**The Oklahoma Cooperative Fish and Wildlife Research Unit will be responsible for objectives 1 through 3, and the Texas Cooperative Fish and Wildlife Research Unit will be responsible for objectives 4 and 5. Oversight of objective completion and reporting of deliverables for all work described herein will be coordinated through USGS/-CRU, Oklahoma Cooperative Fish and Wildlife Research Unit to USDA/NRCS.**

Project Proposal

# Title: Influence of U. S. Department of Agriculture Programs and Conservation Practices on Ecological Services Provided by Playa Wetlands in the High Plains

## INTRODUCTION AND JUSTIFICATION

Wetlands are generally considered the most ecologically productive ecosystems in the world. However, these systems are also some of the most degraded. Indeed, more than 50% of the wetlands in the contiguous United States have been lost since European settlement (Dahl 2000). Most losses have been caused by draining or filling for urban expansion and agricultural production (Dahl 2000).

However, for the past 50 years, values of wetlands to a healthy functioning environment and human society have been increasingly recognized by scientists, conservationists, and the general public (Mitsch and Gosselink 2000). Moreover, worldwide wetland services have been valued at $1 trillion annually (Christensen 2005). Values include, but are not limited to, carbon sequestration to mitigate climate change, flood prevention, groundwater recharge, and wildlife habitat. Knowledge of these values has caused recent U. S. presidential administrations to promote a policy goal of “no net loss” of wetlands. This policy and associated incentives to protect wetlands have been assumed to have greatly slowed wetland loss. Estimates of loss, however, only consider complete loss of a wetland, and not the loss or degradation of important wetland functions or values in the remaining wetlands (Smith 2003). For example, a wetland might exist in the landscape, but because it is so degraded, it no longer functions to provide wildlife habitat or recharge groundwater.

The United States Department of Agriculture (USDA) has implemented numerous and extensive natural resources conservation practices across the country; but this effort has been especially rigorous in the Great Plains (Berthelsen et al. 1989, Reynolds et al. 2001). Effects of these conservation practices on wetlands are being evaluated elsewhere, but knowledge is lacking for impacts on the High Plains. Playas are the dominant wetland type in the High Plains (LaGrange 1997, Smith 2003). Playas are shallow depressional recharge wetlands, each existing within their individual catchments (Smith 2003). Because of their similar catchment and hydrologic features, individual playas make ideal experimental replicates to evaluate influences of USDA programs on the ecological services provided by playas (Smith 2003). Also, as the definition implies, playas recharge the aquifer underlying the High Plains, the largest in North America. Finally, because the High Plains is one of the most intensively cultivated regions in the world (Bolen et al. 1989), playas are the key remaining sites of biodiversity throughout the High Plains (Haukos and Smith 1994).

## ECOLOGICAL SERVICES PROVIDED BY PLAYAS

As noted, services provided by playas include being key sites of biodiversity, focused recharge points to the underlying aquifer, flood-water catchments, and sediment traps. They also serve as important outdoor classrooms for regional educators (Smith 2003). Their role in global climate change is unknown; but it is known that playa soils contain little carbon (Luo 1994), indicating rapid plant matter decomposition as a result of a rapidly fluctuating hydroperiod

(Anderson and Smith 2002). Carbon stocks in standing vegetation provide storage of atmospheric carbon but the size of this pool has not been estimated.

## Biodiversity

Playas exist in a region of unpredictable and dynamic environments, which are characterized more by short-term extremes rather than long-term averages. All flora and fauna in playas have adapted to these conditions and failure to protect the dynamic nature of playa systems (i.e., hydrology) will reduce biodiversity (Haukos and Smith 1994). Although playas are keystone ecosystems in the High Plains, extensive conversion of former prairie systems to other landuses, primarily agriculture, has resulted in playas being the only remaining natural habitats supporting biodiversity in many areas.

