Cropping management system influences on playa sediments in US southern high plains

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Abstract
Playa wetlands are unique, depressional geomorphic features on the Southern High Plains of the United States. These playas function as runoff catchment basins and bio-diverse wildlife habitat areas. The more than 20,000 playa wetlands in the Southern High Plains are thought to serve as major Ogallala aquifer recharge sites. Playa wetland sediment deposits are thought to impede aquifer recharge and increase evaporative water loss. This study evaluated cropping management system effects on sediment accumulation in six playa wetlands (3 cultivated, 3 rangeland). Soil cores were collected using a hydraulic probe to a depth of 1.5 m at twenty-five locations in each of the playas. Particle-size distribution and soil color proved to be adequate parameters to identify recent sediment added to the playas. Particle size distribution, however, was more useful as an interpretation and analysis tool than for distinguishing sediments. Sediment added to cropped playas was indicated by a very dark grayish brown (10YR 3/2) to very dark gray (10YR 3/1) soil-color transition. Sediment depth and land-use were directly related with greater sediment accumulation in cropped playas than in rangeland playas. Three-dimensional models will be used to depict the original playa basin with and without sediment additions.

Key Words
US southern high plains, wetlands, sediment deposition.

Introduction
Playa wetlands are unique geomorphic features on the Southern High Plains (SHP). The SHP spreads over 77,700 km^2 of West Texas and New Mexico, south of the Canadian River. Playas are natural, circular, closed-drainage watersheds with clayey basin floors (Bolen *et al.* 1989). These wetlands serve as natural catchment basins for surface runoff and deposited sediments. In the SHP, grasslands, rangelands and cultivated row crops dominate the outer-basin watershed areas that surround these playa wetlands. The typical size of playa-lake basin areas range from 57 to 104.3 ha (Gustavson *et al.* 1995). Some common playa lake uses are grazing-cattle water storage, irrigation water supplies, potential flood water collection sites, surface runoff catchments, or feedlot waste discharge catchments (Luo *et al.* 1997). Playa wetlands are important resources for both crop and livestock producers and many wildlife species (Lacewell and Masud 1994). The more than 20,000 playa wetlands also serve as major Ogallala aquifer recharge sites (Osterkamp and Wood 1987, Gustavson *et al.* 1995, Zartman *et al.* 1994, Zartman *et al.* 1996). The amount of sedimentation in playa wetlands is an important aspect of watershed management. Excessive sediment deposition adversely affects ecological services with less infiltration, more evaporation, and shorter hydroperiods.

There are many theories as to what processes were responsible for the development of playa wetlands. No single course of events, however, is responsible for playa lake genesis. Two commonly recognized processes are dissolution and subsidence (Osterkamp and Wood 1987) and deflation from wind (Reeves 1966). Hydrological events and wind also are responsible for soil erosion into and sedimentation within the SHP playa wetlands. Hydrological events, such as rainfall or irrigation, interact with cropped upland areas to produce runoff and sediment erosion (Luo *et al.* 1997). During runoff, sediments become suspended and are transported into the playa wetland. Sediment particle characteristics play an important role in suspension and ultimately, deposition. Once the sediment load has reached the playa wetland, sediment particle size determines order of deposition. Settling velocities of suspended particles increase with increased particle size. High wind gusts are another source of sediment deposition. Wind current speed is relatively low at the soil surface and dramatically increases vertically. In a cropland watershed, tractors or vehicular traffic can lift and aerosolize soil particles. Wind transport of rangeland-watershed sediments is reduced by the permanent vegetation.

Sediment physical and chemical properties play an important role in playa development as well as ecosystem function. Sedimentation can trigger many adverse effects. Severe erosion in a watershed results in excessive sedimentation and costly maintenance. Sediment accumulation in a playa wetland decreases playa depth and the amount of water available for recharge into the Ogallala aquifer (Bolen *et al.* 1989). As more sediment is deposited in a playa, playa depth decreases and wetland surface area increases, which leads to a higher potential evaporation rate and a shorter playa-wetland hydroperiod.

Due to the functions and uses of playa wetlands, it is important to understand sediment properties and sedimentation processes. Because sediments are responsible for "clogging" natural drains through the basin floor, sedimentation is perceived as the major threat to playa ecosystem integrity (Haukos and Smith 1994). The objectives of this study were to (1) measure sediment depth with respect to the original playa basin for cropland and grassland playa watersheds, (2) develop a comprehensive three-dimensional map of the original playa basin and the sediment spatial distribution, and (3) qualitatively evaluate sediment deposition as a function of watershed management.

Methods

Six playas, located in Briscoe, Floyd, and Swisher counties in Texas, USA were selected for evaluation (Figure 1). One of the paired playas in each county had a grassland outer basin watershed and the other playa in the same county had a row-cropped cotton (*Gossypium hirsutum*) or grain sorghum (*Sorghum bicolor*) outer basin watershed.

Figure 1. The location of experimental playa counties in Texas and the US.

