ARCGIS AND COASTAL RESTORATION

Assessing the spatiotemporal patterns of vegetation colonization in a restored salt marsh in the the Bay of Fundy, Canada

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BACKGROUND

As a coastal region, Atlantic Canada is highly susceptible to the impacts imposed by climate change due to the high population of people and infrastructure that are in proximity to the coastline as well as the extent of dependence on coastal ecosystems[2]

Managed realignment (MR) involves the reintroduction of the tidal regime to areas of previously reclaimed land by shifting the dyke landward, allowing for the re-establishment of tidal wetland[3].

Managed realignment schematic showing reduced wave height due to established foreshore marsh. Reproduced with permission from Samantha Lewis.

This form of nature-based adaptation can offer more long-term resilience for coastal communities. However, data regarding the efficacy of these approaches are limited in Atlantic Canada, particularly in our unique environment within the Bay of Fundy. This presents a need to improve our understanding of MR restoration trajectories.

RESEARCH OBJECTIVES

1. What characterized the successional stages at the Converse restoration site?
2. What are the effects of topographic features (protochannels, channels, cracks, elevation differences) on the spatial and temporal patterns of vegetation colonization?
3. What are the initial patterns of vegetation colonization (e.g., clonal, linear)?

DATA COLLECTION

Stations (n=40) were positioned at CB Wetlands and Environmental specialists (CBWES Inc.) monitoring stations (🔴), a previous student's stations (🟡) and additional survey stations (🔵) based on 0.5 m contour intervals using ArcGIS Pro. This achieved a representative dataset by capturing variable elevation, inundation frequencies, and vegetation cover.

Elevation Survey

On August 2, 2022, the location and associated elevation of each vegetation survey station was staked out and measured with a Leica GS14 RTK GNSS unit.

Vegetation Survey

On August 3, 2022, vegetation data was collected using a point method with utilized 1m2 plots (quadrats) divided into a grid of 25 squares. Each species within the plot was recorded, then a wooden dowel was held vertical to each sampling point until it reached the ground below. The species that touched the rod were recorded.

Low Altitude Aerial Survey

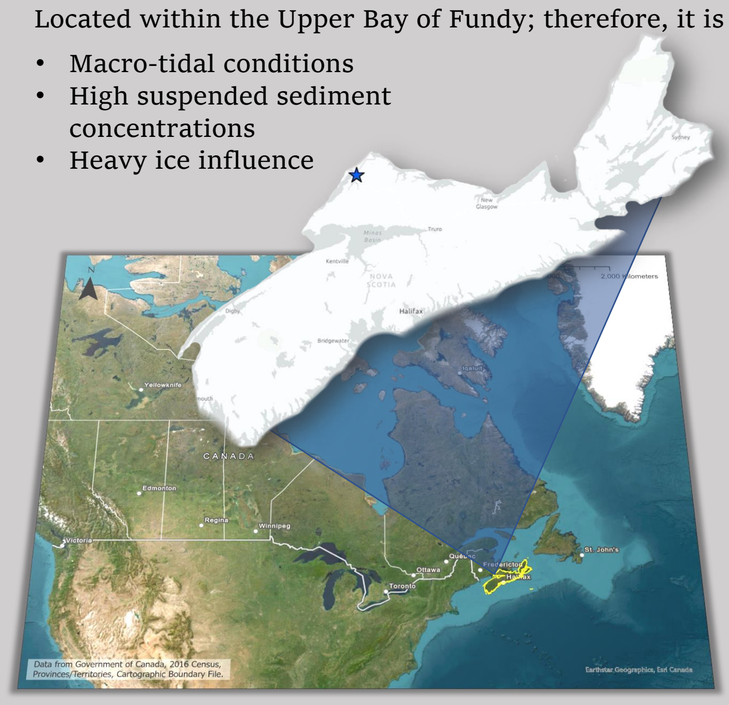
On Sept. 6, 2022, a low altitude RPAS survey was conducted with a DJI Matrice 300 RTK quadcopter offering survey-grade geolocation data. The site was flown at an altitude of 80 m above ground level by CBWES Inc.

STUDY AREA: NOVA SCOTIA, CANADA

The Converse Marsh (NS044) is part of the Tantramar Marsh System; a large tidal wetland complex on the Chignecto Isthmus between Nova Scotia and New Brunswick.