The value of playas to biodiversity can be realized on several spatial scales – individual playa, surrounding watershed (e.g., cropland, grassland, and CRP), regions, or the entire High Plains. For example, plant diversity varies from 19 for individual playas to 43 at county levels, 100 in regions defined by similar vegetation communities, and nearly 350 for the entire Southern Great Plains (Haukos and Smith 2004). Given the dynamic and physiologically stressful environment associated with playas, realization of the total contribution of individual playas to biodiversity of the region may not be realized until measured across all possible environmental conditions. Thus, it is the cumulative influence of all playas that creates and supports biodiversity throughout the High Plains. Therefore, continued loss and degradation of individual playas will result in a diversity loss cascade across all spatial scales as ecological links among playas weaken or are lost. Eventually the significance of the entire region for all species, including humans, will decrease.

Nearly all wildlife species, most plant species, and large numbers of invertebrates in the High Plains use playas at some point in their life cycle (Haukos and Smith 1994). More than 170 macroinvertebrate species, at least 14 amphibian species, more than 20 species of reptiles, a minimum of 185 avian species, and 51 mammal species have been reported in playas (Smith 2003). Although not all are dependent on playas for their existence, abundance and occurrence of most are directly related to the presence of functioning playa wetlands (Haukos and Smith 1994, 2003).

## Sediments and Cropland Influences

Wetlands are important traps for sediment, a role normally in balance with their other ecological services (National Academy of Sciences 1995). However, too much sediment will overwhelm a wetland and completely alter its ability to properly function. Anthropogenic activities, particularly cultivation of surrounding uplands, often accelerate deposition of sediment into wetlands (Luo et al. 1997). This overloading by sediments ultimately reduces hydroperiod length and, in turn, the natural state of the flora and fauna communities of the wetland (Smith 2003). Indeed, sediment deposition into cropland playas in the Southern High Plains has resulted in greater than 100% loss of the hydric soil volume, with severity of sedimentation increasing with coarser soil textures (Luo et al. 1997).

As noted above, playa wetlands support diverse floral and faunal communities and consequently provide for a variety of ecological services that extend beyond the playa itself. Plant communities in and adjacent to playas are critical resources as nesting cover, security cover, and food for many species of animals, including aquatic invertebrates, amphibians, and waterfowl throughout the year. Unfortunately, disturbances to the normal hydrology of playas negatively influence the plant community throughout the annual cycle. For example, although plant communities are more diverse in cropland playas that harbor greater sediment loads than grassland playas, plant communities in cropland playas have increased numbers of exotics and annuals (Smith and Haukos 2002).

The faunal community itself is intimately linked in a complex food web that supports a variety of resident and transient wildlife species that utilize playas during one or more periods of their life cycle. Reproduction and early development of amphibians are intimately linked to playas, and recent studies have demonstrated population and community level differences between cropland and grassland playas. For example, relative density of spadefoot toad (*Spea multiplicata* and *S. bombifrons*) metamorphs was found to be greater in cropland playas, while density of tiger salamanders (*Ambystoma tigrinum*) was smaller in the same playas (Gray et al. 2004). Also, body size of selected species of amphibians in cropland playas are typically smaller than those of grassland playas (Gray and Smith 2005), and metamorphs exhibited a decrease in diet diversity (Smith et al. 2004). In all cases, differences between cropland and grassland playas were attributed to landscape disturbance and the result of increased sedimentation in cropland watersheds. Increased sediment loading in cropland playas and its influence on hydroperiod and possibly other factors is probably the single greatest current threat to the proper of function of playa wetlands (Smith 2003).

## Recharge

Playas are considered key points of water recharge to the Ogallala aquifer, and may represent the only recharge point in the Southern High Plains (Wood et al. 1997). Given the significant reliance on the aquifer as a source of irrigation and potable water, protecting the characteristics of playas that facilitate recharge is critical to maintaining or at least extending the useful life of the Ogallala. In general, groundwater recharge in the High Plains can be classified into interstitial (matrix) and macropore flow. Macropore recharge occurs through cracks, fractures, solution holes, natural pipes, animal burrows, root tubes, and other macro-scale openings, while interstitial flow moves largely between individual grains or a fine mesh of fractures. Macropore flow allows water to reach the water table quicker. Playa floors are dominated by expansive clays that develop large dessication cracks when they dry between inundation events. These cracks create macropores that accept high infiltration rates when the first flush of runoff reaches the playa floor.

