Modeling the Effects of Shipping Vessels on the Distribution of Emergent Plants Throughout the St. Marys River

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Introduction

The St. Marys River connects Lake Huron and Lake Superior and is the site of heavy shipping traffic (freighters). Freighters create large wakes that create intense wave action for surrounding wetland plant communities. Wetlands are sensitive to high wave energy[1] meaning pressure from shipping vessels could be detrimental to plant establishment. In this study I seek to assess the effects of exposure to channel on wetland distribution within the St. Marys River by creating a model that predicts effects of freighter wake exposure on emergent plant presence (bullrush & cattail).

H1: As freighter wake energy increases emergent plant presence decreases

Research Question

Q1: Does exposure to the shipping channel have an impact on wetland distribution?

Figure 1: Me at Lime Island watching a freighter float by.

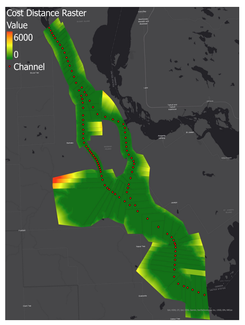

Figure 2: Cost distance raster used as proxy for channel exposure.

Methods

Field Data: I collected vegetation data 5 sites exposed and unexposed to channel then ran 3 transects and established plots every 5-10m. At each plot, I collected density of both emergent plants along with a water depth and GPS point.

GIS: I created a random forest statistical model in R to predict presence of emergent plants with the factors being fetch, slope, water depth, and cost distance. Cost distance is my proxy for exposure and is the weighted accumulation of raster cells from a starting point across space. I used these rasters to apply the model across the St. Marys River.

Results

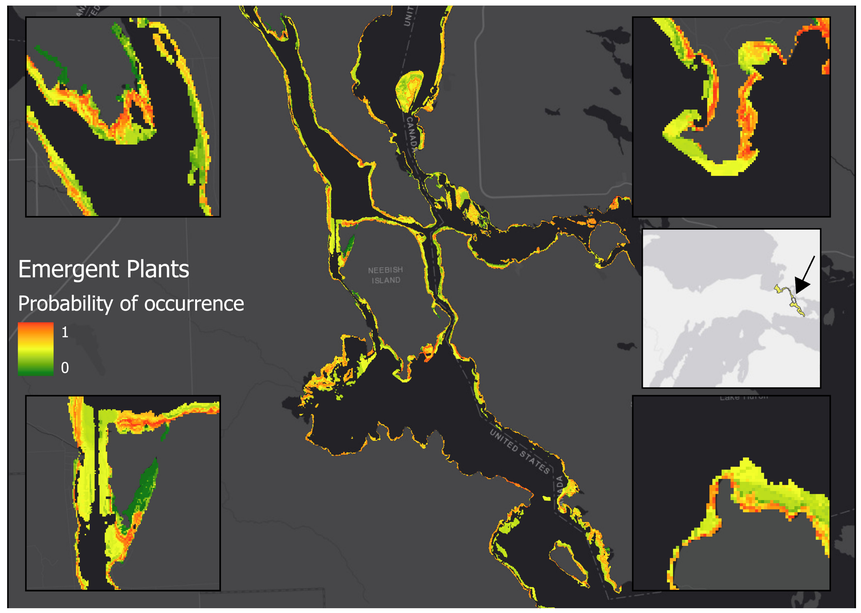

Figure 3: Raster output of the random forest model predicting emergent plant presence shown across the St. Marys River. Red is a higher probability and green is lower. Top left: Sugar Island, top right: Kemps point, bottom left: Sand Island, bottom right: Lime Island.

Factor	*Exposed*	*Unexposed*	*p-value*	*Gini Index*
Water Depth	75.09±3.27	60.57±2.76	.0001	71.8
Fetch	1711±53.03	1485±49.13	.0003	75.9
Slope	1.3±.71	.1187±.08	.0006	87.3
Cost Distance	4.10±.64	21.05±1.71	2.2e-16	119.2

Table 1: Summary statistics (mean±SE) of the data collected based on site exposure, *p*-value results of Mann Whitney U test, and Gini index. Response and predictor variables were the factors used in the model and site exposure. Gini index represents variable importance to model with higher numbers having more influence.

Results

The random forest model has an estimated accuracy of 90%, and a confusion matrix result of 96%. Cost Distance had the highest Gini index value of 119 indicating that it is the most important factor to the model. The results of the Mann Whitney U test show significant difference due to exposure across all factor levels.

Discussion

Fetch[1] has been considered driving force of coastal wetland formation but the results of this study suggest that within the St. Marys River, exposure to the freighter channel has a greater impact on emergent plant distribution.

Future Directions

Going forward I plan to further refine the model by incorporating data from the Great Lake Coastal Wetland Monitoring program. In the summer of 2024 I will be ground truthing the model in the St. Marys across a gradient of predicted probability. I also plan to record water velocities of sites in this study to help further refine my exposure variable. This will allow me to quantitatively measure the energy shipping vessels are exerting on wetlands.

References

1) Albert, Dennis A. *Between Land and Lake: Michigan's Great Lakes Coastal Wetlands*. Michigan Natural Features Inventory, 2003.

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