TEXAS WATER JOURNAL

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Cover photo: Located in far east Texas and stretching into Louisiana, Caddo Lake is known for its extensive forests of baldcypress trees draped with Spanish moss. This famous lake is home to a rich ecosystem and a wide variety of wildlife. The cover photo was taken during normal water levels, but in 2011 the lake's levels dropped significantly during the drought. Photo credit: Texas Water Resources Institute

Spatial Distribution and Morphology of Sediments in Texas Southern High Plains Playa Wetlands

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Abstract: Playas are depressional geomorphic features on the U.S. High Plains. About 20,000 Southern High Plains playa wetlands serve as runoff catchment basins, which are thought to be focal points of Ogallala aquifer recharge. Sediments in playas can alter biodiversity services, impede aquifer recharge, and increase evaporative water losses. The purpose of this study was to evaluate the effects of watershed cultivation systems on post-cultural sediment deposition in 3 pairs of cropland/native grassland playas in Briscoe, Floyd, and Swisher counties of Texas. A hydraulic probe was used to collect soil cores to 2 m or to refusal depth at 25 possible locations in each playa. Particle size distribution and soil color effectively identified sediment additions to the playas. Soil color transitions with depth from very dark grayish brown (10YR 3/2) to very dark gray (10YR 3/1) were always found in cropland playas but not in grassland playas. Particle size distribution was more useful in identifying sediment distribution than type. Using a kriging model, sediment volume in each playa was calculated from sediment thicknesses at the sampling locations and from sediment thicknesses interpolated between sampling locations. Sediment volume was directly related to watershed land use with more accumulated sediment in cropped playas than in grassland playas. Erosion of cultivated watersheds near playas contributes sediments that decrease playa depth and can result in increased evaporative water losses and decreased aquifer recharge.

Keywords: U.S. Southern High Plains, wetlands, sediment deposition

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INTRODUCTION

Playa wetlands are the most significant topographic and surface hydrological features of the High Plains. The Southern High Plains (SHP) extends over 77,700 km^2 of West Texas and New Mexico, south of the Canadian River (Reeves and Reeves 1996) and has been extensively studied for more than 100 years (Johnson 1901; 1902; Reeves and Parry 1969; Gustavson et al. 1995; Gurdak and Roe 2010). Playas are naturally occurring, circular basins that occur in closed-system watersheds with relatively impermeable basin floors (Bolen et al. 1989). These wetlands are classified primarily as palustrine with emergent vegetation (Smith 2003). While the wetlands vary in diameter from a few meters to several kilometers (Johnson 1902), typical diameters are much less than 1.6 km (Gustavson et al. 1995). Playas are typically shallow with depths generally less than 1 m (Haukos and Smith 1992) and average 6.3 ha in size (Guthery and Bryant 1982).

The Texas SHP has a semiarid climate moisture regime with average annual precipitation decreasing from 45 cm in the northeast to 33 cm in the southwest (Bolen et al. 1989). Major rain events occur from April through August and account for nearly 82% of annual rainfall (Gustavson et al. 1995). Due to variable precipitation and high evaporation, most playas are dry for much of the year (Haukos and Smith 1994). Quillin et al. (2005) reported that playas north of the Canadian River and along the Caprock escarpment are clustered, while those southwest of these areas have a regular spatial distribution. Zartman et al. (2003) reported playa alignment of 112 to 117 degrees (east southeast), which is similar to the alignment reported by Finley and Gustavson (1981).

Watershed characteristics play an important role in determining playa geomorphology because playas are depressional wetlands and watershed runoff is the largest influence on playa water budgets. Land slope, watershed shape, infiltration rate, tillage, and vegetative cover all affect runoff parameters (Beasley 1972; Tsai et al. 2007). Using terrain analysis, watershed shape, slope, and size can provide quantitative information to explain sediment accumulation (Wilson and Gallant 2000). Terrain analysis has been used to estimate soil chemical and physical properties, such as organic carbon, pH, and surface horizon thickness (Moore et al. 1993). Tarboton (1997) used grid elevation maps to calculate pixel by pixel values for a variety of translations. Specific catchment area (SCA) is a primary attribute of terrain curvature, which means that SCA measurements are directly related to the geomorphic terrain (Böhner et al. 2006). The SCA is a measure of outflow to neighboring cells (m^2) that drain into a cell (m). A m^2/m unit curvature grid is produced, which indicates drainage patterns across the landscape (Freeman 1991; Böhner et al. 2006). Moore et al. (1993) explained that "low soil loss was associated with sites of low catchment area," and high soil loss was associated with high catchment area sites. SCA measurements facilitate identification of local areas in a landscape where soil is eroded and other areas where it is subsequently deposited.

Upland-soil properties affect playa sediment characteristics. Allen et al. (1972) characterized 3 surface texture zones (fine, medium, and coarse) located from north to south in the SHP. Most playa basins, regardless of outerbasin textural zone, are dominated by the relatively impermeable Randall clay soil series (fine, smectitic, thermic Ustic Epiaquerts) (Nelson et al. 1983). Mineralogy differences are minor between upland soils and the associated playa soils (Allen et al. 1972). In the Texas SHP, cultivated cropland, native grassland, and Conservation Reserve Program (CRP) grassland watersheds dominate the outerbasin/watershed areas that surround playa wetlands, greatly influencing runoff.

The High Plains (Ogallala) aquifer is a mined water resource in the SHP, and playa wetlands are thought to serve as foci for aquifer recharge (Wood and Osterkamp 1987; Zartman et al 1994; Wood et al. 1997; Wood 2000; Gurdak and Roe 2010). Sediments entrained in surface water or transported by wind can negatively affect groundwater recharge. Few data exist on the deposition and spatial distribution of sediments in SHP playas. Sedimentation rates and distribution have been discussed as a function of hydroperiod (the number of days surface water is present), degree of ponding, and elevation, while the amount or lack of input channels may also have an effect (Hupp and Brazemore 1993). Sediment depth and total volume were determined to be directly related to land use and soil texture zone (Luo et al. 1997). In the medium texture zone, cropland playa sedimentation rates averaged 9.7 mm/year while grassland rates averaged 0.67 mm/year (Luo et al. 1997). The contrasting characteristics of the upland soils (color and texture) from playa basin soils have been used to identify sediments from original playa basin (Luo 1994; Luo et al. 1997).

For purposes of this paper, "sediments" are defined as post-cultural deposits that were caused by land-use practices and other factors that will be further explained in this document. Due to the uses and important function of playa wetlands for Ogallala aquifer recharge, it is important to understand sediment properties and sedimentation processes. Sediments may be responsible for "clogging" natural drains through the basin floor, which potentially retards water infiltration into the Ogallala aquifer (Bolen et al. 1989). As deposition increases, wetland surface area increases and results in higher potential evaporation losses and a decreased playa hydroperiod. Recent studies, however, have reported that sediment in cropped playas may increase seepage (Ganesan 2010; Tsai et al. 2010). Sedimentation is also a major threat to native playa biota (Haukos and Smith 1994).