While much of the water that reaches a playa evaporates, the amount of infiltration can also be of significant value to the aquifer below. The amount of recharge that occurs via playas is debatable, but studies demonstrate that significant amounts of water do move through the soil below playas. For example, Wood et al. (1997) evaluated the impacts of recharge through playas wetlands in Carson County, Texas, and found that a significant amount of the total recharge was through macropores in the playa-dominated landscape. Of the total regional annual average recharge of 11 mm/yr, macropore recharge flux ranges between 60 and 80 percent (7 to 9 mm/yr), interstitial recharge flux beneath the playa floors ranges between 15 and 35 percent (1.6 and 4.4 mm/yr), and regional interstitial recharge is approximately 5 percent (0.5 mm/yr). The average infiltration rates through the floors of two grassland playas in Carson County were 1900 and 1200 mm/yr for the two playas, based on the rainfall and runoff they received during the study period. Landuse within the watershed and management immediately surrounding a playa may influence both the amount of water that reaches a playa and the efficacy of the macropores in the playa floor to conduct water into the aquifer. For example, upland sites surrounding playas are typically characterized by row crop agriculture, native grassland, or the Conservation Reserve Program (CRP; the major USDA conservation practice in the region- typically retirement of highly eroded cropland planted to perennial grass). The latter consists of a variety of different plant mixes that often result in stands of heavy rank exotic vegetation, which may inhibit water flow into playa basins. Conversely, although runoff from cultivated uplands is significant, it also carries large quantities of sediments that accumulate across the playa floor and deposit within the cracks before they swell shut (Luo et al. 1997). Thus, a number of factors related to land use and long-term management strategies may ultimately inhibit the ability of playas to serve their important role as recharge wetlands, and understanding these dynamics, and their influence on recharge in playas, is critical and of great value to the landowners and economy of the region.

## Water Storage

One of the primary ecosystem values provided by depressional wetlands is short- and long-term surface water storage (National Academy of Sciences 1995: 35). Surface water storage obviously is a primary habitat component for wetland dependent biota, especially in a semi-arid environment like the High Plains; but depressional wetland water storage also reduces flooding of croplands, native prairies, and human habitation as well as contributing to aquifer recharge. Moreover, wetlands may reduce peak flows in rivers and streams, preventing off-site flood control benefits (Ludden et al. 1983, Hubbard and Linder 1986). Sedimentation and/or direct filling reduce the ability of a wetland to collect and store water, and thus limit the effectiveness of this ecosystem service (Luo et al. 1997).

Estimates of water storage potential in playas exist for the Southern High Plains (that area of eastern New Mexico and western Texas on the Llano Estacado). Although estimates vary based on the predicted numbers of playas, all are of substantial volume (Grubb et al. 1968, Grubb and Parks 1968, U.S. Department of Interior 1982). For example, the U.S. Department of

Interior (1982) estimated 6.6 x $10^8$ $m^3$ of water storage in the Southern High Plains alone, and these historical projections are considered to be nominal given the conservative number of playas used to generate the estimates. Updating and verifying these estimates will also have important implications for recharge estimates and modeling of the effects of conservation practices on recharge.

## PROJECT GOALS AND OBJECTIVES

Our proposal embodies a cooperative effort that supports activities associated with conducting the Conservation Effects Assessment Project-Wetlands Component (CEAP-Wetlands) regional assessment in the High Plains (THP) of Texas, New Mexico, Oklahoma, Kansas, Colorado, and Nebraska. The CEAP-Wetlands regional assessments are designed to produce regional estimates of wetland ecosystem services; quantify the effects with and without implementation of USDA conservation practices and resource management systems; develop predictive wetland functional condition indicator models; quantify and compare effects of alternative environmental or program scenarios on regional wetland services; and, where applicable, develop scientific and technological tools that improve the conservation and sustainability of wetlands on agricultural landscapes. In this context, the results of the proposed research will benefit wetland science, enhance conservation of natural resources, and ultimately benefit society at large.

