 – 1.0 m, and >1.0 m);
- For both the playa and the surrounding upland, we documented the percent cover to the nearest 5% in each of the following categories: bare ground, open water, grass, forb, shrub, cactus, and yucca;
- We documented wildlife use of the playa and the surrounding quarter section. We recorded the number of individuals of each bird species detected by sight and sound during the survey period. We also recorded the number and species of other wildlife, observed by sight or sign.

2.3 Repeat Visits to Wet Playas

Playa in cropland, fall 2006.

We visited the 30 playas verified as wet playas in the initial surveys twice a week from the road August 18 through October 15, 2006 or until they no longer provided standing water. Due in part to a number of smaller subsequent rainfall events in the study area, most playas remained wet throughout the study period. Most playas received 14 repeat surveys each, for a total of over 350 surveys.

At each visit, we conducted a vantage count bird survey (see below). To describe habitat availability, we estimated the percent of the playa basin covered by the following categories: dry ground, dry ground vegetated, dry mud, dry mud vegetated, wet mud (saturated), wet mud vegetated, standing water (inundated), and standing water, vegetated. We also recorded the interspersion pattern of the vegetation.

2.4 Playa Hydroperiods

For playas that were wet (had any standing water) during the initial survey, we conducted weekly or biweekly visits, noting on each visit a visual estimate of the percent standing water.

The aerial imagery was analyzed to determine the proportion of each basin that was filled on the flight date.

2.5 Bird Surveys

For playas surveyed from the road, observers used binoculars and spotting scopes to survey all of the birds seen or heard from their vantage point. All birds detected during the duration of the survey were recorded.

For all surveys, we noted if bird numbers were estimated. When possible, we recorded the habitat association of each bird, using the categories described above (e.g. dry vegetated, wet mud not vegetated, open water, upland). We also recorded the activity of the birds, including bathing, drinking, flushing, foraging, resting, preening, flyby (low flight near playa), flyover (high flight probably unassociated with playa), and other. If individuals of some species could not be identified, they were classed into groups (e.g., Greater and Lesser Scaup [*Aythya marila* and *A. affinis*], Greater and Lesser Yellowlegs [*Tringa melanoleuca* and *T. flavipes*], small sandpipers in the genus *Calidris*).

Roadside vantage count using binoculars and spotting scope

For each bird survey, the beginning and end times and weather conditions including temperature, wind speed using the Beaufort scale, and cloud cover were recorded.

For the playas we surveyed >200m from roads, we employed a form of double sampling adapted from Farmer and Durbian (2006), who applied similar methods for surveying shorebirds on wetlands in Missouri. Field crews of one or two observers conducted a vantage survey followed directly by a flush survey to compare data collected by each technique. Observers minimized the time elapsed between vantage surveys and flush surveys in order to minimize entrances and exits of birds from the site during the surveys. Protocols for the survey methods were as follows:

> *Vantage survey:* Monitor used spotting scope from remote vantage point to survey birds, attempting not to flush any birds. The spotting scope was positioned such that as many birds as possible (preferably all) could be surveyed from the vantage point location. The observer panned from one side of the wetland basin to the other, counting individuals of a given species. The observer repeated this action for each species, until the impoundment was fully surveyed. If few birds were present (e.g., < 50) in the wetland, the panning method was still used, but tallying was done all at once rather than with repeated pans for each species.
>
> *Flush survey:* Following the vantage survey, surveyor(s) walked through or around the wetland flushing any birds, using binoculars or direct observation to identify and do a full re-count of all birds.

We noted if birds arrived, were present throughout, or exited during the survey period, to facilitate comparison of the two survey methods.

2.6 Amphibian Surveys

In the spring of 2007, both nocturnal and diurnal surveys were used to survey for frogs and toads. The protocol used for nocturnal calling surveys was shared with us by Mike Fritz of NPGC and was utilized to collect data in previous anuran surveys in Nebraska. Three windows of time were utilized for nocturnal surveys: April 1-May 4, May 7-June 4, and June 13-July 10. During each of these periods we selected dates within five days of a rainfall event for surveys and visited each wet roadside playa from our study group once (n=95). Surveys began thirty minutes after sunset, with temperatures above 40 degrees Fahrenheit and wind speeds <15mph. Observers noted the weather conditions in the prior 48 hours, playa location, playa identification number, distance and direction to the playa from the survey point, distance from the last playa surveyed, current air temperature, wind speed, sky conditions and start time. Noise index was also recorded as a measure of background noise, noted using a scale of 0-4, ranging from no appreciable effect to profoundly affecting sampling ability. Observers waited two minutes after arriving to record detections. Species were recorded with their call frequency ranging from 1 (individuals can be counted, no overlap) to 3 (full chorus). After three minutes a line was drawn across the data sheet and all species heard for the next two minutes were recorded to provide datasets comparable to other studies. All data were recorded on the data sheet and with a digital recorder. To ensure data quality, digital recordings will be sent to Mike Fritz for species verification.

Woodhouse's Toad found on a playa

Daytime anuran surveys were conducted at playas each time they were visited for a migrating bird survey (March – June, n = 121). All species heard calling during the survey period were recorded.

2.7 Other Species Surveys

We were given the names of the following at-risk species of plants to look for by Gerry Steinauer of NGPC: Eared redstem *(Ammannia auriculata),* Texas Bergia *(Bergia texana),* Shortseed waterwort *(Elatine brachysperma),* Purple spikerush *(Eleocharis atropurpurea),* Blackfoot quillwort *(Isoetes melanopoda),* Lowland rotala *(Rotala ramosior), Schoenoplectus saximontana,* and Poison suckleya *(Suckleya suckleyana).* No faunal species were recommended to us for special survey effort.

2.8 Habitat Characterization

Vegetation

We characterized plant species composition using a 1 m^2 frame. Ten to fifteen plots per playa were used to characterize the vegetation within the playa basin. Ten plots were placed around the perimeter and if plant composition differed between the basin and the perimeter, five additional plots were included in the center of the playa. Several plots were photographed, including those representing dominant plant species.

I m^2 plot for estimating canopy cover.

Once the frames were in place, each cover type was categorized into one of six cover classes: 1=0-5%, 2=5-25%, 3=25-50%, 4=50-75, 5=75-

95% and 6=95-100%. Total percent cover could exceed 100% in some cases due to layering.

In addition to percent canopy cover for each plant species, we estimated cover for litter, bare ground, open water and unknown residual. Plants were identified to species when possible. Any unknown plants were collected, labeled, pressed, and identified by local botanical expert Don Hazlett. Plants in the genus *Carex*, *Juncus* and *Eleocharis*, were generally not identified to species. Before leaving the area, observers scanned the entire wetland to see if there were additional plant species not found on the sampled plots. These species were recorded on the form and if unknown, they were collected for later identification.

Hydrology

For playas for which we gained access, we conducted surface hydrologic surveys to measure water depths for six weeks from September 7 through October 15, 2006. We visited each playa six times, except for two playas that dried during the season and therefore were only sampled three and four times, respectively, and two playas that were only sampled five times. One playa was surveyed twice in one week, for which we present the mean of the two surveys. In total, we report on 73 surveys. A mean of 46.57 ± 1.71 points were recorded for each survey.

Hydrological monitoring along a transect.

We measured water depths while walking four transects across each basin. The transects were placed by pacing a baseline across one edge of the playa, dividing the distance by five, and then walking across the playa in four equally-spaced transects perpendicular to the baseline.

Measurements of water presence and depth and vegetation presence and height were taken at the playa edge and every 10 m (by pacing) thereafter along each transect. Each point was classified as dry, saturated (damp to the touch but no standing water), or wet. For wet points, the depth of standing water was measured to the nearest 0.5 cm. by reading a meter stick at arm's length. Each point was also classified as vegetated if a 0.5 m radius around the observer was at least 25% covered by vegetation (an amount of vegetation we estimated to correspond to providing cover and visual obstruction for birds). We also recorded vegetation heights in categories as follows: A (0-20cm), B (20-50cm), C (50-100cm), and D (>100cm).

2.9 Landscape Metrics and Buffers

Playa sizes within the flight area were interpreted from the aerial photography. In addition, the percent of each wetland that appeared to contain standing water was also delineated. Playa sizes for playas throughout the rest of the study area were best approximated by the polygon contributed by the National Wetlands Inventory, SSURGO, satellite imagery, or a combined footprint if playas were found in multiple data sources.

Landcover types were assigned to each playa in the study area through photo-interpretation. The amount of area covered by agriculture, CRP, or grassland in buffers of 100, 400, 800, and 1600 meters from all playas in the flight areas was determined. In addition, buffers (adjacent land uses) were described during field surveys.

We were not able to estimate watershed sizes for the playas we studied because United States Geological Survey quad maps and 10-meter digital elevation models gave insufficient detail to delineate watersheds in this relatively flat environment. However, the Natural Resources Conservation Service volunteered to delineate watersheds for a number of the playas studied in fall of 2006 in Chase and Perkins counties, using a combination of GIS and fieldwork. When these data become available, we will incorporate them into our understanding of landscape effects on hydroperiod and wildlife use. In addition, once the watershed is delineated we can relate playa hydroperiods to mapped SSURGO soil types within the watersheds. This will allow us to evaluate the effect of soil type on playa hydrology.

2.10 Revised Playa GIS Model

In 2006, we compiled a model of potential playas in the study area that was a combination of polygons derived from the National Wetlands Inventory (NWI), Soil Survey Geographic (SSURGO), and satellite imagery as interpreted by the Playa Lakes Joint Venture (PLJV).

In 2007, our collaborators at USFWS conducted photo-interpretation in association with updating a landcover dataset for the region and also analyzed the color infrared photos taken in the flight area. From these data sources, they updated the estimated number of potential polygons in the Southwest Playa Complex and also associated them with landcover types.