Hydrological events, such as rainfall or irrigation runoff, erode outerbasin soils (Luo et al. 1999). Cultivation decreases aggregate stability and increases sediment transport. Once sediments reach the playa, sediment particle (floc) size determines sediment load deposition order (Lick 2009). Sediment particle characteristics play an important role in suspension and, ultimately, deposition. Settling velocities of suspended particles increase with increased particle size, or aggregate size (Lick 2009). Wind is another source of erosion (Gillette et al. 1980). Wind current speed is relatively low at the soil surface and dramatically increases vertically (Uden 1894; Endlich et al. 1969). Uden (1894) explained that "materials must by some means be lifted through this zone of low velocity in order to be transported a considerable distance by the atmosphere." In a cropland watershed, tractors or vehicular traffic potentially cause the disturbance needed to lift particles into suspension (Gillette et al. 1980). Sediment transport by wind is less in grassland watersheds than cropland watersheds due to permanent vegetation reducing surface wind speed.

The objectives of this study were to (1) measure the depth and characteristics of newly deposited sediments (after cultivation) with respect to the original playa floor for cropland and grassland playa watersheds and (2) qualitatively relate surface-flow characteristics of outerbasins to sediment physical properties and distribution. Information gained from this study should help to reveal soil management practices needed to minimize evaporation and maximize Ogallala aquifer recharge.

MATERIALS AND METHODS

Playa Wetland Selection

Six Texas playa wetlands located in Briscoe, Floyd, and Swisher counties were selected for evaluation (Fig. 1). Three paired playas—a grassland outerbasin watershed playa paired with a cropland outerbasin watershed—were selected per county. In Floyd County, a CRP grassland watershed was chosen to replace a native grassland playa that was flooded. All playas evaluated in this study were located in the fine soil textural zone (Allen et al. 1972) dominated by the Olton soil series. Cropland outerbasin watersheds were planted with cotton (*Gossypium hirsutum*), winter wheat (*Triticum aestivum*), or grain sorghum (*Sorghum bicolor*). The Briscoe and Swisher county grassland playas had permanent, native shortgrass prairie vegetation in the outerbasin watershed. The Floyd County CRP watershed contained approximately 50% cropland (winter wheat and cotton) and was not dominated by native grasslands. Watershed delineation will be discussed in the geographic information system materials section later in this document.

The Briscoe County cropland wetland (N 34.486°, W -101.279°) had the largest watershed and basin area in this study (348 ha and 43 ha, respectively), while the Briscoe County grassland watershed (N 34.498°, W -101.379°) and basin were smaller (143 ha and 12 ha, respectively). The Swisher County playa basins were the smallest (9 ha and
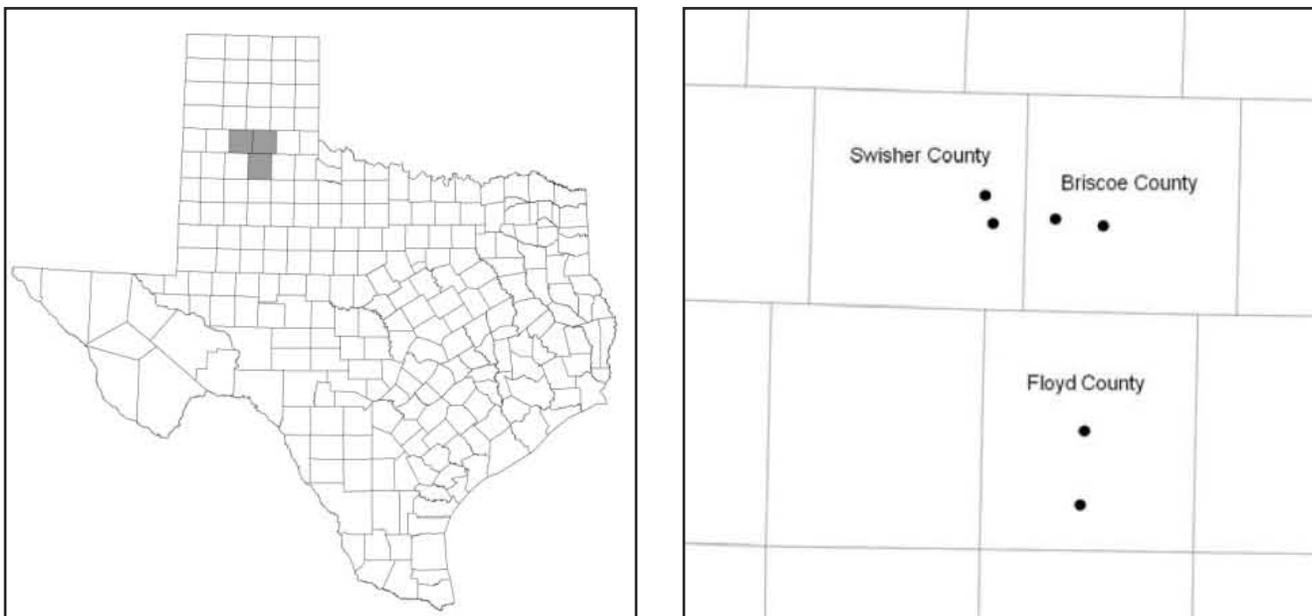
Fig. 1. Locations of selected playa wetlands used for study in the Texas Southern High Plains.

7.1 ha, respectively) for the cropland and grassland basins. The Swisher County cropland (N 34.542°, W -101.571°) watershed area was 71 ha and the Swisher County grassland watershed (N 34.486°, W -101.550°) area was 152 ha. The Floyd County playa basins were 12.9 ha and 15.3 ha for the cropland and grassland wetlands, respectively. The Floyd County cropland (N 34.073°, W-101.314°) and CRP watersheds (N 33.924°, W -101.320°) were 140 ha and 189 ha, respectively. A CRP watershed was evaluated in Floyd County in lieu of a native grassland watershed due to the native grassland watershed being inundated with water at the sampling time.

