Survey and Assessment of Playa Wetlands in Eastern Colorado

Final Report to the Colorado Division of Wildlife

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EXECUTIVE SUMMARY

This is the Final Report for the project entitled *Survey and Assessment of Playa Wetlands in Eastern Colorado*, funded by the Colorado Division of Wildlife (CDOW). Funds were provided through two agreements with CDOW: Cooperative Agreement PSC-1324-06 and Purchase Order OE PBA 07000000080. Matching funds were provided by the United States Environmental Protection Agency (EPA) and the United States Fish and Wildlife Service (USFWS) through a Neotropical Migratory Bird Conservation Act grant. Other phases of the project have been supported by funds from the CDOW State Wildlife Grant program, and the Playa Lakes Joint Venture (PLJV). The study is ongoing, with work continuing through 2008. This report gives findings of the research project to date and outlines future research directions.

Playas are shallow, depressional wetlands fed exclusively by rainfall and runoff and found throughout much of the Great Plains. These wetlands are vital to biodiversity in this ecoregion, but are threatened by agriculture and development. While attention has been focused on playas in other localities such as the High Plains of Texas (Haukos and Smith 2003), prior to this study playa wetlands in Colorado were relatively unknown. This study addresses a need for basic playa distribution and ecological information, which may be used to facilitate the conservation of this wetland type in eastern Colorado.

The *Survey and Assessment of Playa Wetlands in Eastern Colorado* began with acquisition and compilation of available Geographic Information Systems (GIS) layers, resulting in a spatial model of potential playa locations within PLJV's region in the Shortgrass Prairie Bird Conservation Region 18 of eastern Colorado. In 2004 we began ground-truthing the dataset, describing playa conditions, and documenting bird use of playas. We also obtained access to a sample of playas to collect detailed soils and vegetation data. Next we greatly expanded our sample size for ground-truthing the spatial model, continued sampling vegetation on playas, and monitored bird use of wet playas during migration. We implemented a more systematic approach to ground-truthing the GIS model in order to better depict the playas currently missing from the GIS model. We also examined how surrounding land use and direct impacts to playas influenced habitat selection by birds during migration. In all years, we initiated relationships with private landowners, creating opportunities for future conservation activities.

The accomplishments of the *Survey and Assessment of Playa Wetlands in Eastern Colorado* to date are:

1. Creation of a comprehensive map portraying over 7,200 potential playa locations;
2. Creation of a spatial database that integrates field data with remotely sensed data;
3. Ground-truthing and biological data collection on over 1000 playas;
4. Collection of the first multi-year vegetation data set for playas in the northern part of their range;
5. Monitoring the use of over 150 wet playas by wetland-dependent bird species during migration; and
6. Development of relationships with landowners that will help build pathways for successful conservation of playas.

This project has begun to fill information gaps regarding playas in eastern Colorado. We surveyed 1202 (17%) of the potential playa locations in our GIS model and confirmed 56% of these as present in our field surveys. We also found an additional 512 playas in field surveys that were not contained in our GIS model. These findings suggest that the distribution map of playas in Colorado will continue to undergo future refinement.

Forty-seven percent of the playas we visited were surrounded by grassland; 33% were in cropland, and 4% were in CRP (the remaining were surrounded by multiple land uses). Agricultural uses were found on 74% of playas surveyed, with grazing as the most common use (43%). Hydrologic manipulations such as pit excavation, impounding, or constructed inlet or outlet were documented at 29% of the playas. These rates of agricultural use and hydrologic manipulation appear to be lower than those suggested by studies in other parts of the playa region.

Over 90 plant species were documented throughout the study, with playa vegetation dominated by graminoids such as western wheatgrass and annuals such as kochia. Vegetation heights in playas were most often classified as 0.1-0.5 m high.

Through the course of the study, we documented 174 bird species, including over 50 wetland-dependent species and species of concern including Black Tern, Long-billed Curlew, Mountain Plover, Sandhill Crane, Peregrine Falcon, and Ferruginous Hawk. We also documented playa use by seven species of mammals. In 2005 and 2006 we applied techniques for locating wet playas during fall migration by using real-time radar data and rainfall gauge networks. We used migration surveys to estimate abundance and document chronology for waterfowl and shorebirds in September-November 2005-2006.

These data suggest that many playas in Colorado are not directly threatened by sedimentation from farming practices and remain in their native context of shortgrass prairie. In addition, our work identifies playas in cropland or with hydrologic modifications that could be restored. Playas are clearly providing habitat for a large array of wildlife species. Our future work will focus on gaining a better understanding of how surrounding landuse and direct impacts to playas may influence habitat selection by birds during migration and how this relates to the floral characteristics of playas. We will also pursue a more expansive GIS analysis of the distribution, characteristics, and conservation values of playas in eastern Colorado and write several peer-reviewed scientific publications.

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CHAPTER 1. INTRODUCTION

Playas are shallow depressional wetlands of the Great Plains that fill periodically from heavy rainfall and associated runoff (Smith 2003). These clay-lined wetlands occur in closed watersheds and are thought to have formed through a collaboration of wind, wave, and dissolution processes (Smith 2003). While the greatest concentration of playas is in the Southern High Plains of Texas, playas are distributed across northern Texas, western Oklahoma, Kansas, Nebraska, and eastern New Mexico and Colorado (Smith 2003). Playa wetlands provide important ecological and societal functions (Haukos and Smith 1994), including water storage during flood events, irrigation water for crops, recharge to the Ogallala aquifer (Zartman 1994, Wood 2000), and water for livestock (Ostercamp and Wood 1987).

An estimated 30,000 playas occur in the Great Plains, making playa wetlands one of the most numerous wetland types in the region. Ecologically, playas are oases of diversity which provide vital habitat for a wide variety of wildlife and plant species, including over 185 avian species, 13 amphibian species, 37 mammal species, and 124 aquatic invertebrate species (Haukos and Smith 2003). In addition, playas are recognized to provide a key component of the “stepping stone” habitat mosaic used by shorebirds during migration between the Arctic and South America (Skagen and Knopf 1993, Davis and Smith 1998).

Playas are frequently dry for extended periods of time, typically located in flat to gently rolling landscapes, and often surrounded by agricultural land use. Playas receive surface water inflows only from precipitation events and overland flow, and fill periodically following heavy rainfall events. Due to the sporadic, localized rainfall patterns common to the eastern Colorado plains, most playas characteristically exhibit prolonged wet-dry cycles, which can extend up to 10 years or longer (Smith 2003). These factors combined can make recognition of a playa difficult, which can increase susceptibility to alteration.


Playa in an agricultural landscape in Phillips County, CO

Today, playas are primarily found in working landscapes of farm and ranch land, and many have been affected by sedimentation, pit excavation, road construction, urban development, feedlot runoff, livestock grazing, and deliberate filling (Haukos and Smith 1994). In the Great Plains region, where wetlands and rivers have been significantly altered to provide arable farmland and irrigation for crops, playas represent a valuable wetland resource and a conservation opportunity. In some areas, playa distribution and condition has been well-studied (Bolen et al. 1989, Guthery and Bryant 1982, Nelson et al. 1983). However, the status of playas in Colorado was relatively unknown before this study began.

In Colorado, interest in protecting these isolated, temporary wetlands has been strong, particularly by wildlife constituents. Wildlife conservation groups including the U.S. Fish and Wildlife Service (USFWS) Partners for Fish and Wildlife Program, the Colorado Division of Wildlife (CDOW), Playa Lakes Joint Venture (PLJV), Colorado Wetland Partnership's (CWP) Prairie and Wetlands Focus Area (PWFA), and Rocky Mountain Bird Observatory (RMBO) have begun protecting, enhancing, and restoring playas through voluntary programs. The United States Congress has also demonstrated its commitment to protect and restore this resource by creating the Wetlands Restoration Initiative (CP23a) of the USDA Farm Bill Conservation Reserve Program (USDA 2004). In Colorado, CP23a efforts have focused on playa wetlands.

Due to the importance of playas to the people and wildlife of the plains and the threats posed to these wetlands, conservation partners need basic information regarding the distribution and condition of playas in this region. To provide these data RMBO initiated this study in 2004.

Study Objectives

The goal of this study is to contribute to the scientific understanding of playas within the Shortgrass Prairie Bird Conservation Region 18 in eastern Colorado, using a combined approach of GIS modeling and field surveys. In this phase of the study, we continued playa inventory and characterization, with a greater emphasis on bird use of playa wetlands during the migration seasons. We pursued these primary objectives:

1. Ground-truth the GIS model of potential playa wetlands in eastern Colorado;
2. Document land use, soils, surface hydrology, dominant vegetation, human modifications of playas and wildlife habitat;
3. Rigorously describe vegetation characteristics of a random sample of playas;
4. Compare conditions on newly restored playas to previous conditions and those of nearby non-restored playas to inform future conservation practices;
5. Intensively survey wetland-dependent bird use of playa wetlands during migration; and
6. Create a model to identify playas with high conservation potential.

CHAPTER 2. GIS MODEL AND PLAYA CONDITIONS

Playa wetland abundance and distribution in eastern Colorado was not known prior to the undertaking of this study. Previous playa studies have focused on the entire Southern High Plains ecoregion including sites in southeastern Colorado (Guthery and Bryant 1982, Hoaglund and Collins 1997, Smith and Haukos 2002, Smith 2003), but have not encompassed the extent of the state's playa region. To locate and inventory playas in eastern Colorado, RMBO acquired spatial data from the PLJV, developed a GIS model depicting playa distribution, and ground-truthed the model through field surveys. The field surveys provide feedback on the source layers in the GIS as well as characterize the general characteristics of playas in the study area.

Geographic Information System Development

Initial Model

The initial model of potential playa locations was built from a GIS database created by Ducks Unlimited, Inc. (DU) for PLJV in 2003. We utilized three datasets in the PLJV GIS database: (1) DU's satellite imagery (Landsat) dataset of possible playas, (2) the United States Geological Survey (USGS)/EPA National Hydrography Database (NHD), and (3) the Natural Resource Conservation Service's (NRCS) Soils Survey Geographic Database (SSURGO) for counties that explicitly identified playas or intermittent waterbodies in their surveys. The Landsat dataset was developed to serve as a catalog of hydrologically functioning playa lakes present during periods of peak precipitation, as interpreted from the wettest Landsat data between 1986 and 2000 (Ducks Unlimited, Inc. 2003). The NHD is a comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs, and wells. The NHD layer used in this model was a subset of *lake/pond* and *playa* features extracted by DU from the larger dataset. SSURGO data were utilized for 11 of the 27 counties in our area of interest (Baca, Bent, Boulder, El Paso, Elbert, Larimer, Prowers, Pueblo and Weld; Figure 2-1) that contained soil map units in which *playas* or *intermittent water* were explicitly identified. USFWS National Wetlands Inventory data were not utilized as less than 1% of the area in eastern Colorado was available in digital format in 2004.

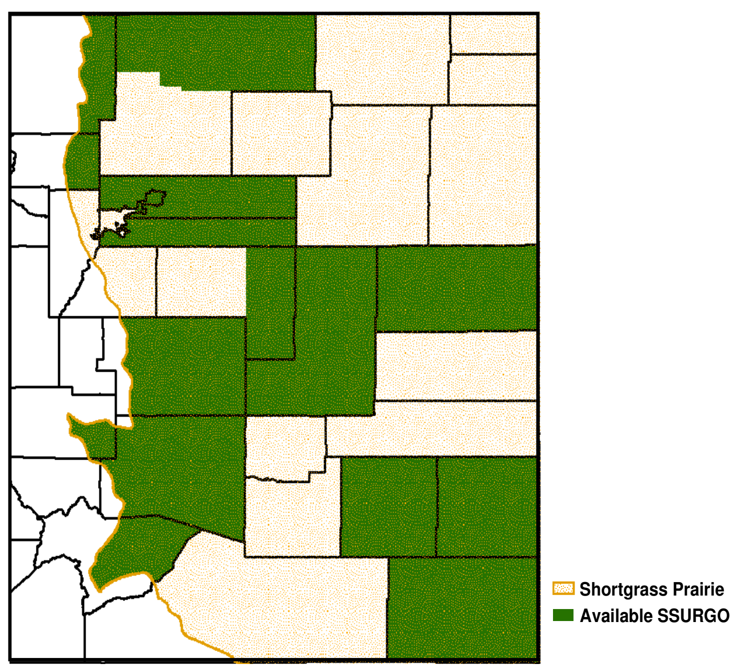

Figure 2-1. Availability of SSURGO data for counties within the Shortgrass Prairie Bird Conservation Region (18) in eastern Colorado in 2004.

We determined that several modifications to the data layers were required to refine the geographic model of playa locations before the GIS could be ground-truthed. We incorporated a more detailed road layer from the Colorado Department of Transportation and the Public Land Survey System (PLSS) to indicate township, range, and section. From the NHD dataset and DU Landsat imagery, we removed features that were identified as a reservoir, saline lake, riparian corridor, stock tank, or well. We also removed any feature that was within 150 m of a riparian corridor since these features were probably not hydrologically isolated and therefore not playas. We also extracted all features that were within 8.5 km of major metropolitan areas (with 1990 populations greater than 50,000) to avoid discrepancies that might be associated with urban parks or impoundments. For features in the SSURGO database, we did not remove any polygons, as they were field-derived and therefore expected to be playas. In total, 1607 features were removed (see Marx 2004 for additional detail).

Our initial GIS model identified a total of 2,508 possible playas among all three data layers in eastern Colorado. We found a low degree of overlap among source datasets. Of all possible playa features, only 178 were commonly shared between Landsat and NHD data, 29 between Landsat and SSURGO, and 104 between NHD and SSURGO. Only nine features were found in all three datasets. The lack of consistency among datasets verified the need for intensive ground-truthing and acquisition of improved spatial data to refine the GIS model of playa occurrence in eastern Colorado.

We incorporated new playas into the GIS model that were discovered during fieldwork and were not captured in any of the SSURGO, NHD, or Landsat imagery datasets. For potential playas which were determined to be some other type of waterbody upon ground-truthing, we created a feature labeled “other waterbody” in the GIS.


Playa found in eastern Colorado during roadside field surveys 2004-2006

Revised GIS Model

After the 2005 field season, we updated our GIS model with more complete Landsat and SSURGO layers created by the PLJV. The PLJV Landsat layer was created by capturing additional probable playa polygons from analysis of imagery from additional dates. PLJV’s supplemental SSURGO layer was comprised of data from ten additional counties that became available digitally by September 2005. The soil types that were interpreted as potential playa soils from the junction of this new layer with the 11 counties in our initial GIS are indicated in Table 2-1.

Table 2-1. Summary of features extracted in September 2005 as possible playas from SSURGO data, by county.

County	Soil Type Interpreted as Playas	Potential Playas (N)	Playa Acres
Adams	Intermittent Water	160	994
Arapahoe	Intermittent Water	41	447
Baca	Playas	182	1574
Bent	Playas	20	576
Boulder	Playas	9	36
Cheyenne	Apishapa family, ponded	156	2209
Crowley	Intermittent Water and Playa beaches	75	1222
Douglas	Intermittent Water	13	53
Elbert	Playas	235	1818
El Paso	Playas	63	597
Kiowa	Playas	187	9195
Kit Carson	Pleasant silty clay loam 0-1%	899	8233
Larimer	Playas	20	199
Lincoln	Apishapa clay loam 0-3% rarely	573	4230
Logan	Intermittent Water	104	859
Phillips	Intermittent Water	235	1688
Prowers	Playas	53	806
Pueblo	Playas	19	470
Sedgwick	Scott silt loam	335	1286
Washington	Pleasant silty clay	852	10072
Weld	Playas	197	2943
Total		4428	49507

With the incorporation of these new data, our revised GIS model now indicates over 7,292 potential playa locations (Figure 2-2).

We also added data from the Southwest Regional Gap Analysis Program http://fws-nmcfwru.nmsu.edu/swregap/default.htm which interpreted Landsat imagery to create a land cover map for five southwestern states. The dataset is considered provisional at this time, but is considered to be more accurate than preceding GAP land cover datasets. We used this to characterize surrounding landcover (land use) for the playas in our GIS model.

Methods for Field Verification of Playa Distribution and Conditions

We conducted roadside surveys on playas close to roads across the study area to ground-truth the potential 7,292 playas predicted by our GIS model. Roadside surveys were designed as a rapid assessment technique, with each survey taking an observer approximately 15 minutes. This methodology allowed us to efficiently determine the accuracy of each source dataset and to document playa locations and conditions. Surveys were conducted between March and November each year.