2.11 Data Processing and Analysis

We entered all of the field data digitally into a *MS Access* database specifically designed for this project. Data management included standardizing nomenclature for birds and plants, searching for missing data records, and proofing the data in multiple queries. Ten percent of all of the datasheets were re-examined for accuracy in data entry. At least 90% of that sample was required to be correct. Failure to meet this criterion triggered a 100% proofing of all datasheets containing similar data. Data analyses were conducted using *MS Access*, *MS Excel*, *Program R* , and *Jump®In 4.0.4* (SAS Institute Inc. 2001).

Birds

We estimated avian abundance and species richness from 490 bird surveys at 55 playas. If multiple bird surveys were completed on a playa within a week, we averaged the data for analysis. We then divided bird abundance estimates by acreages derived from the aerial flight surveys to calculate bird density estimates for each survey week. To observe differences in bird use between playas in the interior part of the landscape versus playas along the road we used a Wilcoxon Rank Sum Test.

Avian Use Models

To describe the response of shorebirds and waterfowl to wetland conditions on our study playas throughout fall migration in 2006, we developed a series of non-linear regression models. We predicted that playa size, percent of open water in the playa (Wet) and percent wet mud in the playa would affect bird use.

A likelihood ratio test for overdispersion indicated that we should use a negative binomial distribution to adjust the error structure of our models. An information theoretical approach to select the best model from a set of candidate models was used. Akaike's information criterion (AIC) was used to rank the candidate models. Due to small sample size an adjustment to AIC was computed and AIC_c was used instead of AIC. Relative variable importance was assessed using Akaike weights over the subset of models that included a given variable (Burnham and Anderson, 1998).

Hydrology Data

For every week during which hydrology transect data were taken, we provide the mean percent of each playa in each cover type class. Secondly, we report the mean water depths for areas that were flooded (i.e., excluding water depths of zero). Third, we summed all of the plots per wetland and generated a proportion in each water depth class. We also calculated proportions of sites that were classified as vegetated and nonvegetated within each of the water depth classes.

We developed a multiple logistic regression model to understand what variables influence playa hydrology. The response variable was whether the playa was wet or dry and the explanatory variables were amount of precipitation, surrounding landcover type, and playa size. The landcover type was a categorical variable with six levels: cropland, shortgrass, CRP, pitted, rural/developed and wet meadow. We excluded pitted, rural/developed and wet meadow levels since there were only two instances of each in the dataset. The other two explanatory variables were continuous. Information theory was used to select the most parsimonious model; we used Akaike's information criterion (AIC) (Burnham and Anderson, 1998).

Rainfall history from August to October for playas within the study area is summarized in Table 3. Playas were associated to monthly rainfall data in ArcMap.

Vegetation Data

Plants were classed as annual or perennial, native or exotic, and according to their wetland indicator status as defined in the United States Department of Agriculture national PLANTS database http://plants.usda.gov/ (USDA, NRCS, 2007). We categorized each plant species into one of five wetland groups according to wetland indicator status (1=obligate wetland, 2=facultative wetland, 3=facultative, 4=facultative upland, 5=obligate upland) as defined in the 1987 *Wetland Delineation Manual* (Environmental Laboratory 1987) and listed in the *National List of Vascular Plant Species that Occur in Wetlands* (Reed 1988). If available, we used the USDA Region 5 indicator status rather than the national status. We also used the USDA PLANTS Database to categorize the status of plants as annual or perennial, native or introduced, and noted if they were invasive or noxious weeds. Because some plants were identified only to genus, not all plants were categorized.

Seeds from alfalfa and curly dock, good seed sources for waterfowl.

We calculated mean percent cover for each species within each playa using cover class midpoints. Data summaries were calculated using MS Access, MS Excel.

3 RESULTS

3.1 Playa Encounter Rates and General Attributes

In the fall of 2006, we attempted to visit 119 potential playa locations predicted by our GIS model. We were unable to access 20 of these because roads were not present or were private (see Figure 4). Of the 99 we accessed, we verified 55 as playas in the field. We classified eleven locations as "possible playas." If we also include those locations as playas, the confirmation rate would be 71%. We found no visible playa at 31 locations and other waterbodies at two locations. In the spring of 2007, we attempted to visit 145 potential playa locations. One location classified as "no visible playa" in fall 2006 was re-classified as a playa when we re-visited in spring of 2007. Thus, some of the "no visible playa" locations may also be found to contain playas if visited again in the future. We also found six additional playas in the field that were not in the GIS model.

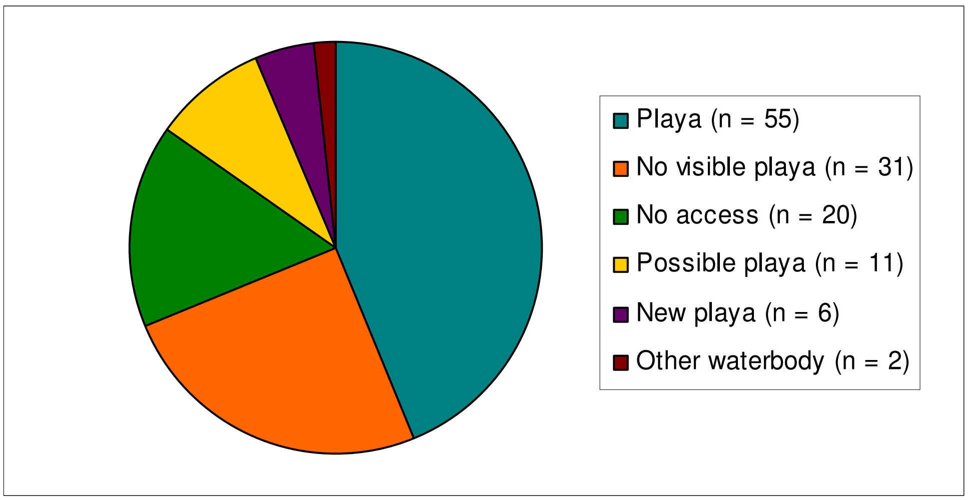


Figure 4. Results of visits to potential playa location, fall 2006.

The mean size of all playas in the revised GIS model for the entire Southwest Playa Complex was 1.38 ± 0.02 acres (n=16,793). The mean size of wet playas that we sampled in the field in fall of 2006 was 1.81 ± 0.29 acres (n=47). For 642 playas for which size estimates were available from the GIS model as well as from the aerial flight, the mean playa size was 0.96 ± 0.07 (standard error) acres (original GIS model), 0.97 ± 0.07 (revised GIS model), and 1.26 ± 0.08 (aerial flight photo-interpretation). Sizes estimated by the revised GIS model and the flight differed by less than one percent for 73% of playas. However, for 97 (15%), size estimates diverged from 1-100% (i.e., one estimate was as much as twice the other), and for 75 (12%), the size estimates diverged more than 100%. In all cases, the playa size estimated from the aerial flight imagery was larger.

Of the 55 playas visited in 2006, we found that 44 were tilled, two were pitted or excavated (one of which was also impounded) and none were apparently grazed, hayed, contained a well, or a constructed inlet or outlet. Of the 11 potential playa locations given the status of possible playa, four were plowed, one was grazed, and one had a constructed inlet or outlet and was impounded.

In the spring of 2007, we visited 105 playas in order to determine their current conditions. This resulted in documentation of tillage on 77 playas. Eleven playas were intact (no modifications observed), two had pit excavations, two were grazed, two were hayed, and two were both tilled and grazed. Less than 1% of the dataset were in each of the following modification categories: impounded, tilled/grazed/impounded, tilled/impounded, pitted/inlet and outlet/impounded, grazed/constructed inlet/outlet/impounded. Of 18 potential playa locations of “possible playa” status, nine were tilled, three were tilled and grazed, two had no alterations, and one fell into each of these categories: grazed, plowed/pitted, plowed/hayed, and plowed/grazed/pitted/an impounded.

3.2 Playa Hydroperiods and Buffer Evaluation

To compare our field descriptions of playa hydrology with the attributes observed in the aerial photography, we compared playas visited within 10 days of the flight (n=39 with data from both sources). Of 24 playas that we estimated were 50-100% full during the initial field visit, 15 (63%) were classified similarly in the aerial photography interpretation. However, four were classified as less than 50% wet, and five were classified as not wet at all according to the photo-interpretation. For those we classified as 1-50% wet, the aerial imagery data concurred two times and in the third instance the imagery classified the playa as dry. Finally, for all playas that we classified as dry in the field, the imagery concurred (n=12). The concurrence of the two data sources did not appear to be related to the buffer or landcover type surrounding the playa, but sample sizes of CRP and grassland playas were low.

Based on the flight data, a higher proportion of playas in CRP remained dry (90%) in response to the rain event than did playas in grassland (59%) or cropland (57%) (Pearson chi-square = 17.82, $p = 0.007$). Playas in CRP averaged 7% wet, as opposed to 30% for playas in grassland or cropland ($F = 5.99$; $p = 0.0026$).

To provide additional insight into playa hydrology dynamics we analyzed the flight data using a multiple logistic regression model (n = 844). The best model was model 1 containing all three variables: landcover type (LndCvrType), playa area (Area) and amount of precipitation (Table 1).

Table 1. Models used in the multiple logistic regression on hydrology dynamics.

Model No.	Models	K	AIC	Δ AIC
1	Wet~LndCvrType+Area+Precipitation	5	1117.89	0.00
2	Wet~LndCvrType+Precipitation	4	1118.63	0.74
3	Wet~LndCvrType	3	1131.48	13.59
4	Wet~LndCvrType+Area	4	1131.69	13.80
5	Wet~Area+Precipitation	3	1133.37	15.48

K=number of parameters, AIC=Akaike’s Information Criterion, Δ AIC= delta AIC, wi = Akaike Weights.

Within the landcover variable, cropland is the reference variable to which all other variables are being compared in the logistic regression. In the logistic regression model the continuous variables Precipitation had the highest estimate followed by Area (Table 2). The categorical variable landcover type with three levels (Cropland, CRP and shortgrass prairie) showed that CRP had the lowest estimate, followed by cropland in the best model describing playa hydrology (Table 2). As expected this means that precipitation has the most influence of determining whether a playa is wet or not. The estimates for logistic regression can be challenging because of the nature of nonlinearity in the regression.