Therefore, our overall project goal is to examine the influences of USDA conservation programs and practices on ecosystem services provided by playa wetlands in the High Plains. To evaluate these influences, we will examine playas embedded within watersheds of cropland, native grassland, and catchments containing USDA conservation programs. The vast majority of

USDA conservation programs in the High Plains involve practices within the Conservation Reserve Program (CRP). Native and perennial grasses have been planted on more than 1.5 million ha of the High Plains under this program using different conservation practices (CPs). In the Rainwater Basin playas of south central Nebraska, many playas have benefited from practices under the Wetland Reserve Program (WRP), but few playas outside that region have been included in WRP. Because the Wildlife Habitat Incentives Program (WHIP) and the Environmental Quality Incentive Program (EQIP) have had relatively little (<1% of playas) influence on playas, they are not being directly evaluated in this study but practices used in those programs will be evaluated when they occur on randomly selected wetlands. Therefore, this proposal will primarily focus on evaluation of CRP practices on ecosystem services provided by playas relative to native grassland and cropland watersheds within the nonglaciated portion of the High Plains as a whole, and for a subset of playas influenced by WRP in the Rainwater Basin Region.

Isolated depressional wetlands within landscapes dominated by agriculture are especially impacted by eroded sediments (e.g., Euliss and Mushet 1996, Luo et al. 1997). Therefore, a primary emphasis of this project will focus on estimation of USDA conservation practice effects on sediments and playa hydrology, and their resultant influence on dependent biota. These influences will then be directly related to ecosystem services provided by playa wetlands in the High Plains.

Three hundred playas (150/year) will be targeted in the overall study. We will estimate sediment depth and watershed characteristics for each playa to examine the influence of USDA programs on playa hydrology. For each playa, we will then examine the playa plant community, because it is a primary influence on other wetland dependent biota and an indicator of a playa’s ability to respond to a changing environment. Because of global concern for amphibian populations, these communities will also be described at the time of floral surveys. Knowing sediment depth and watershed characteristics will allow us to estimate the influence of USDA conservation practices on floodwater storage capacity for the 300 playas, and then to extrapolate those results to the entire High Plains region. Because of an ongoing study (Ogallala Initiative; USDA-ARS) examining the importance of playas as points of recharge to the aquifer in the Southern High Plains, we will also be able to examine how CRP influences recharge for playas in that portion of the High Plains. This study is also examining how sediments will influence recharge. Agriculture is dependent on irrigation from groundwater in this region, and many municipalities also require groundwater to meet public needs.

### Specific Objectives

1) Determine sediment depth and watershed characteristics of High Plains playas influenced by CRP practices and within native grassland and cropland landscapes (also WRP in the Rainwater Basin).

2) Examine the catchment influence (CRP, native grassland, and cropland) on plant and amphibian communities in High Plains' playas.

3) Compare hydrology and flood storage capacity of playas influenced by CRP practices, and within cropland and native grassland landscapes in the High Plains (and WRP in Rainwater Basin).

4) Compare recharge rates among playas within cropland, CRP, and native grassland catchments, and relate that to regional land use and economic value of water within the Southern High Plains Region.

5) Examine the influence of CRP practices and cropland and native grassland landscapes on local and regional groundwater levels in the Southern High Plains.

# METHODS

## Study Area and Site Selection

The study area will include the nonglaciated High Plains from western Nebraska and eastern Colorado, south to eastern New Mexico and western Texas. This area largely coincides with the short-grass prairie ecoregion (see fig 1.2 Smith 2003:5). The study area will also include the Rainwater Basin region of Nebraska which, historically, encompassed mixed-grass and tall-grass ecoregions. Most playas in the Southern Great Plains and Nebraska have been mapped based on the presence of hydric soils. Playas existing in northeastern Colorado and northwestern Kansas are being added to the data base (A. Bishop; USFWS). In the Southern Great Plains playa soils are primarily mapped as Randall clay; but Lipan, Ness, Lofton, Stegall, and Pleasant series are also included. In Nebraska, playas are most often mapped as Scott and Filmore soils, but also include Butler and Massie soils.

As is common in the Great Plains, precipitation is erratic; but annual averages range from 38 cm in the southern portion of the study area to 63 cm in the north. Evaporation similarly varies from 280 cm in the south to 165 cm in the northern portion of the study area.