Soil core samples were collected using a 2 cm-diameter hydraulic probe to a depth of 1.5m. The cores were collected in plastic sleeves and taken to Texas Tech University for color and particle size analysis. The 25 samples from each playa were collected in a "spoke-wheel" sampling pattern (Figure 2). Soil samples were analyzed for soil color using a Munsell color chart and particle-size distribution using the Gee and Bauder method (Gee and Bauder 1986).

Results

Many conditions can affect sediment spatial distribution in SHP playa wetlands. Tillage and hydrological events create input channels into playa wetlands and are the main sediment point-sources in the SHP. Overland flow and wind are responsible for nonpoint-source sediments. The cropland watersheds produced greater sedimentation than rangeland/grassland watersheds. Although cropland and grassland playas should have different sediment volumes, the spatial distribution of the sediment should be similar. With respect to watershed size and amount of sediment, playas with large watersheds are expected to have greater amounts of sediments than playas with smaller watersheds. The playa-wetland watersheds in this study were similar and watershed size was not a factor.

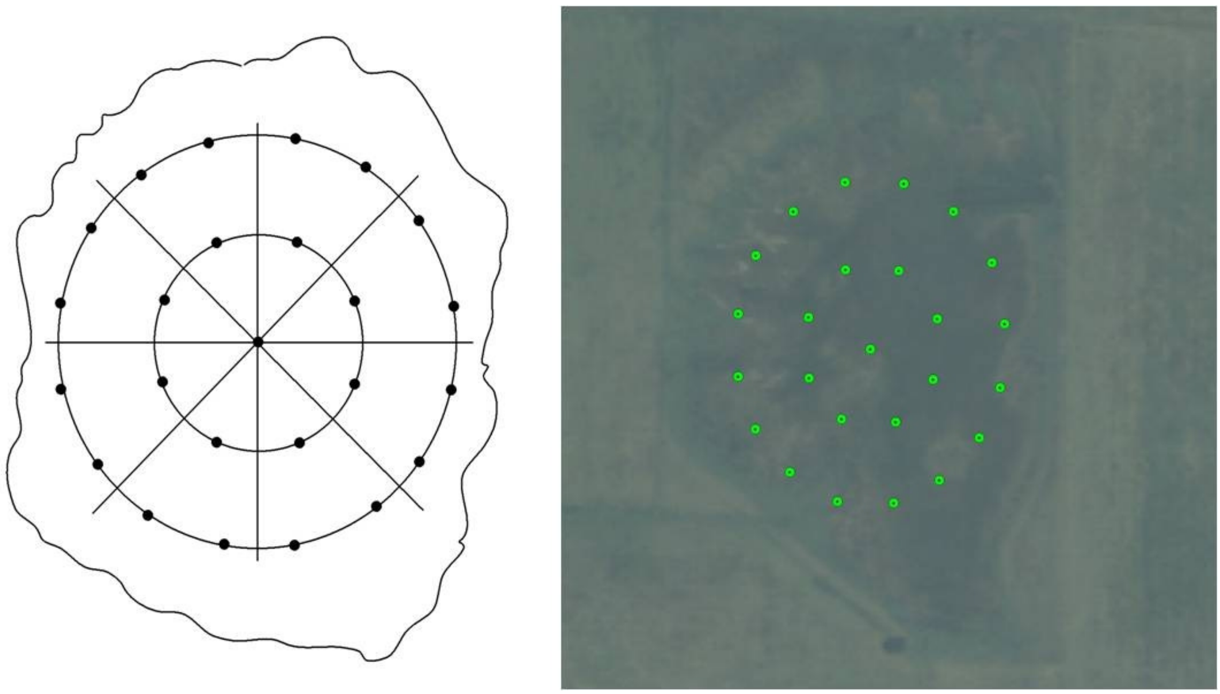

Figure 2. Wheel sampling location and playa basin (dark area) with sampling locations.

Sediments and original basin soils were distinguished by particle size analysis and soil color. Soil color proved to be most effective in distinguishing sediments from the original playa basin soil. In most cases, the sediments had a 10YR 3/2 (very-dark, grayish brown) soil color, whereas, the basin soil was darker colored with a 10YR 3/1 (very-dark, gray) soil color. The soil color change was more evident in cropland watershed playas than in the rangeland watershed playas. Sediments above the color change were more clayey in texture than sediments below the line of color change. Particle size distribution played a role in sediment distinction, but was more useful for interpretation than analysis. Sediment depths were measured and recorded and 3-D surface maps of the playa basin and associated sediment distributions will be presented.

Conclusion

Cropping systems on the outer basin watersheds that surround playa wetland basins directly influenced sediment deposition in the playas. Row-crop cultivated soils on outer basin watersheds provided more sediments to the playa wetlands than did grassland outer basin watersheds. The sediments from row-cropped watersheds were deeper and browner in color than grassland watershed sediments. An increased amount of sand-size sediments occurred below the color-change contact because the sands dropped out of suspension before the clays. The greater amounts of eroded sediments from row-cropped watersheds will probably adversely affect ecological services provided by the playa wetlands.

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