We estimated the probability for the three levels in the landcover variable from the logistic regression model by using the standard logit transformation. The probability that a playa will be wet for the categorical variable landcover type when all other variables in the logistic regression model are held constant is highest for cropland (49%) followed by shortgrass prairie (43%) and CRP (7%).

Table 2. Statistic results for best model describing playa hydrology.

Variable	Estimate	Std. Error	*p*
Cropland (Intercept)	-1.40	0.28	0.00
CRP	-1.91	0.54	0.00
Shortgrass	-0.14	0.26	0.59
Total Acres	0.05	0.03	0.10
Precipitation	0.44	0.10	0.00

Precipitation Patterns

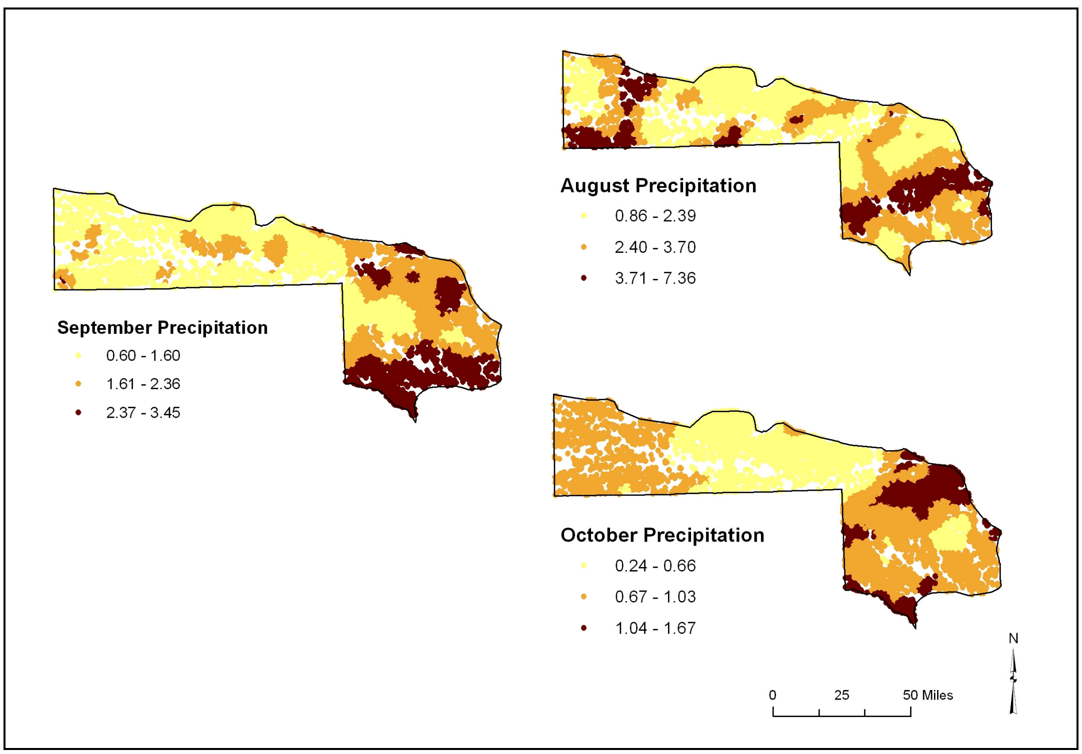


Figure 5. Total Monthly Precipitation Patterns in the Southwestern Playa Complex.

Twenty-nine playas were tracked from the beginning of the study season and received at least seven repeat visits. Eighteen (62%) remained wet throughout the study season; most received a final visit October 31, 2006. The time between our August flight date and the end of October represents a minimum hydroperiod length of 77 days. Eleven playas (38%) were found to be dry on the final visit; however, all were still wet on the penultimate visit. Averaging the last date with wet conditions and the final visit with dry conditions yielded an average hydroperiod length of 62 ± 2 days. Only one playa in this set was classified as within shortgrass, so the data were insufficient for determining if surrounding landuse affected hydroperiod length. Over forty percent of playas received 1 inch of precipitation or more within each month. This was due to a series of rain events that occurred during the sample period (Table 3, Figure 5).

Table 3. Amount of precipitation and playas within the Southwest Playa Wetland Complex, 2006.

	Percent Playas		
***ppt* (in)**	**August**	**September**	**October**
0	0	0	0
1	9	0	1
2	47	0	0
3	28	0	0
4	11	0	0
5	4	0	0
6	1	0	0
7	0	0	0

3.3 Avian Use

Solitary Sandpiper

In the fall of 2006, we documented 31,532 birds comprising 107 avian species using playas or adjacent uplands. For the spring of 2007, we recorded 54,488 individual birds of 71 avian species. The cumulative total was 86,003 individual birds and 125 species. For both years, the category representing the largest number of individual birds was waterfowl (63%, 91%), followed by landbirds (29%, 8%) and shorebirds (9%, 5%), respectfully. Secretive marsh birds and wading birds were also detected in low numbers for both years. The most commonly observed species within these categorys are represented in Table 4. Within the shorebird category, Killdeer were seen in highest numbers; however, for the purpose of this table they were removed. We also documented several species rare for the area, including Buff-breasted Sandpiper (*Tryngites subruficollis*), American Golden-plover (*Pluvialis dominica*), and Yellow-crowned Night-heron (*Nyctanassa violacea*).

	Category		
Year	**Waterfowl**	**Shorebird**	**Landbird**
2006	Mallard (n=6,027)	Lesser Yellowlegs (n=251)	Horned Lark (n=1302)
2007	Snow Goose (n=18,963)	American Avocet (n=68)	Red-winged blackbird (n-1310)

Table 4. Most common species from each category observed throughout the field seasons.

Species of Concern

In the fall of 2006, we detected 19 Tier 1 and Tier 2 avian species of interest to the Nebraska Natural Legacy Project (Table 5).

Table 5. Tier I and II avian species found using playa wetlands within the Southwest Playa Complex.

Common Name	Scientific Name
Tier I	
Brewer's Sparrow	*Spizella breweri*
Burrowing Owl	*Athene cunicularia*
Long-billed Curlew	*Numenius americanus*
McCown's Longspur	*Calcarius mccownii*
Short-eared Owl	*Asio flammeus*
Tier II	
American Avocet	*Recurvirostra americana*
Black Tern	*Chlidonias niger*
Brewer's Blackbird	*Euphagus cyanocephalus*
Canvasback	*Aythya valisineria*
Chestnut-collared Longspur	*Calcarius ornatus*
Cinnamon Teal	*Anas cyanoptera*
Dark-eyed Junco	*Junco hyemalis*
Lesser Scaup	*Aythya affinis*
Merlin	*Falco columbarius*
Peregrine Falcon	*Falco peregrinus*
Savannah Sparrow	*Passerculus sandwichensis*
Swainson's Hawk	*Buteo swainsoni*
Western Grebe	*Aechmophorus occidentalis*
White-faced Ibis	*Plegadis chihi*
Willet	*Tringa semipalmata*

Avian Densities and Species Richness

The average densities of shorebirds and waterfowl were not significantly different between roadside and interior playas ($W = 175$, $p = 0.11$). In addition, we looked at changes in richness and density throughout the study period for shorebirds and waterfowl. Shorebird species richness declined throughout the majority of the study period with a slight increase at week 39 (September). Shorebird average density was variable and peaked at weeks 34 (August) and 42 (October). Waterfowl species richness and average density peaked at week 37 (September).

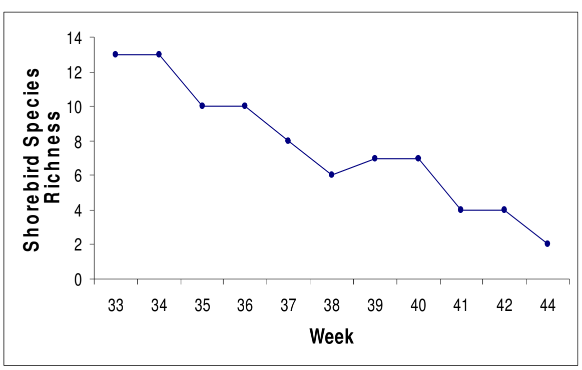


Figure 6. Shorebird species richness throughout survey period.

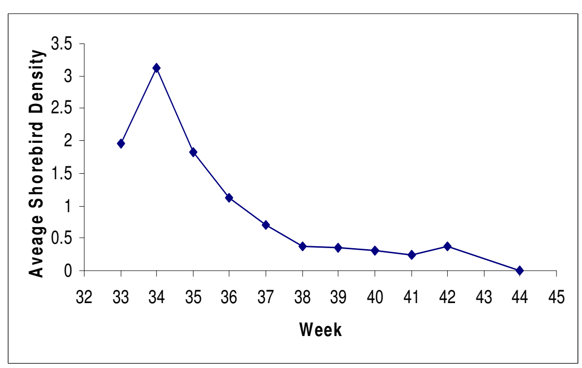


Figure 7. Shorebird average density throughout survey period.

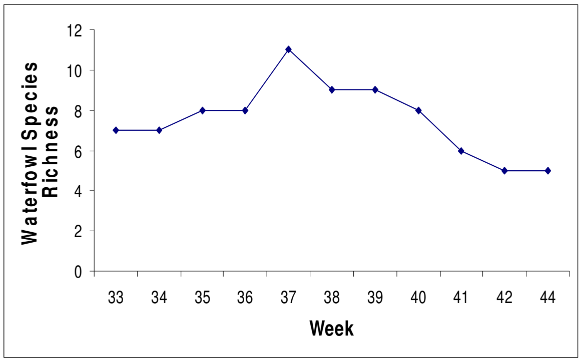


Figure 8. Waterfowl species richness throughout survey period.