The basic study design will be a stratified random design. Study playas will be selected from a map being compiled from existing databases (A. Bishop, USFWS). The map will contain known playa locations along with land use information on their catchments (including USDA conservation practices). Three hundred playas will be selected for study, with approximately 100 being selected with cropland catchments, 100 in native grassland, and 100 in USDA conservation programs. Because selection of playas will be stratified based on density, no more than 210 will be selected from the Southern Great Plains (western TX, eastern NM, western OK, southwestern KS, southeastern CO), the region has the highest playa density, to ensure coverage of the entire region. Initial selections will be determined according to playa density within a county. The initially randomly selected playa will then be paired with playas in the other two land uses that were not in the catchment of the initially selected playa.

## Objective 1

The pre-cultivation area of each playa will be determined using a Global Positioning System based on hydric soil defined boundaries as determined from soil cores (see below). The playa boundary will be determined based on changes of slope, vegetation, and soil (Luo et al. 1997). Soil sampling will follow standard USDA methods and be taken from nine locations across the diameter of the playa. From our existing EPA study, we have determined that to estimate wetland volume loss from sedimentation, we should use fewer sediment cores from the playa floor, but more on the playa edge (Luo et al. 1997). Estimating the hydric soil edge is crucial to original (non-sedimented) volume estimates (Luo et al. 1997). We will therefore take three cores on each edge and three in the floor (nine total). These estimates will be made on each of the 150 playas each year. Sediment deposited on the top of the hydric Randall Clay is distinguished by differences in soil color and texture (Luo et al. 1999). Soils will be classified based on current accepted soil taxonomy and Muncell soil color charts. Depth to hydric soil will also be determined from soil cores and then used to determine its influence on hydric soil defined volume (Luo et al. 1997). If a playa is no longer visible, we will estimate its previous occurrence on survey maps and then sample soils as noted above. Slope will be estimated for the surrounding watershed at the measured edges. Watershed size will be estimated as noted in objective 3 below. Land use within the watershed will be recorded on aerial photos at the time of the sediment estimates.

Sediment depths and water volume loss among the three land uses will be compared using analysis of variance. Regression models with extent of cultivation in the watershed, type of land use and conservation practice, slope, major soil type, and annual precipitation will be developed to estimate the relative (AIC) influence of various factors on sediment deposition in playas. These results will allow specific regional recommendations for different levels of playa conservation.

## Objective 2

Extant vegetation will be sampled following Smith and Haukos (2002) in each playa during the year that the wetland is surveyed for sediment and watershed characteristics. Two transects will bisect the playa, and species presence will be recorded at 1-m intervals. Transects will be conducted in spring following potential playa inundation and occurrence of cool-season species, and then in July-August to account for species turnover, weather variation, and establishment of warm-season species (Smith and Haukos 2002). In addition to this dataset, we have a similar dataset (including CRP watersheds), in which the field procedures were identical, collected in 223 playas over a five-state region during 1995 (Haukos and Smith 2004). Therefore, we will be able to compare plant communities in playas roughly 10 and 20 years after establishment of conservation practices within CRP. In a randomly selected subset of playas, annual aboveground production at the end of the growing season (vegetation and seed) will be estimated using clip plots, drying, and weighing of samples. These data will be used to compare the number and cover of annuals and perennials as well as natives and exotics; predict plant associations; estimate diversity; measure production; and determine the relative influence of rare and common species on plant assemblages.  Ordination techniques, cluster analysis, and regression procedures including biotic (e.g., watershed cover type and conservation practice, livestock disturbance) and abiotic factors (e.g., sediment depth, size, weather events, watershed characteristics, disturbance, water quantity and quality) will be used to model the influence of USDA practices on spatial occurrence, temporal establishment, and aboveground production of plant communities or associations in playas.  Further, meta-analyses will be used to model the influence of spatial juxtaposition of playas with similar watershed characteristics on regional plant communities.  Non-destructive production models will be created to estimate annual wildlife carrying capacity throughout the region.

