Mapping Pollution Risk Using GIS-Based Management Tools for Waterfowl Production Areas in the Rainwater Basin Wetland Management District of Nebraska

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Introduction

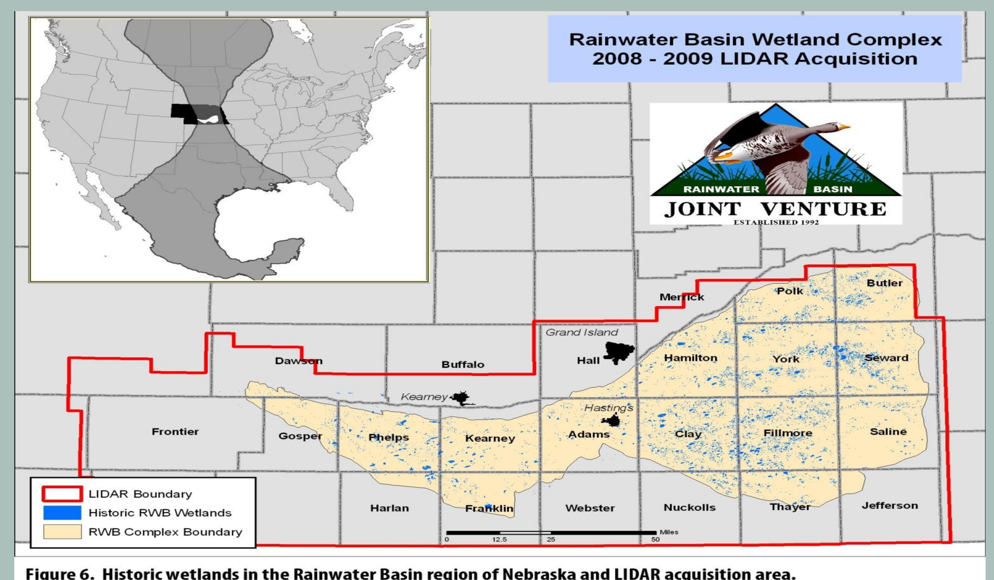
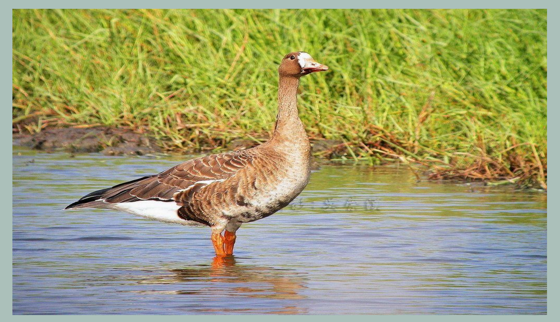


Figure 6. Historic wetlands in the Rainwater Basin region of Nebraska and LIDAR acquisition area.



The Rainwater Basin (RWB) in south-central Nebraska is among the most threatened wetland ecosystems in the United States. Less than 10 percent of the pre-settlement wetland area currently remains. Furthermore, remaining wetlands exist in a landscape dominated by agriculture, and as a result, siltation and poor water quality are continual problems.

Despite wetland loss and degradation the RWB continues to provide essential habitat for migratory birds. An estimated five to nine million ducks and several hundred thousand geese use this area every spring. Aquatic macroinvertebrates and wetland plants are an essential food items for many migratory birds and are also important in maintaining the aquatic health of RWB wetlands.

Agricultural runoff includes nutrients, elemental contaminants, and pesticides. In other studies agricultural runoff into wetlands has been associated with decreased invertebrate and plant abundance, species density, and richness, dominance by few nutrient tolerant taxa, and loss of endemic and characteristic species. The most cost effective defense of pollution runoff in these systems are the implementation of vegetative buffer strips. However, in this agriculture dominated landscape managers lack models to prioritize and examine the success of their management actions across the Wetland Management District properties.

The purpose of this study was to develop an inexpensive, repeatable management Geographic Information Systems model that managers could implement to more efficiently locate, analyze, and respond to pollution runoff produced by surrounding land-use in RWB Waterfowl Production Areas.