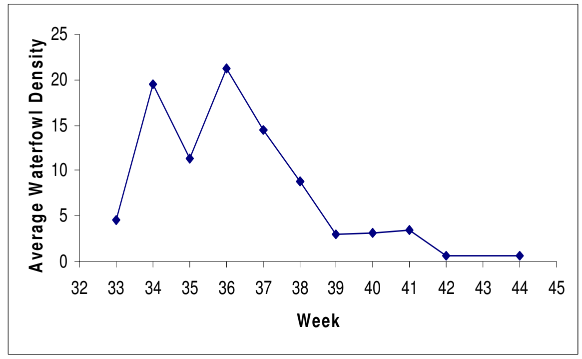


Figure 9. Waterfowl average density throughout survey period.

Avian Use in Relation to Habitat

Fall avian use models were developed for shorebirds and waterfowl using roadside playas (n=29). Model 1 for shorebirds was determined best among the seven candidate models (Table 6) even though AIC values suggest three competing models to fit the data equally well. The variables in Model 1 contain biologically significant variables for shorebird use, hence were retained in the best model.

Table 6. Shorebird playa use models.

Model No.	Model	K	AICc	Δ AICc
1	Count~Area+Wet+Wet Mud	4	231.34	0.00
2	Count~Area+Wet Mud	3	231.83	0.49
3	Count~Area+Wet	3	232.83	1.48
4	Count~Area	2	234.62	3.27
5	Count~Wet+Wet Mud	3	234.06	2.71
6	Count~Wet Mud	2	235.27	3.93
7	Count~Wet	2	237.04	11.88

K=number of parameters, AIC_c=Akaike's Information Criterion, Δ AIC_c= delta AIC, W_i = Akaike Weights.

Akaike weights (W+) were used to obtain the relative importance of variables for the bird use models. In the shorebird models playa area (W+ = 0.86) is ranked the highest followed by percent wet mud (W+ = 0.76) and percent of open water (W+ = 0.61).

The results for the best non-linear regression shorebird model selected from table 6 shows that playa area has the highest mean response compared to percent wet mud and percent open water (Wet) (Table 7). One way we can interpret the regression estimates is by exponentiating them which gives us a multiplicative effect on the dependent variable. The regression estimates for the shorebird model indicate shorebirds increased by 1.22 times when the playa area increases by one acre. Shorebird use increased by 1.05 times for each percent increase of wet mud and 1.02 times for each percent increase of open water.

Table 7. Non-linear regression results for shorebird model.

Variables	Estimate	Std. Error	*p*
Intercept	1.47	0.46	0.00
Area	0.20	0.09	0.03
Wet	0.02	0.01	0.16
Wet Mud	0.04	0.02	0.05

Fall waterfowl abundance appeared to be related to playa size (area), percent open water, and to a lesser extent, wet mud (Table 8). We selected the model that contained playa area and percent open water (Wet) as the best model.

Table 8. Waterfowl playa use models.

Model No.	Model	K	AICc	Δ AICc
1	Count~Area+Wet	3	196.61	0.00
2	Count~Area	2	197.27	0.66
3	Count~Area+Wet Mud	3	196.79	0.18
4	Count~Area+Wet+Wet Mud	4	197.67	1.06
5	Count~Wet	2	202.93	6.32
6	Count~Wet+Wet Mud	3	204.16	7.55
7	Count~Wet Mud	2	205.71	9.09

K=number of parameters,AIC**c**=Akaike's Information Criterion, Δ AIC**c**= delta AIC, W_i = Akaike Weights.

Akaike weights (W+) indicate that Area was the most important variable in the waterfowl model, followed by percent open water (Wet) and wet mud (Area W+ = 0.98, Wet W+ = 0.50, Wet Mud W+ = 0.47).

The best waterfowl model from table 8 showes that Area had the highest estimate followed by percent open water (Wet) (Table 9). The regression coefficient for area increases the mean response by 2 times (~54% increase) the number of birds for each increase in area (acres). The percent of open water variable increases the amount of birds by 1.03 times (~2%) for each increase in percent open water.

Table 9. Non-linear regression results for the waterfowl model.

Variables	Estimate	Std. Error	p
Intercept	-0.41	0.66	0.53
Area	0.75	0.14	0.00
Wet	0.03	0.02	0.07

3.4 Amphibian Use

Of the 95 playas surveyed for nocturnal anuran calls, 89 (94%) were found to have anurans present during the season. Of these same 95 playas, only 57 (60%) were found to have anurans present using daytime surveys. Nocturnal surveys detected more than twice the percentage of playas containing Western Striped Chorus Frogs (*Pseudacris triseriata*), Woodhouse's Toad (*Bufo woodhousei*), Great Plains Toad (*Bufo cognatus*), and Plains Spadefoot Toad (*Scaphiopus bombifrons*) in comparison to diurnal surveys. Forty percent of playas surveyed using both techniques showed no anurans present during the day but did have anurans present during nighttime surveys. In only two playas did daytime surveys detect anuran presence when nighttime surveys did not. In playas surveyed using both techniques, nocturnal surveys detected all species known to be present 90% of the time while diurnal surveys detected all species known 15% of the time. Daytime surveys most often detected Western Striped Chorus Frogs and Great Plains Toads (Table 10).

Table 10. Percent of playas occupied by each species throughout sampling period.

Common Name	Scientific Name	Nocturnal	Daytime
Western Gray Treefrog	*Hyla chrysocilis*	1	0
Bull Frog	*Rana catesbeiana*	0	1
Northern Cricket Frog	*Acris crepitans*	1	1
Western Striped Chorus Frog	*Pseudacris triseriata*	73	36
Woodhouse's Toad	*Bufo woodhousei*	48	2
Great Plains Toad	*Bufo cognatus*	77	14
Plains Leopard Frog	*Rana blairi*	1	0
Plains Spadefoot Toad	*Scaphiopus bombifrons*	51	9
Unknown Species Frog or Toad	N/A	0	9

Using daytime surveys, we found Western Striped Chorus Frogs in 36% and Great Plains Toads in 14% of playas surveyed. Woodhouse's Toad, Plains Spadefoot Toad, one Bullfrog (*Rana catesbeiana,* 14 March 2007, Keith County) and one Northern Cricket Frog (*Acris crepitans,* 14 March 2007, Keith County) were also detected with this technique (Table 11). Nocturnal surveys detected Great Plains Toads in the greatest proportion of playas (77%) followed closely by Western Striped Chorus Frog (73%). Plains Spadefoot Toad was detected in 51% and Woodhouse's Toad in 48% of playas. Nocturnal surveys detected one Western Gray Tree Frog (*Hyla chrysocelis,*20 June 2007, Perkins County), one Northern Cricket Frog (20 May 2007, Chase County) and one Plains Leopard Frog (*Rana blairi,* 20 May 2007, Chase County) (Table 10). Anurans were detected in the greatest percentage of playas during window 1 (April 1-April 30) and 3 (June 13-July 10), with a drop in detections during the second window of observation (May 7-June 4) (Table 11). Both survey methods revealed this drop in anuran detection during May.

Table 11. Percent of playas with anurans detection during each survey period.

Survey Window	% Playas with anurans (Nocturnal)	% Playas with anurans (Diurnal)
March	N/A	11
April 1-April 30	86	31
May 7-June 4	59	24
June 13-July 10	85	32
Entire Season	**94**	**45**

We analyzed call frequencies across the season as an index to the relative abundance of each species (Figure 10). Data on Western Gray Tree Frog, Bullfrog, Northern Cricket Frog and Plains Leopard Frog were not analyzed because two or fewer records existed for each of these species. Both the Great Plains Toad and Plains Spadefoot Toad peaked in April and decreased in abundance as the season advanced, with the Plains Spadefoot Toad undetected during the June 13-July 10 window of observation. Western Striped Chorus Frog abundance peaked during May with an average call frequency only slightly above 1 during April and June. Woodhouse's Toad abundance declined slightly in May but increased in June.

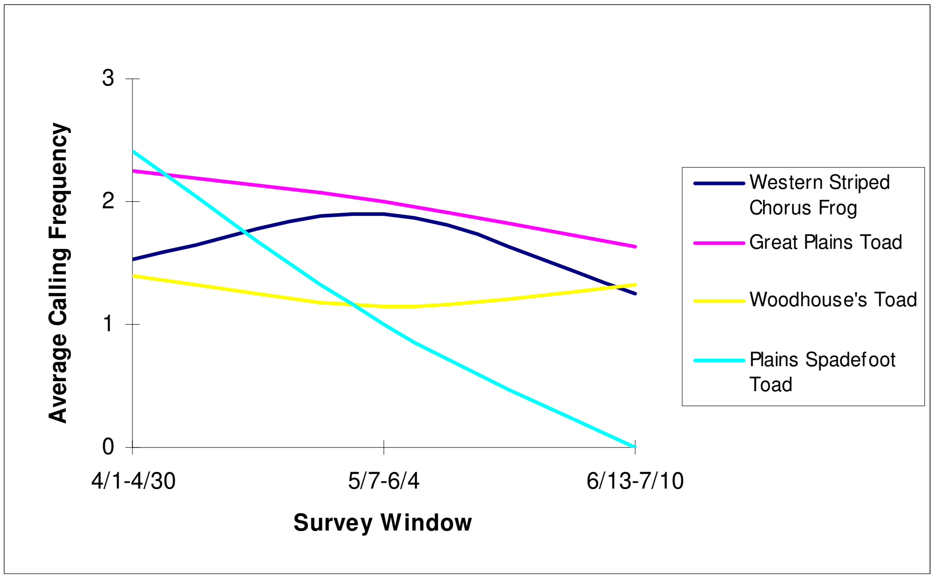


Figure 10. Anuran species composition throughout season based on average call frequency.

The average temperature during May 7 – June 4 surveys was 16 ºC, while average temperatures for April 1 - 30 and June 13 – July 10 surveys were 21 ºC and 24 ºC respectively.

3.5 Other Species

We detected one at-risk plant species from our list; eared redstem occurred as 1% cover or less in five of the twelve playas surveyed for vegetation.

