Playa Wetlands: Ecosystem Functions and Potential Risks in a Changing Climate

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Background

- Playas provide crucial nutrient filtration, groundwater recharge, and wildlife habitat in the High Plains (3).
- Regional climate models for the High Plains predict an increase in temperature and intensity of precipitation events in the next thirty years (2).
- Playa wetland ecosystems are sensitive to changes in precipitation and temperature (1).
- Changes in the hydroperiod (frequency, duration and depth of inundation) could alter the soil chemistry, vegetation community dynamics and overall ecosystem function (1).
- Changes to playa ecosystem function have the potential to impact human and wildlife populations in agricultural and urban areas throughout the High Plains region (3).

Objectives

1) Quantify effects of changing climatic conditions on plant production, soil chemistry, greenhouse gas emissions, microbial community structure and function, and the overall ecological tipping point of the wetlands.
2) Compare ecosystem response of Northern and Southern playa soils to changing climatic conditions.

Site Characteristics

- Playas are shallow, recharge wetlands located in the High Plains region, USA (Figure 1).
- Five "Northern" playa soils were collected from the Rainwater Basin in Nebraska and five "Southern" playa soils were collected from the Southern High Plains in Texas.
- Initial soil samples were analyzed for basic physiochemical properties (Table 1).

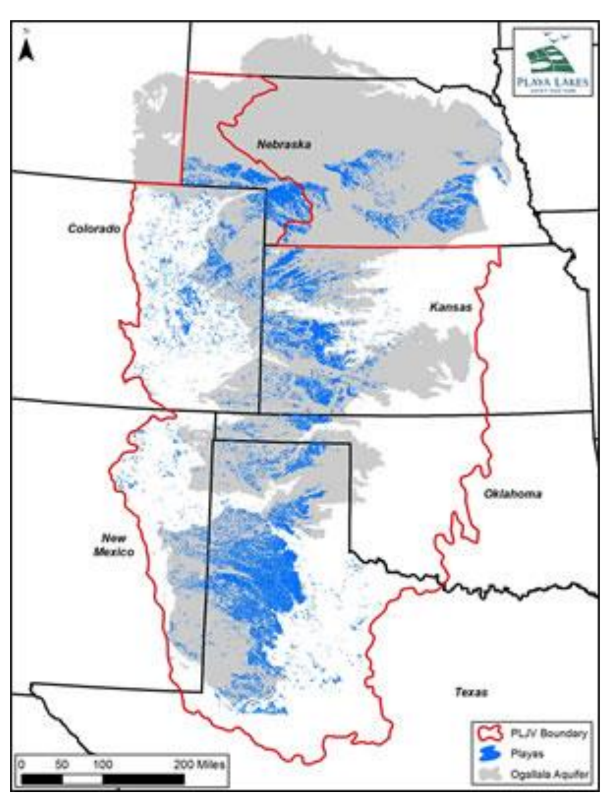

Figure 1: Geographical distribution of playas (*www.pljv.org*)

Table 1: Physical and chemical soil properties for samples collected in Nebraska (n=3) and Texas (n=5) playas.

	Nebraska	Texas
Physical Properties		
Texture	Silty Clay Loam – Silty Clay	Silty Clay – Clay
% Clay	31.6 - 41.5	54.2 - 84.2
Chemical Properties		
pH (H_2O)	5.5 - 6.7	5.7 - 7.8
EC (dS m^{-1})	0.17 - 0.44	0.30 - 0.87
Total Nitrogen (mg kg^{-1})	0.072 - 0.319	0.052 - 0.352
Bray 1 P (mg kg^{-1})	47.4 - 98.4	38.3 - 129.2
Organic C (mg kg^{-1})	0.7 - 3.4	0.5 - 4.1
CEC ($cmol_c$ kg^{-1})	12.9 - 25.3	18.9 - 44.9

Experimental Design

Set-up
- Greenhouse environment
- Six month duration (June-December 2016)
- Native seedbank expression

Treatments
- Historic and future climate precipitation projections (Figure 2)

Test Parameters
- Plant community dynamics (height, count, classification)
- Soil chemical properties (pH, EC, N, P, Fe, Mn, TOC, ORP)*
- Soil microbial community (Targeted 16s rRNA gene amplicon sequencing)