We know that cropland playas containing substantial sediment produce more annuals and exotics than grassland playas with little sediment (Smith and Haukos 2002).  Climate change predictions exacerbate these shifts in plant community composition (current EPA study). Using data collected from the proposed study with the current and previous projects will allow estimation of the point at which the playas become nonfunctional from a floristic standpoint (i.e., species composition, diversity, and production). Moreover, after attaining hydrology and vegetation data, we will model potential avian communities in the Rainwater Basin (Brennan 2006) and those in playas of the Southern Great Plains (current EPA study; Tsai unpublished data).

Collection of amphibian data will be more problematic because amphibians can only be sampled when water is present. Because we cannot sample playas at set hydrological points in time, such as immediately following inundation, we likely will not get a complete estimate of species presence. For example, some amphibians such as *Spea*, are only present during short larval periods immediately following inundation whereas *Rana* are present later in the hydroperiod. Amphibians will be surveyed at the same time as vegetation surveys, if water is present, using transects and seine hauls. One 300 m transect will be walked along the edge of each playa to detect adult and metamorph amphibians. In addition, four 10-m seine hauls will be conducted at random locations in the playa to detect amphibian larvae. Adults, metamorphs, and larvae will be identified to species and enumerated. Up to 20 individuals per species and life stage (larvae, metamorphs, adults) will be staged (Gosner 1960) and measured (snout-vent length, ±1mm). Any *Spea* spp. in the groups of 20 that are not readily identifiable to species will be collected for later identification using electrophoretic markers (Simovich and Sassaman 1986). Voucher specimens for other species will be collected and preserved if needed for verification of species identity using standard keys (ACUC procedures for amphibians will be followed). Community richness and species abundance will be determined from transect and seine haul data and compared among land use types using Type III two-way analysis of variance with interaction. Main effects include land use (fixed effect: cropland, native grassland, and CRP) and year (random effect). Data will be tested for normality and homogeneity of variance and transformed as appropriate prior to analysis. We will also develop predictive models to examine the effects of conservation practices on community diversity, relative abundance, and body size of resident amphibians.

### Objective 3

Using soil core data, we will estimate the effect of sedimentation on the hydric soil defined volume/flood storage capacity of each playa. Some of the playas selected for study may be relatively unrecognizable in the field due to excessive sediment loads. In these cases, we will use known areas of hydric soils from historic soil survey maps and slopes from field surveys and topographic maps to estimate playa volume and surface area. In addition, we will take soil core samples down to 50 cm to estimate the extent of sedimentation in these playas. Playas that are not recognizable in the field and with sediment depths greater than 50 cm will be classified as fossil playas. These data will then be extrapolated to the entire High Plains for use to improve the accuracy of ongoing USDA conservation planning and implementation efforts. Changes in wetland volume (% loss) and hydroperiod (% reduction) will be analyzed using a type III two-way analysis of variance with interaction. Main effects include land use (fixed effect: cropland, native grassland, and conservation practices within CRP) and year (random effect). Data will be tested for normality and homogeneity of variance and transformed as appropriate prior to analysis.

Potential changes in flood storage capacity and hydroperiod will also be estimated using the modified APEX model (current EPA study). We will rely on assembled GIS data layers from the U.S. Fish and Wildlife Service (A. Bishop) that include location, soils, size, and land use for most playas in the High Plains. With current satellite imagery and topographic maps we can determine watershed size, soil texture, slope, distance among wetlands, and playa density around study playas. These data, along with soil infiltration values from the literature and known evaporation rates, will allow calculation of runoff and erosion of soils into playas, and permit estimation of hydroperiods for playas as a function of climate, land use, and conservation practice at the landscape scale using the modified APEX model.

**Objective 4**

Playas will be selected as clusters of three playa types (n=10 for each landuse), cropland playas, former cropland playas now in the CRP, and native grassland playas which have never been row cropped. Initial infiltration rates will be estimated by thermal detection of the wetting front during precipitation and runoff leading to flooding events. Surface evaporation and infiltration losses will be calculated using measured environmental variables.