Data Collection

Up to 25 samples were taken from each playa at the center and at 2 different radii. Each playa was divided into 8 zones with a center and inner and outer radius (Fig. 2). Sample locations were placed at equal intervals along both radii and in the center of the circles. The concentric circles sampling method was chosen because it facilitates sample data comparisons between the radii. Soil core samples were collected using a
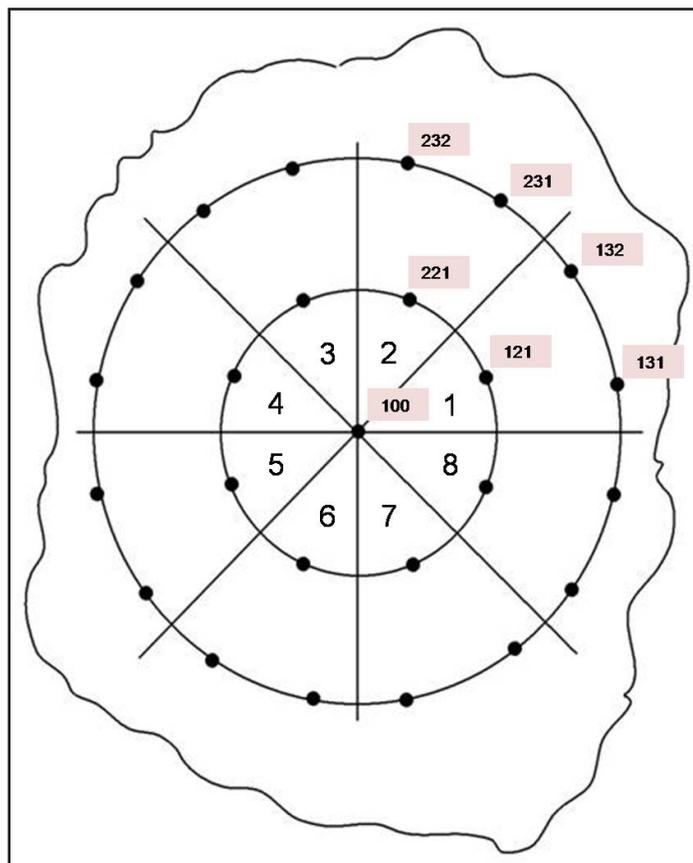
Fig. 2. Sample naming convention of the concentric circle sampling method used in the sampling of 6 playa wetlands in the Texas Southern High Plains.

5 cm (2 in)-diameter hydraulic probe (Concord Environmental, Wall, NJ) with an 80-pound hammer to refusal or 2 m depth, whichever came first. Samples were collected in plastic sampling-sleeves, capped, and taken to Texas Tech University for analysis. Less than 25 samples were taken from some sites because soil samples were not taken when a concentric-circle sampling location was outside the playa floor or when playa surface disturbance or alteration was evident.

Samples were separated into pedogenic horizons. Changes in soil color, soil texture, soil structure, and observed $CaCO_3$ masses or effervescence, and the presence of slickensides and gleyed materials aided in horizon separation. Samples were air-dried, ground, and passed through a 2-mm sieve. Particle-size distribution (PSD) was determined using the Texas hydrometer method (USDA-SCS 1980). Sand-sized particles were separated by wet-sieving, and total sand weights were used to calculate percent sand. The percent clay was determined using a 6-hr hydrometer reading (USDA-SCS 1980). Silt percentage was calculated as 100 minus the sum of sand plus clay percentages.

Geographic Information Systems (GIS)

Watersheds were delineated to quantify characteristics of the outerbasins that surround the playas. Playa basin watersheds are characterized by a playa basin surrounded by a narrow, sloping ring of soil called the annulus. Beyond the annulus, the remainder of soil in the watershed is considered the outerbasin. Watershed shape, slope, and size from terrain analysis provided quantitative evidence to support sedimentation data. Terrain analysis maps, created with the terrain analysis using digital elevation models (TauDEM extension for ArcGIS), used grid elevation maps to calculate elevations pixel by pixel (Tarboton 1997). The ArcGIS (ESRI Inc. Redlands, Ca. Version 9.2, 2007) computer program was used for data mining. For purposes of analysis, watersheds for each playa were delineated using contour lines and 3D surface grids along with other surface feature maps, such as slope percent and aspect. Wetland basins were delineated using Natural Resources Conservation Service (NRCS) Soil Survey Randall Clay delineations.

To obtain an estimate of sediment volume, an interpolation map of the sampled data was produced using a kriging model (Johnson 2010). The default settings for kriging were used as the interpolation parameters. The area and volume statistics tool from the ArcGIS 3D-Analyst extension was used to calculate sediment volume. To assist visualization of clay and sand contents, the Inverse Distance Weighted interpolation model was used with the default parameters.

Both interpolation methods produce a square grid that encompassed sample points. The estimation grid only included areas within the basin where samples were collected. Total

sediment volumes were calculated using the estimation grid, and the basin area outside the grid was discounted.

Qualitative Surface Flow Analysis Comparison

Following Hupp and Brazemore (1993) and using watershed surface flow analysis maps, channel inputs can be compared to the amount and distribution of sediments. Terrain analysis grids were created using calculations provided by Moore et al. (1993). The TauDEM tool used for analysis was SCA. The measurement units for SCA are m^2/m, hence high values indicate water-receiving areas and low values indicate lower water inputs. Previous studies using terrain analysis have calculated surface properties and analyzed soil properties within the pixels (Moore et al. 1993). Little research, however, exists in which measurements for an area were compared to unknown measurements for another area. It would be difficult to relate areas within the playa basin to surface analysis from the outerbasin watershed. To recognize significance between the watershed SCA and spatial distribution of sediment, visual trends were chosen for analysis. The term "high activity" will be used to specify areas with greater potential water accumulation, and the term "low activity" will be used to specify less potential accumulation.

Data Interpretation

Sediment depth was further investigated to determine whether the data came from a normally distributed population. The Shapiro-Wilk test is one of a few acceptable tests that produce low errors for smaller datasets (n < 20) [Shapiro and Wilk 1965 (SPSS Inc. Somers, NY)]. It was assumed that data were not normal if one or more datasets failed to meet requirements for a normally distributed population. In this research, one or more samples did not have normally distributed data; therefore, all datasets were transformed using the arcsine transformation method (Equation 1), a proportional theory that results in a distribution

$$p' = \text{arcsine } (p^{0.5}) \qquad \text{Equation 1}$$

that is "nearly level" (Zar 2010). The arcsine transformation solves for a predicted proportion (p') by taking the arcsine of the square root of each proportion ($p^{0.5}$) (Zar 2010). Blom's transformation (Blom 1958) was used in estimating proportions (p). For purposes of comparison between measured data and transformed data, one-way analysis of variance was performed. Luo et al. (1999) reported that the silt fraction in playa sediments did not vary along the basin floor; rather, an inverse relationship between the clay and sand fractions was responsible for textural differences in sediments. In this study, only the clay and sand contents of sediments were subjected to analysis. Radial measurables were analyzed with the Bonferroni multiple-range test (Holm 1979).

Numerical values, such as depth or clay content, could be interpreted through standard statistical methods. A quantitative assessment of soil color, however, was not performed because soil color is a nominal attribute. Although measured sediment depth was important in determining estimated sediment distribution maps, the statistical analysis may be misleading because playa samples were not taken on the exact position on every playa. Rather, samples were taken from the same area of the playa. For example, zone 1 (from the concentric circles diagram) samples from one playa were similar, but distances between the 2 within quadrant and circle locations were different in other playas. To address this issue, quadrants were created to represent sections within the playa basin. Sediment volume, clay, and sand content raster grids were clipped by quadrants. In addition to analyzing whole playa sediment properties, quadrant sections were compared to evaluate spatial similarities in sediment distribution.