Located within the Upper Bay of Fundy; therefore, it is subject to:

- Macro-tidal conditions
- High suspended sediment concentrations
- Heavy ice influence



Managed realignment at Converse involved the removal of 420 m of eroding dyke, 150 m of new dyke constructed, a borrow pit created, aboiteau removed, and 15.4 Ha of restored tidal wetland habitat.

PROCESSING WORKFLOW

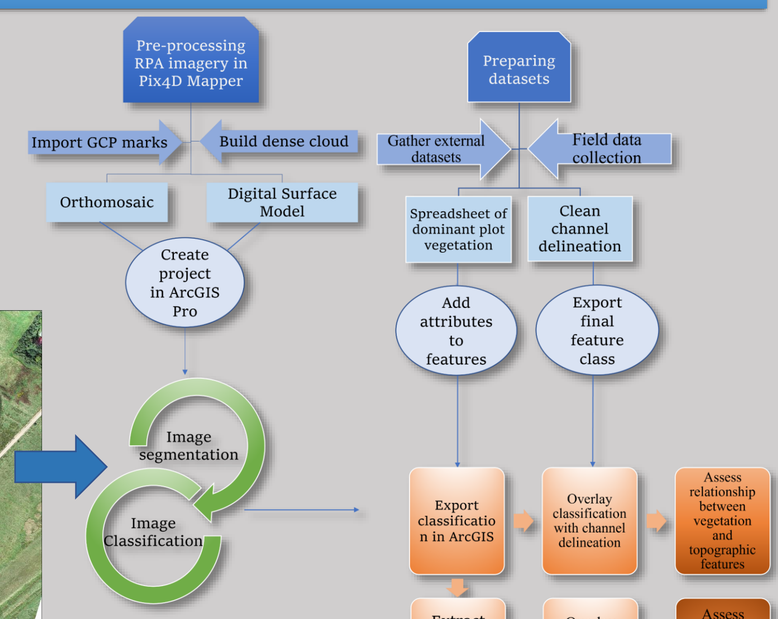
External datasets (CBWES Inc.):

- Channel delineations (2019 - 21)
- Habitat classification (2019 - 21)
- Orthos & DSMs (2019 – 21)
- DoDs (2019-2021)

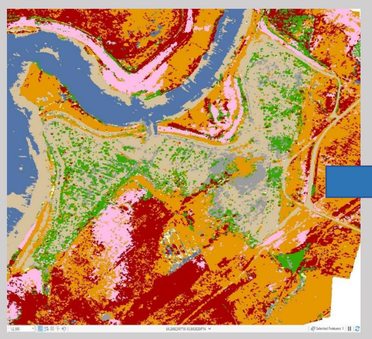
Created dataset:

- 2022 orthomosaic & DSM
- 2022 channel delineation
- 2022 habitat classification

Orthomosaic imagery produced from September 2022 aerial survey.

