Predictive Mapping of Wetlands and Wetland Soils in the Canadian Prairie Pothole Region

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Introduction

Wetlands of the Prairie Pothole Region (PPR) have a significant influence on the water storage and chemistry of the watersheds that contribute to Lake Winnipeg. These wetlands can be categorized according to their salinity content. Wetlands with higher salinity typically have greater quantities of calcium carbonates in their soils and, as a result, filter phosphorus runoff at a greater capacity[1]. Freshwater and saline wetlands may also store carbon and emit greenhouse gases at different capacities[2]. The ability to predict freshwater and saline wetland distributions across the PPR would enable more focused management and restoration efforts to optimize these ecosystem services while maximizing the agricultural land base. It could also allow for more informed decision-making for crop management by determining wetlands that may be sources for salinity issues.

A recent study[3] determined key landscape controls on the distribution of freshwater vs. saline wetlands in the PPR. These principles may be incorporated into a digital soil mapping (DSM) model to predict the distribution of wetland types and associated wetland soils.

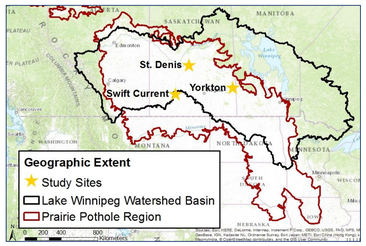

Fig. 1. Study site locations. Geographic extents of PPR[4] and Lake Winnipeg Watershed Basin[5].

Objectives

1) Develop and field-test a DSM model to predict the distribution of freshwater and saline wetlands and associated soils for three PPR sites
2) Contribute wetland SOC values to an existing database to improve average SOC estimates for the PPR

Site Selection

Three test sites (20 km north-east of Swift Current, SK; 5 km north of St. Denis, SK; and 60 km south-east of Yorkton, SK) were chosen based on: available spatial information; having physical characteristics representative of the PPR; and representing the three different soil climate zones of the PPR (brown, dark brown, and black, respectively).

Fig. 2. Aerial photos of the St. Denis National Wildlife Area, SK[6] (left) and the Smith Creek Watershed, SK[7] (right).

Saline Pond Distribution Prediction

PPR wetlands are hydrologically connected through episodic fill and spill occurrences resulting from large inputs of precipitation. With increased spillover events, the wetlands lower in the landscape that receive runoff from wetlands higher in the landscape are expected to have greater salinity and carbonate depositions. The DSM model uses GIS techniques to estimate potential spill channels, spill channel activity frequency, and wetland orders in the fill and spill sequence to predict the distribution of freshwater vs. saline wetlands within a watershed.

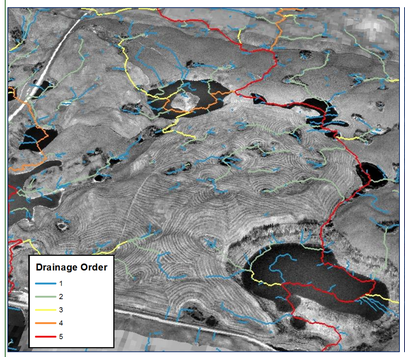

Fig. 3. Drainage network with ascribed orders for St. Denis site.

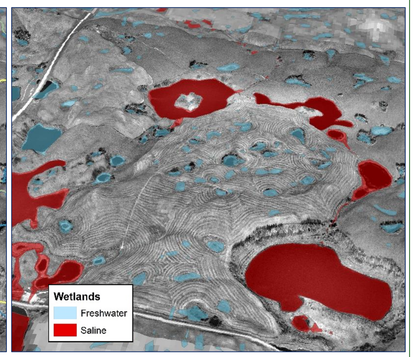

Fig. 4. Wetlands classified as freshwater or saline based on drainage orders for St. Denis site.

Drainage networks were estimated based on digital elevation model (DEM) morphology (Fig. 3). Streams within the drainage network were ascribed orders based on the number of streams draining to them. Wetland polygons were related to the drainage networks and ascribed drainage order. Wetland polygons were classified as freshwater or saline based on that drainage order (Fig. 4). Multiple prediction scenarios were created using different model parameters for drainage network connectivity and wetland orderings. The three prediction scenarios with the greatest prediction success rates at St. Denis and Swift Current sites are shown in Fig. 5.

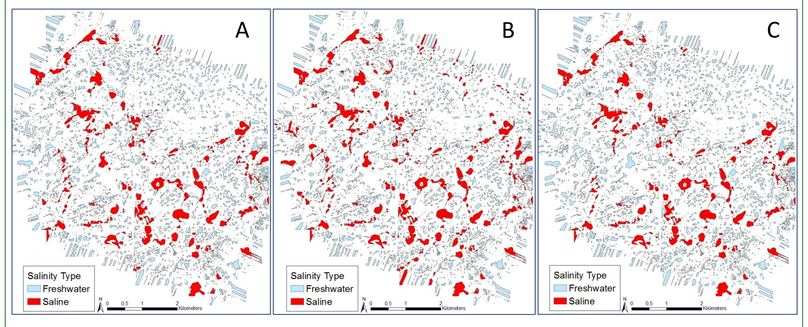

Fig. 5. Wetland salinity classification predictions for (A) the prediction scenario that correctly classified the most wetlands, (B) the prediction scenario that correctly classified the most saline wetlands, and (C) the prediction scenario that correctly classified the most freshwater wetlands across the St. Denis drainage basin. Prediction success rates per scenario are shown in Table 2.

Preliminary Results

Wetland salinity was tested through electromagnetic survey (EM) and water sampling at over 200 wetlands across the St. Denis and Swift Current sites to test the various model prediction scenarios. Historic salinity data for St. Denis were also used. Wetlands were grouped into three categories based on their EM and water EC values (Table 1). Wetlands classified as "brackish" were omitted for the preliminary model testing.

Table 1. Wetland category parameters.

Wetland Type	EM for 0 - 1.5 m (mS/m)	Water EC (µS)
Freshwater	< 60	< 1000
Brackish	60 - 70	1000 - 1500
Saline	> 70	> 1500

Table 2. % of wetlands correctly classified by prediction scenarios A, B, and C at St. Denis and Swift Current sites. n = actual number of wetlands per category.

Site	Prediction Scenario	Freshwater	Saline	Total
St. Denis		n = 82	n = 64	n = 146
	A	96.3 %	54.7 %	78.1 %
	B	95.1 %	57.8 %	78.8 %
	C	100 %	34.4 %	71.2 %
Swift Current		n = 66	n = 11	n = 78
	A	97.0 %	63.6 %	91.0 %
	B	87.8 %	81.8 %	85.9 %
	C	98.5 %	18.2 %	85.9 %

The preliminary results indicate relative success of certain model prediction scenarios in correctly classifying wetlands (Table 2) although in every prediction scenario, the model underestimates the occurrence of saline wetlands. Prediction scenario A correctly classified the most wetlands, prediction scenario B correctly classified the most saline wetlands, and prediction scenario C correctly classified the most freshwater wetlands.

Project Progress and Next Steps

Year 1 (2015) wetland salinity and soil sampling was conducted from August to October at St. Denis and Swift Current. Lab and data analysis will be completed by spring 2016. Refinements to be made to the DSM model may include using wetland boundaries based on sill elevations and classifying wetlands according to Millar's system of wetland classification: isolated, overflow, channel, and terminal[8]. Wetland soil sample SOC data results will contribute to an existing database to determine average SOC estimates for the PPR. Further sampling will be conducted in 2016 at all **three** sites to (1) fill gaps in knowledge as required and to (2) test relationships between wetland type and phosphorus mobility.

References

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