3.6 Vegetation Data

A total of 115 vegetation plots were read across all sites, with an average of 10.4 plots per site (range=10-15). We documented the occurrence of 49 non-cultivated plant species within 12 playa basins. A list of all plant species documented during surveys is presented in Appendix B. In addition, we also collected cover, frequency, and height data.

Field technicians identifying vegetation on a playa.

Five of the twelve playas were dominated by cultivated species. Two playas were dominated by *Carex* species and three by barnyardgrass (Table 7).

Table 12. Dominant Plant Species in Each Playa

Playa ID	Species (% Cover)
574	Soybean crop (28.75)
10559	Wheat crop (6)
10562	Wheat crop (3.75)
10571	Unknown forb (25)
10625	Disk waterhyssop (4.25)
10651	Barnyardgrass (19.75)
13251	Barnyardgrass (4.75)
13253	Carex sp. (1.75)
13281	Barnyardgrass (1.75)
13289	Carex sp. (9.75)
13292	Wheat crop (12)
13408	Wheat crop (28.5)

Facultative or obligate wetland plant species were observed in all playas, and four playas were dominated by wetland species. In addition, average percent cover was higher for wetland plants than for non-wetland plants. Cover by annual plants was higher than cover by perennial species. Average percent cover by exotics (6.8%) exceeded cover by native plants (4.5%), although half of the playas surveyed contained a higher percent cover of native plants than exotics. Bare ground accounted for the highest average percent cover for all playas sampled (range 22 – 97, Table 14).

Table 13. Percent cover of playas surveyed for vegetation.

Playa ID	Crop	Annual	Perennial	Native	Exotic	Bare Ground	Duff	Unknown sp.	*Wetland Plants	**Non Wetland Plants
574	28.75	0.25	0	0	0.25	73.25	14.5	0.25	0.25	0
10559	9.5	2.5	0	2.5	0	26.5	20.5	0	2.5	0
10562	3.75	1.25	1.75	0.75	2.25	75.75	21.25	1.25	2.75	0.25
10571	0.5	23.5	0	1.75	21.75	47.5	27.5	25.25	2.25	21
10625	0	1.25	6.5	7.5	0.25	78	12	2.25	7.25	2.5
10651	5.75	44.5	0	4.25	40.25	40.5	4.25	1	24.5	19.25
13251	0.25	9.5	0.25	0.5	9.25	75	6.5	3.75	5.25	4.5
13253	0	2	0.25	2	0.25	97.5	6.5	0	2	0.25
13281	0	5.75	0	1.25	4.5	96.25	3.25	0	4.25	2.75
13289	3	7	13.25	19.5	0.75	35.5	34.75	5	5	16.25
13292	12	12.25	1.75	12.25	1.75	23.75	50.75	1.5	19.5	1
13408	28.5	1	0	1.75	0	22	19	0	14.5	0
Average	**7.67**	**9.23**	**1.98**	**4.5**	**6.77**	**57.63**	**18.4**	**3.35**	**7.5**	**5.65**

* Wetland indicator status Obligate and Facultative Wetland

** Wetland indicator status

3.7 Hydrologic Data

The average hydrologic characteristics on all playas throughout the season was 27% wet unvegetated, 22% wet vegetated, 19% saturated vegetated, 12% dry unvegetated, 11% dry vegetated, and 9% saturated unvegetated. The proportion of habitat that was classified as saturated or wet varied from week to week but did not decline incrementally (Table 15).

Table 14. Proportion of playas that was saturated or wet according to hydrologic transects.

	Week					
Playa	**36**	**37**	**38**	**39**	**40**	**41**
574	*	1	0.75	0.81	0.7	0.95
10559	1	0.92	1	0.83	0.81	1
10562	1	0.82	0.59	0.79	0.78	1
10571	0.88	0.98	0.84	1	0.9	1
10625	0.83	0.91	0.67	0.71	0.54	0.91
10634	0.65	0.77	*	0	*	*
10651	0.89	0.92	0.72	0.72	0.71	0.95
13251	1	0.59	0.43	0.47	0.46	0.84
13253	0.85	0.95	0.36	0.41	*	*
13281	0.88	0.42	0.22	0.48	0.36	0.29
13289	0.6	0.77	0.87	0.91	0.84	0.85
13292	1	0.89	0.52	0.93	0.63	1
13408	0.99	0.84	0.85	0.82	0.75	1
Average	**0.88**	**0.83**	**0.65**	**0.68**	**0.68**	**0.89**

* not sampled

Water depths on sampled playas were shallow (all averages < 30 cm deep) and decreasing through the study period (Table 16). The maximum water depth recorded on any playa was 43 cm (16.9 in). Averages across the playas sampled were less than 16.5 cm (6.5 in).

Table 15. Average water depths (cm) for playas sampled September 7 – October 15, 2006.

	Week					
Playa	**36**	**37**	**38**	**39**	**40**	**41**
574	*	31.3	20.57	17.45	13.57	7.48
10559	23.31	21.92	19.91	18.63	16.34	14.4
10562	15.39	16.91	14.29	13.85	10.27	8
10571	29.28	32.3	25.89	25.83	22.97	19.36
10625	18.8	15.27	13	12.7	11.38	8.06
10634	3.89	2.6	0	*	*	*
10651	20.85	19.8	16.59	15.91	12.11	11.06
13251	16.17	15.05	10.5	12.12	9.07	8.5
13253	4.84	4.53	3	0	*	*
13281	7.73	8.63	7.25	13.62	7.91	4
13289	22.88	26	20.81	22.67	17.57	14.45
13292	2.67	4.61	5.33	*	3	3
13408	11.24	14.93	11.09	11.78	11	7.62
Average ± SE	**14.75 ± 2.4**	**16.45 ± 2.7**	**12.94 ± 2.2**	**14.96 ± 2.1**	**12.29 ± 1.6**	**9.63 ± 1.5**

* not sampled

3.8 Revised Playa GIS Model

859 potential playas were removed from the original model because they represented overlapping polygons or polygon fragments that were probably not playas. In addition, 2,122 new potential playas were added from photo-interpretation, resulting in a new

estimate of 16,793 playas in the Southwest Playa Complex of Nebraska. This represents an 8% increase over the 15,530 in our original model.

If we apply a 54-64% confirmation rate to the number of potential playas and assume that the models are not missing real playas, this would equal an estimated 8,386 – 9,939 playas in the study area.

3.9 Outreach Activities

In addition to the research work outlined above, we conducted outreach as part of the project. We presented information about playas, conservation practices and opportunities, and our research at six venues, including the Nebraska Game and Parks Annual Wildlife Division Meeting, Natural Resource Conservation Service Leadership Meeting, Natural Resource Conservation Service Area Two Meeting, two Nebraska landowner workshops, and the 125th American Ornithologists' Union Meeting.

Public outreach event

4 DISCUSSION

In the fall of 2006 and spring of 2007, we visited 264 potential playa locations predicted by our GIS model. Over half (58%) were confirmed as playas. In addition, we found playas that were not in the GIS layer, as we did during a similar project in Colorado. The PLJV estimates over 60,000 playas within the Joint Venture boundaries (http://www.pljv.org); however, estimates specific to states north of the Southern Great Plains, including Nebraska, have been unknown (Smith 2003).

Aerial view of wet playas

We obtained an estimate of 16,793 playas in the Southwest Playas Complex of Nebraska by cleaning our set of GIS layers. By calculating field confirmation rates, we obtained a new minimal estimate of 8,386 – 9,939 playas in this Complex. This estimate is biased low because it does not account for playas missing from the GIS layers. Estimating the number of playas in the study region is difficult, in part because of the cryptic nature of playas. Field experience indicates that playas may be evident in one month and not another, due to factors such as prolonged lack of rain, time of year, or obstructions such as dense crop cover. In addition, we found that not all playas were represented in the GIS layer (Cariveau and Johnson 2007). However, photo-interpretation (landcover work conducted by USFWS) has proven invaluable, as over 2,000 new potential playas were added.

Playas in Nebraska's Southwest Playa Complex are on average smaller than the estimated 6.3 ha or 15.6 acres for playas of the Southern High Plains (Guthery and Bryant 1982). This may have implications for hydroperiod, as smaller playas do not pond water for as long as larger playas (Smith and Haukos 2002; Howard et al. 2003); however, during our fall study period, most playas retained wet conditions for the majority of the season. In addition, larger playas in the Southern High Plains supported more wetland plant species (Smith and Haukos 2002).

Tilling was the most commonly encountered modification of playas within our study (80%). Tilling playas and their watersheds leads to increased sedimentation, which is one of the primary threats to playa wetlands. Sedimentation leads to reduced basin size, shorter hydroperiods due to increased evapotransporation, and complete loss of the playa (Smith 2003).

We found that playas surrounded by cropland and shortgrass prairie were more likely to become wet from a major rain event than playas surrounded by CRP, although sample size was limited. More work examining a greater number of playas in CRP, as well as CRP plant composition, is warranted. In addition, soil type may affect playa hydrology. This is a factor we may be able to analyze in future phases of this work if playa watersheds can be delineated.

The percent of wet habitat within the playas did not decline through the fall 2006 season as one might predict. This is probably due to subsequent rain events that occurred during the season. Playas provide a habitat mosaic not dissimilar from prairie potholes, a well-studied system. A recent large-scale study of prairie potholes showed that shorebirds selected small, isolated wetlands that sustained inundated or saturated conditions throughout the spring migration period (Niemuth *et al*. 2006). These size and hydrologic patterns are similar to those exhibited by the playas in this study. Furthermore, migrating shorebirds have been shown to select for shallow, sparsely vegetated wetlands with substantial mudflats (Colwell and Oring 1998, Helmers 1993). The playas we sampled generally lacked dense vegetation and averaged 58% bare ground.