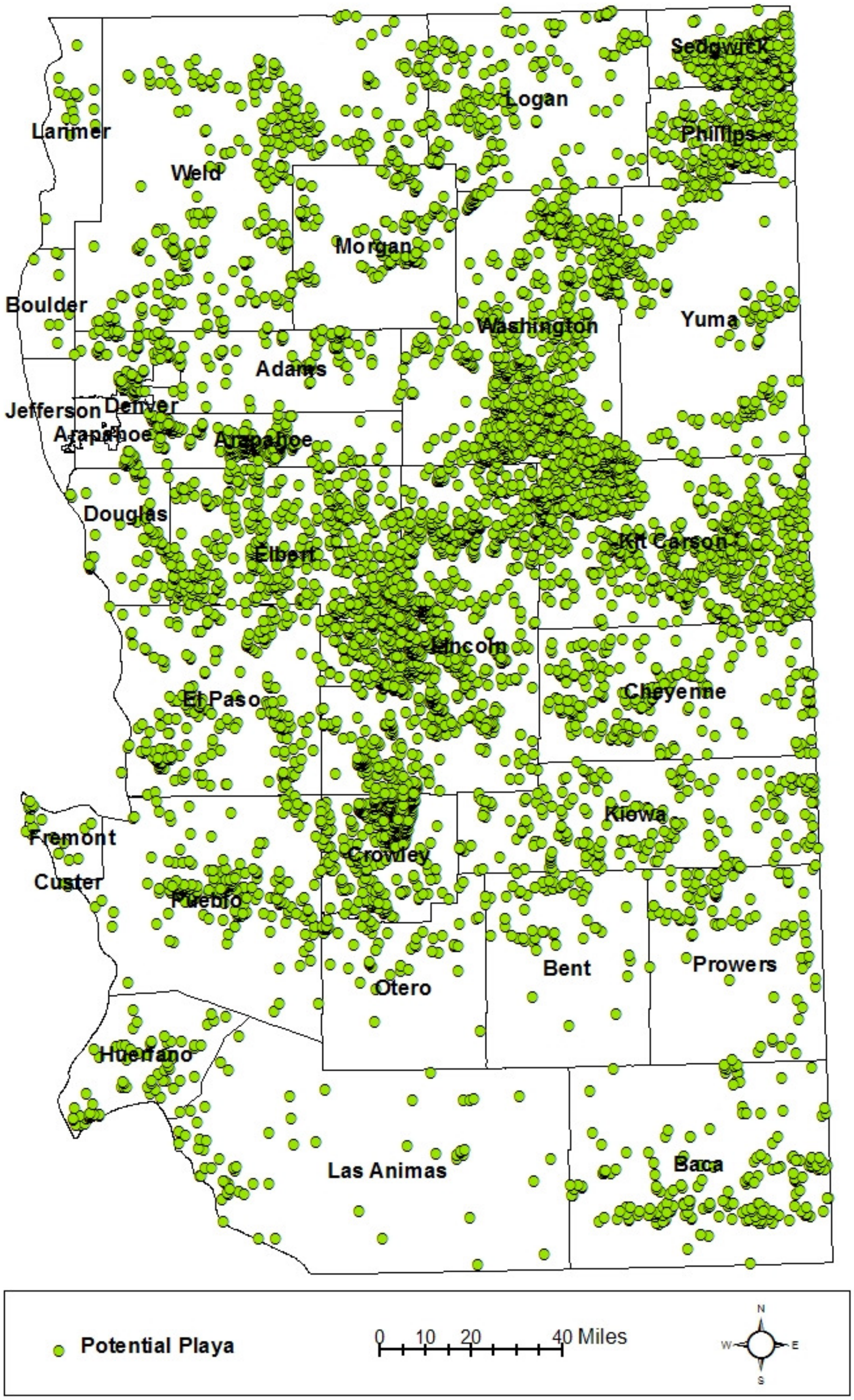

Figure 2-2. Map indicating the distribution of over 7200 potential playas in our revised GIS model.

In 2004, we targeted potential playa locations within .05 mi. (80 m) of the road, and in subsequent years we expanded our selection to locations within 0.5 mi. (800 m) of the road, based on our experience that visibility to one half-mile is possible in the generally flat terrain of eastern Colorado. Survey routes were selected to correspond with locations of playas being characterized in other facets of this study, thus maximizing the number of potential playas surveyed each day. Potential playa locations were visited up to three times for verification purposes; for instance, we re-visited many locations where playas could not initially be verified due to dry conditions or cover by crops.

Playa confirmed and surveyed from roadside

For each potential playa location visited, we assigned one of several status categories: 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 (Hutton and Cariveau 2005). Possible playas could not be confirmed at the time of visit, but were prioritized for repeat visits in a different season of the year, preferably after a heavy rainfall event. 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. Because of difficulty in identifying playas during dry periods, we have temporarily re-classified potential playa locations that were assigned “no visible playa” during field surveys as “undetermined status” for further investigation. Potential playas with unconfirmed status will be investigated further by reviewing observer comments and field photographs, conducting additional field visits, and/or examining aerial photography to attempt to classify these into one of the other categories (i.e., other waterbody, playa, no visible playa).

For each playa, possible playa, or other waterbody, 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 (> or <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 agriculture, USDA Conservation Reserve Program (CRP), and/or grassland;
- We noted any of the following agricultural uses in the playa basin: farmed, grazed, or hayed;
- We noted hydrologic modifications to the playa: pitted/excavated, constructed inlet or outlet, impounded/bermed/terraced, and whether a well was present;
- 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; and
- 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.

Results

GIS Model Verification

In three years of surveys, we attempted to visit 1420 potential playa locations predicted by the GIS model. Two-hundred eighteen of these were not accessible by roads, yielding a sample size of 1202 potential playa located visited (see Figure 2-3). A breakdown of the status designations for potential playas is presented in Table 2-2, first listing the potential playa locations derived only from single GIS data sources and then those that were predicted by multiple datasets.

When all data sources are combined, we confirmed playas at 56% of the visited potential playa locations predicted by the GIS model. The lowest encounter rates for confirmed playas were for locations predicted by single data sources. The NHD dataset alone was the least accurate in predicting playa locations, with a confirmation rate of only 33%. Landsat and SSURGO data were only slightly more accurate with confirmation rates of 43% and 54%, respectively. Combining layers improved playa confirmation rates considerably; we confirmed 76% of the playas predicted by two or more data sources.

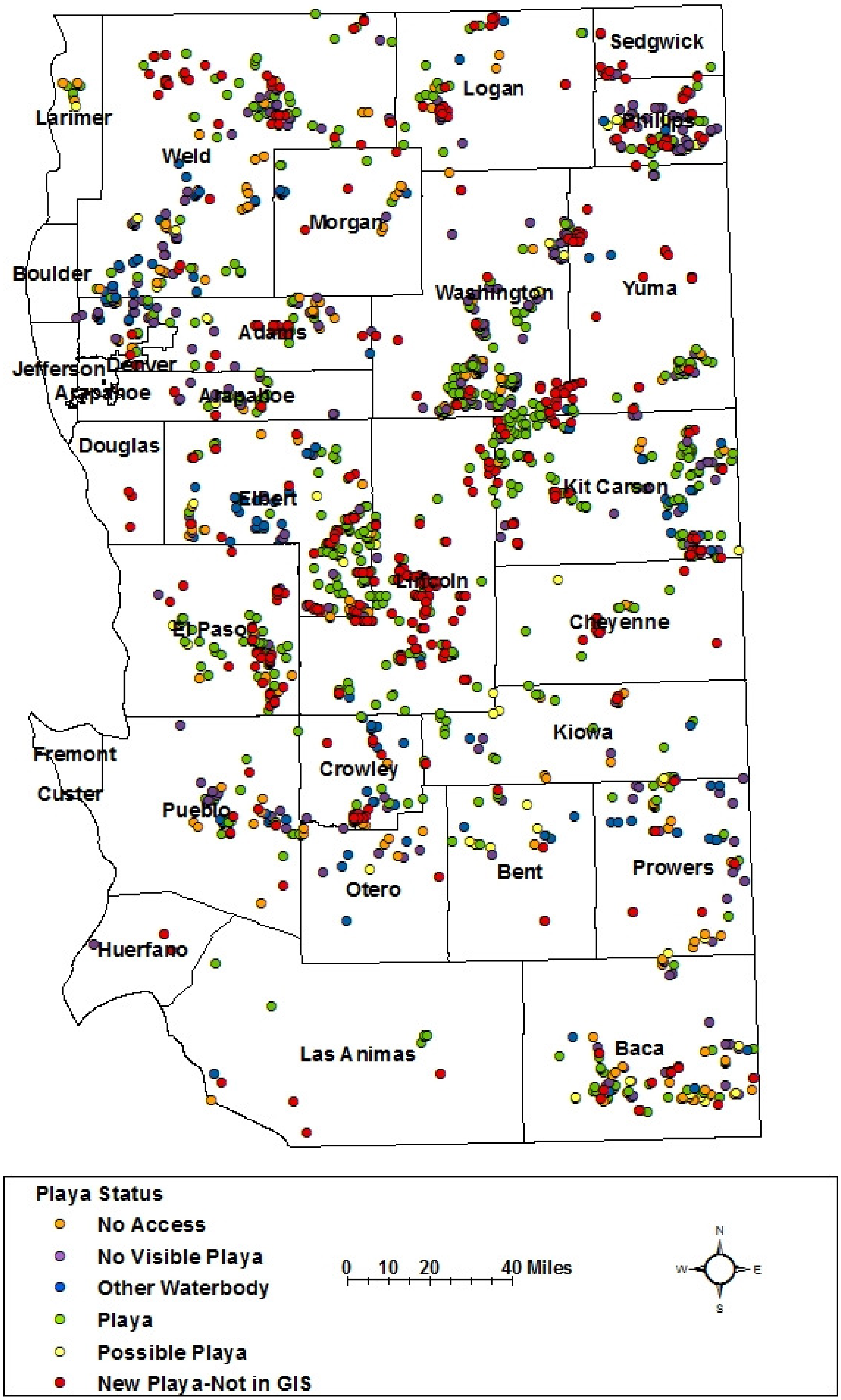

Figure 2-3. Map indicating the status of playas visited by roadside surveys 2004-2006.

Table 2-2. Summary of playa status as determined by roadside survey, by GIS data source.

	Number (%) from each source				
GIS Data Source	Playa	Possible Playa	Other Waterbody	Undetermined Status	Total Visited
NHD	47 (33)	8 (6)	41 (29)	45 (32)	141
Landsat	98 (43)	12 (5)	57 (25)	60 (26)	227
SSURGO	267 (54)	32 (6)	18 (4)	176 (36)	493
Landsat, NHD	14 (39)	0	15 (42)	7 (19)	36
Landsat, SSURGO	104 (79)	4 (3)	2(2)	21 (16)	131
SSURGO, NHD	84 (82)	3(3)	6(6)	10 (10)	103
Landsat, SSURGO, NHD	57 (80)	1(1)	5(7)	8 (11)	71
All Data Sources	671 (56)	60 (5)	144 (12)	327 (27)	1202

Our field surveys verified other waterbodies at 12% of potential playa locations. For an additional 27% of potential playas visited, we could not confirm whether or not a playa was present, despite the fact that the predicted playa was not visible; these playas will be investigated in future phases of the project.

In 2004 we documented 51 new playa locations (playas not predicted by the GIS model). In 2005, we found 111 new playas, and 350 new playas were found in 2006, for a total of 512 new playa locations.

For potential playa locations predicted by our GIS model that we visited in the field, we compared the SWReGAP land cover classification in our GIS model to the surrounding land use we recorded in the field. We restricted our analysis to potential playas that were mapped by SWReGAP in a single land cover type. We also restricted our analysis to the two dominant landcover types for playas in our study area, Agriculture and Western Great Plains Shortgrass Prairie, which were the landcover types for 91% of the playas. This yielded a dataset of 664 playas. Table 2-3 provides the surrounding land uses recorded in the field in relation to the two SWReGAP dominant land cover types surrounding these playas. The SWReGAP classification of Shortgrass Prairie corresponded highly (93%) to grassland encountered in the field. The SWReGAP agriculture category less frequently corresponded to observed cropland (75%).

Surrounding Land Use

For 1009 confirmed playas for which we recorded surrounding land uses, 47% were surrounded by grassland, 33% were in cropland, and 4% were in CRP. The remaining playas had multiple adjacent land uses (15%) or other land uses (1%). Because of the restoration potential for playas in cropland, we noted that 104 playas were partially surrounded by both cropland and grassland or CRP. Thirteen playas were partially surrounded by both grassland and CRP.

Table 2-3. Field-observed land uses surrounding playas versus the two dominant GIS-predicted landcover types.

Surrounding Land Use	Agriculture	Shortgrass Prairie
Agriculture:		
Dryland Agriculture	162	6
Irrigated Agriculture	58	2
Dryland Agriculture, Irrigated Agriculture	18	0
Dryland Agriculture, CRP	6	2
Irrigated Agriculture, CRP	5	0
Dryland Agriculture, Other Land Use	2	0
Irrigated Agriculture, Other Land Use	6	0
Dryland Agriculture, Irrigated Agriculture, CRP	2	0
Dryland Agriculture, Irrigated Agriculture, Other Land Use	3	0
Dryland Agriculture, Grassland	32	
Irrigated Agriculture, Grassland	11	
Dryland Agriculture, CRP, Grassland	4	
Irrigated Agriculture, Grassland, Other Land Use	4	
Dryland Agriculture, Grassland, Other Land Use	3	
Dryland Agriculture, Irrigated Agriculture, Grassland	1	
Subtotal Agriculture	**317 (75%)**	10 (4%)
Grassland:		
Grassland	52	183
Grassland, CRP	4	4
Grassland, Other Land Use	11	15
Grassland, CRP, Other Land Use	1	0
Dryland Agriculture, Grassland		17
Irrigated Agriculture, Grassland		3
Dryland Agriculture, CRP, Grassland		3
Irrigated Agriculture, Grassland, Other Land Use		0
Dryland Agriculture, Grassland, Other Land Use		0
Dryland Agriculture, Irrigated Agriculture, Grassland		0
Subtotal Grassland	68 (16%)	**225 (93%)**
Other:		
CRP	24 (6%)	7 (3%)
Other Land Use	12 (3%)	1 (<1%)
Total	**421**	**243**

Human Impacts to Playas

We characterized human impacts (agricultural uses and hydrologic manipulations) at 1,035 playas. Agricultural uses were evident on 74% of the playas we visited, with grazing as the most common use (Figure 2-4; not pictured, haying was observed at 5 (<1%) playas).

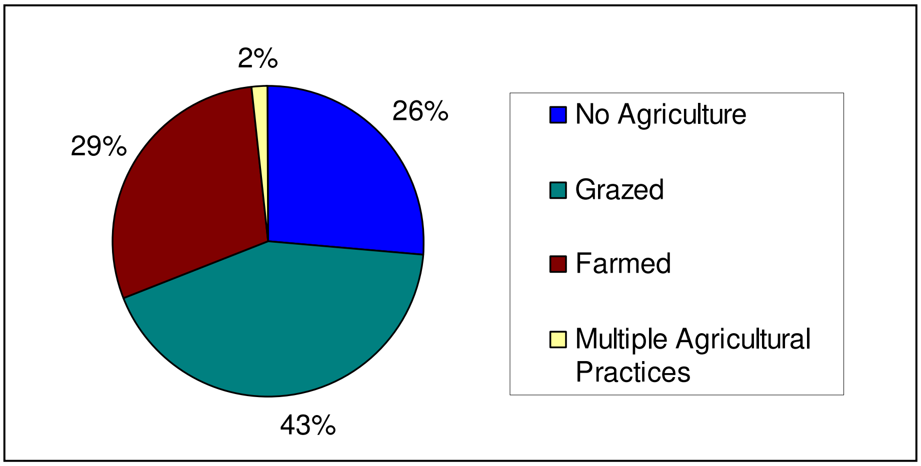

Figure 2-4. Percent of playas visited in 2004-2006 with evidence of agricultural practices.

Evidence of hydrologic manipulations was documented on 130 (12%) of playas, such as impounding, terracing, pit excavation, or constructed inlet or outlet (Figure 2-5). Not pictured are categories representing less than 1% of the dataset: five playas with wells; three playas with constructed inlet/outlet and berm; four playas with a combination of pit, constructed inlet/outlet, and berm; one playa with a pit and a well; one playa with a well and a berm; and one playa with a pit, well, and berm.