*EC = Electrical Conductivity; TOC = Total Organic Carbon; ORP = Oxidation Reduction Potential

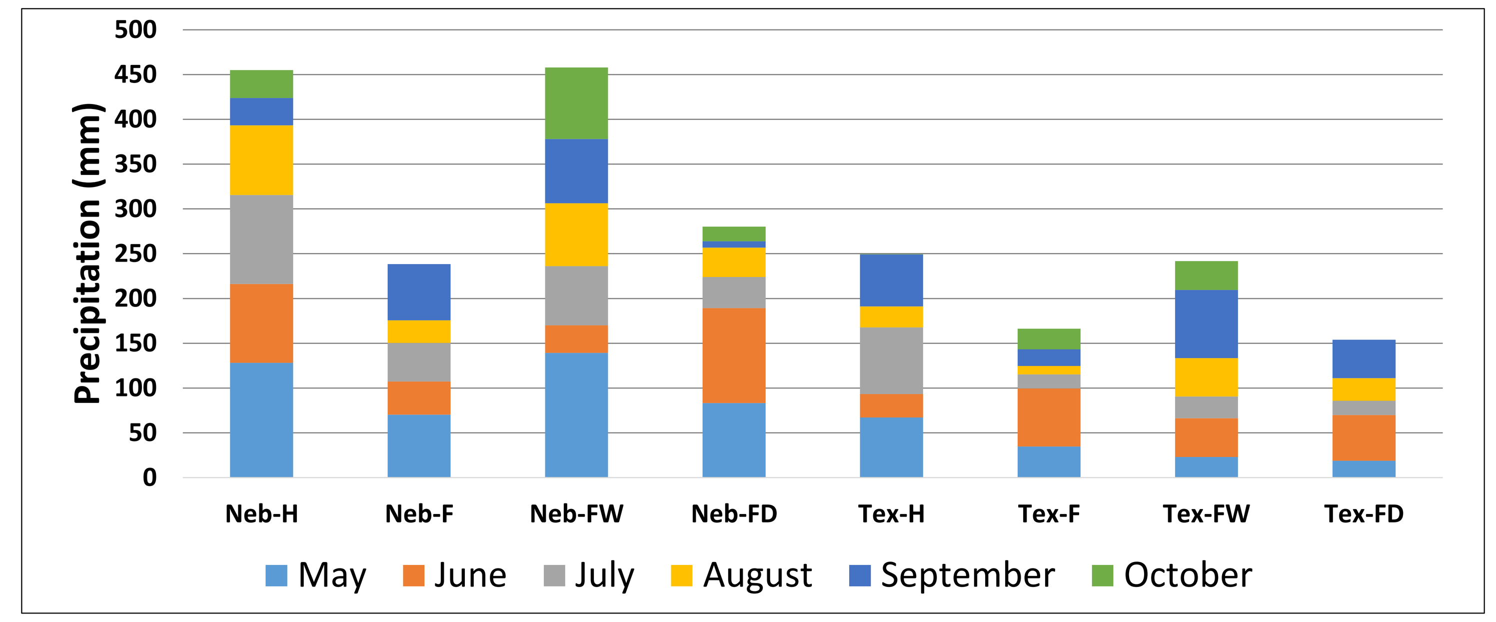

Figure 2: Precipitation treatments for sample cores collected in Nebraska (Neb) and Texas (Tex) for historic data (H) and scenarios based on downscaled CMIP5-BCCA downscaled atmosphere ocean general circulation models for the RCP 4.5 emission scenarios (2070-2099) – future average (F), wet future (FW), and dry future (FD)

Preliminary Results

- Four months of the greenhouse experiment have been completed.
- Redox potential (ORP) was measured using *in situ* sensors and preliminary results show that ORP responds to precipitation events (Figure 3).
- Plant species vary by wetland. Based on classifications of the National Wetland Plant List (NWPL), treatments that receive more precipitation are better suited to support obligate (OBL) and facultative wetland (FACW) plants, and drier treatments may be more suited to support facultative (FAC) and facultative upland plants (FACU) (5) (Figure 4).

