Identifying wetland inundation extent and patterns in Illinois

Category: Biological Sciences

Wetland inundation, habitat availability, wetland resources, water allocation

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Introduction

Continued increase in human population combined with increasing climatic variability associated with climate change will likely exacerbate future demands on our limited water supply throughout North America. Managing water for wildlife is one of several competing interests for limited water resources. Maximizing efficiency of water use for wildlife will require precise knowledge of wildlife habitat requirements and how those requirements vary throughout the annual cycle. For example, the hydrologic variation of wetlands makes them the most productive habitat in our ecosystem (Mitsch and Gosselink 2000, Batzer and Sharitz 2006). This same hydrologic variation, however, often limits the availability of resources provided by wetlands to wetland-dependent organisms in that wetlands may be dry when organisms are most dependent on them (Batzer and Sharitz 2006). This variation of inundation in wetlands makes accurately developing restoration goals based on the resource needs of wildlife populations difficult.

The National Wetlands Inventory provides an estimate of the total acreage of wetlands, but we are currently unable to estimate the acreage of wetlands that are inundated by water in a given time period. In the upper Midwest region, February-March, May-July and August-September are the most biologically important time periods for waterfowl, breeding wading birds and shorebirds, respectively. Estimates of inundation during those periods will allow for more precise allocation of water to provide habitat for those groups.

The location of inundation is also important if it is to provide resources to those groups. Directly monitoring inundation at all of the state's wetlands via ground survey is unfeasible on a seasonal or annual basis. Traditional remote sensing techniques such as aerial and optical imagery are unable to detect inundation in heavily vegetated areas. Classification error in the NWI can be exaggerated by vegetation cover type, with classifications of forested wetlands often having the highest error (Kudray and Gale 2000). Considering that Illinois has lost over 85% of its historical wetland area, with palustrine wetlands most heavily impacted (Dahl and Allord 1996), it is crucial to develop a method to estimate the availability of remaining wetlands to inundation-dependent species.

By developing models to estimate seasonal wetland inundation at the state level, this study could be used to develop more accurate wetland protection and restoration goals, allowing more efficient use of limited water resources for wildlife. Further, the estimates of wetland inundation obtained may be used as baselines to detect changes in the availability of water resources in wetlands in the future.

Project objectives and scope

This project aims to develop models to estimate wetland inundation for the entire state of Illinois. Two different approaches are being used to reach these ends.

Objective 1 will use ground surveys to estimate the seasonal changes in inundation and NWI error at random sites and then scale those values to the statewide NWI layers. This will provide an estimate of total wetland inundation in the state, specific to wetland type. Objective 1 constitutes a portion of a larger project which is funded by Federal Grant-in-Aid W-184-R-1-4 in

cooperation with IDNR. That project also includes quality assessments of the areas determined to be inundated. Habitat quality will be determined using several metrics including vegetation sampling and stress indicators, and will be analyzed by a Master's student at the University of Illinois under the advisement of Heath M. Hagy, Director of Illinois Natural History Survey's Forbes Biological Station.

Objective 2 will utilize satellite-based synthetic aperture radar (SAR) imagery to detect inundation on a larger scale and use the results from that analysis to model inundation patterns in the state. Unlike optical methods such as Landsat, L-band SAR can penetrate the forest canopy. The intensity of the radar return and polarity shifts in the radiation are used to estimate the presence of inundation (Lang et al. 2008). Imagery resolutions range from 3 meters to 100 meters. Funds to purchase imagery for preliminary analyses have been provided by the Upper Mississippi River and Great Lakes Joint Venture. Technical assistance with imagery processing and analysis will be provided by Donald Atwood, Senior Research Scientist at Michigan Tech Research Institute and former Senior Researcher at the Alaska Satellite Facility's SAR archives.

Methods

Sample sites were selected by stratified random sampling, using the 15 natural divisions of IL as the different strata with a Neyman allocation used to weight the number of samples per division. Lake Michigan was excluded due to logistical constraints. Survey sites were then assigned from the NWI using the reverse randomized quadrant-recursive raster (RRQRR) algorithm to create a spatially-balanced sampling pattern. The order in which each survey was conducted was randomized using the Mersenne Twister algorithm, but some exceptions were made to the sampling order due to logistical constraints such as private land access, boat availability, and ice.

Surveys are being conducted in three discrete seasons to coincide with the spring waterfowl migration, the summer marsh and wading bird nesting season and the fall shorebird migration (respectively): mid-February to mid-April, May-June and August-September. Surveys will be conducted at each site once per season. During surveys, a team of 2-3 technicians will utilize GPS units to record the perimeter of all inundated areas that they encounter. Two teams will operate concurrently to maximize coverage: one from INHS and one from SIU. Geo-coded photographs and field notes will be used with GPS tracks to create thematic maps of inundated and non-inundated areas within the surveyed areas. In 2015, ~90 sites of ~25 hectares each were surveyed in each of the three sampling seasons. We expect similar coverage in future years.

For objective 1, the thematic maps will be compared to NWI polygons using ArcGIS to determine what proportion of each NWI wetland type is inundated in each season and highlight any areas that have inundation, but are omitted in the NWI dataset. Determining these proportions specific to wetland type will allow us to scale the proportional inundation to the remainder of the dataset, providing an estimate of statewide wetland inundation, along with an uncertainty value.

For objective 2, two SAR images taken on August 28th, 2015 were purchased. The images were taken at 6-m resolution and used the maximum number of polarizations (four). Downscaling and removal of polarizations will be conducted to simulate lower

resolution/polarimetry options. Thematic maps from wetlands surveyed within one week of the imagery capture will be used to compare the accuracy for each imagery option. This will be weighed along with cost-per-unit-area of the coverage to determine the optimal imagery for further studies. Additional imagery will be purchased in Spring of 2016 to develop a classification model. A random forest classification model will be used along with ancillary data and a portion of the GIS inundation data to parse areas of inundation and non-inundation across the extent of the imagery. A separate subset of the GIS inundation data will be used to assess the accuracy of the classifier for each resolution level.

Upon the development of an accurate classifier, two more years of field survey will be conducted and a greater extent of imagery will be purchased. These data will be used to further refine the classifier and extend the estimates of inundation to the state level. Seasonal inundation extent and variability will be evaluated using geostatistical methods, allowing an estimation of the average proportion of available wetland area and variation across each of the seasons. The dissertation associated with the project is scheduled to be completed in 2018.

Expected results

The inundation portion of the overall Federal project will support one dissertation, 3-4 peer-reviewed publications and several presentations at regional and national conferences. Presentations on preliminary analyses have already been given at Society of Wetland Science and The Wildlife Society chapter meetings, and an oral presentation is scheduled for the North American Duck Symposium in February. Additional publications may be produced in synergy with the wetland quality study. Algorithms, models, satellite imagery, and survey data derived from the overall project will be made available to contributing agencies for further analysis and implementation.

Participating students

- John O'Connell – Doctoral student at SIU – dissertation on wetland inundation
- Abigail Blake-Bradshaw – Master's student at U of Illinois – thesis on wetland quality
- Micah Miller – Master's Zoology student at SIU – field assistant
- Harley Copple – Senior Zoology student at SIU – field/lab technician
- Shawn Caldwell – Senior Geography student at SIU – field/lab technician
- Travis Preston – Senior Geography student at SIU – field/lab assistant
- Additional undergraduate students TBD as technicians for 2016 and 2017 field seasons
- Additional undergraduate students TBD as volunteer GIS assistants
- Several recent graduates employed as technicians (four in 2015, TBD in future)

Literature citations

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