Quantifying Wetland Dynamics and Hydrologic Function with Landsat Thematic Mapper

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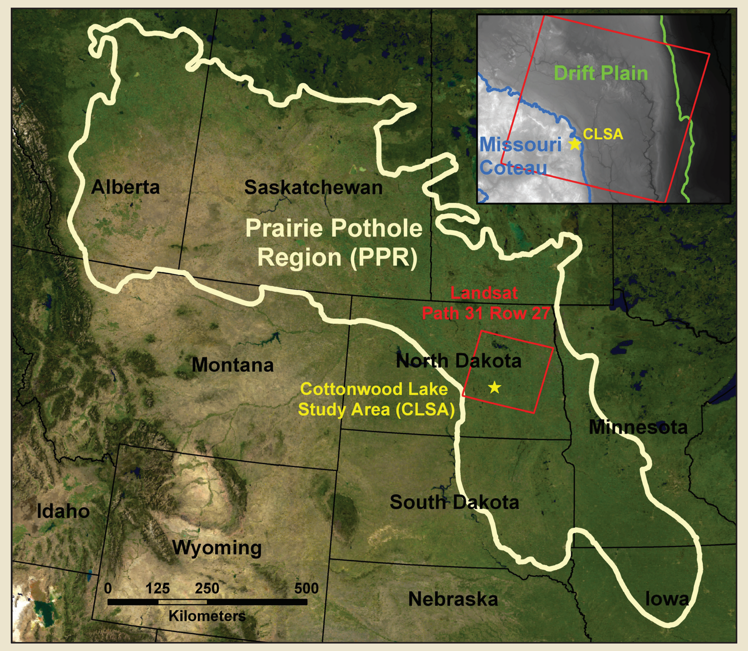
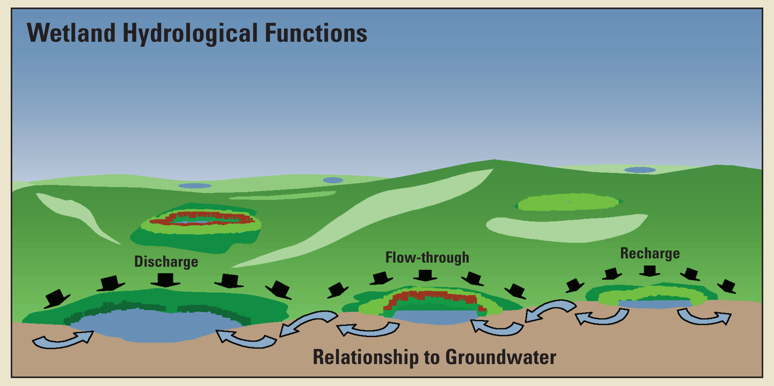
Introduction

The Prairie Pothole Region (PPR) extends from central Alberta to northern Iowa. Retreat of the Wisconsin glaciation (~ 12,000 years ago) left behind a landscape dotted with millions of depressional wetlands, or potholes – the most productive waterfowl habitat in North America (Batt et al. 1989). Subject to an interannual climate cycle characterized by infrequent wet periods interspersed with prolonged drought, prairie potholes exhibit dramatic fluctuations in their surface water extent.



A single Landsat path and row (30,625 km²) was selected as the study area. The study area contains the Cottonwood Lake Study Area (CLSA) where in situ data was available for model calibration and validation.