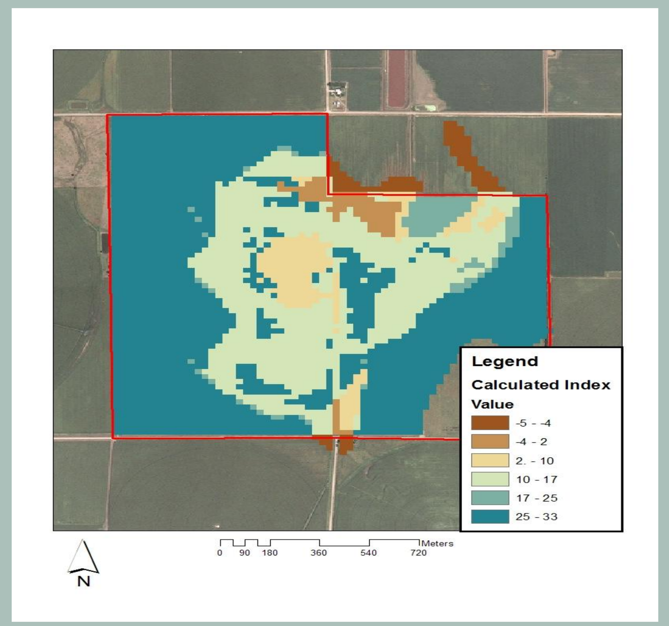
Methods

Five Waterfowl Production Areas throughout the RWB were chosen for the study and common ecological factors (vegetation, property size, soil, and drainage footprint) were used in the model. Necessary data layers were acquired from the United State Fish and Wildlife Service and Rainwater Basin Joint Venture.

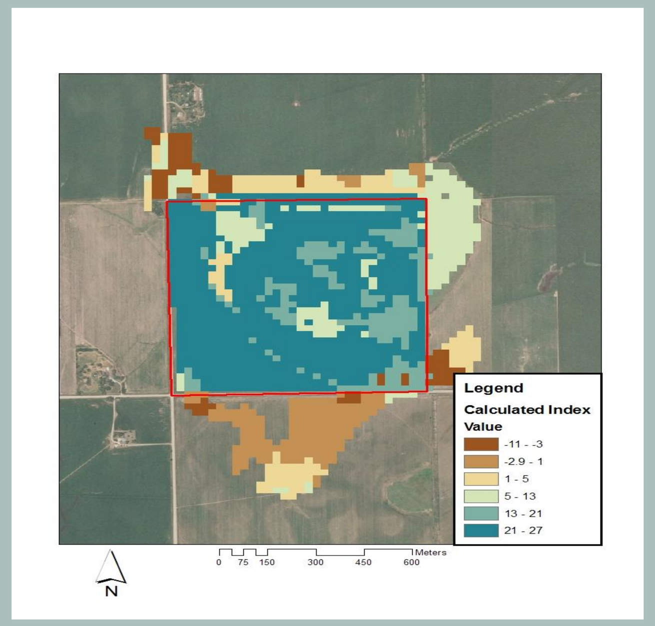
For each of the five wetlands, acquired attribute data for the five layers (FWS_WPA properties, 2004 Vegetation, 2007 Vegetation, Hydric Soils, and Footprint) were examined among a selected panel to determine the weight and rank of the layers and adjoining attributes. In this process, each layer was assigned a weight and each attribute of interest within the layers was assigned a rate. Results were multiplied and an arbitrary index value was created. This index value was used to convert polygon features to a 10 meter grid raster for data compilation. Newly created rasters were compiled and combined to develop a single grid value. This grid value allowed for a visual and quantifiable method to locate, rank, analyze, and respond to pollution runoff issues across the scope of the five wetland sites.

