Predicting Variation in Springtime Playa Occurrence and Flooded Area in Nebraska's Rainwater Basin: Summary

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For full project details see:
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Overview:

The Rainwater Basin region of south-central Nebraska, U.S.A., is a critical stopover location for migratory waterfowl, waterbirds and shorebirds traveling along the Central Flyway. Here, shallow, rain-fed playa wetlands distributed across an agriculturally-dominated landscape provide stopover habitat in the spring and autumn for 7 – 14 million waterfowl, and various other waterbird and shorebird species. These wetlands serve as staging sites, allowing migratory birds to rest, pair, and increase lipid reserves by feeding on invertebrates, wetland vegetation, and waste grain in neighboring agricultural fields.

Collectively, the playa wetlands found in the region form the Rainwater Basin Wetland Complex, encompassing a 6,150 square-mile area of rolling loess plains that extend over 21 counties. Analyses of the State's historic soil surveys (1910-1917), National Wetland Inventory (NWI 1980-1982) and the Soil Survey Geographic Database (SSURGO 1961-2004) indicated that approximately 11,000 individual playa wetlands once existed in the landscape. Since European settlement, however, approximately 90% of wetlands in the region have been destroyed due to land-use intensification. Furthermore, many of the remaining wetlands are severely degraded and may lack functionality altogether. Despite these losses, remnant and restored playas continue to serve as important spring migratory stopover locations for a variety of avian species.

The majority of Rainwater Basin wetlands are ephemeral in nature and the occurrence and degree of springtime playa inundation varies between locations and years. Various hydrologic, geomorphic, and weather-related factors influence the magnitude, frequency and duration of wetland ponding, including precipitation, runoff, evapotranspiration, infiltration, soil type, and surrounding land-use. However, the ways in which these drivers interact is not fully understood. Furthermore, weather patterns in the Great Plains, which are believed to play a critical role in wetland inundation, are highly dynamic and difficult to predict. Wetlands are typically inundated by runoff or snowmelt following major precipitation events. Other factors affecting water retention are site specific, such as the hydrological integrity of the clay-pan, clay-based hydric soils that seal the wetland. During extended dry periods, cracks can form in the clay-pan, inducing rapid infiltration and limiting inundation even when major precipitation events occur.

Although habitat loss continues to impact the Rainwater Basin, recent drought has had compounding effects on migratory birds, significantly reducing the available stopover habitat during spring migration. In an effort to increase habitat availability, habitat managers in the Rainwater Basin can utilize groundwater to flood certain wetlands prior to migration. Yet, deciding when and where to pump is challenging, and predicting future habitat availability is complicated by uncertainty over future weather events, anthropogenic alterations and limited understanding of watershed intactness of each individual wetland. Successfully predicting the magnitude and duration of wetland inundation in the Rainwater Basin at peak spring migration could assist managers in providing sufficient stopover habitat to migratory waterbird populations, especially in drier years. The objectives of this study were to predict wetland inundation (presence/absence of water), and for those that were inundated, to predict ponded area.

Methods:

Annual Habitat Survey (AHS) data from 2004 and 2006 – 2009 were provided by the Rainwater Basin Joint Venture (Fig. 1). AHS data are collected annually at peak spring bird migration in late February or early March via aerial photography and are used to quantify wetland inundation throughout the Rainwater Basin. For the purposes of this study, a total of five years of AHS data have been analyzed using a generalized linear mixed modeling approach. A series of climatic, land-use and environmental variables have been added to the model to help explain the variation among wetlands in addition to aiding in the prediction of future ponding and flooding events in the Rainwater Basins. Akaike's Information Criterion (AIC), a model selection approach, was used to determine which environmental and weather related variables were the most important drivers of wetland ponding and wetland flooding within the Rainwater Basins. The best supporting models in each model set (within top 10% AICc weight) were included to form a confidence set. Coefficient estimates for all parameters in the confidence set were calculated by averaging models that contained respective parameters and combining the parameter estimates into a final predictive model for both wetland inundation and wetland ponded area.

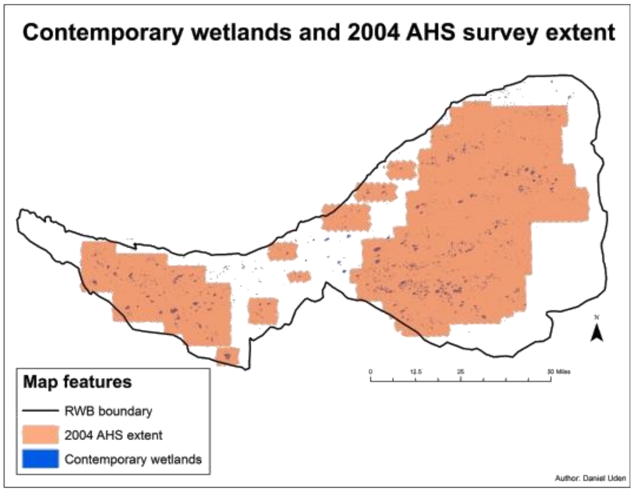

Fig. 1. Wetland Annual Habitat Survey extent and Rainwater Basin boundary for 2004.

In order to assess the predictive power of the wetland inundation and wetland ponded area models, AHS data from wetlands outside of the 2004 extent in 2006 – 2009 were used for model validation (Fig. 1). Data from all wetland locations were utilized for training and testing the inundation model, regardless of whether or not water was present in the wetland, whereas only records documenting the presence of water were retained for training and testing the ponded area model.

Results and Discussion:

A total of five models were included in the wetland inundation confidence set. The probability of a wetland ponding increased with the total summer and total fall precipitation, and if the wetland was semi-permanent. The likelihood of a wetland inundating decreases if the surrounding irrigation type is a center-pivot and dryland farming practices. Proximity to nearest irrigation reuse pit also influences wetland inundation. Specifically, as distance increases from an irrigation reuse pit, the less likely a wetland will occur. Although this pattern may be surprising since it is widely held that closer irrigation reuse pits are more likely to compromise the hydrological intactness of the wetland, many of the irrigation reuse pits in the Rainwater Basin were intentionally built adjacent to or near wetlands in an effort to centralize the flooded area, allowing for the agricultural development of additional acres in surrounding areas. Wetland shape-complexity is another local factor that negatively impacts the likelihood of a wetland inundating. The more convoluted the wetland border, the less likely the wetland will be inundated. Impacting over broad areas of the basins, the mean autumn maximum temperature decreases the likelihood that a wetland will inundate.

A total of four models were included in the confidence set for ponded area. Semi-permanent wetlands had a higher probability of having more ponded acres. The total winter precipitation, number of winter days with maximum temperature below freezing and first winter/spring date with minimum temperature above freezing all had a positive relationship with acres of ponded water. Temporary wetlands, wetlands in areas using gravity or center-pivot irrigation practices, and wetlands with highly convoluted shapes had a lower probability of the amount of ponded acres.

Although we cannot control weather events, the results from this study can provide habitat managers, wildlife biologists and policymakers some insight on broad landscape- and weather-related factors impacting the likelihood of a wetland inundating and the flooded area. In addition, the statistical findings from this study can be integrated into a decision support system using spatially explicit data and a geographic information system (GIS). A decision support system of this nature may assist habitat managers in forming decisions on where to conduct fall and spring pumping using scenario planning. Even when pumping is not an option, by integrating the statistical models from this study with spatial data, we can increase our understanding of some of the many complex relationships impacting wetland functionality in the Rainwater Basin and identify which wetlands may have the highest sensitivity to local factors and weather events.