RESULTS AND DISCUSSIONS

Spatial Distribution and Physical Properties of Sediments

The estimated sediment distribution grids show varying patterns and concentrations of sediments throughout the floor areas. Mean sediment depths were different between cropland and grassland playa floors (Table 1). Along the outer radius of the concentric circles, sediment depths were greater, sand contents were higher, and clay contents were lower than the inner radii (Table 2). In all cases, sediment volume was larger in cropland than grassland (Table 3). There were no differences in land use between the spatial distribution of sediment volumes along the playa floors (P > 0.16 – 0.38, for quadrants; Table 4).

Typical playa sediment soil characteristics included, but were not limited to, strong to moderate structure grade, subangular blocky structure, and noneffervesence. Grassland playas had more pressure faces at the surface, which indicated greater shrink-swell activity than the cropland playas. The color change between sediments and original basin material was more evident in cropland outerbasin wetlands than in grassland outerbasin wetlands. Based on a hue color change from 10YR to 2.5Y, cropland playa floors have oxidized and reduced iron horizons between 0.5- and 2-m depths.

Soil color analysis proved to be an efficient indicator for sediment and the original playa basin floor; however, sediment color varied. The predominant sediment colors for Briscoe and Swisher counties were 10YR 3/2 (very-dark, grayish brown), while the minor color was 10YR 3/1 (very-dark gray). Within

these 2 counties, larger areas with browner surfaces were present in the cropland systems (Table 5). In the Floyd wetlands, 10YR 3/1 was the dominant sediment color. Along with soil morphology and color, PSD was used to distinguish sediment from Randall Clay. In most cases, surface textures contrasted with subsurface textures.

Table 1. Measured sediment depths for 6 playa wetlands in the Texas Southern High Plains.

	County					
	Briscoe		Floyd		Swisher	
	Land use					
Sediment Depth	Cropland	Grassland	Cropland	Grassland	Cropland	Grassland
	···cm···					
Minimum	8	11	9	11	13	9
Maximum	40	58	27	37	55	66
Mean	23a[1]	24a	18a	18a	29b	20a

Note: Measured sediment depths are presented, but data were analyzed with One-way ANOVA on proportion ranks.

[1] Different lower case letter represents significant difference (P =0.05) for comparisons within county between treatments (cropland vs. grassland) at locations.

Table 2. Measured sediment depth, sand content, and clay content means for 6 playa wetlands in the Texas Southern High Plains.

	County					
	Briscoe		Floyd		Swisher	
	Land use					
Factor	Cropland	Grassland	Cropland	Grassland	Cropland	Grassland
Sediment Depth	··cm··					
Outer Radius	24a[1]A[2]	25aA	16aB	20aA	34aA	23aB
Inner Radius	20aA	24aA	14aB	18aA	20bA	15bB
Sand Content	···%··					
Outer Radius	8aB	18aA	23aA	11aA	10aB	28aA
Inner Radius	3bB	11bA	8bA	11aA	7bB	15bA
Clay Content	···%··					
Outer Radius	54bA	47bB	56bA	62bA	58bA	44bB
Inner Radius	65aA	55aB	66aA	69aA	61aA	52aB

Note: Measured sediment depths are presented, but data were analyzed with One-way ANOVA on proportion ranks. Sand and clay contents are percentages of total particle size distribution

[1] Different lower case letter represents significant difference (P =0.05) for comparisons within playa between outer and inner radii.

[2] Different upper case letters represents significant difference (P =0.05) for comparisons within county between treatments (cropland and grassland land use).

Table 3. Estimated sediment volume for 6 playa wetlands in the Texas Southern High Plains.

Factor	County and land use					
	Briscoe		Floyd		Swisher	
	Land use					
	Cropland	Grassland	Cropland	Grassland	Cropland	Grassland
	m³					
Sediment Volume	50,664	13,604	14,450	13,669	16,888	8,688

Table 4. Estimated sediment volume by quadrant for 6 playa wetlands in the Texas Southern High Plains.

Location	County						
	Briscoe		Floyd		Swisher		
	Land use						
	Cropland	Grassland	Cropland	Grassland	Cropland	Grassland	Sig.†
	m3						
Northeast [a]	11,300	2,200	3,800	4,700	4,100	2,200	0.16
Northwest	12,300	3,600	3,400	3,400	4,400	2,100	0.38
Southwest	14,900	5,200	3,600	3,000	5,100	2,000	0.20
Southeast	12,100	2,600	3,700	2,600	3,400	2,400	0.17

Note: Estimated sediment volumes are present, but data were analyzed with One-way ANOVA on proportion ranks.
[a] Directional locations are based on quadrants located in the concentric circle sampling diagram.
† P = 0.05

Table 5. Percent of sediment soil colors from sampled locations for 6 playa wetlands in the Texas Southern High Plains.

Soil Color	County					
	Briscoe		Floyd		Swisher	
	Land use					
	Cropland	Grassland	Cropland	Grassland	Cropland	Grassland
	%					
10YR 3/2	87	81	33	58	96	75
10YR 3/1	4	14	58	40	4	17

Comparison of Playas by County

Briscoe County

Watersheds for the Briscoe County cropland (BRC) and grassland (BRG) playa locations are displayed in Fig. 3 and Fig. 4, respectively. The majority of the area represented in these figures is the "outerbasin" areas that surround the playa wetlands. The annular region that joins outerbasin to wet-

land is represented by relatively high SCA values in the 50 to 100 m² m⁻¹ range. The relatively flat playa wetland floor has relatively lower SCA values.