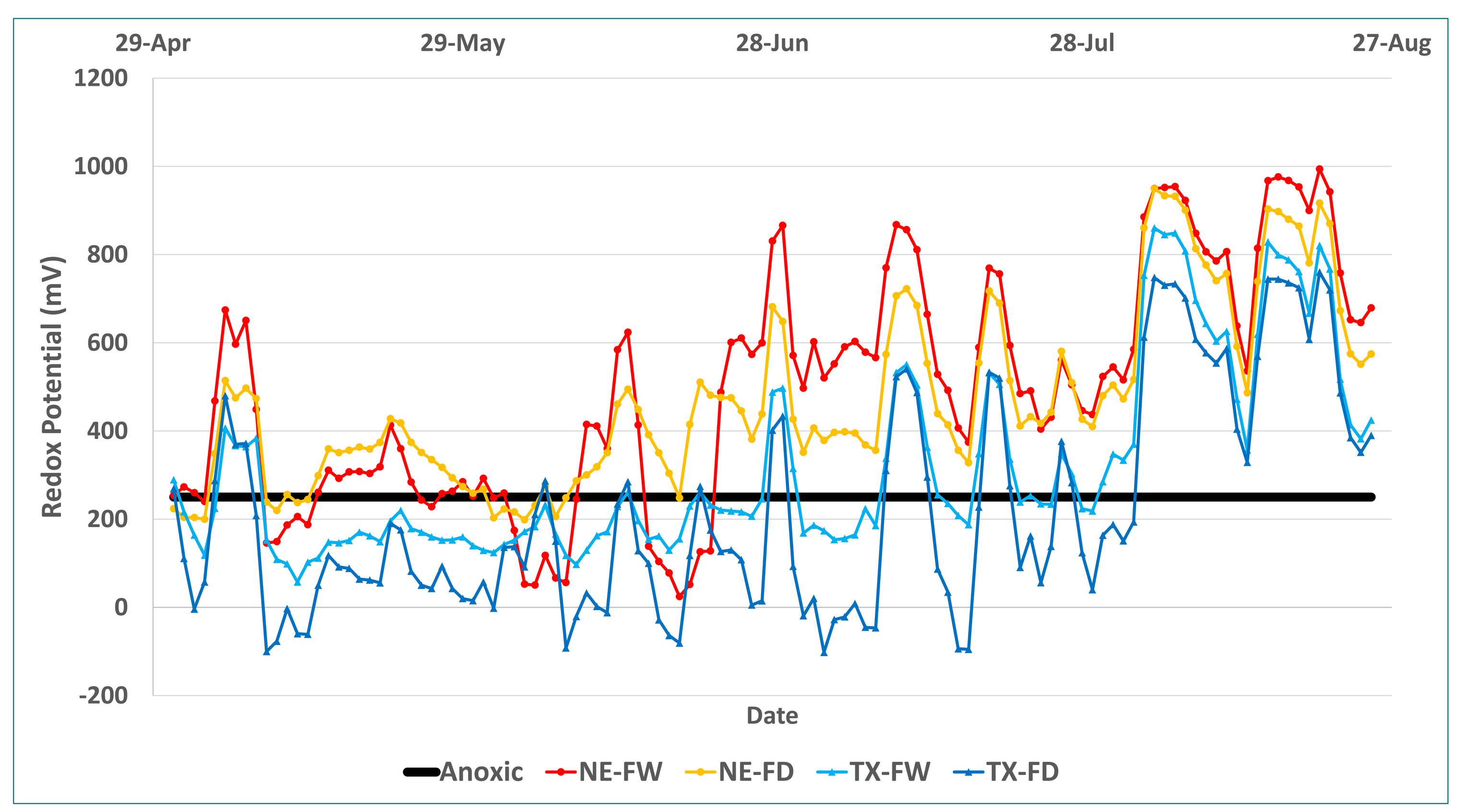

Figure 3: Average daily redox potential (ORP) as a response of precipitation treatments simulating a future wet (FW) and future dry (FD) climate scenarios for Nebraska (NE) and Texas (TX) playas from May 1 – August 30. Anoxic conditions are defined by NO_3^- to N_2 transition at pH 6.5 (ORP = 250 mV).