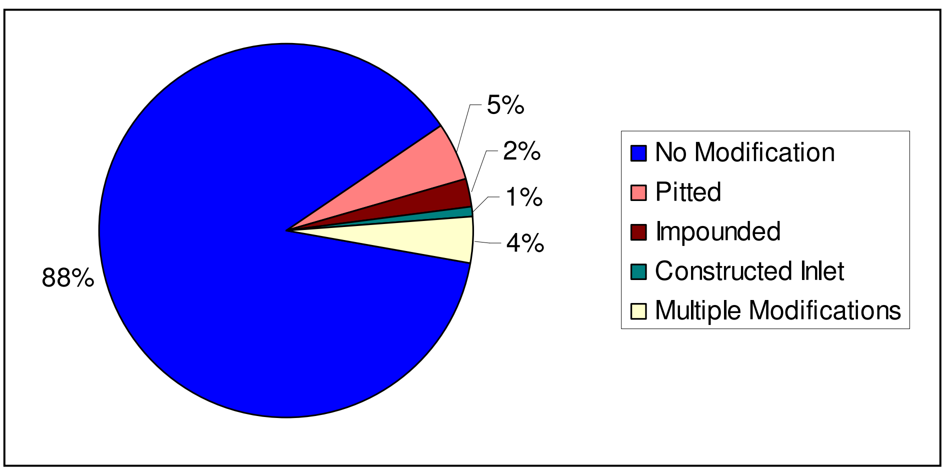

Figure 2-5. Percent of playas visited in 2004-2006 with hydrologic modifications.

The following characterizations are for 607 playas visited in 2004-2005 (2006 data have not yet been analyzed).

Playa Sizes

Playa size classes estimated in the field were as follows: 182 (32%) playas were less than 2 acres, 330 (58%) were 2-12 acres, and 60 (10%) were greater than 12 acres. See Appendix A for representative photographs of playas encountered during roadside visits.

Surface Hydrology

Over one third of the playas we visited in 2004-2005 contained standing water (Figure 2-6). A greater proportion of playas in 2005 contained standing water (48%) than playas surveyed in 2004 (31%). In addition, more of the new playas contained standing water (55%) than playas derived from the GIS model (26%). Nearly 20% of dry playas showed some signs of recent inundation (mud cracks or hydrophytic vegetation); however, in many cases no indicators of wetland hydrology were observed in dry playas.

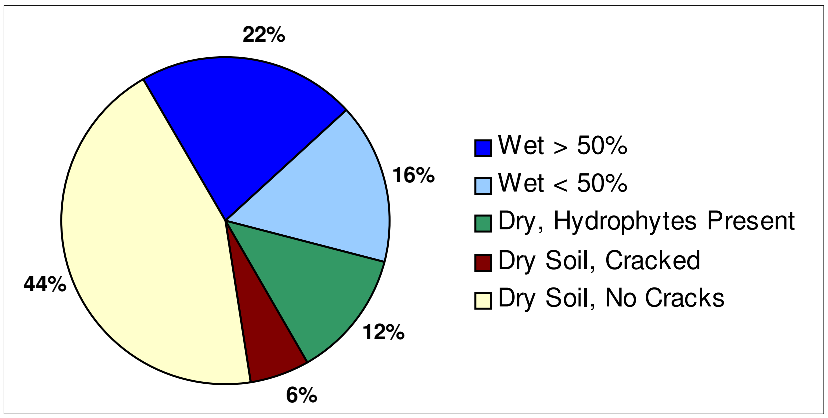

Figure 2-6. Hydrologic categories of playas visited in 2004 and 2005.

Vegetation in Playas

The dominant vegetation type in playas was grass, followed by forbs. On average, bare ground accounted for approximately 25% of areal cover (Table 2-4).

Table 2-4. Estimated cover (%) from roadside visits to playas, 2004-2005.

	Playa Basin		Surrounding Upland	
Cover Type	Mean	Maximum	Mean	Maximum
Bare Ground	26	100	21	100
Cactus	<5	5	<5	30
Yucca	<5	5	<5	35
Grass	45	100	56	100
Forb	28	100	19	85
Shrub	<5	70	<5	65

Some playas were exclusively covered by grass, forbs, or bare ground. Grass was also the dominant upland cover type, followed by bare ground.

We report vegetative species for playas within 200 m of the road, not farmed through the basin, not in CRP, and with vegetation species (or genus) recorded. To report the plants recorded from within the playa basins, we compare playas surrounded by grassland (n=198) to those surrounded by cropland (n=31). For playas in grassland, the most commonly recorded plant was buffalograss (35%), followed by western wheatgrass (32%), blue grama (15%), spikerush (10%), and kochia (10%). For playas in cropland, kochia was recorded at 42% of the playas, followed by sunflowers (26%), western wheatgrass (19%), and spikerush (10%). Scientific names and a full plant species list are provided in Appendix B.

Vegetation in the upland surrounding playas is reported for playas within 200 m of the road, not farmed through, in a grassland matrix, with species or genus identified (n=225). Blue grama was recorded at the highest number of playas (52%), followed by buffalograss (28%), western wheatgrass (23%), and prickly pear cactus (15%).

Vegetation heights estimated during roadside surveys were as follows: 33% of playas were estimated to have an average vegetation height less than ankle high (<0.1 m); 47% had average vegetation height 0.1 - 0.5 m, 13% were classified as 0.5-1.0 m, and 7% were classified as containing vegetation greater than 1.0 m tall.

Wildlife Use

We detected 2,770 birds of 76 species on 291 (59%) of 490 roadside surveys (see Appendix C for a list of all birds detected throughout the study; Chapter 4 presents migration survey findings from September-November 2006, not reported here). Surveys documented 15 species of shorebirds, 9 species of waterfowl, 6 other waterbirds, and 6 raptor species. Fifty-three avian species occurred in playa basins, while 31 species were recorded in the upland habitat surrounding playas. Presenting data only from playas that hosted birds, the mean number of birds per survey was 9.52 (± 1.31 SE (standard error)), with a maximum count of 231 on September 29, 2004. The average number of species per survey was 2.4 (± 0.10 SE), with a maximum of 11 species. The mode of both species and birds was 1, indicating a highly skewed dataset with many playas hosting few birds and bird use concentrated on particular playa visits. The most commonly encountered species was the Horned Lark, found at 24% of all playas surveyed, followed by Western Meadowlark, Lark Bunting, Killdeer, and Mourning Dove. The species counted in the highest numbers across all surveys combined were Horned Lark (n=416), Killdeer (205), Lark Bunting (193), Blue-winged Teal (192), and Mourning Dove (171).

We reported non-avian wildlife species opportunistically on 99 playas, with the black-tailed prairie dog as the most-frequently reported species at 31 playas. Other mammals seen using playas include pronghorn antelope, jackrabbit, coyote, mule deer, red fox and thirteen-lined ground squirrel. Plains spadefoot toad, tadpoles, dragonflies, and damselflies also were reported.

Discussion

GIS Model Verification

This study has collected field data from over 1000 verified playas in eastern Colorado, and our GIS model suggests the occurrence of 4,000-7,000 playas within the study area. Until recently, few playas were thought to exist outside of the Southern Great Plains, and previous studies included only the most southeast portion of Colorado within their range (Smith 2003). For instance, one study estimated only 198 playas for Colorado (Guthery et al. 1981 in Smith 2003). Estimates of the number of playas in the Southern Great Plains average around 25,000 (e.g., Curtis and Beierman 1980, Guthery and Bryant 1982, and Ostercamp and Wood 1987 in Smith 2003). Numbers of playas north of the Southern Great Plains in Kansas, Colorado, and Nebraska have been unknown (Smith 2003), although the PLJV now estimates 40,000 rangewide (http:\\www.pljv.org). This study represents a major contribution to our understanding of playas in the northern part of their range.

Visits to 17% of the locations in our GIS model resulted in confirmation of 56% as playas. This somewhat low percentage is due to several factors. Ten percent of potential playa locations turned out to be other water bodies (e.g., reservoirs, ponds), indicating a misclassification by the GIS model. For a remaining 27% of potential playa locations, the presence of a playa at that location remains undetermined. Despite the fact that we classified many potential playa locations in the field as "no visible playa," our field experience indicates that playas may be evident in one month and not another, due to factors such as a prolonged lack of rainfall or obstructions such as dense crop cover. Accordingly, we will combine analyses of GIS data, aerial imagery, and field visits after rainfall events to attempt classification of undetermined potential playa locations in the final phases of this research.

Estimating the number of playas in the study region remains difficult. An additional 512 playa locations were found during the course of our field surveys, which were not predicted by the initial GIS model. The high number of playas not predicted by the GIS model paired with a low confirmation rate of predicted playas creates high uncertainty regarding the number of playas in the study area. If we apply a confirmation rate of 56% to our revised GIS model numbers and add newly discovered playas, we can estimate a total of 4,595 playas. However, without estimating the rate of encountering playas in the field that are lacking in the GIS model, our estimates of playa numbers are biased low. In 2006, we implemented a grid-based search system to determine numbers of playas in the field, and analysis of these data will greatly improve our estimates of playa numbers in the study area.

When playas were predicted by single data sources, our confirmation rates were 33-54%; however, when playas were predicted by multiple datasets including SSURGO soils data, confirmation rates were much higher (75%). We also found that the NHD and Landsat data layers had higher misclassifications of other waterbodies (25-29%) as compared to 4% by SSURGO. This concurs with the experience of others who have found SSURGO to be very effective in predicting playa locations in other states (Karin Callahan, PLJV, personal communication). The National Wetlands Inventory is another dataset that will likely enhance our model of playa distribution, as it has been quite effective in predicting playa locations in other parts of the playa region (Ted LaGrange, Nebraska Game and

Parks Commission, personal communication). When this dataset becomes available electronically for our study area, we will also add these data to our GIS model.

When we investigated the accuracy of the dominant SWReGAP land use classifications, we found high correlation of the Western Great Plains Shortgrass Prairie land cover type with grassland as classified during field visits. We found a much lower correspondence of SWReGAP agricultural land use with cropland as seen in the field. A change in land use since the imagery was taken (1999-2001) could explain the 6% found to be in CRP during field surveys. In general however, the SWReGAP agricultural land use classification is limited in identifying cropland, because it includes areas of pasture grass as well as annual crops. Because playas are threatened by the movement of sediments from row crop agriculture, a GIS layer that explicitly identifies this land cover type would be particularly useful for modeling playa conservation opportunities.

Playa Characteristics

Playas in Colorado appear to be smaller than the average 6.3 ha (15.6 acres) estimated for the 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). In addition, larger playas in the Southern High Plains supported more wetland plant species (Smith and Haukos 2002). Also, playas with longer hydroperiods due to moist-soil management supported a greater density and abundance of invertebrates in winter (Anderson and Smith 2000).

Playa in grassland

Approximately half of the playas we visited during our fieldwork were dry, even though we planned visits in 2005 to correspond with wetter periods. This underscores the ephemeral nature of playa wetlands in this region, and is a reminder that in any given season only a subset will provide wetland habitat. In a recent study of Texas playas, 58% were found to hold water at least 75% of the time, while an additional 36% held water between 25-50% of the time, based on interpretation of year-round satellite imagery from 1985-2000 (Howard et al. 2003). These figures indicate that during 2004-2005, Colorado playas were drier than long term trends observed for Texas playas. This may be due to regional differences in rainfall patterns or greater inputs from irrigation tail water that are reported for Texas (Smith 2003). Given the importance of ponded water in affecting vegetation, invertebrate, and wildlife use of playas, a similar study of playas further north in the range would be useful. These findings also highlight the need to conserve playas in wide distribution across the landscape so that in each given season and year some playas will become inundated by localized rainfall events and provide wetland habitat.

Approximately half of the playas we visited were found to be directly surrounded by grassland. This is much higher than elsewhere in the playa region, where farming is more prevalent than ranching and more than 75% of playas are in cropland (Nelson et al. 1983). Sedimentation due to farming practices is believed to be the single greatest threat to the persistence of playa wetlands (Luo et al. 1997; Smith 2003). Playas surrounded by grassland may have high conservation values as they are currently less threatened by sedimentation and contaminated runoff as are farmed playas. Indeed, sedimentation had replaced all of the wetland volume for 18 of 20 playas in cropland in Texas, and cropland playas contained over 8 times as much sediment as grassland playas (Luo et al. 1997). However, rangeland playas were not free of sedimentation effects; sedimentation rates exceeded the natural deepening of these playas, which the authors indicated may have been due to cultivation elsewhere in the watershed (Luo et al 1997). Sedimentation may directly impact the existence of the playa, shorten the hydroperiod, increase evaporation rates, increase infiltration rates, alter plant communities, and negatively impact wildlife utilization (Luo et al. 1997).

As expected in this agricultural region, we found high rates of agricultural uses on playas. However, we found only 29% were being farmed, in contrast to 46% with more than 25% of the basin disked or cultivated in the Southern High Plains (SHP; Guthery and Bryant 1982). In the SHP, smaller playas (< 4 ha) were more extensively farmed than larger ones, so it is unlikely that size differences explain the differences between the two regions.

We also found evidence of hydrological manipulations, mostly designed to impound water, at 12% of the playas we surveyed. This is to be expected in such an arid landscape. This is much lower than the estimated 69% of playas greater than 4 ha that had been modified by pits within the Southern High Plains, where pits are usually employed to collect irrigation tail water (Guthery and Bryant 1982). Pits can have detrimental impacts on habitat conditions for wildlife. In a study comparing excavated playas to unmodified playas in Texas, waterfowl use and insect abundance and diversity were reduced in the excavated playas (Rhodes and Garcia 1981). Although our records of hydrologic modifications should be considered minimal estimates because they are based on data collected from the road, it is unlikely that this bias is sufficient to explain the magnitude of difference between our study and others.

Pitted playa

Vegetation composition in the playa basins was dominated by grass, which contrasts with studies of playas in the Southern High Plains, where annual plants dominated (Smith and Haukos 2002). However, we more frequently recorded forbs on playas surrounded by cropland than those surrounded by grassland, which is consistent with playas in cropland having more annuals than playas in grassland (Smith and Haukos 2002). Thus, the differences in the predominance of grass may be due to differences in landuse, a finding that may be further investigated in the future.

Forbs were also more abundant within the playa basins than in the surrounding uplands, providing seed resources with high nutritional value important for many species of birds. Waterfowl use of playas in winter was four to five times higher on moist-soil managed playas where seed availability was increased significantly over that of unmanaged playas in a Texas study (Anderson and Smith 1999). Seeds may also be an important part of the diet of migrating shorebirds, as seeds comprised approximately 20% of the dietary mass for five species of migrating shorebirds on a Texas playa (Baldassarre and Fischer 1984). The productivity of playas in producing seeds and invertebrates both are probably important for supporting migrating waterbirds (Anderson and Smith 1999).

Colorado playas apparently provide suitable habitat for migrating shorebirds. The playas we visited averaged an estimated 26% bare ground, and 80% contained vegetation less than 0.5 high. These conditions are favorable for migrating shorebirds, most of which prefer habitats with less than 25% vegetative cover (Burger et al. 1977, Colwell and Oring 1988, Hands 1988, and Helmers 1991 in Helmers 1993). One third of the playas had vegetation less than 0.1 m tall; these playas would be particularly attractive for migrating shorebirds, most of which prefer vegetation with heights less than half the bird's body height (Hands 1988 and Rundle and Fredrickson 1981 in Helmers 1993). When playas are dry, these sparsely vegetated conditions also provide habitat for species such as Mountain Plover, which prefer sites with at least 30% bare ground (Knopf and Miller 1994 in Knopf 1996). In addition, twenty percent of the playas in this study supported vegetation greater than 0.5 m, which with the appropriate flooding conditions, could provide habitat for breeding waterfowl, as in the playas of the Southern High Plains (Rhodes and Garcia 1981).

In addition to shortgrass prairie bird species, we observed 30 species of waterfowl, shorebirds, and other wetland-dependent birds using playa wetlands. A survey in western Kansas found similar species were abundant in playas in springtime (Mallard, Northern Shoveler, Blue-winged Teal, Killdeer), although higher numbers of Red-winged Blackbird, Sandhill Crane, and Wilson's Phalarope were potentially more abundant in Kansas (Tom Flowers, NRCS, unpublished data).

Male Wilson's Phalarope

Our methodology of employing road-based surveys for this portion of the project may bias our results. However, due to the prevalence of public roads along section lines in eastern Colorado, a large proportion of playas are visible from the road. In addition, due to the predominance of private land in eastern Colorado (estimated 85-93%; Frank 1997), sample sizes on land away from roads would be limited by the extensive time required to build relationships with landowners. Although we expect the effects to be minimal, future investigations should determine if attributes of playas differ significantly from those located further from roads. We can analyze our on-site surveys of playas away from roads to compare attributes of playas near and far from roads, but our power will be limited by low sample sizes of on-site playa surveys.