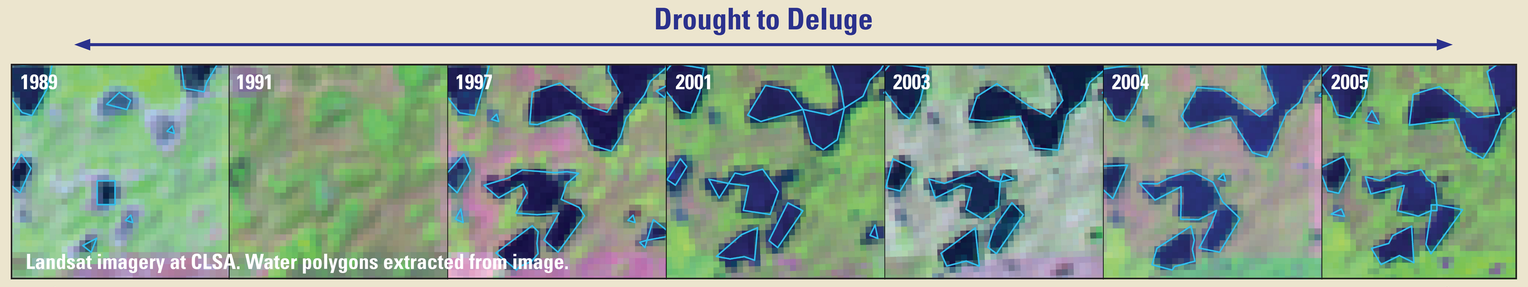


Hydrologically, PPR wetlands can be divided into three functional types: recharge, discharge, and flow-through (Euliss et al. 2004). The functional difference between these wetland types is their connectivity to groundwater. Recharge wetlands lose water to groundwater and typically occur at topographic highs. Discharge wetlands receive groundwater and are generally located at topographic lows. Flow-through wetlands function as intermediates, discharging and recharging groundwater. We developed a new method, based on multipixel objects, for extracting wetland dynamics from Landsat TM and ETM+ imagery and digital elevation models (DEM) to estimate hydrologic function.

Our working hypothesis: **The hydrologic function of wetlands can be determined by classifying surface water dynamics extracted from Landsat TM and ETM+ imagery and digital elevation models during a drought to deluge cycle.**

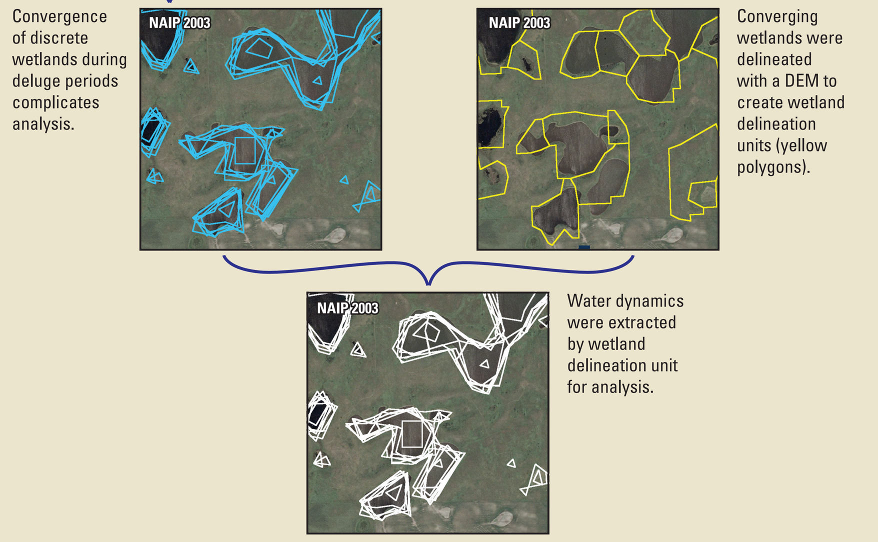
Methods

Seven Landsat images from the MRLC archive, spanning a 17-year period, during a drought-deluge cycle, exhibit the dramatic fluctuations common in wetland surface water extent.