Documentation and analyses of floral dynamics, composition, and distribution throughout the Playa Lakes Region (PLR) are the initial steps necessary in establishing an ecological understanding of playa wetlands. However, when compared to other inland freshwater wetlands, few surveys of playa vegetation have been conducted (Haukos and Smith 2004). Based on our data, playas in Nebraska's Southwest Playa Complex share many characteristics in common with playas in other states. For example, similar vegetation species have been found in studies in other parts of the playa region (Reed 1930; Hoagland and Collins 1997; Smith and Haukos 2002). We identified 49 non-cultivated plant species in the vegetation of sampled playas. This smaller subset of the 346 species potentially occurring in playas of the PLR (Haukos and Smith 2004) is to be expected, as this study included only 12 playas in a small portion of the PLR. We expect that the species list will increase as more playas are sampled in future phases of this project.

Upland plant species: Tumblegrass (*Schedonnardus panniculatus*), left, and Purple three-awn (*Aristida purpurea*), right.

In our study area playas, total percent cover was made up of more annuals than perennials in nine out of twelve playas. This corresponds with the findings by Haukos and Smith (1993), who found that the seed banks of playas with cropland watersheds were dominated by annuals.

For the playas we studied, exotic species (6.8%) accounted for slightly more over than native plants (4.5%), indicating heavy impacts by invasive species. This concurs with the findings of Haukos and Smith (2004), who state that native plant communities within and among playas have been degraded or eliminated due to intensive grazing or cultivation in much of the PLR.

The productivity of playas in producing seeds and invertebrates is well-recognized as being important for supporting migrating waterbirds (Anderson and Smith 1999). We found that annual plants, which provide abundant seed resources for foraging birds, were more abundant than perennials in the playas. Based on their analysis of Northern Pintail (*Anas acuta*) crop contents, Sheeley and Smith (1989) found that barnyard grass, curly dock, spikerush, and smartweed were important food resources for migratory birds. Although sometimes in low numbers, we observed all of these plants during surveys, and barnyardgrass was the dominant plant on three of the playas we surveyed. In addition, while it is well-documented that migrating shorebirds forage on invertebrates as a protein source, seeds may also be an important part of their diet, as seeds comprised approximately 20% of the dietary mass for five species of migrating shorebirds on a Texas playa (Baldassarre and Fisher 1984).

Throughout the study we documented over 86,003 individual birds of over 125 avian species using playas or adjacent uplands. We also documented species rare for the area and 19 Tier 1 and Tier 2 avian species of interest to Nebraska Natural Legacy Project. The average density of waterfowl and shorebirds for interior playa surveys did not differ significantly from roadside surveys, but sample size was small for interior surveys (n=12), which may provide insufficient power to observe a difference. The importance of playas in the Rainwater Basin of Nebraska and in the High Plains of Texas has been well-documented (Smith 2003); however, until this study migratory bird use of playa wetlands of Southwest Playa Complex of Nebraska was relatively unstudied. In future phases of this research we will continue to pursue this comparison to determine if birds are responding to road presence. This has importance in evaluating the representativeness of roadside bird surveys, which are currently more efficient than interior surveys.

Shorebird species richness for shorebirds declined throughout the study period. This decline is attributed to the natural migration patterns of shorebirds within 40°-45° latitude. In this area, shorebird migration peaks in July and declines throughout the migration season (Skagen *et al*. 1999). Peaks in average density at weeks 34 and 42 were not related to an increase in species richness. Waterfowl species richness peaked at week 37; however, we did not see a corresponding change in density and the species that increased the richness had been seen in previous surveys.

Bird abundance on an individual wetland on a particular occasion is influenced by external factors such as timing during the migration season, large-scale weather patterns, and proximity to other wetlands, as well as on-site conditions such as water depth and vegetation composition (Austin et al. 2002). We found that playas within our study area provide water depths that meet the needs of foraging waterfowl and shorebirds during the migratory season. Playas during fall of 2006 averaged less than 30 cm deep and decreased through the study period. A recent study shows that migrating waterfowl in the South Platte River corridor in Colorado prefer water depths less than 40 cm and shorebirds prefer water depths of less than 20 cm (Cariveau and Risk 2007).

Percent cover by water, playa area, and percent of cover in wet mud within the playa are important in determining use by shorebirds. Because different species of shorebirds use both mud and shallow water for foraging, these findings are not surprising. For example, Least Sandpiper (*Calidris minutilla*) and Western Sandpiper (*C. mauri*) prefer mudflats near the water's edge (Davis and Smith 1998, Colwell and Landrum 1993), whereas Lesser Yellowlegs prefer shallow (<4 cm) water (Davis and Smith 1998). Dowitchers (*Limnodromus sp.*) and American avocets (*Recurvirostra americana*) are associated with even deeper water (Weber and Haig 1996).

Percent cover by water and playa area are the best predictors of waterfowl use within these playas. Most waterfowl species spend more time in open water than mud surrounding the playa. This implies that larger playas provide more suitable habitat for waterfowl than smaller playas, as they have the potential to contain more open water within the basin.

Mallard (*Anas platyrhynchos*)

Playas are invaluable resources for migratory birds in the Great Plains, where transcontinental shorebirds disperse and use available wetlands opportunistically during migration (Skagen and Knopf 1993). Migratory stopover habitats provide critical staging areas for avian migrants requiring rest and replacement of depleted energy reserves when traveling long distances between breeding and wintering grounds (Bolen *et al.* 1989, Skagen and Knopf 1993, Skagen and Knopf 1994a, Rivers and Cable 2003). Included are some species with declining population trends, such as Lesser Yellowlegs, Baird's sandpiper (*Calidris bairdii*), Northern Pintail (*Anas acuta*) and Lesser Scaup (Brown et al. 2001, North American Waterfowl Management Plan). Our study detected the presence of these and other species with declining population trends on playas in the study area. Unfortunately the location of this habitat within the agricultural belt of the United States makes it difficult to conserve and manage due to a high rate of private ownership (Playa Lakes Joint Venture).

We detected anurans in a high percentage of playas surveyed (94%). Woodhouse's Toad, Western Striped Chorus Frogs, Great Plains Toads, and Plains Spadefoot Toads were found in abundance, while two or fewer observations were made of Western Gray Tree Frog, Bullfrog, Northern Cricket Frog, and Plains Leopard Frog. Nocturnal survey results revealed that nocturnal call surveys detected both a greater number of species and species presence in a greater percentage of playas despite a higher number of playas surveyed during the day. The biology of the species found within our study area may account for this difference. According to Hammerson (1999), Woodhouse's Toad, Great Plains Toad, and Plains Spadefoot Toad are more active at dusk and/or night. In addition, lowland Western Striped Chorus Frogs are diurnal in early spring, but shift to a more nocturnal or crepuscular schedule as weather warms (Hammerson 1999). Many other studies on each of these species use nocturnal surveys or collections (Western Striped Chorus Frog, Bolek et al. 2003; Woodhouse's Toad, Sullivan 1986 and Woodward 1982; Great Plains Toad, Krupa 1994; and Plains Spadefoot Toad, Trowbridge and Trowbridge 1937), suggesting that nocturnal methods are most reliable for studying these species. Our results support this idea.

Anuran species composition and abundance fluctuated throughout the study period. Fewer individuals of each species were detected during our second window of surveys (May 7 – June 4) than the first or third survey windows. Low temperatures prior to surveys may have impacted anuran performance. According to Putman and Bennet (1981), the optimum performance temperature of similar anurans is between 20-30 ºC, and performance levels, including mating and territory defense, decline below 20 ºC. This decline in activity based on ambient temperature may account for the lower rate of detection in May.

Plains Spadefoot Toad detections dropped significantly between the first and third window of surveys. A three-year study of breeding Plains Spadefoot Toads in Cleveland County, OK, by Trowbridge and Trowbridge (1937) revealed that the breeding season of this species is late April to early May and lasts no longer than two weeks. Although not all studies agree that Plains Spadefoot Toads have a set breeding pattern related to time of year, most reveal that their breeding season is very short and they rarely breed after the first breeding congregation, or congress (Bragg 1945, Woodward 1982, Mabry and Christiansen 1991). It has also been noted that these toads do not sing when they emerge for food, so hearing them in an aural survey outside their short breeding period would be unlikely (Smith 1934). It is likely that a breeding congress was initiated by rainfall early in our surveys and Spadefoot Toad calling rapidly decreased as their short breeding season came to a close.

The calling frequency of Great Plains Toads decreased throughout the season as well. The breeding season of these toads corresponds with rainfall, with fewer nights of breeding per rainfall event as the season progresses (Krupa 1994). In Oklahoma, choruses are indicative of breeding activity (Krupa 1994) and the breeding season can range from March to June (Bragg 1937, Krupa 1988, Krupa 1994). Our observations realize this trend, showing a greater number of Great Plains Toads early in their breeding season and fewer during our late June/early July surveys when their breeding season comes to a close.

Western Striped Chorus Frogs were most abundant during our second window of surveys (May 7-June 4). According to Hammerson (1999), these frogs just begin to chorus in late March and early April in Colorado. We observed some Western Striped Chorus Frogs calling in April and an increase in call frequency during May 7-June 4 surveys, when their breeding season is fully underway. Calling may decrease or come to a stop by late spring (Hammerson 1999), which could explain the decrease in calling frequency during our final summer surveys.

Woodhouse Toad abundance remained relatively unchanged throughout the season. This is likely due to the wide range of their breeding season (April-June) and long period over which breeding occurs (for 3-7 weeks after rain) (Hammerson 1999).

Because of the sensitivity of playa ecosystems to amount, duration and timing of rainfall, several seasons of investigation are required to describe the ecological function of these wetlands. In future phases of this project we will build on the data presented here. Future goals include: 1) revisit playas with the status of possible playa to confirm their status 2) increase the number of playas in grass and CRP landcover types to more accurately evaluate the effect of landcover on hydrology and wildlife use 3) delineate watersheds of a subset of playas to evaluate the effect of watershed size, condition and soil type on playa hydrology 3) compare the number of birds observed during vantage counts to flush counts so that roadside vantage counts can be adjusted to more accurately depict avian numbers 4) Analyze the relationship between amphibian use and habitat variables within the wetland and landscape attributes of the surrounding watershed 5) delineate watersheds of a subset of playas to evaluate the effect of watershed size, condition and soil type on playa hydrology.

