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The Yellow Lake Experiment

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Introduction

The term playa is often used to describe the flat-floored bottom of a closed basin that becomes at times a shallow lake (Blackwelder, 1931; Shaw & Thomas, 1989; Blank *et al.*, 1999). On the Southern High Plains, there are two distinctly different types of playas – the small circular playas and the larger and more irregular saline playas (Reeves & Parry, 1969). Though both playa types appear to share many common features, the saline playas are not equivalent in either form or origin to the circular playas (Sabine & Holliday, 1995).

Circular playas lie on the Blackwater Draw formation well above the water table of the underlying Ogallala formation (Wood *et al.*, 1992). Runoff that collects in the circular playas slowly drains through the soil to the underlying Ogallala aquifer flushing away salts in the process (Osterkamp & Wood, 1987). As a freshwater playa dries out; plants take root and limit aeolian deflation (Haukos & Smith, 1997).

Saline playas, on the other hand, are in close contact with the saturated zone of the Ogallala aquifer, which limits drainage (Holliday *et al*., 1996). A salt encrusted clay surface develops as surface runoff and groundwater discharge evaporates. High salinity levels prevent plant growth leaving the bare playa surface highly susceptible to aeolian deflation. During periods of aeolian activity, clay aggregates are dislodged and transported across the playa surface. Fine fractions become suspended and form dust plumes that may extend great distances. Coarse grains deposit near the partially vegetated playa margins where they form clay dunes, also referred to as fringing dunes or lunettes (Bowler, 1968; Reeves and Parry, 1969; Bowler, 1973). During periods of heavy rain, some of the dune sediments wash back onto the playa surface where they eventually dry out and become source material for future aeolian transport. This process sets up a continuous cycle of aeolian deflation and transport of playa sediments to the fringing dunes and fluvial erosion and transport of dune sediments back to the playa surface.

An attempt was made to study aspects of this dynamic system by measuring and monitoring some of the active physical processes that shape the saline playa environment.

Physical Setting

Located at the southern end of the Great Plains, the Southern High Plains, also known as the Llano Estacado, is an immense elevated plateau of approximately 78,000 km^2 (Reeves & Reeves, 1996). There are 21 large (>5 km^2) topographically closed basins scattered across the Southern High Plains that contain an estimated 40 saline playas (Reeves, 1966; Sabine and Holliday, 1995; Wood and Sanford, 1995; Holliday, 1997). Yellow House Basin is the third largest closed basin on the Southern High Plains with a depression area of 74 km^2 (Reeves, 1966). It contains two saline playas — Yellow Lake and Illusion Lake (Fig. 1). This study focuses on Yellow Lake.

The playa surface at Yellow Lake is 4.4 km long by 0.9 km wide with a surface area of approximately 3.5 km^2. Partially vegetated clay dunes that extend to as high as 35 to 40 m above the playa surface line the east side of the playa. Although the water table fluctuates seasonally, it remains near the surface even when the playa is dry. At times, surface waters form a broad shallow pool that occupies a limited fraction of the playa surface. The location of the shallow pool has been observed to slowly move about the flat lakebed as it is pushed by the wind. The portion of the playa surface not wetted by the shallow pool remains susceptible to aeolian deflation.

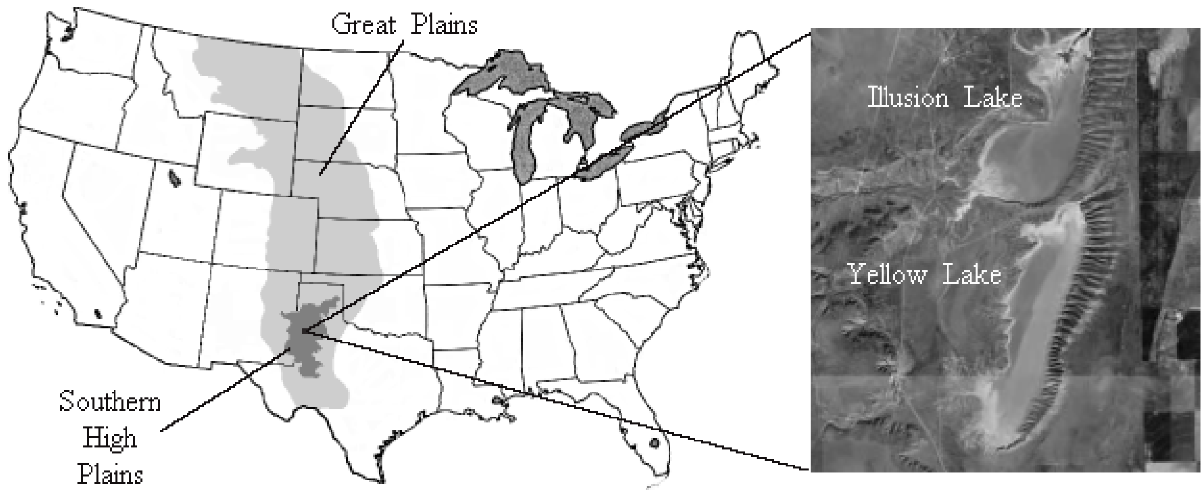

Figure 1. Map showing the location of Yellow Lake, the Southern High Plains (dark gray), and the Great Plains (light gray).