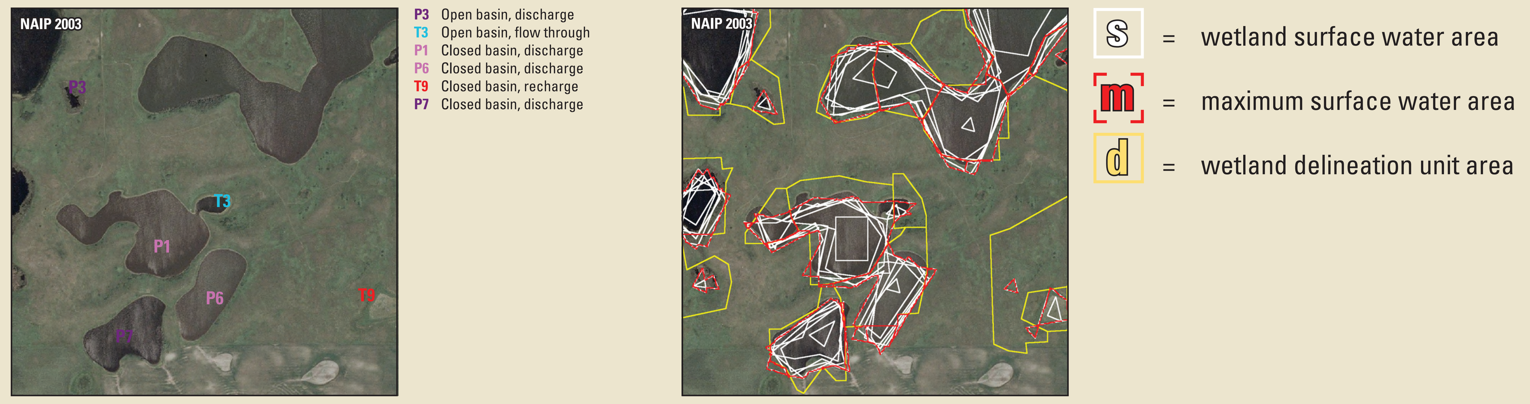


Acquisition dates for Landsat imagery

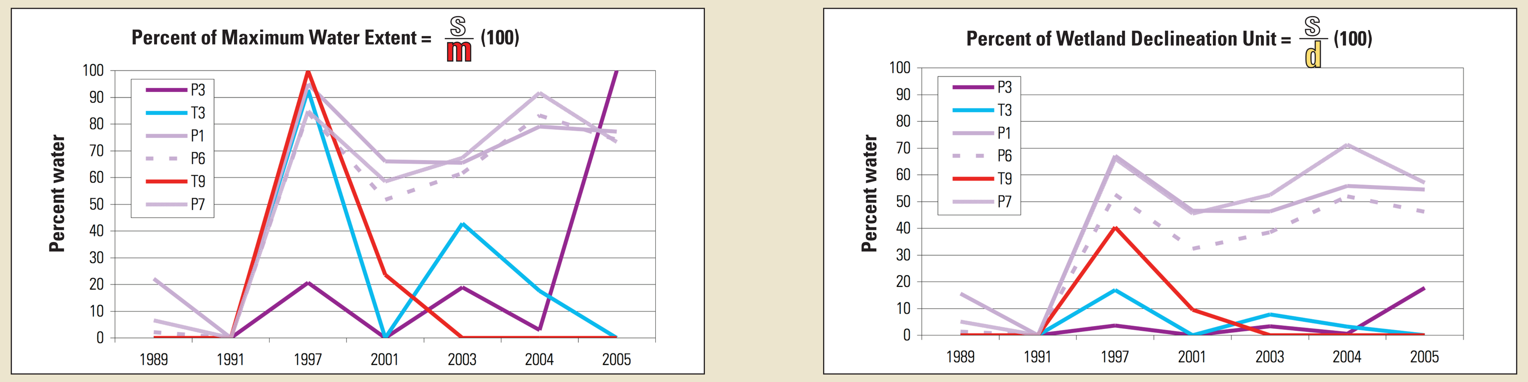
Year	Date	Sensor
1989	21 May	TM 5
1991	12 Jun	TM 5
1997	14 Jul	TM 5
2001	1 Jul	ETM+ 7
2003	12 May	TM 5
2004	9 Jul	ETM+ 7 SLC-off
2005	18 Jun	TM 5



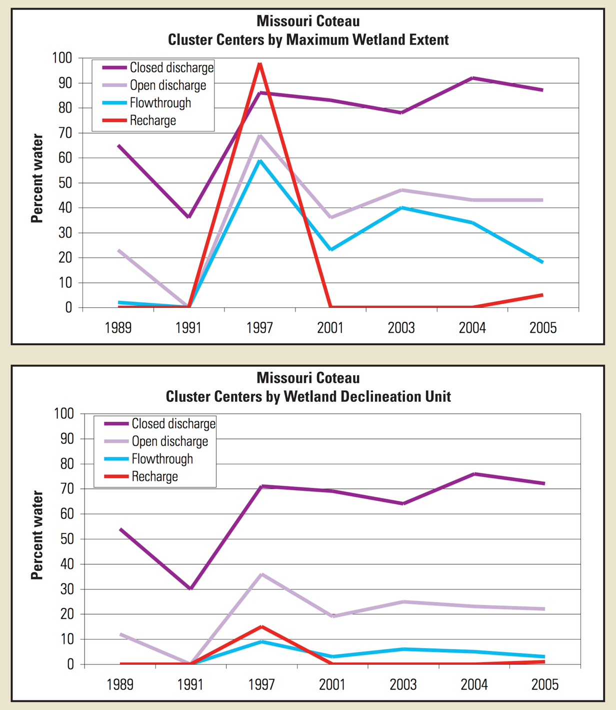
We extracted the surface water dynamics from six CLSA wetland delineation units. Two values were calculated for each unit: (1) percent of maximum water extent and (2) percent of wetland delineation unit.