5 LITERATURE CITED

Anderson, J.T.and L.M. Smith. 2000. Invertebrate response to moist-soil management of playa wetlands. Ecological Applications 10:550-558.

Austin, J.E., D.A. Granfors, M.A. Johnson and S.C. Kohn. 2002. Scaup migration patterns in North Dakota relative to temperatures and water conditions. Journal of Wildlife Management 66(3):674-882.

Baldassarre, G.A. and D.H. Fisher. 1984. Food habits of fall migrant shorebirds on the Texas High Plains. Journal of Field Ornithology 55:220-229.

Baker, M.C. and A.E.M. Baker. 1973. Niche relationships among six species of shorebirds on their wintering and breeding ranges. Ecological Monographs 43:193-212.

Bolek, M.G., J. Janovy Jr. and A.R. Irizarry-Rovira. 2003. Observations on the Life History and Descriptions of Coccidia (Apicomplexa) from the western chorus frog (*Pseudacris triseriata triseriata*), from Eastern Nebraska. The Journal of Parasitology 89(3):522-528.

Bolen, E.G., L.M. Smith, and H.L. Schramm Jr. 1989. Playa lakes: prairie wetlands of the Southern High Plains. Bioscience 39:615–623.

Bragg, A.N. 1937. Observations on *Bufo cognatus* with Special Reference to the Breeding Habits and Eggs. American Midland Naturalist 18(2):273-284.

--------. 1945. The spadefoot toads in Oklahoma with a summary of our knowledge of the group. II. The American Naturalist 79(780):52-72.

Burnham, K.P and D.R. Anderson. 1998. Model Selection and Inference: a Practical Information—Theoretic Approach. Spinger-Verlag, New York Inc.

Brown, S., Hickey, C., Harrington, B. and Gill, R. 2001. United States Shorebird Conservation Plan, 2nd ed. Manomet Center for Conservation Science, Manomet, Massachusetts, USA.

Cariveau, A.B. and L. Johnson. 2007. Survey assessment of playa wetlands in Eastern Colorado. Final Report to the Colorado Division of Wildlife. Rocky Mountain Bird Observatory, Brighton, CO. 59 pp.

Colwell, M.A. and S.L. Landrum. 1993. Nonrandom shorebird distribution and fine-scale variation in prey abundance. The Condor 95:94-103.

Colwell, M.A. and L.W. Oring. 1988. Habitat use by breeding and migrating shorebirds in southcentral Saskatchewan. Wilson Bulletin 100(4):554-556.

Davis, C.A. and L.M. Smith. 1998. Ecology and management of migrant shorebirds in the Playa Lakes Region of Texas. Wildlife Monographs 140:3-45.

Farmer, A. and F. Durbian. 2006. Estimating shorebird numbers at a migration stopover site. The Condor 108:792-8.

Hammerson, G.A. 1999. Amphibians and Reptiles in Colorado: A Colorado Field Guide. University Press of Colorado, Niwot, CO.

Hands, H. 2005. Playa Lakes Joint Venture/BCR18-19 Shorebird Team Report (draft). Playa Lakes Joint Venture: Lafayette, CO.

Haukos, D.A., and L.M. Smith. 1994. The importance of playa wetlands to biodiversity of the Southern High Plains. Landscape and Urban Planning 28:83–98.

Helmers, D.L. 1993. Shorebird management manual. Western Hemisphere Shorebird Reserve Network, Manomet, Massachusetts.

Howard, T., G. Wells, L. Prosperie, R. Petrossian, H. Li and A. Thapa. 2003. Characterization of playa basins on the high plains of Texas. Report 357. Texas Water Development Board, Austin, TX. 24pp.

Krupa, J.J. 1994. Breeding biology of the Great Plains toad in Oklahoma. Journal of Herpetology 28(2):217-224.

LaGrange, T.G. 2005. Guide to Nebraska's Wetlands and their Conservation Needs, Nebraska Game & Parks Commission, Lincoln, NE 68503.

Mabry, C.M. and J.L. Christiansen, 1991. The activity and breeding cycle of *Scaphiopus bombifrons* in Iowa. Journal of Herpetology 25(1):116-119.

NRCS (Plants) Plants DATABASE (http://plants.usda.gov, 25 October, 2007). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Nebraska Game and Parks Commission. 2005. The Nebraska Natural Legacy Project—a Comprehensive Wildlife Conservation Strategy (http://www.ngpc.state.ne/us/wildlife/programs/legacy/review.asp, 25 October, 2007). Lincoln, NE 68503.

Niemuth, N.D., M.E. Estey, R.E. Reynolds, C.R. Loesch, and W.A. Meeks. 2006. Use of wetlands by spring-migrant shorebirds in agricultural landscapes of North Dakota's drift prairie. Wetlands 26:30-39.

North American Waterfowl Management Plan, Plan Committee. 2004. North American Waterfowl Management Plan 2004. Strategic Guidance: Strengthening the Biological Foundation. Canadian Wildlife Service, U.S. Fish and Wildlife Service, Secretaria de Medio Ambiente y Recursos Naturales, 22 pp.

Pezzolessi, T.P., R.E. Zartman, E.B. Fish, and M.G. Hickey. 1998. Nutrients in a playa wetland receiving wastewater. Journal of Environmental Quality 27:67–74.

"Playa Lakes Joint Venture." ConocoPhillips: Energy for Tomorrow. ConocoPhillips. 30 Oct 2007 http://www.conocophillips.com/social/engagement/Environmental/flyway/playalakes/index.htm.

Putman, R.W. and A.F. Bennet, 1981. Thermal dependence of behavioral performance of anuran amphibians. Animal Behavior 29:502-509.

Reed, P.B. 1988. National list of plant species that occur in wetlands: national summary. Biological Report 88(24). US Fish & Wildlife Service, Washington, DC.

Rivers, J.W. and T.T. Cable. 2003. Evaluation of farmed playa wetlands as avian habitat using survey data and two rapid assessment techniques. Transactions of the Kansas Academy of Science 106:155-165.

SAS Institute Inc. 2001 (http://support.sa.s.com, 25 October 2007). SAS North Carolina, 27513, USA.

Sheeley, D.G. and L.M. Smith. 1989. Tests of diet and condition bias in hunter-killed northern pintails. Journal of Wildlife Management 53:765-769.

Skagen, S.K., and F.L. Knopf. 1993. Toward conservation of midcontinental shorebird migration. Conservation Biology 7:533-541.

Skagen, S.K. and F.L. Knopf. 1994a. Residency patterns of migrating sandpipers at a midcontinental stopover. Condor 1996:949-958.

Skagen, S.K., P.B. Sharpe, R.G. Waltermire, and M.B. Dillon. 1999. Bioregional profiles of shorebird migration in midcontinental North America. Biological Science Report USGS/BRD/BSR—2000-0003. U.S. Government Printing Office, Denver, CO.

Smith, H.M. 1934. The Amphibians of Kansas. American Midland Naturalist 15(4):377-527.

Smith. L.M. and D.A. Haukos. 2002. Floral diversity in relation to playa wetland asrea and watershed disturbance. Conservation Biology 16:964-974.

Smith, L.M. 2003. Playas of the Great Plains. University of Texas, Austin, TX.

Sullivan, B.K. 1986. Intra-populational variation in the intensity of sexual selection in breeding aggregations of woodhouse' toad s (*Bufo woodhousei*). Journal of Herpetology 20(1):88-90.

Trowbridge, A.H. and M.S. Trowbridge. 1937. Notes on the cleavage rate of *Scaphiopus bombifrons* Cope, with additional remarks on certain aspects of its life history. American Naturalist 71:460-480.

Weber, L.M. and S.M. Haig. 1996. Shorebird use of South Carolina managed and natural coastal wetlands. Journal of Wildlife Management 60:73-82.

Woodard, B. 1982. Male persistence and mating success in woodhouse's toad (*Bufo woodhousei*). Ecology 63(2): 583-585.

APPENDIX A

BIRD SPECIES DOCUMENTED ON SOUTHWEST PLAYA COMPLEX PLAYAS 2006 AND 2007

Common Name	Scientific Name	Spring 2006 Total	Spring 2007 Total
American Avocet	*Recurvirostra americana*	1	68
American Coot	*Fulica americana*	28	261
American Crow	*Corvus brachyrhynchos*	215	31
American Golden-Plover	*Pluvialis dominica*	1	1
American Goldfinch	*Carduelis tristis*	24	0
American Kestrel	*Falco sparverius*	2	0
American Pipit	*Anthus rubescens*	279	1
American Robin	*Turdus migratorius*	34	43
American Tree Sparrow	*Spizella arborea*	10	0
American Wigeon	*Anas americana*	106	1,848
Audubon's Warbler	*Dendroica coronata auduboni*	1	0
Baird's Sandpiper	*Calidris bairdii*	214	44
Bank Swallow	*Riparia riparia*	2	1
Barn Swallow	*Hirundo rustica*	808	83
Black Tern	*Chlidonias niger*	51	25
Black-bellied Plover	*Pluvialis squatarola*	9	0
Blue Grosbeak	*Passerina caerulea*	3	0
Blue Jay	*Cyanocitta cristata*	6	0
Blue-winged Teal	*Anas discors*	532	777
Brewer's Blackbird	*Euphagus cyanocephalus*	133	187
Brewer's Sparrow	*Spizella breweri*	1	0
Brown-headed Cowbird	*Molothrus ater*	412	17
Bufflehead	*Bucephala albeola*	1	21
Bullock's Oriole	*Icterus bullockii*	1	0
Burrowing Owl	*Athene cunicularia*	24	20
Canada Goose	*Branta canadensis*	0	3,244
Canvasback	*Aythya valisineria*	0	504
Chestnut-collared Longspur	*Calcarius ornatus*	485	0
Chipping Sparrow	*Spizella passerina*	1	0
Cinnamon Teal	*Anas cyanoptera*	6	4
Clay-colored Sparrow	*Spizella pallida*	12	0
Cliff Swallow	*Petrochelidon pyrrhonota*	6	0
Common Goldeneye	*Bucephala clangula*	0	1
Common Grackle	*Quiscalus quiscula*	294	40
Common Yellowthroat	*Geothlypis trichas*	4	0
Cooper's Hawk	*Accipiter cooperii*	6	0
Dark-eyed Junco	*Junco hyemalis*	8	0
Dickcissel	*Spiza americana*	2	0
Eared Grebe	*Podiceps nigricollis*	2	6
Eastern Kingbird	*Tyrannus tyrannus*	5	1
Eastern Phoebe	*Sayornis phoebe*	3	0
European Starling	*Sturnus vulgaris*	230	80
Gadwall	*Anas strepera*	42	1,367
Grasshopper Sparrow	*Ammodramus savannarum*	3	0
Great Blue Heron	*Ardea herodias*	9	7
Great Horned Owl	*Bubo virginianus*	6	0
Greater White-fronted Goose	*Anser albifrons*	0	773
Greater Yellowlegs	*Tringa melanoleuca*	104	24
Green-winged Teal	*Anas crecca*	1,149	2,295
Horned Lark	*Eremophila alpestris*	1,302	456
House Sparrow	*Passer domesticus*	6	0
House Wren	*Troglodytes aedon*	1	0
Killdeer	*Charadrius vociferus*	1,685	303
Lapland Longspur	*Calcarius lapponicus*	5	0
Lark Bunting	*Calamospiza melanocorys*	3	14

