Relationship Between Landscape Aspect and Playa Alignment on the Texas High Plains

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ABSTRACT

Playas (ephemeral lakes) of the Texas High Plains (THP) appear to be aligned when observed on small scale maps or aerial photographs. Playa orientation, however, has eluded spatial description and the landscape topography relationships are unknown. This study examined the relationship between landscape aspect and playa alignment for 23 THP counties. Landscape topography was evaluated using aspect direction as determined from 100 ft (~33m) contours presented on U. S. Geological Survey 1:250,000 topographic quadrangle maps. Playa alignment was evaluated with the Hough transform using a Linear Evaluation of Actual Points Program (LEAPP). Playa alignment from LEAPP correlated with landscape aspect from USGS map contours with a correlation coefficient of 0.17. Playas were aligned with aspect direction by quadrant for 13 of the 23 THP counties evaluated. For those 13 counties, the average aspect was 112 degrees for the contour method compared to 117 degrees for the LEAPP method indicating a relationship between landscape aspect and playa alignment.

KEYWORDS: Hough transform, Linear Evaluation of Actual Points Program, Texas High Plains.

INTRODUCTION

One of the most interesting geomorphic features on the Texas High Plains (THP) is the ephemeral lake known as a playa. These transient wetlands provide critical wildlife habitat throughout the region (Bolen et al. 1989). Playa lakes are defined in terms of the fine-textured soils that typically occupy the lowest elevational position in the otherwise flat topography (Zartman and Allen 1999). Most playa soils were historically mapped as Randall clay (fine, smectitic, thermic Ustic Epiaquerts). Current efforts by the Natural Resources Conservation Service have remapped and reclassified many of the playas making the ubiquitous Randall soil just one of several playa lake soils. Competing soil series are the Ranco, Rosston and Ustibuck while similar soils are the Chapel, McLean, Lazbuddie, Lockney and Sparenburg.

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Playas appear to be aligned when viewed from the air or on small-scale aerial photographs and maps. Finley and Gustavson (1981) noted this linear orientation of playas and speculated that underlying geologic structures may control playa location. Reeves (1990) stated that most playas formed from a combination of eolian activity at the soil surface and dissolution and subsidence of underlying geologic strata. Gustavson et al. (1995) attributed playa formation to complex pedogenic, geologic and biological processes.

Zartman and Fish (1989, 1992) evaluated playa alignment by several different methods. Linear regression worked quite well ($r^2 \geq 0.98$) when the playas were within 5 km of draws (Zartman and Fish 1992). Their work, however, suggested no significant linear relationships away from the natural drainage ways. Using a geostatistical approach, Zartman and Fish (1989) reported almost east-west (275 degrees) and north-south (350 degrees) lineation of playas on a subset of the playas of Castro County, Texas. Playa analysis of the whole county showed the strongest linear spatial distribution was along an axis of approximately west-northwest through east-southeast (Zartman and Fish 1992).

The efforts of Zartman and Fish (1989, 1992) were very time intensive and may include human bias in pattern interpretation. Recent efforts in pattern recognition have utilized the Hough transform (HT) to evaluate natural shapes for lineament detection (Samal and Edwards 1997, Wang and Howart 1990). HT is a mathematical means to identify straight lines (Hough 1962). A principal application of the HT has been by the military (Casasent and Krishnapuram 1987, Krishnapuram and Casasent 1989, Kiryati and Bruckstein 1991, Yankowich and Farooq 1998). Cross (1988) used the HT to detect circular geological features while Cross and Wadge (1988) determined geological lineaments. Wang and Howarth (1990) and Karnieli et al. (1996) used HT for automatic lineament detection of geologic features. Zartman et al. (2000) developed the LEAPP algorithm to use the Hough transform to analyze linear features.

Our hypothesis was that the playa alignment should be related to landscape aspect on the THP. Our objective was to quantify the relationship between landscape aspect direction using USGS maps and playa alignment through LEAPP.

MATERIALS AND METHODS

Twenty-three Texas counties within the Texas High Plains (THP) form the study area (Fig. 1).

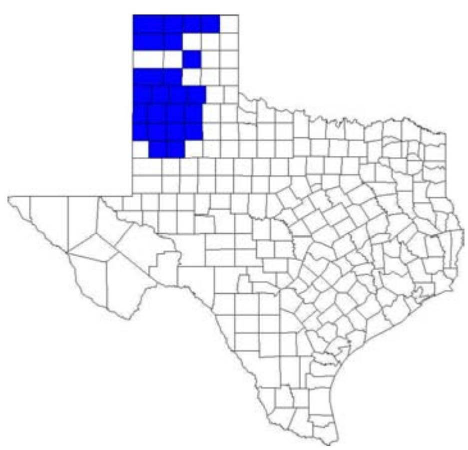

Figure 1. Counties evaluated for landscape aspect and playa alignment.