The study sites will be widely distributed clusters of similarly sized playas, differentially sedimented by erosional deposition. Each wetland within the cluster will be located within a relatively short distance of the other two to minimize differences in rainfall and surrounding soils. Differences in land use subject the soil to differential water erosion and those sediments primarily accumulate in the playa wetlands (Luo et al. 1997).

Playa wetland area and watershed area will vary as necessary to encompass typical playa wetland characteristics and agricultural influences. Playa wetland and watershed area will be surveyed using Global Positioning Systems (GPS). High resolution elevation maps of the playa basin and annulus will be made using a combination of GPS and traditional transit systems. The maps will be used to estimate the basin volume, standing water volume as a function of depth, and water surface area presented to the atmosphere and available for evaporative loss during the hydroperiod.

Instrumentation packages consisting of ultrasonic transducers, tipping bucket gauges, and thermocouple probes will be deployed at the deepest point within each basin to record flood stage, precipitation rate and duration leading to inundation events, and water temperature. To assess data quality, check system reliability, and ease system maintenance, the instrumentation packages will be remotely accessible by wireless telemetry services provided through a local cellular provider. Texas Mesonet data will be used to model the evaporative component of playa volume loss using a standard Penman (1948) surface evaporation model (Xu and Singh, 1998, 2000, 2001 and references therein). The remainder of total volume loss will be used as an infiltration estimate. If reliable Mesonet data are unavailable, one instrumentation package within each playa group will be included that will record rainfall, water depth, wind speed, air temperature, relative humidity, water surface temperature, incoming solar radiation, and incoming/upwelling radiation at 15-minute intervals to provide the necessary environmental variables.

To quantify the initial movement of water through the wetland basin, temperature devices will be inserted into augered holes in the annulus and wetland areas. The temperature devices are high resolution dataloggers connected to probes having four temperature sensors at depths of 0.5 to 2.0 m. Upon inundation or after a significant rainfall event, infiltrating water will move into the soil and contact the sensors. The resulting abrupt change in soil temperature will be used to estimate water movement into soil (Constantz et al. 2003).

The calculated volume of water infiltrating through the playa floor will be used to assess the functional role of playas in aquifer recharge and estimate the regional value of this playa service as affected by land use and conservation practices. Whether, and to what extent, land use surrounding playas has affected infiltration will be determined through simple analysis of variance and subsequent multiple comparisons such as Tukey’s HSD range procedure. Soil survey maps will be used to obtain an estimate of the relative contribution of the three types of playas (crop, CRP, and native grassland) to the population of playas within the Southern High Plains. Characterization of infiltration through the three types of playas will be used in conjunction with the contribution of playa types to provide a simple empirically based regional model of aquifer recharge.

### Objective 5

As part of the Ogallala Aquifer Initiative (USDA-ARS), the Texas Tech University Center for Geospatial Technologies (CGT) and Water Resources Center (WRC) have generated maps of annual water levels, changes in depth to water, and storage in the Ogallala Aquifer in the SHP of Texas. The dataset includes values from thousands of well locations from the Texas Water Development Board and local groundwater conservation district databases for 1990 to 2004. The maps exist as geographic information system (GIS) geodatabase layers. These layers will be overlaid with other GIS layers that depict the locations of CRP lands, croplands, and native grasslands in the SHP. ArcGIS tools will be used to examine the changes in depth to groundwater in and near selected sub-regions that are dominated by native grassland, irrigated cropland, or CRP lands. Rates of water table decline have been noted by the local groundwater conservation districts, but the variability in the rates of change have not been correlated to above-ground land use, except for the consideration of irrigation withdrawals. In fact, some subregions with no irrigation have been experiencing water table elevation increases.

Areally averaged annual changes in water table elevation for the selected sub-regions will plotted with respect to time for the period of record. These results will demonstrate trends in water table movement that can be used to form simple trend models for prediction of future changes, assuming similar land use practices in the future. Comparison of rates of change of water level elevation between the three land use types will be made to identify the possible impacts of these land use choices on the rates. It should be noted that the timing of the potential impacts of the land use choices will be affected by the thickness of the unsaturated zone, or depth to water from the land surface. This consideration will be used, along with the findings of the recharge estimates in Objective 4, to develop of predictions of future water level changes.

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