Our work has been useful in identifying conservation opportunities. Through our roadside surveys, we identified 319 playas that are currently farmed. These playas potentially could be enrolled in conservation programs such as the Wetlands Restoration Initiative (CP23a) under the USDA Farm Bill. We found 104 playas that were partially surrounded by cropland and partially surrounded by grassland or CRP. These represent cost-effective opportunities for conservation, where fewer acres would need to be retired in order to buffer the entire playa basin. We also found 130 playas that had been hydrologically altered; these also represent restoration opportunities. Several programs, such as the USFWS Partners for Fish and Wildlife, will cost-share for the removal of hydrologic alterations such as berms or pits. In an on-going aspect of our work, we are monitoring the ecological effects of these restoration practices.

CHAPTER 3. ECOLOGICAL CHARACTERISTICS OF PLAYAS

One of the primary objectives of this study is to describe the ecological characteristics of Colorado playas. To accomplish this effort, we selected a subset of dry playas on which to conduct intensive monitoring, including vegetation assessment, soils characterization, and bird surveys. Whenever possible we also interviewed landowners to determine landuse history, management practices, hydrologic history, wildlife use of the area, and interest in conservation. This effort has yielded a first-ever multi-year data set for Colorado playas.

Daubenmire frame for vegetation sampling

Methods

Site Selection

In 2004 we generated a list of randomly selected playas to receive intensive monitoring, originally stratified by GIS model source layer, size, and surrounding land use. We attempted to achieve an even sized sample among playas in combinations of these categories. However, difficulty making contact with some landowners and the uneven dispersion of playas among categories resulted in our sampling uneven numbers of playas among categories. In addition, using contacts we had with private landowners, we sampled an additional five playas (non-randomly selected) in 2004. In 2005, we revisited the playas selected using the random approach in 2004 and added two additional randomly selected playas. Sample playas were dispersed across the study area (see Figure 3-1). In 2006, we added an additional randomly selected 24 playas to the 20 randomly selected playas visited in 2004 and 2005, for a total of 44 playas dispersed across the study area. However, the data collected in 2006 have not yet been summarized. Therefore, the data reported in this chapter are limited to 2004-2005.

Landowner Contacts and Interviews

The majority of playas in eastern Colorado are found on private land; therefore, we needed to gain access to private land to collect a sample unbiased by land ownership. Our list of potential playa locations was cross-referenced with Public Land Survey System (PLSS) information to identify township, range and section locations. We then used a combination of plat maps, county assessors' records, and county land ownership databases to identify ownership of selected potential playa locations.

Vegetation

After determining ownership of potential playa locations we contacted the owner by phone and discussed our project objectives, asked permission to conduct a site visit, and answered any of the landowner's questions. We attempted to receive permission from landowners at least one week prior to our visit, so that we could arrange to interview the landowner regarding hydrology, wildlife use, management practices, land use history, and interest in conservation. We marked the playa center and established two transects

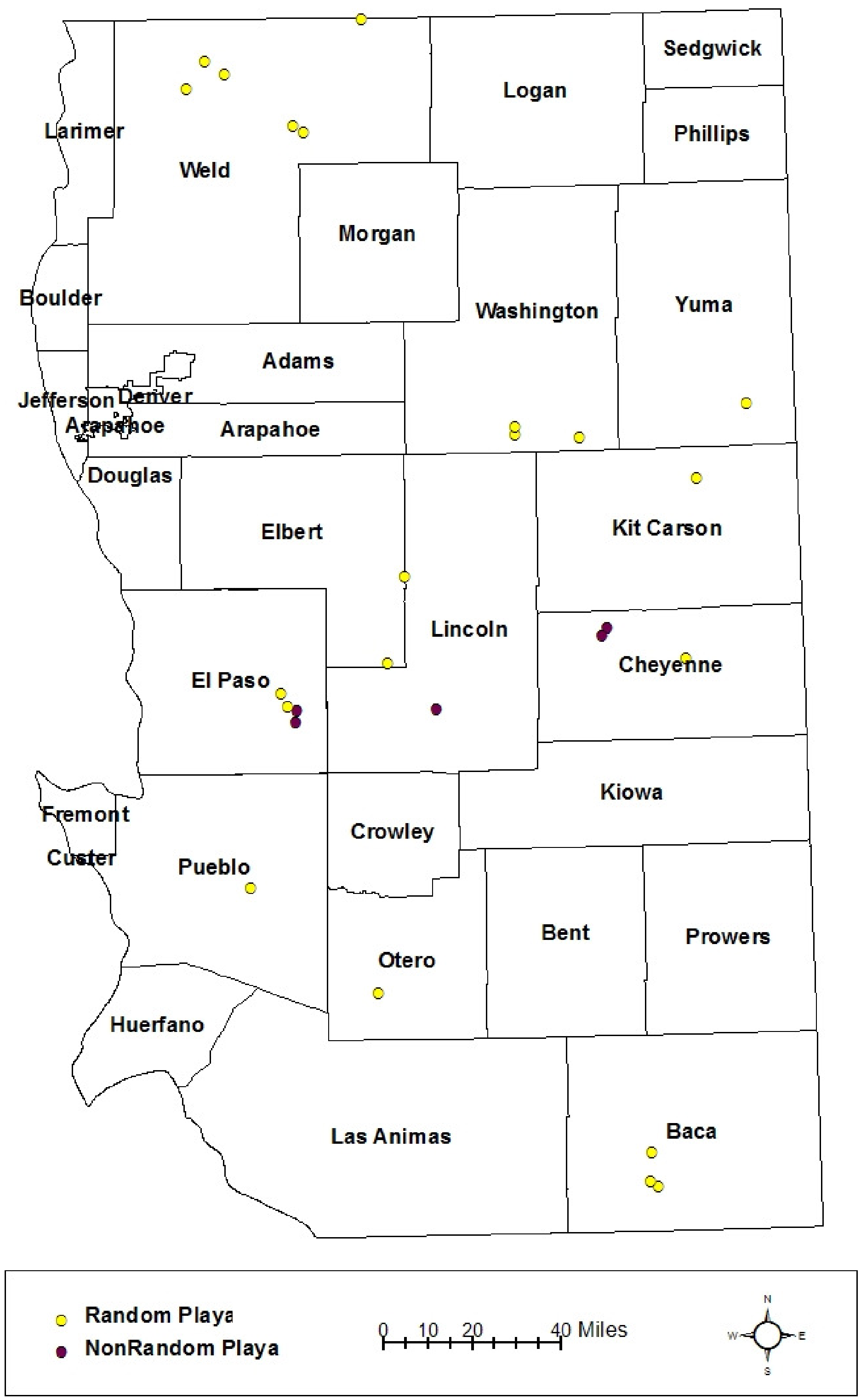

Figure 3-1. Map indicating the location of playas intensively monitored 2004-2005.

Establishing vegetation transects

originating from that point, the first extending along the longest axis of the playa and the second perpendicular to the first. For each transect, we measured the distance from the playa's center to the observable upland interface (Flowers 1996, Rivers 2003). We then added up to 150 m to each transect, depending on the playa's size, to describe the characteristics of the upland immediately surrounding the playa. Transects were divided into 20 equal intervals within the playa and at least 5 intervals in the upland, in order to standardize sampling effort among playas of various sizes. Vegetation sampling yielded a minimum of 40 quadrats per playa and 10 quadrats per upland.

In order to characterize vegetation, we used a 25 x 50 cm plot (Daubenmire 1959), and positioned the long edge of the frame parallel to the transect line. Plots were placed on alternating sides of the transect line to improve the probability of adequately sampling playa heterogeneity. The transect bearing and beginning quadrat side were recorded for each playa to allow repeatability in future years. Within each quadrat we recorded plant composition according to species, percent bare ground, water, litter/crop residue, and cow manure (evidence of grazing). Percent canopy cover was recorded using the following cover classes: 1=0–5%, 2=5–25%, 3=25–50%, 4=50–75%, 5=75–95%, 6=95–100% (Daubenmire 1959). We also noted the occurrence of any vegetation observed in the playa but not captured within the quadrats, to generate a complete species list for each site.

Using the USDA PLANTS database (http://plants.usda.gov/) 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 invasives or noxious weeds. Because some plants were identified only to genus, not all plants were categorized; 50 (63%) and 65 (81%) of 80 plants were classified as annual or perennial and native or introduced, respectively.

We calculated mean percent cover for each species within each playa using cover class midpoints. Data summaries were calculated using MS Access, MS Excel, and JMP® statistical software for Windows. Comparisons of absolute plant cover between years and habitats were conducted using paired t-tests. For all other tests, we analyzed the average from both years and conducted paired t-tests.

Soils

In the first field season, if the playa was dry at the time of the site visit, we dug a single pit within the playa's center to describe soil characteristics. Initial consultation with soil scientists indicated that a single pit would provide sufficient information to characterize the playa soils. We excavated each pit to a depth of about 20 inches. For each soil layer we recorded the depth, texture (e.g., percent sand, silt, clay, and organic matter), Munsell color in the standard sequence of hue, value, and chroma (e.g. 10YR5/2), and presence or absence of hydric features such as oxidized pore linings or redoximorphic features.

Avian and wildlife use

We conducted a five minute survey at the beginning of each playa visit to detect birds and other wildlife using the playa and surrounding upland. In addition, birds or wildlife detected while sampling for vegetation and soil characteristics were also recorded. The species, number, detection type (visual or aural), habitat use (playa, upland, or fly over), and behaviors were recorded for each new detection.

Results

Landowner Contacts and Interviews

In total we completed interviews with 19 private landowners and two public land managers. We found that only six individuals were able to answer all of our questions, 12 were able to answer some of the survey questions, and three were not able to answer any questions. According to our survey, most Colorado farmers till through playas in cropland when they are dry and graze playas in grassland with livestock. We also found that landowners and managers are often aware of the wildlife use on their playas and are generally interested in conservation programs. A few individuals were able to recount playa hydrology throughout the year; however, most interviewees did not visit their playas frequently enough to observe monthly hydrologic patterns.

Vegetation

In total we completed intensive vegetation surveys on 21 randomly selected playas and five non-random playas (Table 3-1). Fifteen playas were visited both in 2004 and 2005, providing the first set of multiyear data from playas within the state. The remaining eleven playas were surveyed only once for a variety of reasons: the waterbody was not a playa, the playa was plowed, was wet at the time of survey, was not randomly selected, or was newly added in 2005.

Table 3-1. Summary data for playas receiving on-site surveys in both 2004 and 2005.

Number	County	Surrounding Landcover	Data Source	Playa Size (Acres)	Survey Date 2004	Survey Date 2005
1	Baca	Prairie	SSURGO	17.8	8/17	8/3
2	Baca	Prairie	SSURGO	6.3	8/17	8/4
3	Baca	Prairie	SSURGO	2.2	8/19	8/5
4	Cheyenne	Prairie	NHD	5.8	9/29	ND
5	Cheyenne	Dryland Agriculture	DU	6.1	ND	9/9
6	Cheyenne	Dryland Agriculture	N/A	>12	9/29	ND
7	El Paso	Prairie	SSURGO, NHD	6.8	7/15	7/28
8	El Paso	Prairie	SSURGO, NHD	6.9	ND	7/27
9	El Paso	Grassland	N/A	<2	6/24	ND
10	El Paso	Grassland	N/A	<2	ND	5/20
11	Elbert	Prairie	SSURGO	4.0	8/31	7/19
12	Elbert	Dryland Agriculture	DU, SSURGO	2.5	7/16	ND
13	Kit Carson	Irrigated Agriculture	DU	4.2	9/23	7/26
14	Lincoln	Prairie	NHD	7.2	ND	7/21
15	Otero	Prairie	NHD	70.5	ND	9/8
16	Pueblo	Irrigated Agriculture	DU, SSURGO	20.3	7/5	9/7
17	Washington	Prairie	DU	3.8	7/6	7/14
18	Washington	Prairie	DU	3.6	ND	8/17
19	Washington	Dryland Agriculture	DU, NHD	9.4	9/1	8/16
20	Weld	Prairie	SSURGO	15.0	ND	8/25
21	Weld	Prairie	SSURGO, NHD	11.1	8/27	8/26
22	Weld	Prairie	SSURGO	21.9	9/17	8/23
23	Weld	Prairie	SSURGO	9.1	8/27	6/13
24	Weld	Prairie	SSURGO	6.3	7/31	8/24
25	Weld	Prairie	SSURGO	5.2	7/29	8/22
26	Yuma	Dryland Agriculture	DU	4.4	9/21	7/15

N/A=Not available; playa was new and therefore not predicted by the GIS.
ND=Data was not collected in that year.

We identified 96 species in the vegetation of sampled playas. A list of all plant species documented during surveys is presented in Appendix B. Mean plant cover did not vary between years within playas (p=.6266) or uplands directly surrounding the playas (p=.5873). Combining years, percent cover averaged 50.0% (±3.38 SE; range 19.5-98.1%) for playas and 55.7% (±3.02 SE; range 23.3-85.4%) in the uplands. Percent vegetative cover did not differ between playas and their surrounding uplands (p=.1404 in 2004; p=.1875 in 2005).

Mean species richness was significantly higher (p=.0007) in playas (12.8±3.37 SE) than in uplands (9.1± 0.52 SE). Annual species represented 37% (± 0.02) of the species within the playas in contrast to 26% (±0.03 SE) of the upland species (p=.0484).

Native plants represented a high percentage of the species in our surveys (82 ± 0.02 SE of playa species; 88 ± 0.03 SE of upland species). Introduced species were more prevalent within the playa basins than in the adjacent uplands (p=.0028). We documented two Colorado noxious weeds, field bindweed (*Convolvulus arvensis*) and cheatgrass (*Bromus tectorum*), in two of the twenty-six playas; however these species had a mean percent total canopy cover of <1 percent.

Facultative or obligate wetland species were observed in 10 playas in 2004 and 14 in 2005 (Table 3-2). Eight playas increased in mean percent cover of wetland species and four decreased; however there was no significant difference in total percent cover of wetland species between years (p=.9409). Overall percent change in wetland species cover averaged 4% with a range of 0-15%.

Table 3-2. Most abundant plant species per playa and surrounding upland, 2004 and 2005.

Playa	Species in Playa (Total % Cover) 2004	Species in Playa (Total % Cover) 2005	Species in Adjacent Upland (Total % Cover) 2004	Species in Adjacent Upland (Total % Cover) 2005
1	Western wheatgrass (54)	Western wheatgrass (21)	Toothed spurge (26)	Western wheatgrass (20)
2	Buffalograss (70)	Buffalograss (22)	Purple threeawn (16)	Meadow barley (12)
3	Spikerush (12)	Frog-fruit (10)	Buffalograss (12)	Buffalograss (38)
4	Russian thistle (15)	ND	Buffalograss (19)	ND
5	ND	Spikerush (28)	ND	Kochia scoparia (10)
6	Goosefoot (11)	ND	Blue grama (18)	ND
7	Goosefoot (18)	Narrowleaf goosefoot (19)	Goosefoot (17)	Blue grama (23)
8	ND	Buffalograss (29)	ND	Blue grama (34)
9	Bouteloua gracilis (18)	ND	Buffalograss (22)	ND
10	ND	Buffalograss (53)	ND	Blue grama (25)
11	Buffalograss (73)	Buffalograss (60)	Buffalograss (34)	Buffalograss (64)
12	Russian thistle (30)	ND	Unknown Forb (56)	ND
13	Kochia (14)	Kochia (14)	Buffalograss (67)	Western wheatgrass (8)
14	ND	Dwarf spikerush (31)	ND	Blue grama (24)
15	ND	Mustard (16)	ND	Western wheatgrass (11)
16	Lambsquarters (7)	Poverty sumpweed (13)	Alkali sacaton (47)	Alkali sacaton (8)
17	Western Wheatgrass (25)	Western wheatgrass (21)	Buffalograss (74)	Buffalograss (20)
18	ND	Spikerush (9)	ND	Meadow barley (5)
19	Western Wheatgrass (25)	Western wheatgrass (22)	Western wheatgrass (20)	Western wheatgrass (12)
20	ND	Narrowleaf goosefoot (5)	ND	Sedge (18)
21	Western wheatgrass (9)	Spikerush	Western wheatgrass (42)	Buffalograss(16)
22	Buffalograss (30)	Buffalograss (25)	Buffalograss (26)	Buffalograss(32)
23	Buffalograss (36)	Western wheatgrass (13)	Blue grama (26)	Sedge (19)
24	Bursage (11)	Skeletonleaf bursage (13)	Buffalograss (30)	Buffalograss (21)
25	Western wheatgrass (14)	Buffalograss (40)	Spikerush (24)	Sedge (18)
26	Spikerush (8)	Western wheatgrass (15)	Spikerush (24)	Blue grama (23)

ND= No data.