Experiment

Two sampling systems were installed on the playa surface at Yellow Lake. An acoustic water level sensor was placed near the center of the playa to record surface water depth. Another sampling system was placed near the foot of the fringing dunes on the east side of the playa to record climatic variables such as wind speed, wind direction, temperature, relative humidity, solar radiation, and precipitation. Saltation activity was measured with a piezoelectric saltation sensor mounted next to the meteorological tower.

During periods of active saltation, the piezoelectric transducer produces a signal that is used simply as an on-or-off indicator of saltation activity. Each pulse signal generated by each saltating grain that impacts the sensor is detected and if one or more impacts are detected during a given second then that second is recorded as one “saltation second” or one second of saltation activity. At the end of each hour the total number of saltation seconds are summed and output to final storage.

For each day of the experiment, the total number of saltation seconds were summed and then divided by 86,400 s to form a dimensionless value of “daily saltation activity.” Daily saltation activity expresses the fraction of time within a given day that active saltation was detected.

Results and Discussion

Daily saltation activity is plotted as a time series in Fig. 2. A seasonal reference frame is provided across the top of the graph. In addition, a seasonal summary of saltation activity, measured climatic factors, and water depth is presented in Table 1. The results provide a record of aeolian activity at Yellow Lake from December 1998 to June 2002.

Figure 2. Daily saltation activity measured at Yellow Lake, Texas.

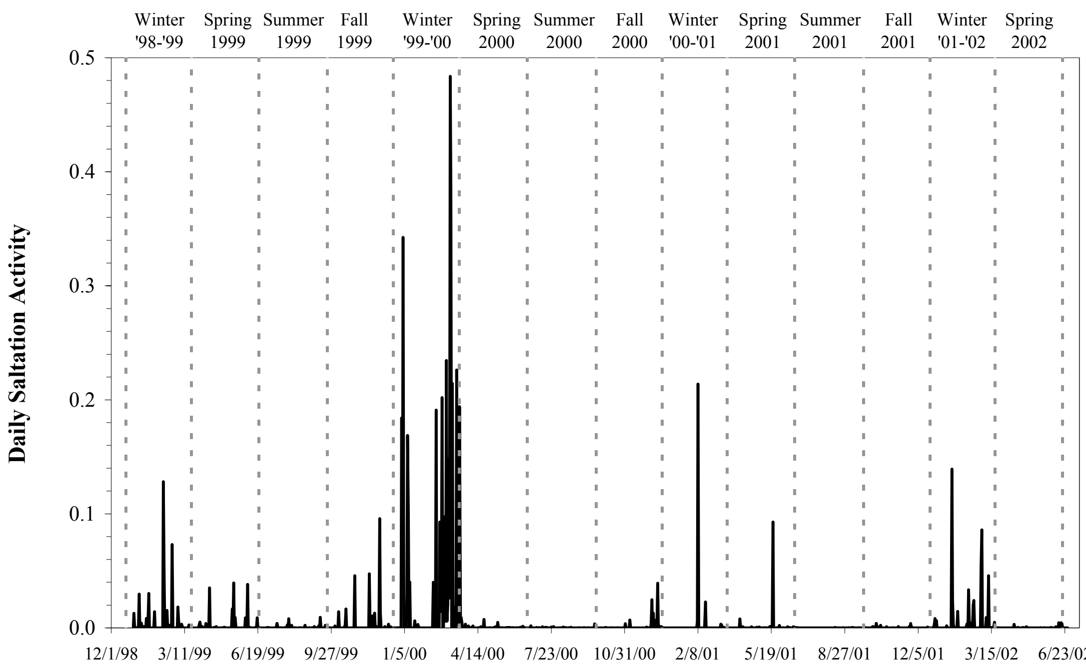

Table 1. Seasonal summary for Yellow Lake, Texas.

Season	Total Rainfall (mm)	Average Relative Humidity (%)	Average Water Depth (cm)	Maximum Water Depth (cm)	Average Wind Speed (m/s)	Total Saltation Seconds (s)
Winter 1998-1999	52	49	3	17	4.3	38,011
Spring 1999	182	55	13	35	4.6	21,042
Summer 1999	232	61	16	45	3.1	9,221
Fall 1999	27	56	3	13	3.4	25,528
Winter 1999-2000	4	48	1	2	3.8	306,671
Spring 2000	75	54	2	17	4.5	23,294
Summer 2000	72	50	3	18	3.2	2,906
Fall 2000	82	71	7	17	3.2	10,584
Winter 2000-2001	87	78	5	18	3.3	22,437
Spring 2001	85	58	8	40	3.9	18,227
Summer 2001	67	57	1	7	3.0	5,198
Fall 2001	61	64	3	16	3.2	3,356
Winter 2001-2002	30	45	1	2	3.7	42,691
Spring 2002	138	53	4	19	4.3	7,600

Saltation activity tends to peak during winter when dry conditions and moderately strong winds combine to produce ideal conditions for aeolian activity. This is especially true for winter 1999-2000 with a total of 306,671 saltation seconds. This value is nearly an order of magnitude larger than any other period and this intense saltation activity is clearly visible in Fig. 2. Saltation activity is relatively low during the summer due to the unfavorable conditions of light winds, significant rainfall and high humidity. Moist conditions tend to increase threshold and this combined with light winds leads to highly intermittent saltation activity. Surprisingly, the playa surface is fairly inactive during spring when winds are the strongest. The primary reason is most likely due to significant spring rains that moistens the playa surface and essentially shuts down saltation activity despite strong winds.

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