Measured sediment depths are displayed in Figs. 5 and 6. Estimated sediment volume for the BRC and BRG playas were 50,700 m³ and 13,600 m³, respectively (Table 1). Many playa watersheds have the least deposited sediments in the northeast quadrant because the dominant wind-transported sediment infill arises from winds from the southwest. Many times
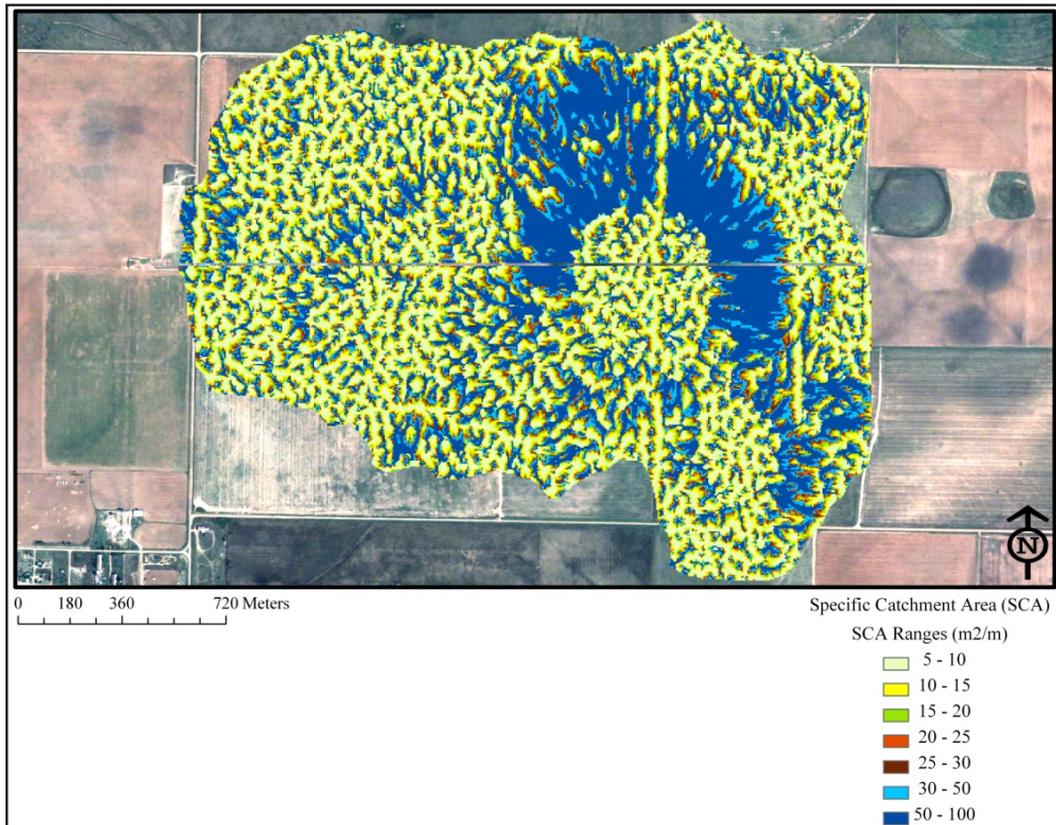
Fig. 3. Measured specific catchment area at the watershed for the Briscoe County, TX cropland playa.
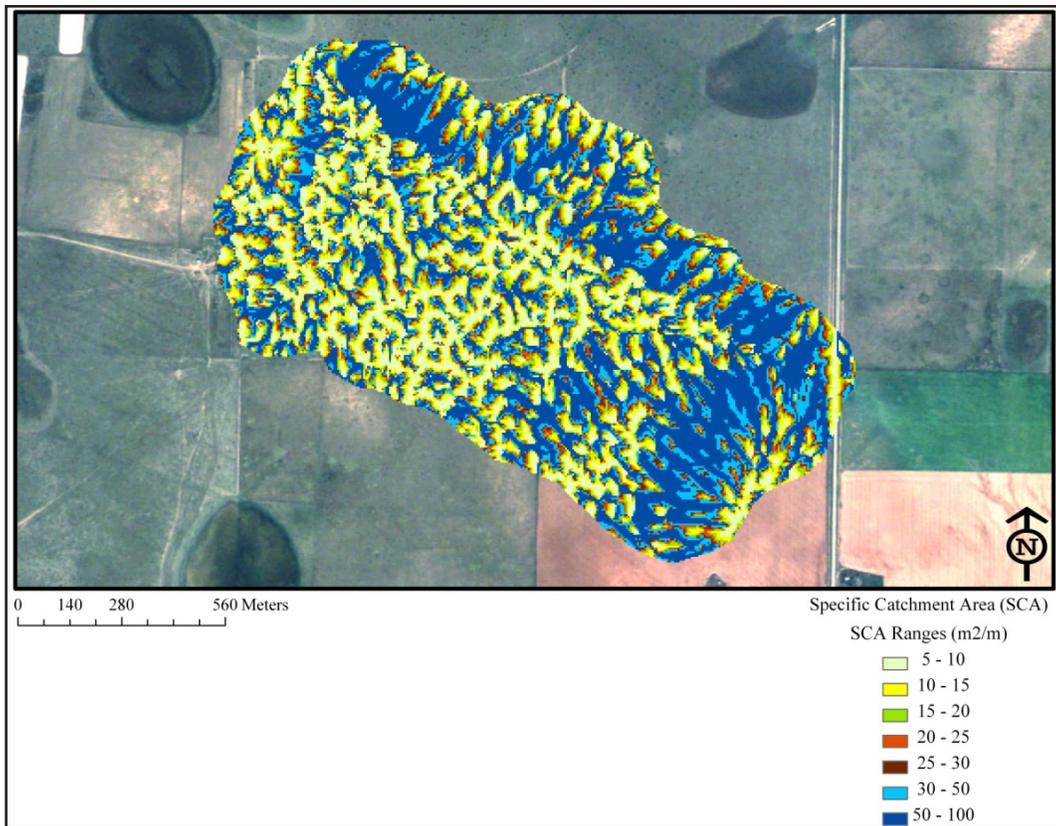
Fig. 4. Measured specific catchment area at the watershed for the Briscoe County, TX grassland playa.
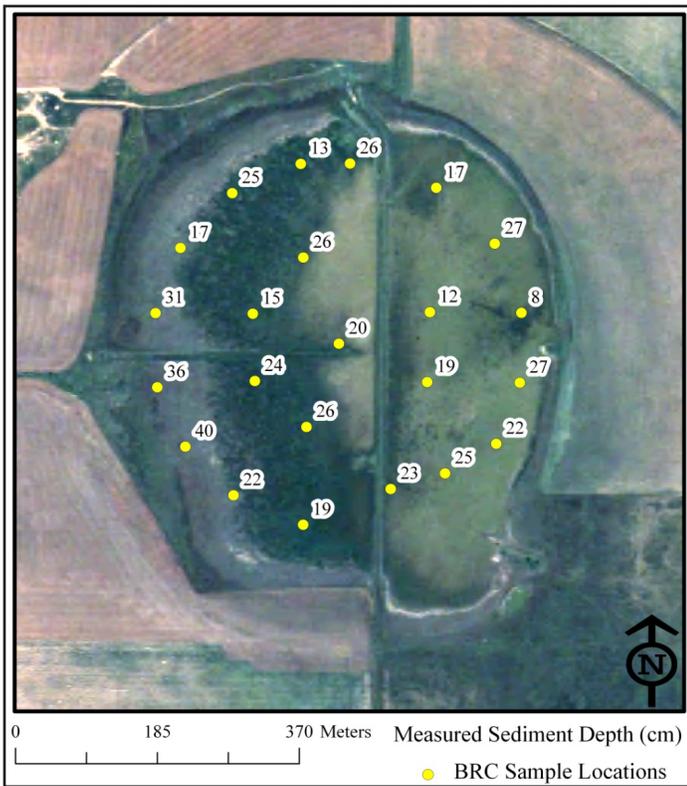
Fig. 5. Measured sediment depths in cm at 23 sample locations within the Briscoe County, TX cropland playa.
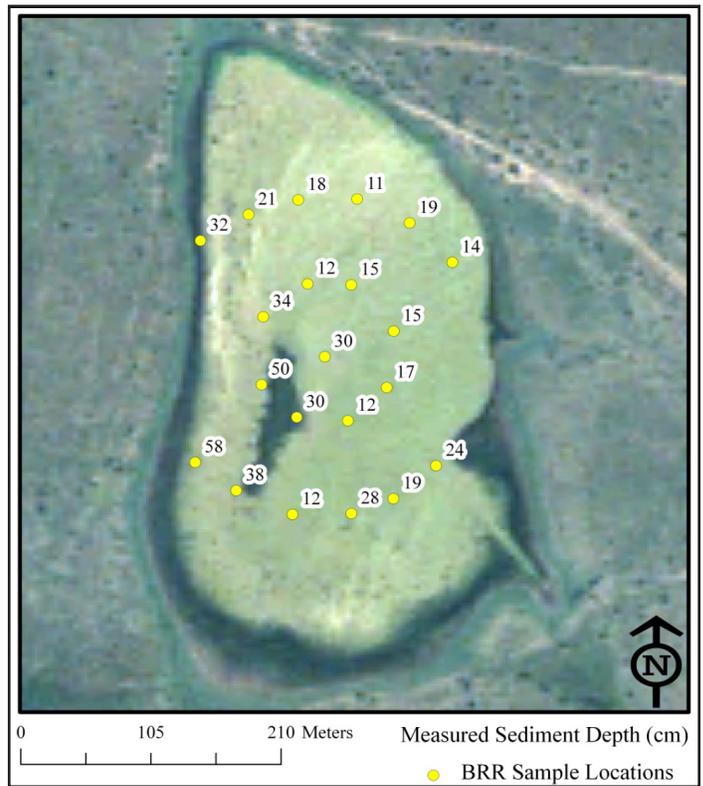
Fig. 6. Measured sediment depths in cm at 21 sample locations within the Briscoe County, TX grassland playa.