Area containing surface water at each acquisition was compared with maximum surface water area and wetland delineation unit area.



Results

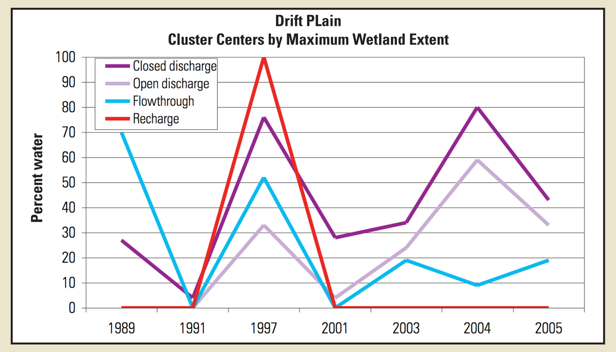


Missouri Coteau

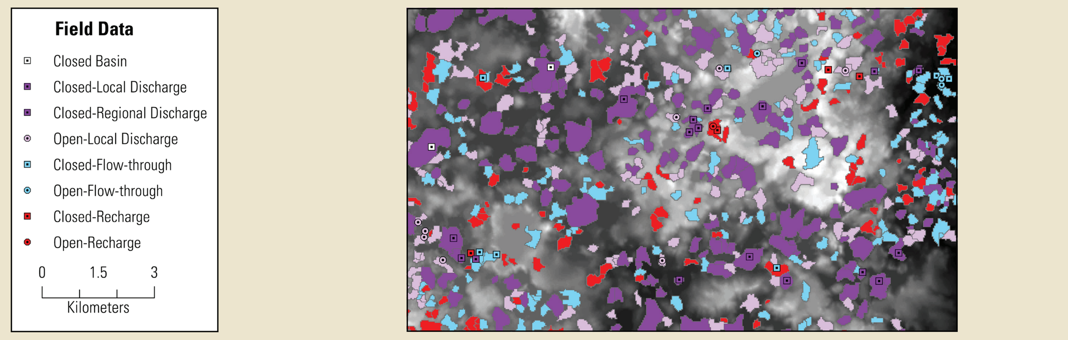
Cluster analysis of surface water dynamics on the Missouri Coteau shows that closed discharge basins maintained consistently higher water levels than other wetland types over the entire study period. Open discharge and flow-through wetlands responded similarly to the substantial pulse of water in 1997 and over subsequent oscillations. But from 2003 to 2005, water extents in flow-through wetlands trend downward while closed discharge basins remain relatively constant. Differences between closed discharge and flow-through wetlands are most apparent when comparing percent water within wetland delineation units, as flow-through wetlands occupied substantially less relative area. Recharge wetlands are distinguished by the 1997 spike and minimal, or typically nonexistent, surface water at other dates. Note that water bodies appearing only in single years, exclusive of 1997, were also classified as recharge wetlands.

Drift Plain

On the Drift Plain, surface water variation was less distinct than the patterns observed on the Missouri Coteau. A lack of significant vertical relief precluded construction of acceptable wetland delineation units, so we clustered percent water only as a function of maximum water extent. Two classes that trend upward over the study period are identified as closed and open discharge wetlands. Closed basins consistently contain a greater proportion of their maximum extent. A downward trending class is identified as flow-through wetland while recharge wetlands are characterized by the spike in 1997. Water bodies that appeared in only one or two years, exclusive of 1997, were classified as recharge. While these patterns resemble those observed on the Coteau, wetland classifications for the Drift Plain are preliminary and require additional fieldwork to evaluate accuracy. If accuracies are not acceptable, we will modify the cluster analysis.