Soils

In the first field season we collected information on soil characteristics for playas in nine counties (Table 3-3). Every playa that was analyzed for texture contained a clay component. Soils were generally dark with value/chroma reading at or below 3/2 and six playas had obvious hydric features. Three playas were recently tilled but one still had two distinct layers. The depth of the A layer ranged between 2 in and 20 in, often without an obvious organic layer. Because of low variability among playas, the presence of a clay component for almost all playas surveyed, and the amount of field time required to conduct soil characterizations, we did not continue soils investigations in 2005.

Table 3-3. Soil characteristics of 24 dry playas.

County	Upland Landuse	Depth (in)	Horizon	Munsell Color (wet)	Texture	Structure	Hydric Features
Baca	Prairie	0-20	A	10YR 3/2	ND	Blocky	No
Baca	Prairie	0-3.5	A	10YR 3/2	Silty Clay Loam	Blocky	No
		3.5-7.5	B	10YR 3/2	Sandy Clay Loam	Blocky	No
		7.5-18	C	7.5Y 2.5/1	Silty Clay	Blocky	No
Baca	Prairie	0-3	A	10YR 3/2	Sandy Clay	ND	No
		3-14+	B	10YR 3/2	Silty Clay	ND	No
Baca	Dryland, Irrigated Agriculture	0-12.5	A	10YR 3/2	Sandy Loam	ND	No
		12.5-21	B	10YR 2/1	Silty Clay	ND	No
Baca	Irrigated Agriculture	0-4	A	10YR 2/2	Sandy Clay	ND	No
		4-16	B	10YR 3/1	Sandy Clay	ND	No
Cheyenne	Prairie	0-3	O	ND	ND	ND	No
		3-18	A	2.5Y 3/1	Silty Clay	Blocky	No
Cheyenne	Prairie	0-3	O	ND	ND	ND	No
		3-20	A	10YR 3/1	Silty Clay	ND	Yes
Elbert	Prairie	0-18	A	2.5Y 3/1	Clay	Prismatic	No
Elbert*	Dryland Agriculture	0-14	A	2.5Y 3/1	Silty Clay Loam	ND	Yes
		14-19	B	2.5Y 3/1	Clay	ND	No
El Paso	Prairie	0-3.5	A	10YR 3/1	Clay Loam	Blocky	No
		3.5-15	B	2.5Y 3/1	Sandy Clay	Granular	No
El Paso	Prairie	0-1	O	ND	ND	ND	No
		2-6	A	10YR 3/2	Sandy Clay Loam	ND	No
		6-11	B	7.5YR 3/1	Clay Loam	Blocky	No
		11-19	C	10YR 3/1	Clay	Prismatic / Blocky	No
Kit Carson*	Prairie, Irrigated Agriculture	0-20	A	2.5Y 2.5/1	Silty Clay	None	No
Pueblo	Prairie, CRP	0-15	A	2.5Y 5/2	Clay	Prismatic / Blocky	Yes
Washington	Prairie	0-2	O	ND	ND	ND	No
		2-18	A	2.5Y 3/1	Clay	Blocky	No
Washington	Prairie	0-4	A	10YR 4/1	Silty Clay	ND	No
		4-20	B	2.5Y 2.5/1	Silty Clay	Prismatic / Blocky	Yes
Washington*	Dryland Agriculture	0-20	A	10YR 3/1	Silty Clay	Massive	No
Weld	Prairie	0-8	A	10YR 3/2	Clay Loam	Blocky	Yes
		8-21	B	10YR 3/3	Sandy Loam	Massive	Yes
Weld	Prairie	0-13.5	A	2.5Y 4/1	Clay	ND	No
Weld	Prairie	0-3	A	2.5Y 3/1	Silty Clay	ND	No
		3-14+	B	2.5Y 4/1	Clay	ND	No
Weld	Prairie	0-3	A	10YR 4/2	Silty Clay	ND	Yes
		3-6	B	10YR 3/2	Silty Clay	Blocky	Yes
		6-11	C	10YR 3/2	Silty Clay	Blocky	Yes

Table 3-3. Soil characteristics of 24 dry playas (cont'd.)

County	Upland Landuse	Depth (in)	Horizon	Munsell Color (wet)	Texture	Structure	Hydric Features
Weld	Prairie	0-6	A	10YR 3/2	Clay	ND	No
		6-20	B	2.5Y 5/3	Sand	Massive	No
Weld	Prairie	0-3	O	ND	ND	ND	No
		3-20	A	2.5Y 2.5/1	Clay	Prismatic / Blocky	No
Weld	Prairie	0-9	A	10YR 3/1	Silty Clay	Blocky	No
		9-21	B	10YR 4/1	Silty Clay	Blocky	No
Yuma	Prairie, Dryland and Irrigated Agriculture	0-2	O	ND	ND	ND	No
		2-20	A	10YR 3/1	Clay	Blocky	No

ND = No Data.
*=Playa recently plowed

Avian and Wildlife Use

We observed a total of 50 avian species during our site visits. Several species were observed using both playas and the surrounding uplands. Forty-one species were found in playas and 24 in the surrounding uplands. Seventeen of these species were shorebirds, waterfowl, wading birds, and other waterbirds; the remaining 33 were landbirds (Appendix C). In addition we commonly encountered several other species of wildlife including black-tailed jack rabbit, coyote, horned lizard, spadefoot toad, Woodhouse's toad, lesser earless lizard, snakes, damselflies, butterflies, and clams.

Discussion

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 Colorado 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 96 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 spans only a small portion of the PLR. In addition, we expect that the species list may increase with the greater number of playas to be sampled in Phase II of this project.

Like rangeland playas in other regions that receive minimal runoff from irrigation, the majority of the playas we surveyed were dominated by perennial grasses, such as western wheatgrass (*Pascopyrum smithii*) and buffalograss (*Buchloe dactyloides*) (Haukos and Collins 1997). Similarly, in a study of Kansas playas, western wheatgrass was the second-most dominant plant after spikerush in playas surrounded by grassland (Wilson 1999). This contrasts to the findings of Haukos and Smith (2002), who in their survey of the PLR, found that annual plants were dominant in playas, whether the playas were surrounded predominantly by cropland or by grassland.

Most playas we sampled contained at least one wetland obligate or wetland facultative species, and three playas were dominated by species in these wetland indicator classes. Thus, Colorado playas are also supporting hydrophytic vegetation and the associated wetland functions. Given the persistence of dry conditions in Colorado over the last several years and that we deliberately selected dry playas for vegetation surveys, the presence of wetland plants is significant.

Like Reed (1930), we found that playa vegetation composition differs from the surrounding upland. We found that annuals were more abundant and that species richness was higher in the playa than the surrounding upland, although further analysis will be required to ensure that this is not a relict of greater sampling effort within the playa basin. This juxtaposition of plant communities between playas and grassland increases regional and local biodiversity (Hoagland and Collins 1997).

In Colorado playas, total percent cover was made up of more perennials than annuals. This contrasts with the findings of Haukos and Smith (1993), who found that the seed banks of playas with cropland watersheds were dominated by annuals. However, this fits with the finding that more annuals were found in playas surrounded by cropland than grassland (Haukos and Smith 2002).

Native plant communities within and among playas have been degraded or eliminated due to intensive grazing or cultivation in much of the PLR (Haukos and Smith 2004). In Colorado, introduced species accounted for 18% of the species list in playas. However, only two Colorado noxious plants were observed during our surveys, comprising less than one percent cover.

Because only 63-81% of our species were classified as to duration of life cycle (i.e., perennial) and nativity, our results regarding the greater number of annuals and invasives within the playas in comparison to the uplands should be considered exploratory. In future phases of this work, we emphasize the identification of all plants to species and will collaborate with regional botanists to classify all plants in our surveys with regard to life cycle and nativity. In addition, once all species have been classified, we can better compare the attributes of the flora using cover data.

Functioning playas support plant communities that readily adapt and respond to changes in hydrology. Dry playas are characterized by plant species more commonly found in surrounding uplands, including species of the native prairie (Haukos and Smith 2004). Haukos and Smith (1997) have shown that the primary variable driving plant species composition is the length of time the playa is inundated with water. Our data, the first multi-year study of Colorado playas, did not show significant difference in mean percent canopy cover of all plants or of wetland species between years. However we did detect shifts in species dominance from upland to wetland plants between years. For the next phases of this research, we will apply rainfall data to better relate playa hydrology to vegetation responses, and explore the application of rainfall data into our sampling scheme. We will also sample two times per growing season, based on the recommendations of Haukos and Smith (2001), who found that based on germination patterns from seed banks, playa plant community composition would be expected to change in composition over the course of a growing season.

Like playas in other areas, we confirmed that most playas in Colorado have characteristic clay soils. Clay soils contribute to playa hydrologic function by impounding water and are vital to many functions of playas, such as recharging ground water and providing habitat for migratory birds and other wildlife (Smith 2003).

We found that Colorado playas provide important avian habitat. The playas we sampled generally lacked dense vegetation, with bare ground accounting for nearly 50% cover in both years. This open habitat is favored by migrating shorebirds, which prefer habitats with vegetative cover less than 25% (Helmers 1993). 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 in the playa basins than the surrounding upland. Based on their analysis of Northern Pintail crop contents, Sheeley and Smith (1989) found that barnyard grass, curly dock, spikerush, and smartweed were important food resources for migratory birds. Although in low numbers, we observed all of these plants during surveys. 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).

We observed a diverse suite of bird species using playas during our intensive surveys. As would be expected, bird use of dry playas was less than that of wet playas but we did observe bird species of conservation significance using dry playas, including Mountain Plover, a Colorado species of concern which selects for barren soil when nesting. On wet playas, we observed 13 species of shorebirds and 5 species of waterfowl with American Avocet and Blue-winged Teal being the most common. In addition, we observed species such as Chestnut-collared Longspur, Mallard, and Wilson's Phalarope, each of which is of conservation concern within their respective continental bird conservation plans. A study of four species of shorebirds using playa lakes in Texas during migration found that they spend most of their time foraging, further supporting the idea that playas are important stopover locations for migrating shorebirds (Davis and Smith 1998). Further investigation of bird use and other values such as floral diversity in association with dominant land use is a high priority, and will be incorporated into future phases of this study.

In addition to collecting baseline data we formed professional relationships with multiple landowners. Because over 90% of playas in eastern CO are located on private land, these relationships are invaluable to the conservation of playas. We found that landowners and managers are generally interested in conservation, playas, and wildlife using their land. Landowner interviews revealed that some playas in Colorado have been dry for at least 10 years. However, many of the landowners could not provide details regarding the past hydrology of their playas. Thus, to characterize playa hydroperiods, we suggest utilizing a combination of rainfall data and ground truthing to better understand playa hydrology.

CHAPTER 4. AVIAN USE OF PLAYAS DURING MIGRATION

The numbers, species composition, and chronology of bird use of wet playas during migration has not been documented for this region. This information will directly support bird population objectives and benefit habitat conservation efforts undertaken by the PLJV, CDOW, and other partners. To gain a better understanding of how playas that fill with rainfall support migratory bird populations, we conducted repeat visits to wet playas during the migration seasons of 2005 and 2006 to determine use by shorebirds, waterfowl, and other birds.

Methods

We focused our monitoring efforts on areas that had recently received heavy rainfall and therefore where we expected to find playas containing standing water. In the weeks preceding and during fieldwork, we used daily rainfall data from Next Generation Radar and local rain gauges (http://www.srh.noaa.gov/rfcshare/ precip_download.php) to identify areas that received at least 2 in. of rainfall within a 24 hour period or 4 in. within a week. These thresholds were estimated to be sufficient to pond water for several weeks in most playas, as determined using best professional judgment in consultation with other wetland scientists familiar with playas.

We then mapped possible playas in the high rainfall areas and surveyed all wet playas within a distance of the road from which waterfowl and shorebirds could be distinguished. Surveys were repeated every 7 to 10 days for as long as playas contained standing water or moist soil within the migratory season (surveys finished November 10). In addition, every seven to ten days, we surveyed reservoirs within 20 miles of the edge of heavy rainfall areas.

Surveyors used a spotting scope placed along the roadside to visually identify and count all birds using the playa and the upland within 100 m of the playa edge; any aural detections also were recorded. Bird data collected included species, habitat, activity, and when known, sex and age class. In addition, we employed our roadside survey protocol (Chapter 2) to gather basic information on the playas and surrounding land use. To better understand habitat availability we also estimated the percent of the playa basin covered by the following categories: dry mud, dry mud vegetated, wet mud (saturated), wet mud vegetated, and standing water (inundated).

Lesser Yellowlegs

We entered into RMBO's *MS Access* Colorado Playa database and summaries were calculated using *MS Access*, *MS Excel*, *JMPin*® statistical software for Windows (SAS Institute Inc. 2001), and R Statistical Software (R Foundation for Statistical Computing).

We estimated the hydrology period for the dry sites by first calculating the midpoint of the date between the second-to-last survey and the last, and then subtracting the date of the first survey from this quantity. We excluded one site because there was a substantial gap in the time between surveys (25 days instead of 7 or 8 days). For playas that were never observed as dry but were sampled at least four times, we used the number of days between the first and last surveys (sampling period) to represent minimum hydroperiods.

To summarize bird use, we first averaged all surveys at each playa and then present the means and errors for averages across playas. To test for differences in bird use among playas, we transformed the data with log +1 to meet assumptions of normality. We used analysis of variance to compare bird use on playas in the two dominant land uses, restricting analysis to playas surveyed at least three times and surrounded exclusively by grassland (n = 43) or farmland (n = 37). We used linear regression to assess bird abundance in relation to percent wet habitat on playas. When analyzing bird densities we further restricted the analysis to playas with 6 or more surveys.

Results

Playa Surveys

Between September 14, 2005 and November 10, 2006, we conducted 851 visits to 247 playas. Because we were piloting protocols in the fall of 2005 and few playas were wet in the spring and early fall of 2006, we limit our data summary in the following section to surveys conducted between September 12 and November 10, 2006. These playas were surveyed an average of 4.2 times (± 0.20 SE). Excluding the 42 playas that were surveyed only once, playas were surveyed for an average duration of 32.5 days (± 1.39 SE). The average time between surveys was 8.0 days (± 0.10 SE). The number of surveys per playa is depicted in Fig. 4-1. We further limit our analysis of bird use to playa visits with wet conditions (at least 5% cover by water or mud). This yielded 688 visits to 171 playas. The distribution of playas surveyed for fall migration 2006 is portrayed in Figure 4-2.

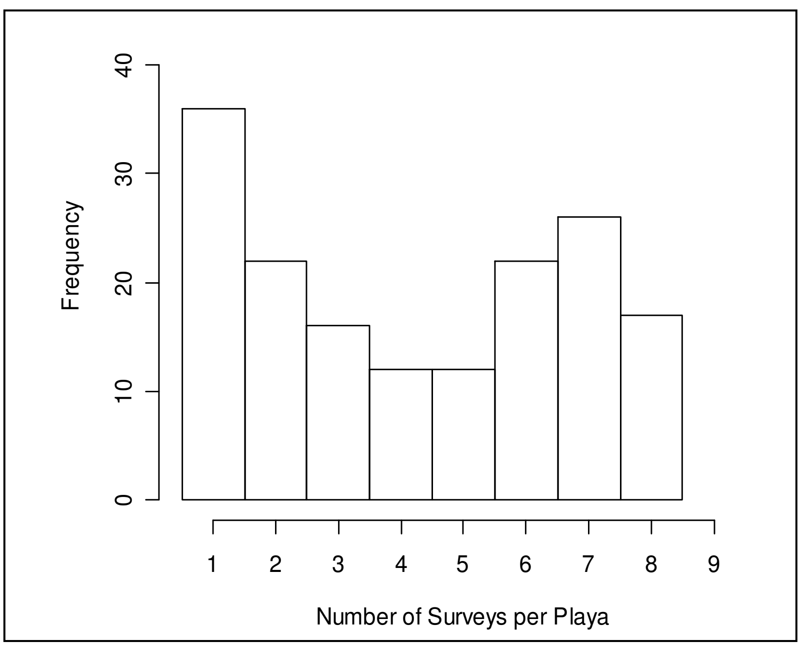

Figure 4-1. Frequency of playas by number of repeat surveys September-November 2006.