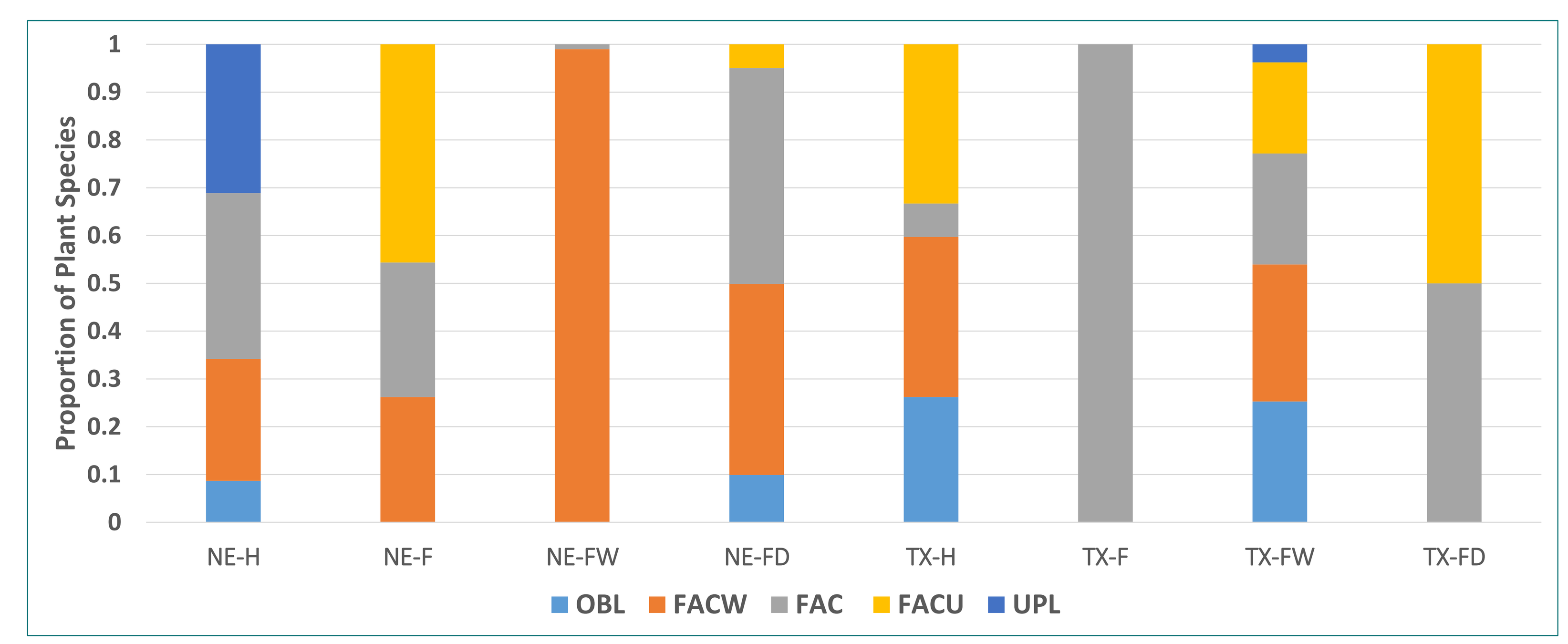

Figure 4: Proportion of plant community that falls into each wetland plant classification category [obligate wetland (OBL), facultative wetland (FACW), facultative (FAC), facultative upland (FACU), and obligate upland (UPL)] after 6 weeks of climate treatments.

Expected Outcomes

- Identify plant and soil properties that are most sensitive to changes in precipitation.
- Identify interactions between soil and plant properties as they respond to precipitation changes.
- Identify climate scenarios with potential to push playas past an ecological tipping point.
- Create vulnerability indices to inform future management and policy decisions to conserve playas.

References

1. Haukos, D.A. and L.M. Smith. 2006. Effects of soil water on seed production and photosynthesis of pink smartweed (*Polygonum pensylvanicum* L.) in playa wetlands. Wetlands 26: 265-270.
2. Melillo, J.M., T.C. Richmond, and G.W. Yohe. 2014. Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. Washington, D.C.
3. Smith, L.M. 2003. Playas of the Great Plains. University of Texas Press. Austin, TX.
4. Wuebbles, D.J., K. Kunkel, M. Wehner, and Z. Zobel. 2014. Severe weather in United States under a changing climate. Eos. 95(18): 149-156.
5. Lichvar, R.W., N.C. Melvin, M.L. Butterwick, and W.N. Kerchner. 2012. National Wetland Plant List Indicator Rating Definitions. U.S. Army Corp of Engineers Engineer Research and Development Center.

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