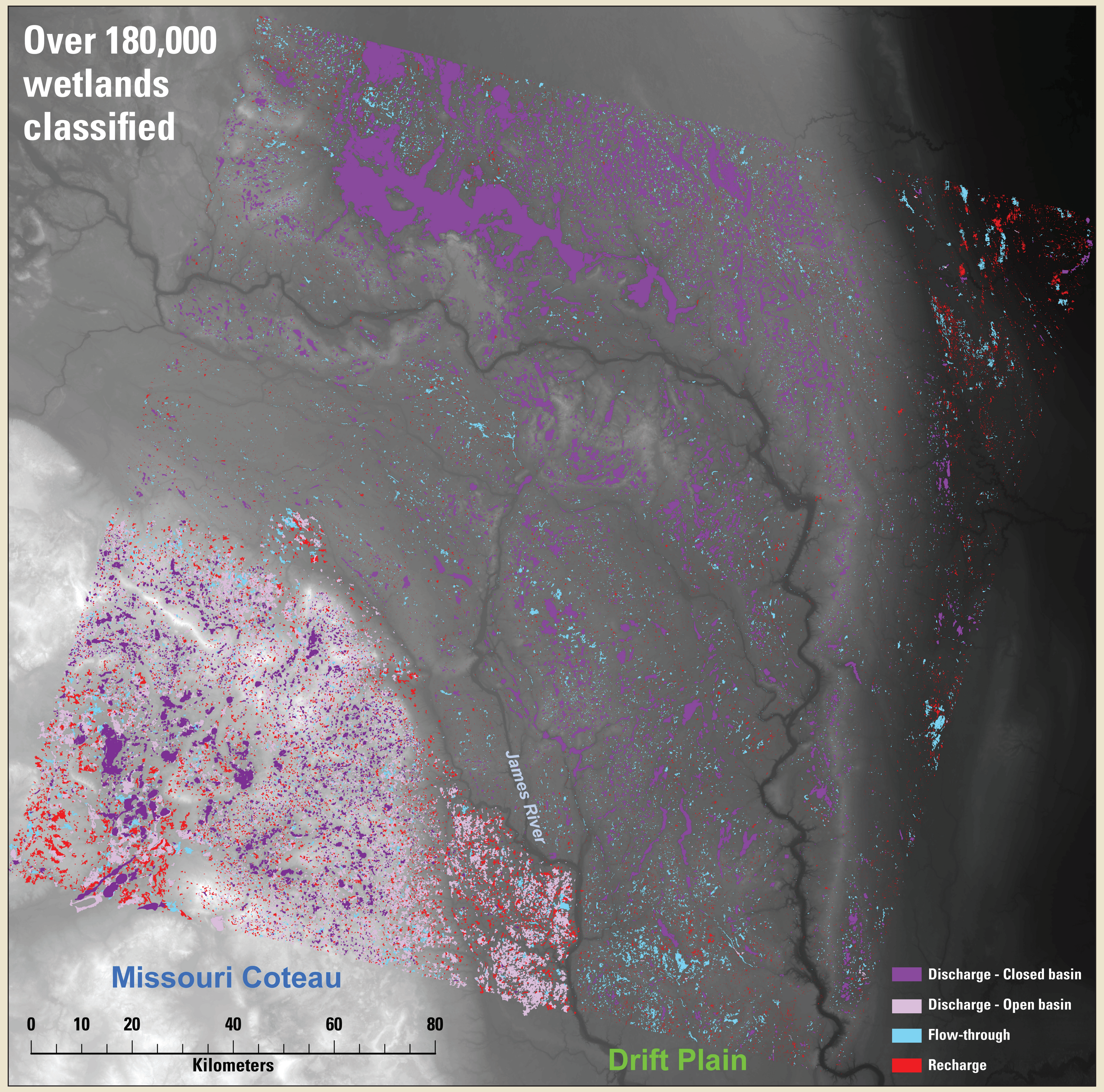


Hydrologic function field data provided by N.H. Euliss and D.M. Mushet at 43 independent wetland locations agreed well with the preliminary classification and resulted in accuracies ranging from 71 to 100 percent. All recharge basins and open discharge basins identified in the field were classified correctly. Two closed discharge basins were misclassified as a flow-through. Two flow-through wetlands were classified as recharge. Several small wetlands (<1 pixel) identified in the field were not identified as wetlands using the current methodology.



Actual Function	Predicted Function: R	CD	FT	OD	*Accuracy*
CD	0	17	2	0	*89%*
FT	2	0	5	0	*71%*
OD	0	0	0	6	*100%*
R	2	0	0	0	*100%*
				Overall	*88%*

The above methodology was applied to an area (30,625 km²) of the PPR. An accuracy assessment is currently in progress.



Future Research

Hydrologic function has a substantial effect on water chemistry and hydroperiod, subsequently determining the composition of wetland plant and animal communities in the PPR (Euliss et al. 2004). An ability to classify wetlands by their hydrologic function at a regional scale using satellite remote sensing will significantly advance our ability to model wildlife landscapes in the PPR, assess the efficacy of wetland conservation practices, and predict wetland response to climate change.

References

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Acknowledgements

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