Common Name	Scientific Name	Spring 2006 Total	Spring 2007 Total
Least Sandpiper	*Calidris minutilla*	158	12
Lesser Scaup	*Aythya affinis*	1	58
Lesser Yellowlegs	*Tringa flavipes*	251	0
Long-billed Curlew	*Numenius americanus*	0	2
Long-billed Dowitcher	*Limnodromus scolopaceus*	26	0
Mallard	*Anas platyrhynchos*	6,027	9,560
Marbled Godwit	*Limosa fedoa*	1	5
Marsh Wren	*Cistothorus palustris*	5	0
McCown's Longspur	*Calcarius mccownii*	16	0
Merlin	*Falco columbarius*	2	0
Mourning Dove	*Zenaida macroura*	103	79
Northern Flicker	*Colaptes auratus*	10	0
Northern Harrier	*Circus cyaneus*	40	12
Northern Pintail	*Anas acuta*	2,510	4,720
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	3	0
Northern Shoveler	*Anas clypeata*	387	1,374
Northern Shrike	*Lanius excubitor*	0	1
Pectoral Sandpiper	*Calidris melanotos*	40	0
Peregrine Falcon	*Falco peregrinus*	2	0
Pied-billed Grebe	*Podilymbus podiceps*	42	0
Prairie Falcon	*Falco mexicanus*	1	0
Redhead	*Aythya americana*	1	0
Red-headed Woodpecker	*Melanerpes erythrocephalus*	3	0
Red-necked Phalarope	*Phalaropus lobatus*	3	0
Red-tailed Hawk	*Buteo jamaicensis*	4	0
Red-winged Blackbird	*Agelaius phoeniceus*	777	1,310
Ring-billed Gull	*Larus delawarensis*	0	23
Ring-necked Pheasant	*Phasianus colchicus*	4	0
Rock Pigeon	*Columba livia*	7	0
Rock Wren	*Salpinctes obsoletus*	1	0
Ruby-crowned Kinglet	*Regulus calendula*	3	0
Ruddy Duck	*Oxyura jamaicensis*	0	140
Sandhill Crane	*Grus canadensis*	148	0
Savannah Sparrow	*Passerculus sandwichensis*	280	0
Semipalmated Plover	*Charadrius semipalmatus*	5	0
Semipalmated Sandpiper	*Calidris pusilla*	28	0
Short-eared Owl	*Asio flammeus*	0	2
Snow Goose	*Chen caerulescens*	0	18,963
Snowy Owl	*Bubo scandiacus*	0	1
Solitary Sandpiper	*Tringa solitaria*	68	0
Song Sparrow	*Melospiza melodia*	11	0
Sora	*Porzana carolina*	5	0
Spotted Sandpiper	*Actitis macularia*	13	1
Spotted Towhee	*Pipilo maculatus*	2	0
Stilt Sandpiper	*Calidris himantopus*	9	3
Swainson's Hawk	*Buteo swainsoni*	5	1
Unknown Bird		10	113
Unknown Blackbird		1,210	120
Unknown Dowitcher	*Limnodromus griseus*	16	1
Unknown Duck		1,125	3,750
Unknown Peep	*Calidris Sp.*	40	15
Unknown Sandpiper		1	22
Unknown Scaup		0	92
Unknown Shorebird		5	35
Unknown Sparrow		157	0

Common Name	Scientific Name	Spring 2006 Total	Spring 2007 Total
Unknown Swallow		44	0
Unknown Teal	*Anas sp.*	7,898	30
Unknown Yellowlegs	*Tringa sp.*	2	4
Upland Sandpiper	*Bartramia longicauda*	8	0
Vesper Sparrow	*Pooecetes gramineus*	246	0
Western Bluebird	*Sialia mexicana*	0	1
Western Grebe	*Aechmophorus occidentalis*	0	22
Western Kingbird	*Tyrannus verticalis*	5	6
Western Meadowlark	*Sturnella neglecta*	368	245
Western Sandpiper	*Calidris mauri*	3	0
White-breasted Nuthatch	*Sitta carolinensis*	1	0
White-crowned Sparrow	*Zonotrichia leucophrys*	22	0
White-faced Ibis	*Plegadis chihi*	1	4
White-rumped Sandpiper	*Calidris fuscicollis*	0	40
Willet	*Tringa semipalmata*	3	3
Wilson's Phalarope	*Phalaropus tricolor*	26	968
Wilson's Snipe	*Gallinago delicata*	169	58
Wilson's Warbler	*Wilsonia pusilla*	1	0
Wood Duck	*Aix sponsa*	5	3
Yellow Warbler	*Dendroica petechia*	3	0
Yellow-crowned Night-Heron	*Nyctanassa violacea*	1	0
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	856	142
Yellow-rumped Warbler	*Dendroica coronata*	10	0
Total Number of Birds		**31,515**	**54,488**
Total Number of Species		**106**	**71**

Cummulative Bird Total = 86,003
Cummulative Species Total = 125

APPENDIX B

PLANT SPECIES DOCUMENTED IN SOUTHWEST PLAYA COMPLEX PLAYAS, 2006

Common Name	Scientific Name (USDA Plants)	Nativity	Wetland Indicator Category (Region 5)
American Licorice	*Glycyrrhiza lepidota*	Native	FACU
Arrowhead	*Sagittaria sp.*		
Aster	*Aster sp.*		
Barnyardgrass	*Echinochloa crus-galli*	Exotic	FACW
Bearded Flatsedge	*Cyperus squarrosus*	Native	OBL
Bearded Sprangletop	*Leptochloa fusca*	Native	OBL
Bigbract Verbena	*Verbena bracteata*	Exotic	FACU
Blue Mudplantain	*Heteranthera limosa*	Native	OBL
Buffalobur Nightshade	*Solanum rostratum*	Exotic	
Bushy Knotweed	*Polygonum ramosissimum*	Native	FAC
Canadian Horseweed	*Conyza canadensis*	Exotic	FACW
Cheatgrass	*Bromus tectorum*	Exotic	
Chickweed	*Cerastium sp.*		
Common Sunflower	*Helianthus annuus*	Native	FACU
Cottonwood	*Populus deltoides*	Native	FAC
Cuman Ragweed	*Ambrosia psilostachya*	Native	FAC
Curly Dock	*Rumex crispus*	Exotic	FACW
Dandelion	*Taraxacum sp.*		
Disk Waterhyssop	*Bacopa rotundifolia*	Native	OBL
Dwarf Spikerush	*Eleocharis parvula*	Native	OBL
Eared Redstem	*Ammannia auriculata*	Native	OBL
Evening-primrose	*Oenothera sp.*		
Foxtail Barley	*Hordeum jubatum*	Native	FACW
Goatsbeard	*Tragopogon sp.*		
Golden Tickseed	*Coreopsis tinctoria*	Native	FAC
Green Bristlegrass	*Setaria viridis*	Exotic	
Green Carpetweed	*Mollugo verticillata*	Exotic	FAC
Knotweed	*Polygonum sp.*		
Kochia	*Kochia scoparia*	Exotic	FACU
Mustard	*Brassica sp.*		
Pennsylvania Smartweed	*Polygonum pensylvanicum*	Native	FACW+
Pigweed	*Amaranthus sp.*		
Pitseed Goosefoot	*Chenopodium berlandieri*	Native	
Prairie Cordgrass	*Spartina pectinata*	Native	FACW
Prostrate Pigweed	*Amaranthus albus*	Exotic	FACU
Purslane	*Portulaca sp.*		
Redroot Amaranth	*Amaranthus retroflexus*	Exotic	FACU
Russian Thistle	*Salsola tragus*	Exotic	FACU
Sand Lovegrass	*Eragrostis trichodes*	Exotic	
Sandbur	*Cenchrus sp.*		
Sedge	*Carex sp.*		
Spikerush	*Eleocharis sp.*		

Common Name	Scientific Name (USDA Plants)	Nativity	Wetland Indicator Category (Region 5)
Stinkgrass	*Eragrostis cilianensis*	Exotic	FACU
Sweetclover	*Melilotus sp.*		
Switchgrass	*Panicum virgatum*	Native	FAC
Thistle	*Carduus sp.*		
Tumble Windmill Grass	*Chloris virgata*	Exotic	NI
Waterclover	*Marsilea sp.*		
Western Wheatgrass	*Pascopyrum smithii*	Native	FACU
Winged Pigweed	*Cycloloma atriplicifolium*	Native	FAC
Witchgrass	*Panicum capillare*	Exotic	FAC
Woollyleaf Burr Ragweed	*Ambrosia grayi*	Native	FAC