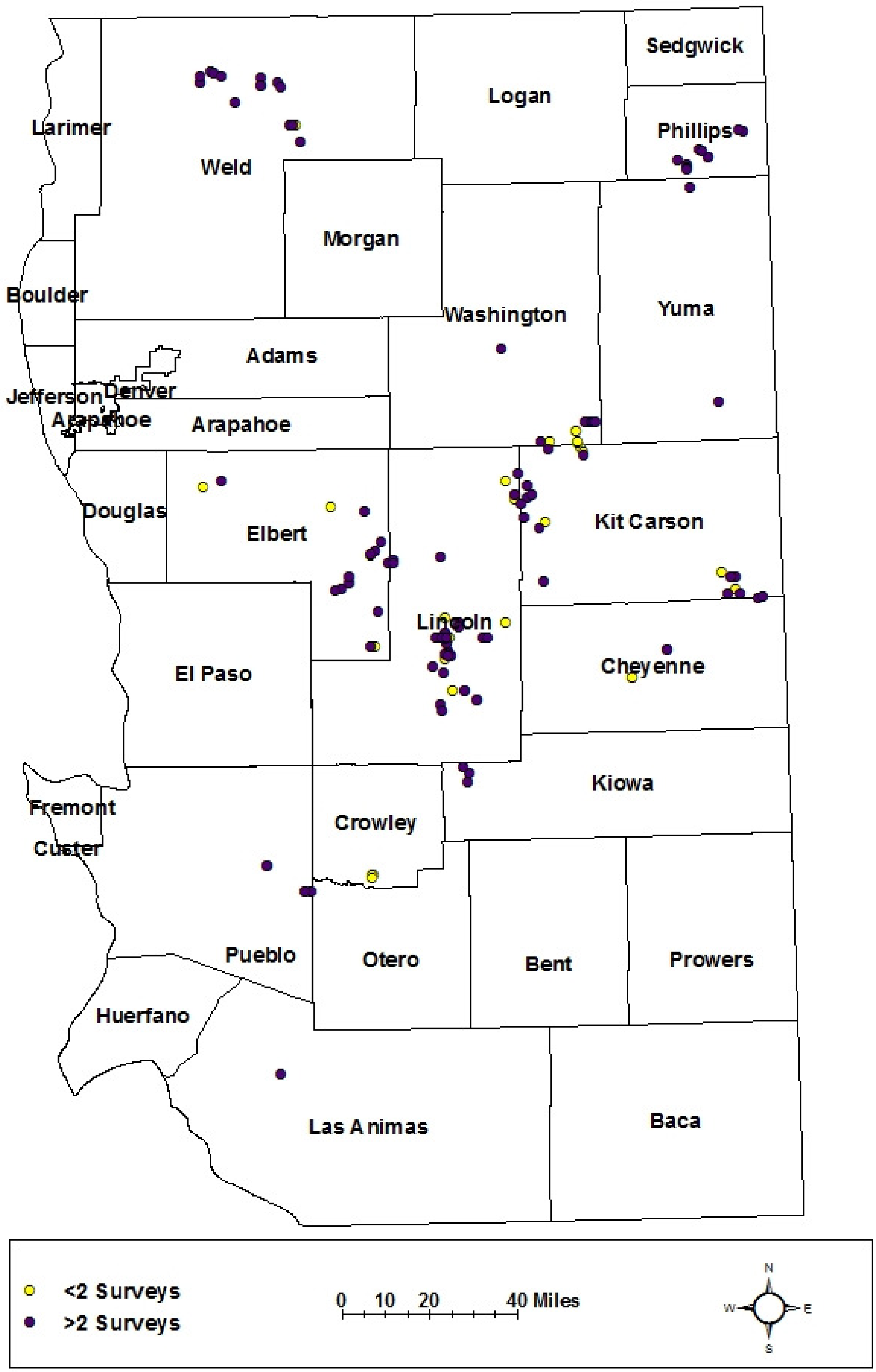

Figure 4-2. Map indicating the location of wet playas monitored during fall migration 2005-2006.

Playa Hydrology

Playas for which a complete hydrology period was observed (i.e., the playa was dry on the final survey), the average hydrology period was 25.9 days (±5.92 SE). Three playas had hydroperiods less than ten days and seven had periods greater than twenty days.

For another 82 playas that were never observed as dry but were sampled at least four times, the number of days between the first and last survey dates (sampling period) was used to represent minimum hydroperiods. The average sampling period for these playas was 40.9 days (± 1.12 SE); the maximum was 57. Thus, some playas supplied wetland habitat for the entirety of the late migration season. The distribution of minimum hydroperiod for these sites is depicted in Fig 4-3.

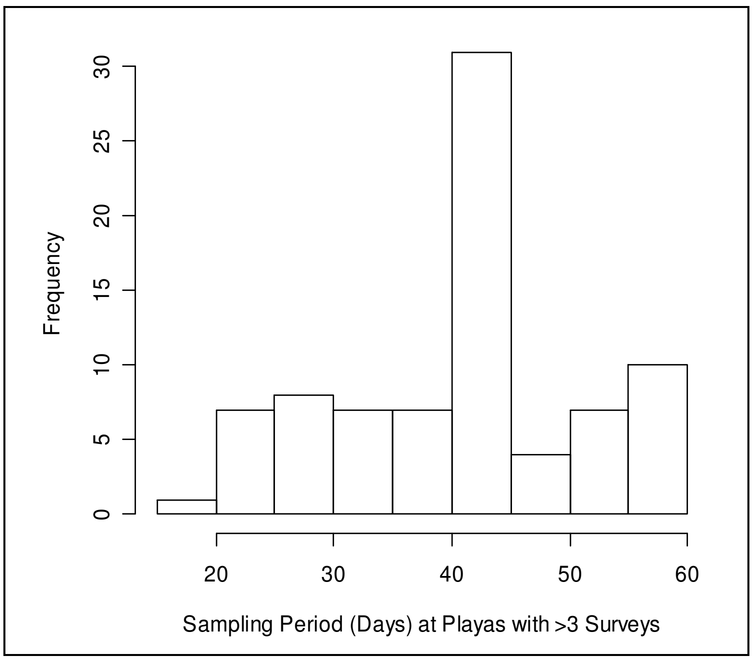

Figure 4-3. Minimal hydroperiods as estimated from playas surveyed at least four times in fall 2006.

The percent wet habitat averaged across all visits to each playa is illustrated in Figure 4-4. The average percent wet habitat for all playas was 73% (± 1.55 SE); excluding dry visits, the average is 74% wet habitat (± 1.47 SE).

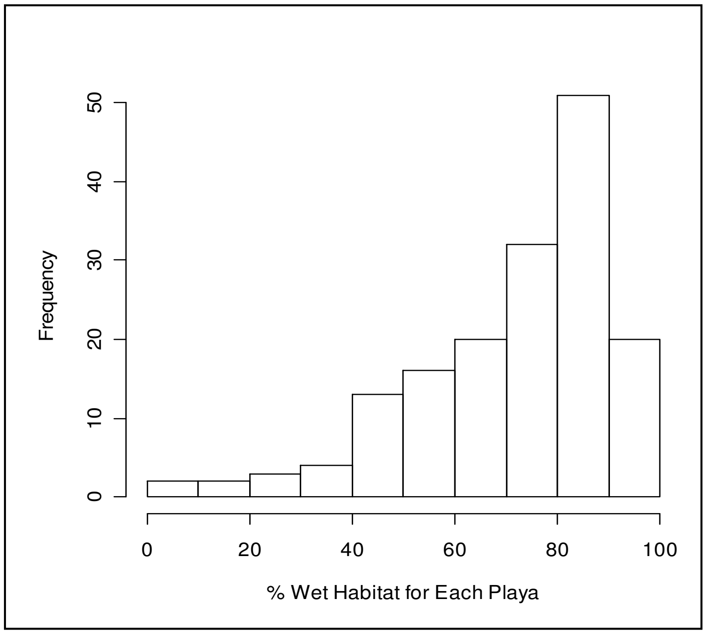

Figure 4-4. Average percent wet habitat for playas surveyed in fall 2006.

Avian Use

During 2006 migration surveys we observed 95 bird species using wet playas, including 16 shorebird, 20 waterfowl, 10 other waterbird, and 49 landbird species (Appendix C). The species recorded in the greatest number was Horned Lark (n=8,130), followed by Sandhill Crane (5,509), Green-winged Teal (4,565), Mallard (2,992) and Chestnut-collared Longspur (1,960). The highest species richness for a single playa visit was 23, with species richness averaging 2.79 (± 0.15 SE) across all surveys. When restricted to only playas surveyed at least three times and surrounded exclusively by grassland (n = 43) or farmland (n = 37), average species richness did not significantly differ among the two dominant land uses ($\chi^2 = 1.76$, p = 0.19).

We documented 42,863 birds using playas. No birds were recorded on 76 visits (11% of all visits) to 62 playas. The average number of birds counted per playa visit was 46.19 (± 7.67 SE). Five surveys yielded over 1,000 birds, with a high count of 4,435. Two playas averaged over 500 birds across all surveys (surveyed 7 and 8 times, respectively). Eighteen playas (11% of all playas surveyed) received no bird use, but 15 of these were only visited once and the remaining three were only visited twice. The majority of birds detected through the season were waterfowl, followed by landbirds (Figure 4-5).

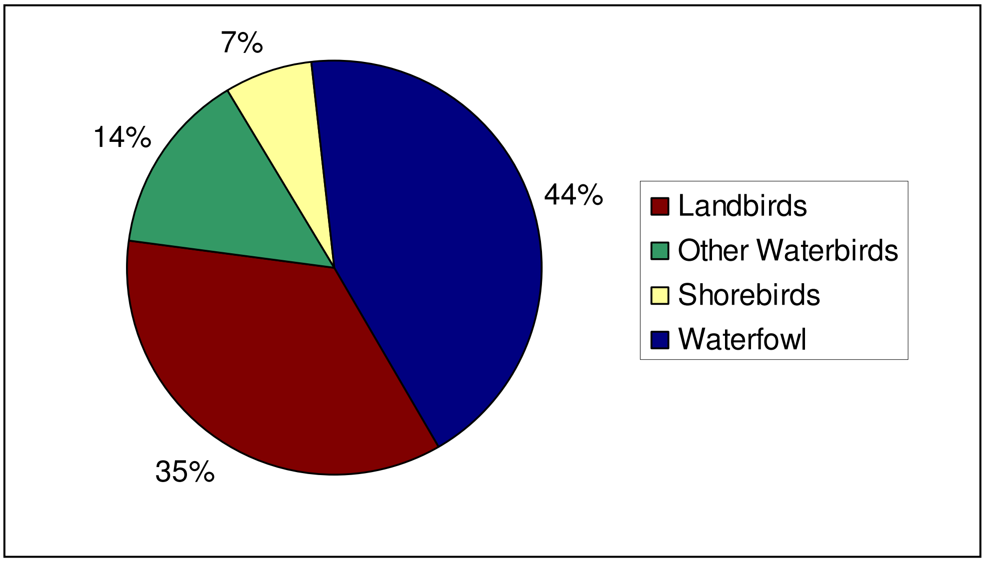

Figure 4-5. Proportion of all birds by taxonomic group surveyed on wet playas in fall 2006.

There was a trend for the mean number of birds per survey to be slightly higher in playas surrounded by farmland than in grassland playas ($F_{1,78}$=2.72, p = 0.10). Landbird abundance also tended to be higher in farmland playas ($F_{1,78}$=3.12, p = 0.08); other waterbirds showed the same pattern ($F_{1,78}$=2.96, p = 0.08). Abundances of shorebirds and waterfowl did not differ between playas in the two dominant land uses (p > 0.40). All categories of birds responded positively to the percent wetland habitat in playas (Table 4-1).

Table 4-1. Relationship between avian abundance and percent wet habitat in playas.

Taxonomic Group	Intercept	Coefficient	R^2	F	p
All Birds	1.61	0.03	0.13	16.04	< 0.01
Landbirds	1.83	0.01	0.05	5.26	0.02
Shorebirds	0.1	0.01	0.06	6.71	0.01
Waterfowl	-0.2	0.02	0.06	6.27	0.01
Other Waterbirds	-0.58	0.02	0.07	7.65	< 0.01

As habitat availability (percent wet) increased the abundance of shorebirds and waterfowl using the playas also increased (Fig 4.6 and Fig. 4.7). Average size of the playas surveyed was 3.68 hectares (± 0.56 SE). On average, habitat available for shorebird, waterfowl and other waterbird species during surveys (at least 5% cover by water or mud) was 2.78 hectares (± 0.41 SE). The average density of shorebirds was 3.2 per hectare (± 0.52 SE) and the average density of waterfowl was 13.62 per hectare (± 2.94 SE).

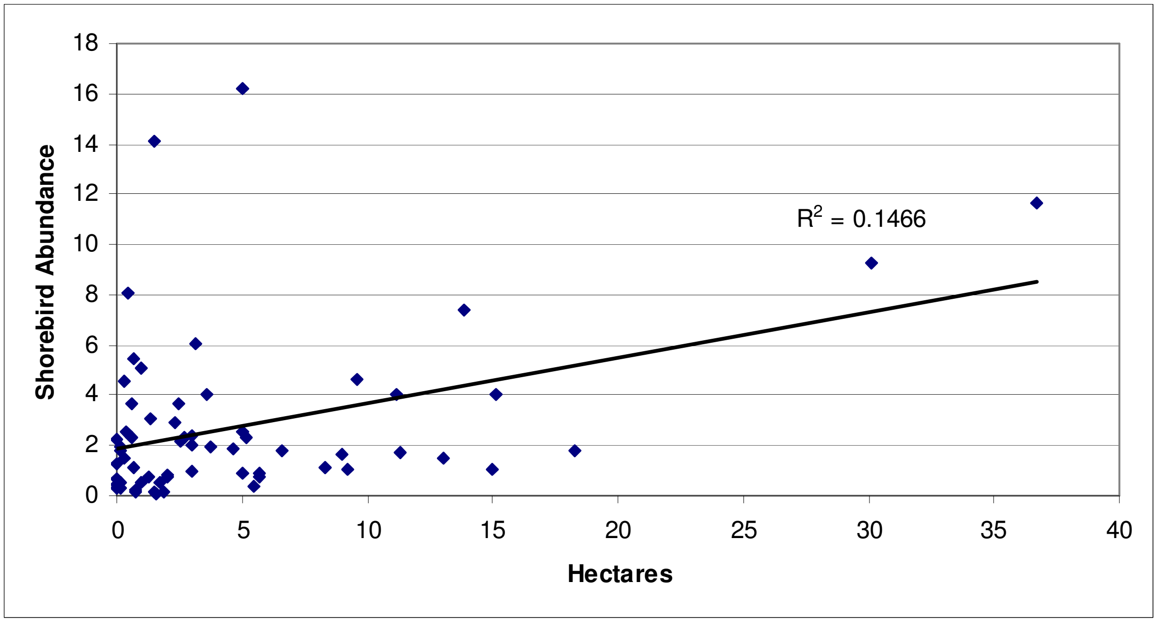

Figure 4-6. Shorebird abundance in relation to percent wet habitat available within the playas surveyed, fall 2006.