Acquired layers consisted of a geo-referenced digital aerial photograph of Nebraska counties with wetland properties and the land uses around to wetlands throughout the Rainwater Basin. Soils consisted of a polygon layer of soil types in the Rainwater Basin and were produced by the U.S. Fish and Wildlife Service in 2005. Two vegetation layers were available and consisted of polygons representing dominant vegetation communities which were produced by vegetation transects and remote sensing data in 2004 and 2007. The drainage footprint of 2005 consisted of a single polygon layer that represented the area of the natural depression drainage into the basin. The footprint's outline was defined by the elevation of the surrounding landscape that descended into the basin. All layers were projected in the North American Datum of 1983 (NAD83), Universal Transverse Mercator (UTM) coordinate system (zone 14) and manipulated using ArcGIS version 9.2.

Results



2007
Cottonwood WPA

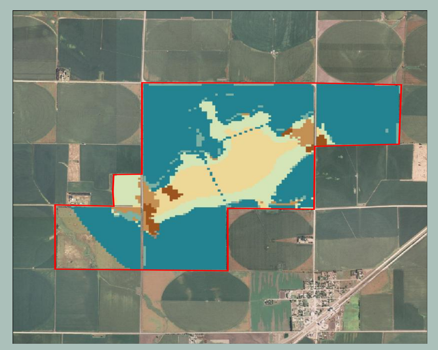


2007
Real WPA

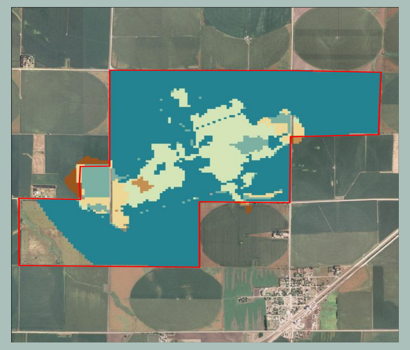
The results of this model provide a method of examining resistance to pollution runoff in a wetland system and responses of wetlands to management actions. This creates a unique approach to examine existing buffer zones to assess wetland conservation needs. The calculated index values for the selected wetlands are represented in the above figures. Areas in brown represent regions with a high risk of pollution influx and areas in blue represent the regions with the most resistance to pollution influx. The five selected wetlands of the Rainwater Basin differed in the percent of area at risk for pollution.

Results

Atlanta WPA



2004



2007

Using the combined capabilities of the GIS-based spatial model, one can visually and mathematically evaluate the impacts of management and restoration efforts within the Rainwater Basin wetlands. This is accomplished by examining the percent of wetland at risk before and after management actions. For example, the model was applied using vegetation composition in 2004 and again using the vegetation composition of 2007. Listed below are the wetland's percent of area with little resistance to pollution runoff (cells with calculated values of 11 or lower) and percent of area well-buffered to pollution runoff (cell with calculated values of 17 or higher). Data represented as N/A attribute to data not available for year.

Wetland	Percent at Risk (2004)	Percent at Risk (2007)	Percent Well buffered (2004)	Percent Well Buffered (2007)
Atlanta	5%	3%	68.2%	78.3%
Cottonwood	6%	8%	71.5%	76.5%
Gleason	N/A	1%	N/A	76.2%
Linder	11%	5%	57.3%	56.4%
Real	N/A	5%	N/A	68.9%

Discussion

By using a GIS model, based on vegetation composition, vegetative buffer width, soil composition, and wetland footprint, we were able to demonstrate a quantifiable method to select areas in the need of management. Results allow visualization of the current routes of pollution around a wetland. The combination of factors that impact risk/resistance to pollution results in a management tool. Vegetation composition, width of buffer, soil, and wetland footprint were chosen for the model because they are considered the most significant determinants in reducing nitrates and other pollutants from entering a water body in the wetland ecosystem. By creating raster-based analyses using these data, we were able to produce a single figure that had the ability to provide a quantifiable value to each wetland system. This model approach combined the function of multiple pollution control elements present in the wetland. Total percent of area with little resistance to pollution runoff can be compared to other wetlands to produce ranks for management priorities. The data collected throughout this project should allow managers to propose management actions. These management actions will improve impacted wetlands by reversing degradation of water quality in the Rainwater Basin wetland complex.

Acknowledgements

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