the steepest outerbasin-basin gradient arises in the northeast quadrant of the annulus. Both playa floors had the least amount of deposited sediments in the northeast quadrant. The BRC's mean sediment depth was 23 cm and the BRG's mean sediment depth was 24 cm (Table 1). These sediment depths were not different between the cropland and grassland outerbasin watersheds (F = 0.04; P > 0.84). For the BRC, the outer radius mean sediment depth was 24 cm and the inner mean sediment depth was 20 cm (Table 2).

Surface clay (F = 5.80; P > 0.02) and sand (F = 16.2; P > 0.001) contents varied between land use. Measured clay

content mean values were greater in the BRC (57%) than in the BRG (51%). Measured mean sand contents were 6% in the BRC and 15% in the BRG (Table 6). In both wetlands, mean sand content was greater along the outer radii than the inner radii (Table 2). Analysis of soil color showed that 87% of the BRC samples had a color of 10YR 3/2 (very-dark, grayish brown) in contrast to the BRG's 81% (Table 5).

In the BRC wetland, the watershed SCA measurements indicated low activity away from the playa basin. There was, however, high activity in the northern half and on the eastern areas of the watershed, adjacent to the playa edge (Fig. 3).

Table 6. Measured clay and sand content of sediments for 6 playa wetlands in the Texas Southern High Plains.

	County					
	Briscoe		Floyd		Swisher	
	Land use					
Factor	Cropland	Grassland	Cropland	Grassland	Cropland	Grassland
	···%···					
Clay Content	57 (+10)[a]	51 (+9)	61 (+12)	65 (+11)	60 (+10)	45 (+9)
Sand Content	6 (+6)	15 (+11)	17 (+13)	11 (+8)	9 (+5)	23 (+9)

[a] Values in parenthesis indicate standard deviation.
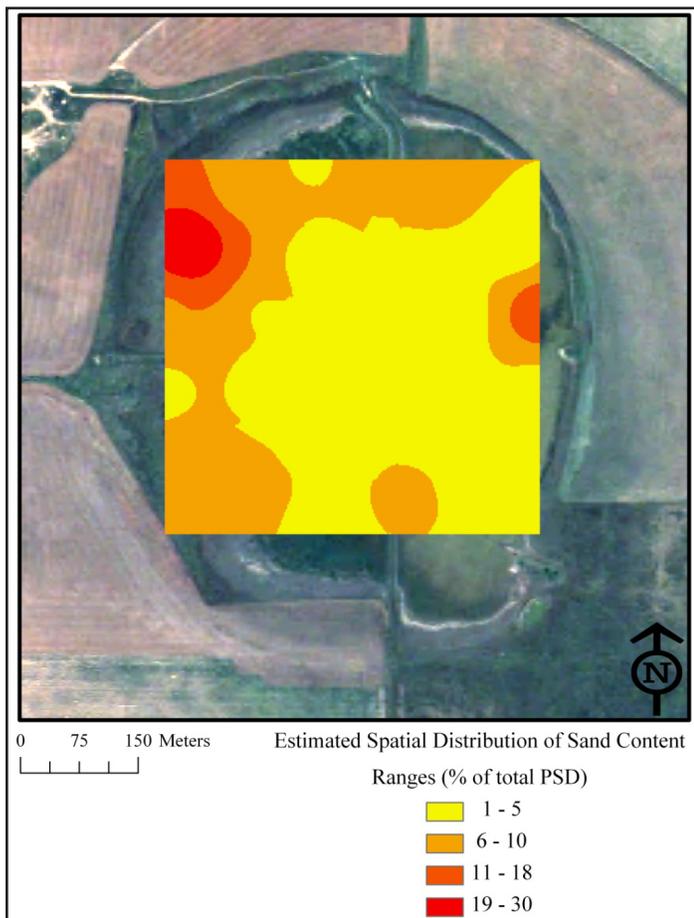
Fig. 7. Estimated sand content within the playa basin floor at the Briscoe County, TX cropland playa.
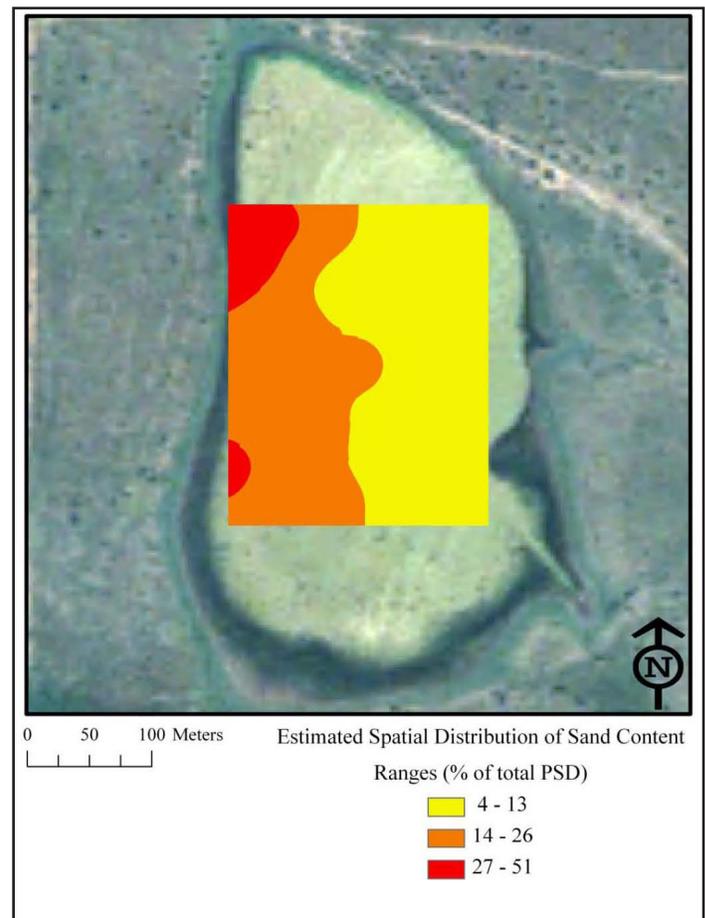
Fig. 8. Estimated sand content within the playa basin floor at the Briscoe County, TX grassland playa.