Playa location data from Fish et al. (1999) were analyzed for playa alignment using the LEAPP algorithm written in C^{++} (Zartman et al. 2000). Those playa locations were expressed in Albers equal area projection grid coordinates for the playa center of mass to the nearest 50 m. Primary data sources for the playas were Landsat imagery and Natural Resources Conservation Service (Soil Conservation Service) County Soil Survey Reports. United States Geological Survey 1:250,000 topographic quadrangle maps for the THP were used to determine the surface aspect topography. Aspect data were manually computed using the perpendicular angle to the chord of the median 100 foot (~33m) contour of the USGS map for that particular county in the THP. For counties split between the THP and the Rolling Plains (Brisco, Crosby and Floyd), only the contours from the THP areas were used. Directional attributes were reported in compass angle from 0° (North) through 90° (East) to 180° (South). Statistical analysis of means, standard deviations and correlation were performed in Excel.

RESULTS AND DISCUSSION

While the general aspect orientation of the Texas High Plains (THP) is towards the southeast, individual counties have their own aspects. Our general hypothesis was that the aspect direction of the county would determine the dominate playa orientation. To evaluate this premise, we evaluated the landscape aspect and dominate playa alignment for each of the 23 THP counties within the study area (Table 1).

Table 1. Best playa lineation angle using the LEAPP program or landscape aspect determined from USGS topographic maps by county on the Texas High Plains.

County	LEAPP angle	Contour angle
Bailey	93	162
Briscoe	139	120
Carson	83	33
Castro	111	152
Cochran	176	103
Crosby	60	130
Dallam	92	11
Deaf Smith	83	143
Floyd	163	112
Hale	3	122
Hansford	91	62
Hartley	119	170
Hockley	103	105
Lamb	103	159
Lubbock	2	127
Lynn	133	119
Moore	74	45
Ochiltree	45	27
Parmer	174	147
Randall	89	122
Sherman	83	130
Swisher	41	120
Terry	89	128

Based upon the aspect directions determined from the USGS maps, 18 of the 23 counties sloped to the southeast, while the remaining five counties sloped to the northeast. Mean contour aspect direction angle for all the counties in the study was 111 degrees (southeast) with a standard deviation of 45 degrees. For those counties that sloped to the southeast, the aspect orientation angle was 132 degrees with a standard deviation of 20 degrees. For the five counties that sloped to the northeast, the aspect orientation angle was 36 degrees with a standard deviation of 19 degrees.

Lineation as determined by LEAPP, was almost equally divided between those playas oriented to the northeast (11) and those oriented towards the southeast (12). Mean LEAPP angle for all counties in the study was 93 degrees (east) with a standard deviation of 46 degrees. The 12 counties with playa orientation to the southeast had an average orientation angle of 125 degrees and a standard deviation of 32 degrees. The 11 counties that had playas oriented towards the northeast, the average angle was 59 degrees with a standard deviation of 33 degrees.

Individual playa alignments and topographic aspect relationships were complex. When all 23 THP counties were evaluated, the landscape aspect and playa lineation had a correlation coefficient of 0.17. The average angles as determined by the two methods were similar (111 vs. 93 degrees). This seems to be, however, an artifact because the average absolute difference in angle between the two methods was 46 degrees. The median difference was 50 degrees and the mode was 51 degrees. Some counties differed greatly in aspect directions (Swisher varied by 79 degrees). While others such as Hockley County, were very similar with the county aspect angle of 105 degrees which agrees with the LEAPP angle of 103 degrees. Lubbock County would appear to differ greatly in orientation angle (2 vs. 127 degrees). The LEAPP orientation of two degrees can be alternatively be thought of as 182 compass degrees. Therefore, the angular differences in Lubbock County are actually only 55 degrees. Additionally, the playa orientation of two degrees for Lubbock County may reflect the presence of the Blackwater Draw. While a correlation coefficient of 0.17 is small, it indicated some spatial relationship between the lineation of the playas and the county aspect direction.

Thirteen of the 23 THP counties had similar quadrant directional aspects determined by contour evaluation and playa alignment angle as determined by LEAPP. For those 13 counties, the contour angle was 112 degrees whereas the LEAPP angle was 117 degrees. The standard deviation of 49 degrees for the contour method and 40 degrees for LEAPP method were also similar. In most instances (10 of 13), these counties sloped to the southeast. For counties that sloped to the southeast, the two methods, however, were negatively correlated (-0.48) with one another. This indicated that while counties and playas sloped the same general direction, specific slopes were not well matched. The remaining three counties (Carson, Moore and Ochiltree) sloped predominately to the northeast probably reflecting the influence of the Canadian River. For these three counties, the contour and LEAPP methods were positively correlated (0.59). This indicated both surface topography and playa alignment were probably influenced by the Canadian River escarpment.

CONCLUSIONS

Surface topography was related to playa alignment in some, but not all, of the areas studied. So far as we could determine, there was no overall pattern of landscape aspect and playa alignment throughout the THP. While the absolute correlation coefficient between the contour method using 1:250,000 topographic quadrangle maps and LEAPP for playa orientation overall was low (0.17), 13 of 23 counties had similar quadrant orientations. For those 13 counties, compass angles determined by the two methods were remarkably similar (112 for contour and 117 degrees for LEAPP). This knowledge may allow us to better understand the origin of playas as well as to better understand the possible consequences of current or projected uses of these critical wildlife habitats.

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