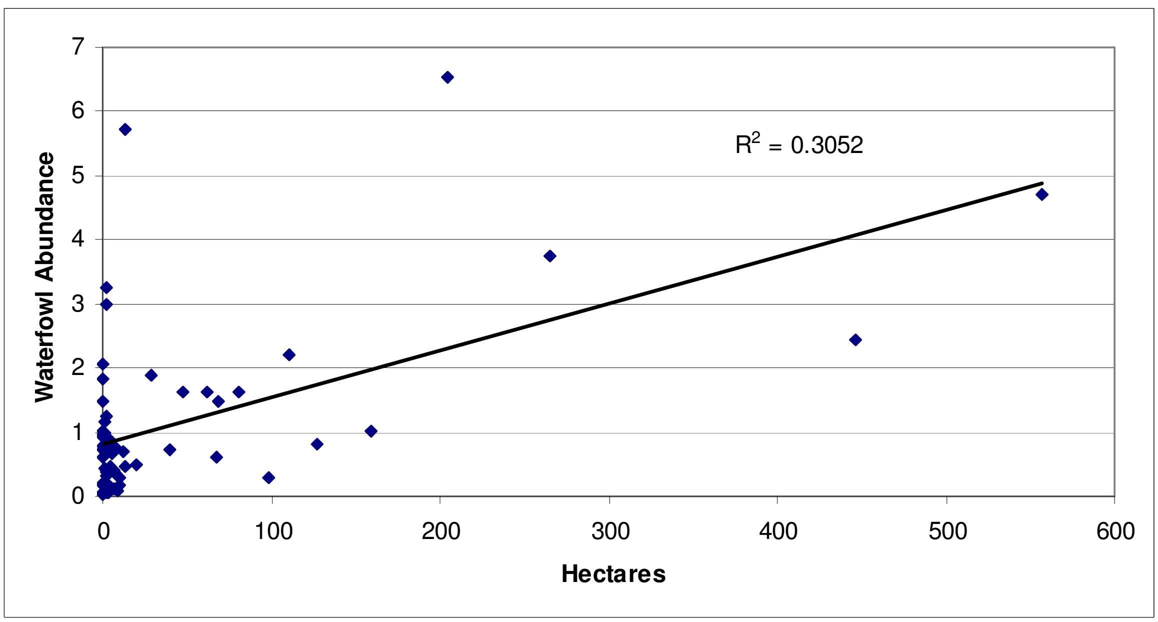

Figure 4-7. Waterfowl abundance in relation to percent wet habitat available within the playas surveyed, fall 2006.

The average number of shorebirds peaked in week 39 (September 30) and declined to 0 in week 45 (November 10; Figure 4-8).

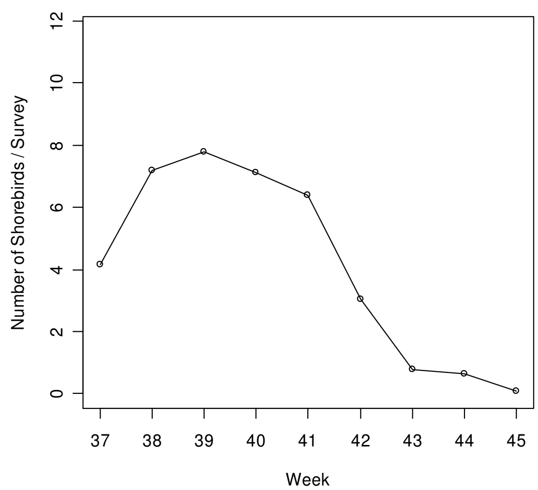

Figure 4-8. Average numbers of shorebirds per playa survey, by week, fall 2006.

Waterfowl numbers were more variable week to week, with peak numbers in week 44 (November 3) without showing a strong temporal pattern across weeks (Figure 4-9).

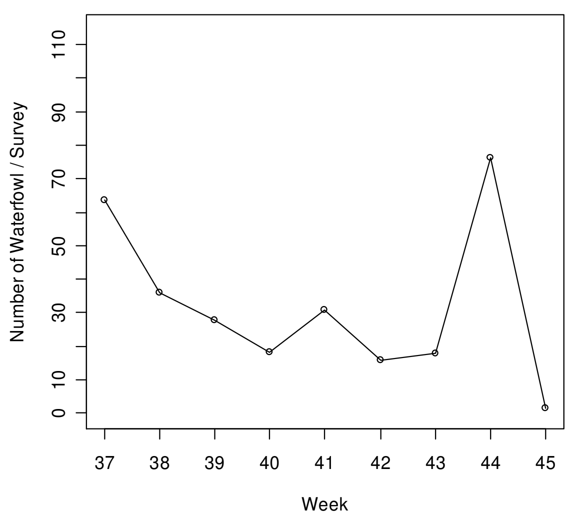

Figure 4-9. Average numbers of waterfowl per playa survey by week, fall 2006.

A total of 4197 birds (10% of all birds) were not identified to species, mostly similar species that can be difficult to distinguish. 2,919 of these were Snow Goose or Ross's Goose, lumped as white geese. 856 were Cinnamon Teal or Blue-winged Teal, which can look similar in fall plumage. 18 were either Lesser or Greater Yellowlegs. Nine birds were either Long-billed or Short-billed Dowitchers. 218 were either Chestnut-collared or McCowan's Longspurs.

A number of species of conservation interest were observed using playas during both years of migration surveys, including four Colorado Species of Concern: Mountain Plover, Peregrine Falcon, Ferruginous Hawk, and Sandhill Crane (CDOW 2006). Waterfowl species ranked high to moderately-high priority at the continental level included Northern Pintail, Mallard, Cinnamon Teal, Blue-winged Teal, American Wigeon, and Redhead (NAWMP 2004). Mountain Plover is designated as Highly Imperiled and American

Golden-Plover is a species of Special Concern under the United States Shorebird Conservation Plan (USSCP 2004). An additional seven shorebird species are Priority Species for the Central Plains/Playa Lakes region (USSCP 2004). Passerines of regional concern under the Partners in Flight (PIF) program include Cassin's Sparrow, Lark Sparrow, and Chestnut-collared Longspur; McCown's Longspur is a PIF species of Conservation Concern and Continental Stewardship.

Discussion

The importance of playas in the Rainwater Basin and in the High Plains of Texas has been well-documented (Smith 2003). However, until this study, migratory bird use of mid-latitude (approximately 40º) playas in the western portion of the Central Plains was relatively unstudied. For instance, until this study, we had little information regarding the time a playa remains inundated following a major rain event. In September 2006, after a prolonged dry period, playas filled by rainfall held water for over 40 days. Some playas were still holding water in 50 days after inundation. Our work over three years suggests that rainfall patterns are highly variable in this region, but that a large enough rainfall event can provide substantial quantities of wetland habitat even following drought.

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 (Skagen and Knopf 1993, Skagen and Knopf 1994a). Playas have been shown to provide an important food source for species such as the Green-winged Teal (Anderson et al. 2000), the most commonly observed waterfowl species in our study.

Bird abundance on a particular wetland on a particular occasion is influenced by external factors such as timing during the migration season, large-scale weather patterns, proximity to other wetlands, as well as on-site conditions such as water depth and vegetation composition (Austin et al. 2002). In addition, we found that average waterfowl and shorebird abundance was tied to the percent habitat available within the playa. The most abundant birds in our study were waterfowl, which may be driven by the time of year we sampled most intensively. In July, August, and September, when shorebirds are migrating, very few playas were wet in Colorado, and we could not conduct many surveys. Rain in early September provided wetland conditions for the later half of the migration season, when waterfowl are most numerous.

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 we studied in eastern Colorado in fall. Furthermore, migrating shorebirds have been shown to select for shallow, sparsely vegetated wetlands with substantial mudflats (Colwell and Oring 1998), a condition observed on many of our playa surveys. However, we did not observe high numbers of shorebirds on our sites; this is most likely attributed to our lack of surveys in August and early September because playas were dry. Indeed, Andres (2007) found that shorebird numbers on reservoirs along the South Platte River within our study area peaked in late August-early September.

Skagen and Knopf (1994a) have found that shorebirds are able to locate and use wetlands as they become available. We also found that shorebirds and waterfowl found and utilized at least some of the playas within days of their initial inundation.

Highly variable use of playas observed in our study indicates that although migrating birds may pass through the area in somewhat consistent numbers, they may occur sporadically in large flocks. Waterfowl were more variable in numbers than shorebirds, which may indicate travel in larger flock sizes.

We found that landbirds and other waterbirds were more abundant in playas surrounded by farmland than in grassland playas, although we did not observe these trends for shorebirds or waterfowl. We will investigate through further analysis which species were exhibiting these trends. We will also analyze in a multivariate model the influence of playa size, distance from roads, and proximity to other wetlands in conjunction with time of year, dominant landcover, and on-site vegetation characteristics on use by different bird species.

CHAPTER 5. FUTURE DIRECTIONS

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 2007, we are continuing fieldwork, statistical analyses, and spatial modeling.

Our fieldwork this year will focus primarily on the floral composition of playas. To better understand the wetland values of playas, we will explore the relationship between the newly developed Floristic Quality Assessment (FQA) tool for Colorado developed by Colorado Natural Heritage Program and wildlife habitat values as determined by bird surveys. We will apply the FQA to playa wetlands to explore the seasonal variation in FQA scores in playas and relate playa FQA scores to measures of disturbance. We will also analyze how land use practices affect FQA scores and wildlife habitat values.

We will also continue our ongoing surveys of playas receiving restoration practices in eastern Colorado, by working with the Colorado Wetlands Partnership's Prairie and Wetlands Focus Area. We document playa conditions before restoration as well as track changes in vegetation and hydrologic conditions through time. This work should assist conservation partners in determining how to allocate their limited habitat restoration resources.

This year we will investigate the relationship of surrounding land use and on-site characteristics of playas to bird use through statistical analyses and spatial modeling. We are particularly interested in the interaction between rainfall, hydroperiod, surrounding land use, playa vegetation characteristics, and use by migrating shorebirds and waterfowl. We will also analyze the vegetation data collected in 2006.

In addition, we will also apply intensive effort to finalizing our estimate of the number of playas in our study region. In our initial years of study, we confirmed playas at about 55% of the locations predicted by our GIS model. Approximately 25% of the potential playa locations we visited were designated as "no visible playa." Because our field experience indicates that playas may be evident in one month and not another, we have been conservative in reassigning these locations an "undetermined" status. In the upcoming months, we will combine analyses of GIS data, aerial imagery, and field visits after rainfall events to attempt classification of "undetermined" potential playa locations. In addition, because, we found many playas during our field efforts that were not predicted by the initial GIS model in our first two seasons, in 2006 we implemented a more systematic approach to locating playas. We will analyze the survey data derived from these sample grid locations to generate a more robust index of the number of playas that are missing from the GIS model throughout the study area.

It is our intention that the findings of our study support the conservation programs for these valuable wetlands and assist conservation partners in planning strategically for their restoration and ongoing protection.

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APPENDIX A

REPRESENTATIVE PLAYA PHOTOS

*Note: Photo records from all photos taken during roadside or on-site visits are on file and available from RMBO upon request. Photos taken of sites owned by private landowners will be shared following approval from landowner.

The following photos depict common playa landscape setting and conditions in eastern Colorado.

Farmed playas.

Bermed playa (top) and pitted playa (bottom).

Grazed playa (top) and playa bisected by power line (bottom).

Playas bisected by roads.

Waterbodies identified by the initial GIS model which were found to not be playas.

APPENDIX B

PLANT SPECIES DOCUMENTED ON EASTERN COLORADO PLAYAS, 2004-2005

Common Name	Scientific Name (Weber)[1]	Scientific Name (USDA PLANTS)[2]	Region 5 Wetland Indicator Status[3]	Documented in Playa	Documented in Upland	2004 Sites (N)	2005 Sites (N)
Redroot pigweed	*Amaranthus retroflexus*	*Amaranthus retroflexus*	FACU	x		2	2
Amaranth/pigweed	*Amaranthus sp.*	*Amaranthus sp.*		x		1	
Slimleaf bursage		*Ambrosia acanthicarpa*		x	x		5
Woollyleaf bursage, woollyleaf	*Ambrosia grayi*	*Ambrosia grayi*	FAC	x	x	5	6
Streaked burr ragweed	*Ambrosia linearis*	*Ambrosia linearis*			x	1	
Bursage, Burr ragweed	*Ambrosia sp.*	*Ambrosia sp.*		x	x	3	2
Skeletonleaf bursage,	*Ambrosia tomentosa*	*Ambrosia tomentosa*		x	x	5	6
Dogbane	*Apocynum sp.*	*Apocynum sp.*		x		1	
Purple threeawn	*Aristida purpurea*	*Aristida purpurea*		x	x	4	1
Threeawn	*Aristida sp.*	*Aristida sp.*		x	x		7
Carruth's sagewort	*Artemisia carruthii*	*Artemisia carruthii*			x	1	
Fringed sagebrush	*Artemisia frigida*	*Artemisia frigida*		x	x	1	3
Aster	*Aster sp.*	*Aster sp.*		x	x	2	3
Pea	*Astragalus*	*Astragalus sp.*		x		1	
Sideoats grama	*Bouteloua curtipendula*	*Bouteloua curtipendula*			x	1	
Blue grama	*Chondrosum gracile*	*Bouteloua gracilis*		x	x	12	15
Mustard	*Brassica sp.*	*Brassica sp.*		x	x		3
Japanese brome	*Bromus japonicus*	*Bromus japonicus*	FACU	x			1
Cheatgrass	*Anisantha tectorum*	*Bromus tectorum*		x	x		2
Buffalograss	*Buchloe dactyloides*	*Buchloe dactyloides*	FACU	x	x	14	18
Sedge	*Carex sp.*	*Carex sp.*		x	x	3	13
Lambsquarters	*Chenopodium album*	*Chenopodium album*	FAC	x	x	3	4
Pitseed goosefoot	*Chenopodium berlandieri*	*Chenopodium berlandieri*		x	x	1	
Aridland/desert goosefoot	*Chenopodium desiccatum*	*Chenopodium desiccatum*		x	x	1	
Mealy goosefoot	*Chenopodium incanum*	*Chenopodium incanum*		x	x	1	
Narrowleaf goosefoot	*Chenopodium leptophyllum*	*Chenopodium leptophyllum*	NI	x	x	5	11
Nettleleaf goosefoot	*Not in Weber*	*Chenopodium murale*		x	x	1	1
Goosefoot family	*Chenopodium sp.*	*Chenopodium sp.*		x	x	11	8
Rabbitbrush	*Chenopodium sp.*	*Chrysothamnus sp.*		x	x	1	1
Wavyleaf thistle	*Cirsium undulatum*	*Cirsium undulatum*	FACU	x			2
Field bindweed	*Convolvulus arvensis*	*Convolvulus arvensis*		x			1
Marestail, horseweed	*Conyza canadensis*	*Conyza canadensis*	FACU-	x	x		2
Fleabane/horseweed	*Conyza sp.*	*Conyza sp.*		x	x		1
Coreopsis, tickseed	*Coreopsis sp.*	*Coreopsis sp.*		x	x		1
Plains coreopsis		*Coreopsis tinctoria*	FAC	x			1
Cholla	*Cylindropuntia*	*Cylindropuntia sp.*		x		1	
Inland saltgrass	*Distichlis stricta*	*Distichlis spicata*	NI	x	x	1	2
Barnyard grass	*Echinochloa crus-galli*	*Echinochloa crus-galli*	FACW	x	x	1	1
Creeping spikerush	*Eleocharis macrostachya*	*Eleocharis macrostachya*	OBL	x			1