The SCA values for the BRG watershed indicate a great area of high activity in the southeastern portion of the watershed and along the northern tip of the wetland (Fig. 4). Within the playa wetland, the BRC sand content interpolation grid estimated higher accumulations adjacent to the high activity areas (Fig. 7). In the BRG playa, the relationship between SCA and sand content was much less pronounced (Fig. 8). Sand accumulation shown in Figs. 7 and 8 represent a dramatic decrease in SCA and the accumulation of sand sediments as suggested by Beasley (1972) and Moore et al. (1993).

Swisher County

In the Swisher County playas, the most sediment was deposited in the western zones. Sediments, however, were also distributed throughout the outer radius and throughout the floor (Figs. 9 and 10). Sediment volumes for the Swisher County cropland (SWC) and Swisher County grassland (SWG) playa floors were 16,900 m³ and 8,690 m³, respectively (Table 3).

The SWC watershed had high SCA activity in the north and northwest divisions of the watershed. The SCA values for the

SWG watershed suggest equal water flow outside the playa along the edge of the basin with smaller areas of high activity along the south division of the watershed. For the factors of sediment depth (F = 12.1; P < 0.00), clay content (F = 32.5; P< 0.00), and sand content (F = 46.0; P < 0.00), differences were shown between land uses. Sediment mean depths (Table 1) were significantly higher (29 cm) in the SWC than the SWG (20 cm). The SWC had 34-cm outer and 20-cm inner mean sediment depths and the SWG had 23-cm outer and 15-cm inner mean sediment depths (Table 2). Radial analysis of mean sand indicated greater sand contents along outer radii (Table 2) of SWC, which is similar to the Briscoe County playas. Mean clay contents throughout the basin floor were 60% for SWC and 45% for SWG basin floors (Table 6). Mean sand contents were 9% for SWC and 23% for SWG. A browner overall surface color in the SWC was indicated by 96% 10YR 3/2 (very-dark, grayish brown), but only 75% 10YR 3/2 in SWG (Table 5).
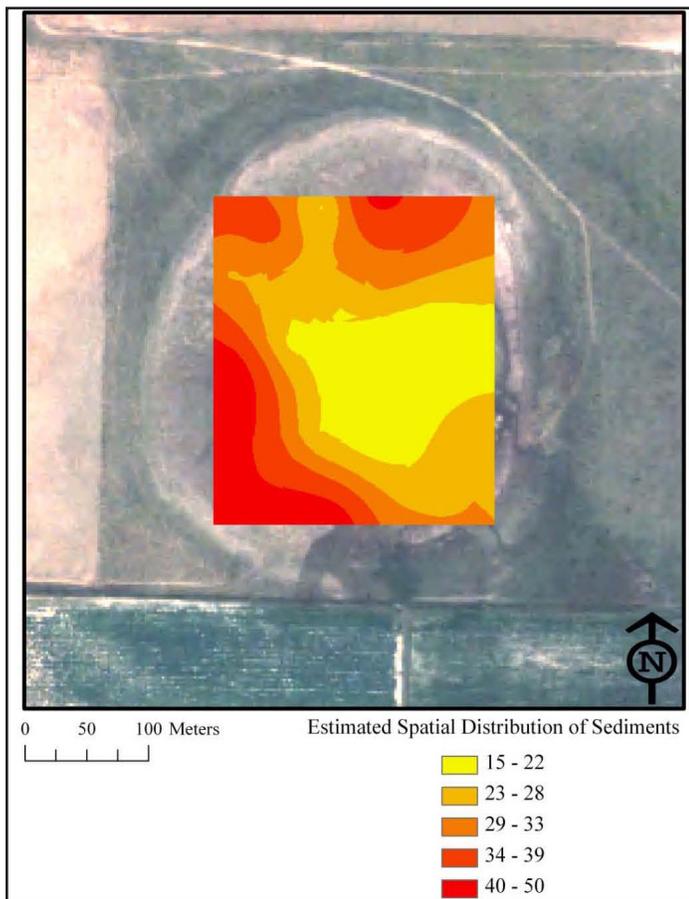
Fig. 9. Estimated playa basin spatial distribution of sediments in cm for the Swisher County, TX cropland playa.
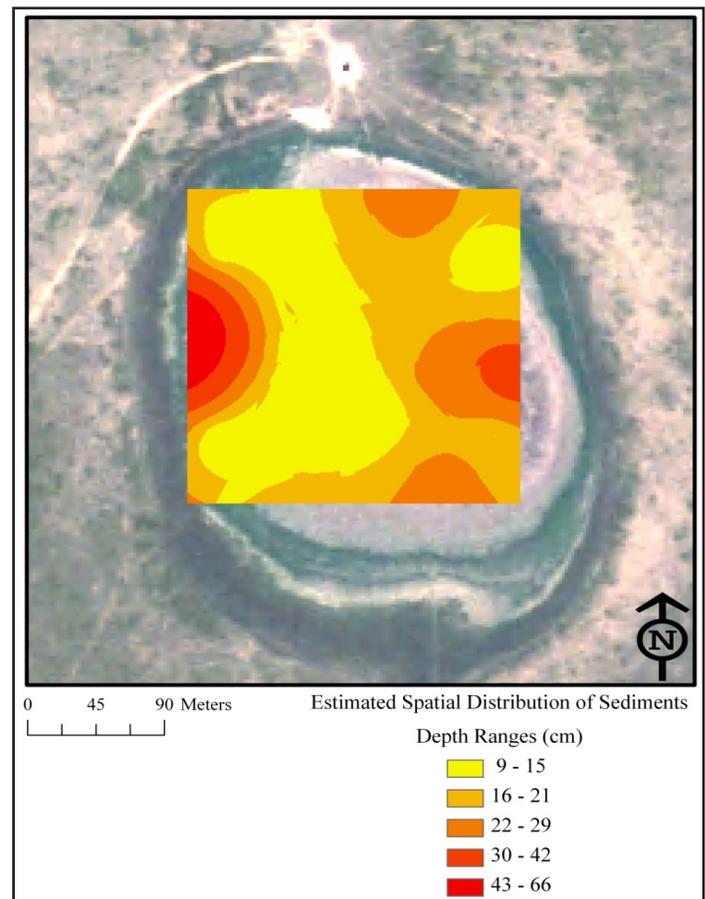
Fig. 10. Estimated playa basin spatial distribution of sediments for the Swisher County, TX grassland playa.