Common Name	Scientific Name (Weber)[1]	Scientific Name (USDA PLANTS)[2]	Region 5 Wetland Indicator Status[3]	Documented in Playa	Documented in Upland	2004 Sites (N)	2005 Sites (N)
Dwarf spikerush	*Eleocharis parvula var.*	*Eleocharis parvula*	OBL	x	x	2	10
Spikerush	*Eleocharis sp.*	*Eleocharis sp.*	OBL	x	x	5	13
Squirreltail	*Elymus elymoides/Elymus*	*Elymus elymoides*	FACU	x	x	2	4
Stinkgrass	*Eragrostis cilianensis*	*Eragrostis cilianensis*	FACU	x	x	1	6
Toothed spurge	*Poinsettia dentata*	*Euphorbia dentata*		x	x	1	
Euphorbia		*Euphorbia sp.*		x			1
Curlycup gumweed	*Grindelia squarrosa*	*Grindelia squarrosa*	FACU-	x		1	4
Snakeweed	*Gutierrezia sp.*	*Gutierrezia sp.*			x	1	
Common sunflower	*Helianthus annuus*	*Helianthus annuus*	FACU	x		1	2
Sunflower	*Helianthus sp.*	*Helianthus sp.*		x		2	1
Needle-and-thread	*Hesperostipa sp.*	*Hesperostipa sp.*		x			1
Golden aster	*Heterotheca sp.*	*Heterotheca sp.*		x			1
Meadow barley	*Critesion brachyantherum*	*Hordeum brachyantherum*		x	x		8
Poverty sumpweed	*Iva axillaris*	*Iva axillaris*	FAC	x		1	2
Kochia	*Bassia sieversiana*	*Kochia scoparia*	FACU	x	x	12	11
Prickly lettuce	*Lactuca serriola*	*Lactuca serriola*	FAC	x			1
Frog-fruit, fogfruit	*Phyla sp.*	*Lippia sp.*	FACW	x	x	6	11
Skeletonweed	*Lygodesmia juncea*	*Lygodesmia juncea*		x	x		3
Western water		*Marsilea vestita*	OBL	x			4
Sweetclover	*Melilotus sp.*	*Melilotus sp.*		x		1	
Spotted evening primrose	*Oenothera canescens*	*Oenothera canescens*	FACW-	x	x	1	15
Evening primrose	*Oenothera sp.*	*Oenothera sp.*		x		1	
Pricklypear	*Opuntia sp.*	*Opuntia sp.*		x	x		5
White locoweed	*Oxytropis sericea*	*Oxytropis sericea*			x	1	1
Locoweed	*Oxytropis sp.*	*Oxytropis sp.*	NONL	x	x	2	4
Witchgrass	*Panicum capillare*	*Panicum capillare*	FAC	x		2	2
Western wheatgrass	*Pascopyrum smithii*	*Pascopyrum smithii*	FACU	x	x	17	22
Woolly plantain	*Plantago patagonica*	*Plantago patagonica*	UPL	x	x	1	8
Plantain	*Plantago sp.*	*Plantago sp.*		x			2
Bluegrass	*Poa sp.*	*Poa sp.*		x	x	1	
Water Smartweed		*Polygonum amphibium*	OBL	x			1
Prostrate knotweed	*Polygonum aviculare*	*Polygonum aviculare*	FACW	x		1	
Erect Knotweed	*Polygonum erectum*	*Polygonum erectum*	OBL	x			1
Knotweed	*Polygonum sp.*	*Polygonum sp.*		x		1	7
Common purslane	*Portulaca oleracea*	*Portulaca oleracea*	FAC	x			3
Purslane	*Portulaca sp.*	*Portulaca sp.*		x	x	1	1
Primrose	*Primula sp.*	*Primula sp.*		x	x	1	
Scurf Pea	*Psoralidium sp.*	*Psoralidium sp.*		x	x	1	4
Goldenweed	*Pyrrocoma sp.*	*Pyrrocoma sp.*		x		1	
Prairie coneflower	*Ratibida columnifera*	*Ratibida columnifera*		x	x	8	9
Spreading yellowcress	*Rorippa sinuata*	*Rorippa sinuata*	FACW	x			1
Curly Dock	*Rumex crispus*	*Rumex crispus*	FACW	x			1
Peachleaf willow	*Salix amygdaloides*	*Salix amygdaloides*	FACW		x	1	

Common Name	Scientific Name (Weber)[1]	Scientific Name (USDA PLANTS)[2]	Region 5 Wetland Indicator Status[3]	Documented in Playa	Documented in Upland	2004 Sites (N)	2005 Sites (N)
Russian thistle	*Salsola australis*	*Salsola tragus*	FACU	x	x	13	15
Sage	*Salvia sp.*	*Salvia sp.*		x	x	1	
Tumblegrass	*Schedonnardus paniculatus*	*Schedonnardus paniculatus*		x		1	5
Buffalobur	*Solanum rostratum*	*Solanum rostratum*		x	x	2	1
Scarlet Globemallow	*Sphaeralcea coccinea*	*Sphaeralcea coccinea*		x	x	4	16
Globemallow	*Sphaeralcea sp.*	*Sphaeralcea sp.*		x	x	9	3
Alkali sacaton	*Sporobolus airoides*	*Sporobolus airoides*	FAC	x	x	7	1
Poison suckleya	*Suckleya suckleyana*	*Suckleya suckleyana*	FACW	x			2
Field pennycress	*Thlaspi arvense*	*Thlaspi arvense*	NI	x		1	5
Goatsbeard	*Tragopogon sp.*	*Tragopogon sp.*		x			1
Clover	*Trifolium sp.*	*Trifolium sp.*		x		2	1
Prostrate vervain,bigtract	*Verbena bracteata*	*Verbena bracteata*	FACU	x	x	1	9
Verbena	*Verbena sp.*	*Verbena sp.*		x		3	
Speedwell purslane	*Veronica peregrina*	*Veronica peregrina*	OBL	x			2
Vetch	*Vicia sp.*	*Vicia sp.*		x		1	
Sixweeks fescue	*Vulpia octoflora*	*Vulpia octoflora*	UPL	x	x		11
Rough cockleburr	*Xanthium strumarium*	*Xanthium strumarium*	FAC	x	x	1	1

[1] Scientific name as assigned in Weber, W. and R.C. Wittmann. 2001. Colorado Flora: Eastern Slope, Third Edition. University Press of Colorado, Boulder, CO.
[2] Scientific name as assigned in USDA, NRCS. 2006. The PLANTS Database (http://plants.usda.gov, 17 July 2006). National Plant Data Center, Baton Rouge, LA.
[3] US Fish and Wildlife Service. Reed, PB. 1988. National List of Plant Species That Occur in Wetlands --
Central Plains (Region 5). National Wetland Inventory, U.S. Department of the Interior, Fish and Wildlife Service, St. Petersburg, FL. 90 pp.
OBL=Obligate, FACW=Facultative Wetland, FAC=Facultative, FACU=Facultative Upland, UPL=Obligate Upland. Blank indicates species not on list.

APPENDIX C

BIRD SPECIES DOCUMENTED ON EASTERN COLORADO PLAYAS, 2004-2006

Common Name	Scientific Name	Taxonomic Group	Number Observed
American Avocet	Recurvirostra americana	Shorebird	362
American Coot	Fulica americana	Other Waterbird	1626
American Crow	Corvus brachyrhynchos	Landbird	8
American Golden-Plover	Pluvialis dominica	Shorebird	4
American Goldfinch	Carduelis tristis	Landbird	9
American Kestrel	Falco sparverius	Landbird	21
American Pipit	Anthus rubescens	Landbird	266
American Robin	Turdus migratorius	Landbird	18
American Tree Sparrow	Spizella arborea	Landbird	1
American White Pelican	Pelecanus erythrorhynchos	Other Waterbird	628
American Wigeon	Anas americana	Waterfowl	1404
Baird's Sandpiper	Calidris bairdii	Shorebird	365
Baird's Sparrow	Ammodramus bairdii	Landbird	3
Bald Eagle	Haliaeetus leucocephalus	Landbird	4
Bank Swallow	Riparia riparia	Landbird	11
Barn Swallow	Hirundo rustica	Landbird	226
Belted Kingfisher	Ceryle alcyon	Landbird	2
Black Tern	Chlidonias niger	Other Waterbird	55
Black Vulture	Coragyps atratus	Other Waterbird	1
Black-bellied Plover	Pluvialis squatarola	Shorebird	23
Black-billed Magpie	Pica hudsonia	Landbird	14
Black-headed Grosbeak	Pheucticus melanocephalus	Landbird	1
Black-necked Stilt	Himantopus mexicanus	Shorebird	14
Blue Grosbeak	Passerina caerulea	Landbird	1
Blue-winged Teal	Anas discors	Waterfowl	1490
Bonaparte's Gull	Larus philadelphia	Other Waterbird	1
Brewer's Blackbird	Euphagus cyanocephalus	Landbird	188
Brewer's Sparrow	Spizella breweri	Landbird	9
Brown Thrasher	Toxostoma rufum	Landbird	1
Brown-headed Cowbird	Molothrus ater	Landbird	123
Bufflehead	Bucephala albeola	Waterfowl	65
Bullock's Oriole	Icterus bullockii	Landbird	5
Burrowing Owl	Athene cunicularia	Landbird	65
Cackling Goose		waterfowl	250
California Gull	Larus californicus	Other Waterbird	41
Canada Goose	Branta canadensis	Waterfowl	2151
Canvasback	Aythya valisineria	Waterfowl	308
Cassin's Kingbird	Tyrannus vociferans	Landbird	1
Cassin's Sparrow	Aimophila cassinii	Landbird	26
Chestnut-collared Longspur	Calcarius ornatus	Landbird	2147
Chihuahuan Raven	Corvus cryptoleucus	Landbird	14
Chimney Swift	Chaetura pelagica	Landbird	2
Chipping Sparrow	Spizella passerina	Landbird	30
Cinnamon Teal	Anas cyanoptera	Waterfowl	94
Clark's Grebe	Aechmophorus clarkii	Other Waterbird	690
Clay-colored Sparrow	Spizella pallida	Landbird	24

Common Name	Scientific Name	Taxonomic Group	Number Observed
Cliff Swallow	Petrochelidon pyrrhonota	Landbird	116
Common Goldeneye	Bucephala clangula	Waterfowl	2
Common Grackle	Quiscalus quiscula	Landbird	134
Common Loon	Gavia immer	Landbird	6
Common Merganser	Mergus merganser	Waterfowl	2
Common Nighthawk	Chordeiles minor	Landbird	17
Common Raven	Corvus corax	Landbird	6
Dark-eyed Junco	Junco hyemalis	Landbird	1
Double-crested Cormorant	Phalacrocorax auritus	Landbird	34
Eared Grebe	Podiceps nigricollis	Other Waterbird	111
Eastern Bluebird	Sialia sialis	Landbird	5
Eastern Kingbird	Tyrannus tyrannus	Landbird	18
Eastern Meadowlark	Sturnella magna	Landbird	
Eastern Phoebe	Sayornis phoebe	Landbird	1
Eurasian Collared-Dove	Streptopelia decaocto	Landbird	25
European Starling	Sturnus vulgaris	Landbird	356
Ferruginous Hawk	Buteo regalis	Landbird	29
Forster's Tern	Sterna forsteri	Other Waterbird	1
Franklin's Gull	Larus pipixcan	Other Waterbird	116
Gadwall	Anas strepera	Waterfowl	1785
Golden Eagle	Aquila chrysaetos	Landbird	2
Grasshopper Sparrow	Ammodramus savannarum	Landbird	14
Great Blue Heron	Ardea herodias	Other Waterbird	67
Great Egret	Ardea alba	Other Waterbird	1
Great Horned Owl	Bubo virginianus	Landbird	2
Greater Scaup	Aythya marila	Waterfowl	1
Greater White-fronted Goose	Anser albifrons	Waterfowl	22
Greater Yellowlegs	Tringa melanoleuca	Shorebird	194
Great-tailed Grackle	Quiscalus mexicanus	Landbird	13
Green-winged Teal	Anas crecca	Waterfowl	7981
Herring Gull	Larus argentatus	Other Waterbird	13
Hooded Merganser	Lophodytes cucullatus	Waterfowl	5
Horned Grebe	Podiceps auritus	Other Waterbird	73
Horned Lark	Eremophila alpestris	Landbird	11484
House Finch	Carpodacus mexicanus	Landbird	8
House Sparrow	Passer domesticus	Landbird	30
Indigo Bunting	Passerina cyanea	Landbird	1
Killdeer	Charadrius vociferus	Shorebird	2740
Lapland Longspur	Calcarius lapponicus	Landbird	796
Lark Bunting	Calamospiza melanocorys	Landbird	701
Lark Sparrow	Chondestes grammacus	Landbird	45
Least Sandpiper	Calidris minutilla	Shorebird	158
Lesser Nighthawk	Chordeiles acutipennis	Landbird	3
Lesser Scaup	Aythya affinis	Waterfowl	398
Lesser Yellowlegs	Tringa flavipes	Shorebird	376
Lincoln's Sparrow	Melospiza lincolnii	Landbird	1
Loggerhead Shrike	Lanius ludovicianus	Landbird	10

Common Name	Scientific Name	Taxonomic Group	Number Observed
Long-billed Curlew	Numenius americanus	Shorebird	37
Long-billed Dowitcher	Limnodromus scolopaceus	Shorebird	746
Mallard	Anas platyrhynchos	Waterfowl	5348
Marsh Wren	Cistothorus palustris	Landbird	6
McCown's Longspur	Calcarius mccownii	Landbird	2026
Merlin	Falco columbarius	Landbird	11
Mottled Duck	Anas fulvigula	Waterfowl	3
Mountain Bluebird	Sialia currucoides	Landbird	44
Mountain Plover	Charadrius montanus	Shorebird	15
Mourning Dove	Zenaida macroura	Landbird	430
Northern Bobwhite	Colinus virginianus	Landbird	2
Northern Flicker	Colaptes auratus	Landbird	5
Northern Harrier	Circus cyaneus	Landbird	155
Northern Mockingbird	Mimus polyglottos	Landbird	14
Northern Pintail	Anas acuta	Waterfowl	2546
Northern Rough-winged Swallow	Stelgidopteryx serripennis	Landbird	4
Northern Shoveler	Anas clypeata	Waterfowl	2664
Orange-crowned Warbler	Vermivora celata	Landbird	3
Orchard Oriole	Icterus spurius	Landbird	4
Pacific Loon	Gavia pacifica	Other Waterbird	1
Pectoral Sandpiper	Calidris melanotos	Shorebird	115
Peregrine Falcon	Falco peregrinus	Landbird	1
Pied-billed Grebe	Podilymbus podiceps	Other Waterbird	118
Pine Siskin	Carduelis pinus	Landbird	2
Prairie Falcon	Falco mexicanus	Landbird	24
Red-breasted Merganser	Mergus serrator	Waterfowl	7
Redhead	Aythya americana	Waterfowl	431
Red-necked Phalarope	Phalaropus lobatus	Shorebird	1
Red-tailed Hawk	Buteo jamaicensis	Landbird	28
Red-winged Blackbird	Agelaius phoeniceus	Landbird	1060
Ring-billed Gull	Larus delawarensis	Other Waterbird	830
Ring-necked Duck	Aythya collaris	Waterfowl	34
Ring-necked Pheasant	Phasianus colchicus	Landbird	7
Rock Pigeon	Columba livia	Landbird	54
Ross's Goose	Chen rossii	Waterfowl	109
Rough-legged Hawk	Buteo lagopus	Landbird	1
Ruddy Duck	Oxyura jamaicensis	Waterfowl	844
Ruff	Philomachus pugnax	Shorebird	1
Sage Thrasher	Oreoscoptes montanus	Landbird	1
Sanderling	Calidris alba	Shorebird	7
Sandhill Crane	Grus canadensis	Other Waterbird	7094
Savannah Sparrow	Passerculus sandwichensis	Landbird	84
Say's Phoebe	Sayornis saya	Landbird	7
Scaled Quail	Callipepla squamata	Landbird	7
Semipalmated Plover	Charadrius semipalmatus	Other Waterbird	5
Semipalmated Sandpiper	Calidris pusilla	Shorebird	9

Common Name	Scientific Name	Taxonomic Group	Number Observed
Sharp-shinned Hawk	Accipiter striatus	Landbird	3
Short-billed Dowitcher	Limnodromus griseus	Shorebird	40
Snow Goose	Chen caerulescens	Waterfowl	207
Snowy Egret	Egretta thula	Other Waterbird	1
Snowy Plover	Charadrius alexandrinus	Shorebird	20
Solitary Sandpiper	Tringa solitaria	Shorebird	9
Song Sparrow	Melospiza melodia	Landbird	8
Sora	Porzana carolina	Other Waterbird	3
Spotted Sandpiper	Actitis macularia	Shorebird	10
Sprague's Pipit	Anthus spragueii	Landbird	4
Stilt Sandpiper	Calidris himantopus	Shorebird	5
Swainson's Hawk	Buteo swainsoni	Landbird	105
Swamp Sparrow	Melospiza georgiana	Landbird	1
Townsend's Solitaire	Myadestes townsendi	Landbird	1
Tree Swallow	Tachycineta bicolor	Landbird	39
Turkey Vulture	Cathartes aura	Other Waterbird	36
Upland Sandpiper	Bartramia longicauda	Shorebird	10
Vesper Sparrow	Pooecetes gramineus	Landbird	136
Virginia Rail	Rallus limicola	Other Waterbird	1
Western Grebe	Aechmophorus occidentalis	Other Waterbird	1036
Western Kingbird	Tyrannus verticalis	Landbird	99
Western Meadowlark	Sturnella neglecta	Landbird	1053
Western Sandpiper	Calidris mauri	Shorebird	1
White-crowned Sparrow	Zonotrichia leucophrys	Landbird	18
White-faced Ibis	Plegadis chihi	Other Waterbird	29
White-rumped Sandpiper	Calidris fuscicollis	Shorebird	1
Wild Turkey	Meleagris gallopavo	Landbird	3
Willet	Tringa semipalmata	Shorebird	10
Wilson's Phalarope	Phalaropus tricolor	Shorebird	240
Wilson's Snipe	Gallinago delicata	Shorebird	83
Wilson's Warbler	Wilsonia pusilla	Landbird	9
Wood Duck	Aix sponsa	Waterfowl	5
Yellow Warbler	Dendroica petechia	Landbird	1
Yellow-headed Blackbird	Xanthocephalus xanthocephalus	Landbird	494
Yellow-rumped Warbler	Dendroica coronata	Landbird	2