Floyd County

Measured sediment depth for the 2 Floyd County playas are presented in Figs. 11 and 12. The spatial sediment distribution in the Floyd County cropland (FLC) and grassland (FLG) playa floors are best described as "horseshoe" patterns. The FLC has accumulated sediment in the south and west divisions with less sediment in the northwest. This sediment accumulation differs from the FLG watershed with less accumulated sediment in the southeast. Estimated sediment volumes for the FLC and FLG playa floors were 14,500 m³ and 13,700 m³, respectively.

There was no variation in measured sediment depth between the different land uses (F = 1.05; P > 0.31). Mean sediment depths for FLC and FLG were both 18 cm (Table 1). Mean sediment depth in outer and inner radii for both FLC and FLG playas differed by 4 cm with greater sediments in outer radii than inner radii (Table 2). Both surface clay (F = 1.32, P > 0.26) and sand (F = 3.63, P > 0.06) contents did not vary between land use. The Floyd County playas had higher mean clay contents than the other playas. Mean clay contents were

65% for FLG and 61% for FLC. Mean sand contents were 11% for FLG and 17% for FLC (Table 6). In many cases, both the sediment and the original basin materials had the same color of 10YR 3/1 (very-dark gray). The cropland playa, however, was 33% 10YR 3/2 (very-dark, grayish brown), while the grassland playa was 48% 10YR 3/2.

There were high-activity SCA areas in the FLC watershed farther away from the playa basin (data not presented). More areas of high SCA activity were concentrated around the entire perimeter of the basin in less amounts than the Briscoe and Swisher County wetlands. The SCA values were lower throughout the FLG watershed.

CONCLUSIONS

The measured sediments distributions in playa wetlands indicate uneven deposition with thicker sediment deposits along outer radii. Watershed drainage networks and SCA measurements were not successful in predicting the spatial distribution of sediments. The SCA, however, was used to predict particle size distribution on playa floors. Installation of terrac-
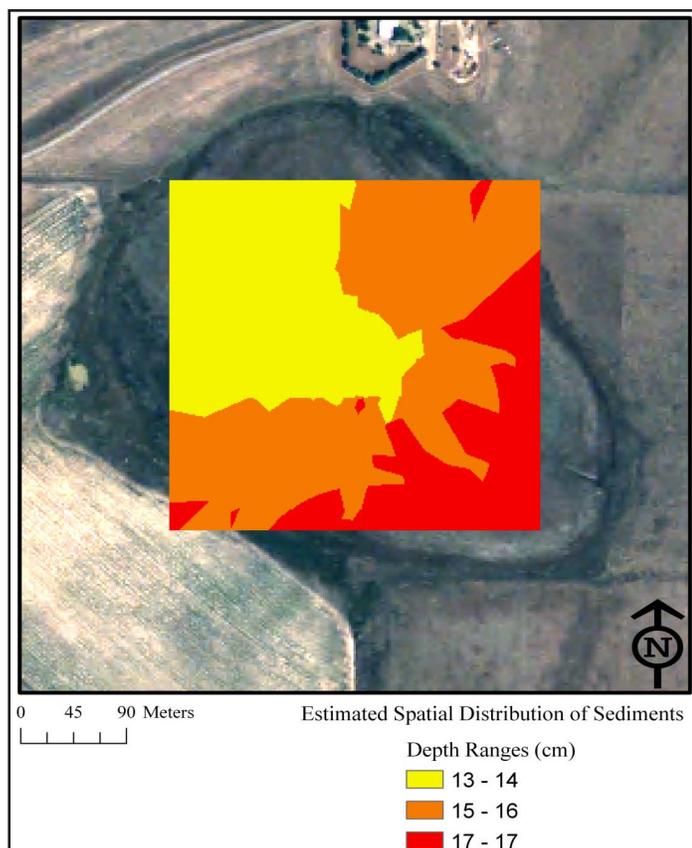
Fig. 11.   Estimated playa basin spatial distribution of sediments for the Floyd County, TX cropland playa.
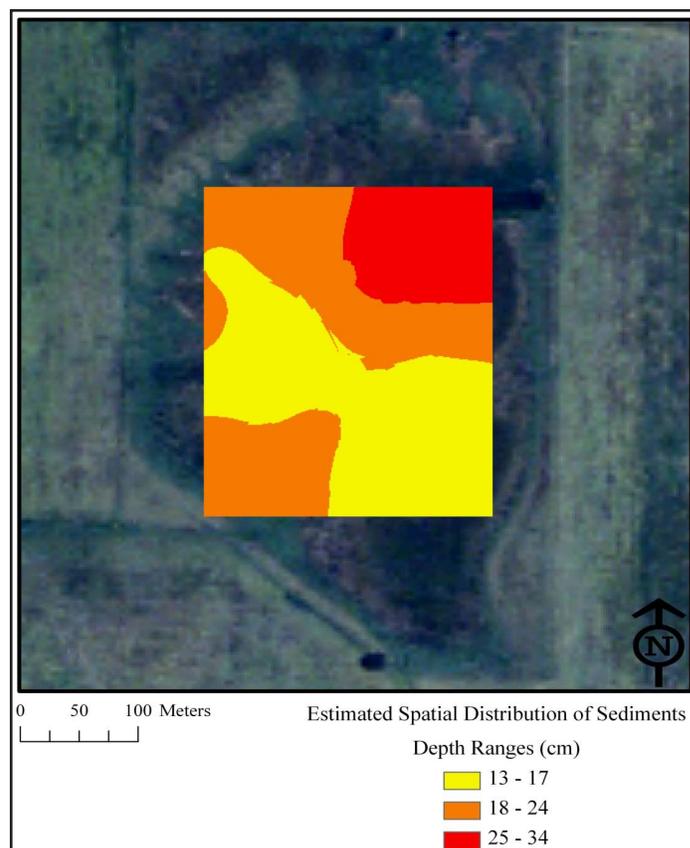
Fig. 12.   Estimated playa basin spatial distribution of sediments for the Floyd County, TX grassland playa.

es, crop-row orientation, and overall hydrological patterns of a dynamic watershed does not allow for accurate assumptions to explain sediment spatial tendencies. Outer radii of the concentric circles had greater sediment accumulations and coarser materials compared to the inner radii. The surface color in the cropped playas was browner in color than the grassland playas. This sediment color difference could be used to separate the cropland from the grassland playas.

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