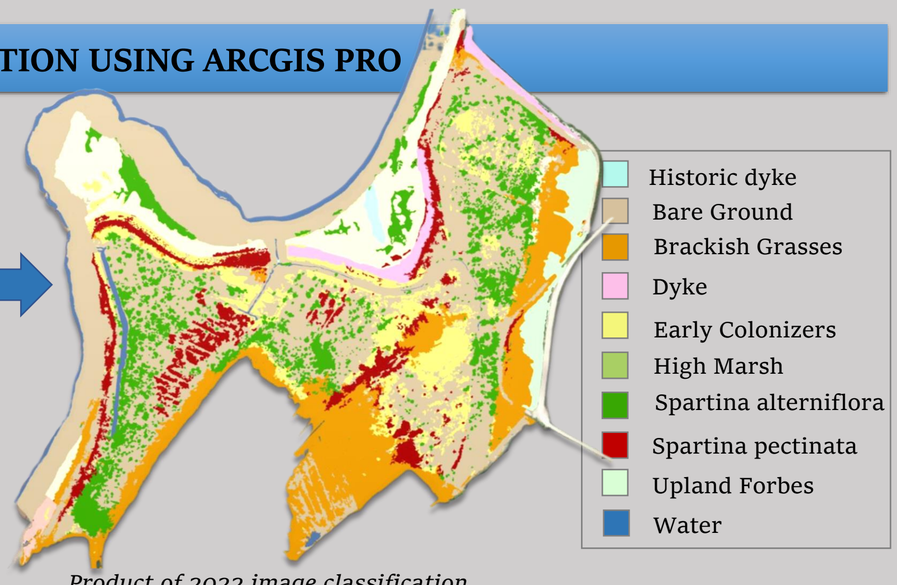


HABITAT CLASSIFICATION USING ARCGIS PRO



Classification Wizard

- Supervised Object-based
- Image segmentation
- Support Vector Machine



Product of 2022 image classification

SPATIAL ANALYSES USING ARCGIS PRO

Objective 1

1. Summary Statistics of habitat attributes table to summarize area and frequency of each class

Objective 2

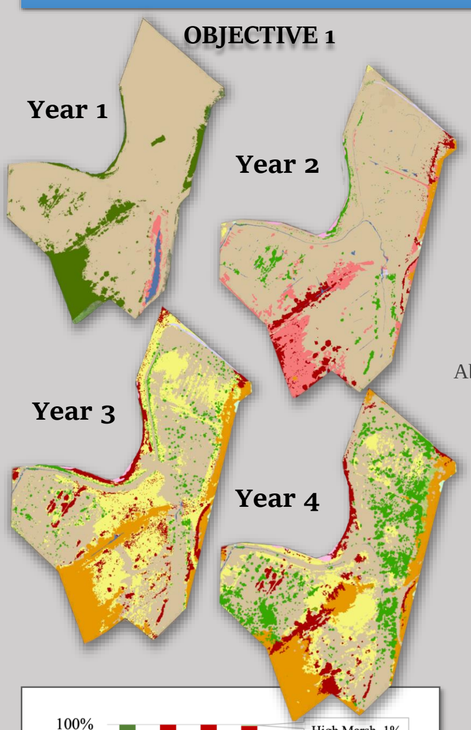
3. Extracted the salt marsh species from each habitat shapefile (2019-2022) using Select by Attribute and created new layer layers with only classes representing salt marsh species.
4. Quantified and mapped persistent vegetation from one year to next using the Intersect tool, resulting in 3 output shapefiles of where vegetation persisted spatially from 2020 into 2021, and 2021 into 2022. Next, the halophyte feature class (Step 3) and persistent vegetation was input into the Erase tool, leaving only new colonization in the output layer.

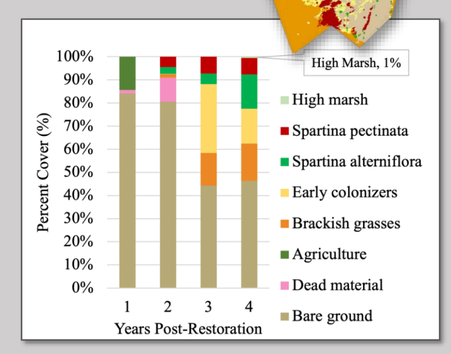
Objective 3

5. Channel delineation shapefiles were paired with the new colonization shapefiles to analyze the relationship between vegetation colonization and channel networks using the Near tool
6. Digital elevation models of difference (DoDs) were paired with the new colonization shapefiles to capture the relationship between vegetation colonization and accretion/erosion rates using Zonal Statistics

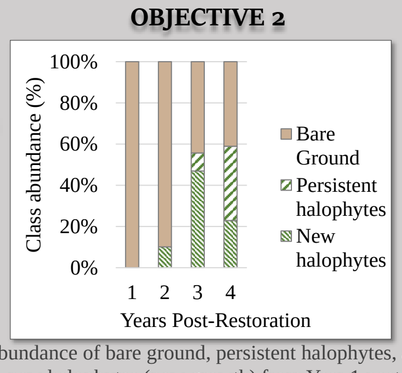
RESULTS

OBJECTIVE 1

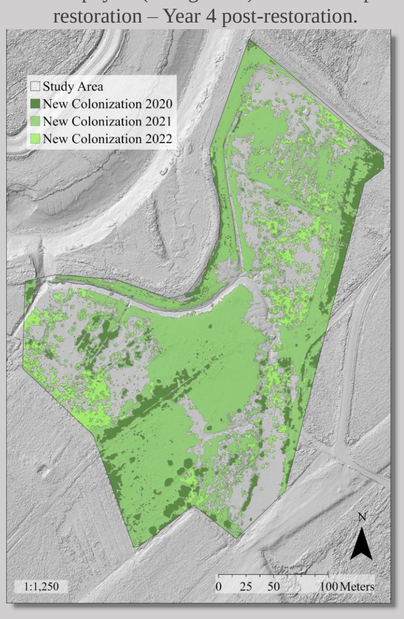




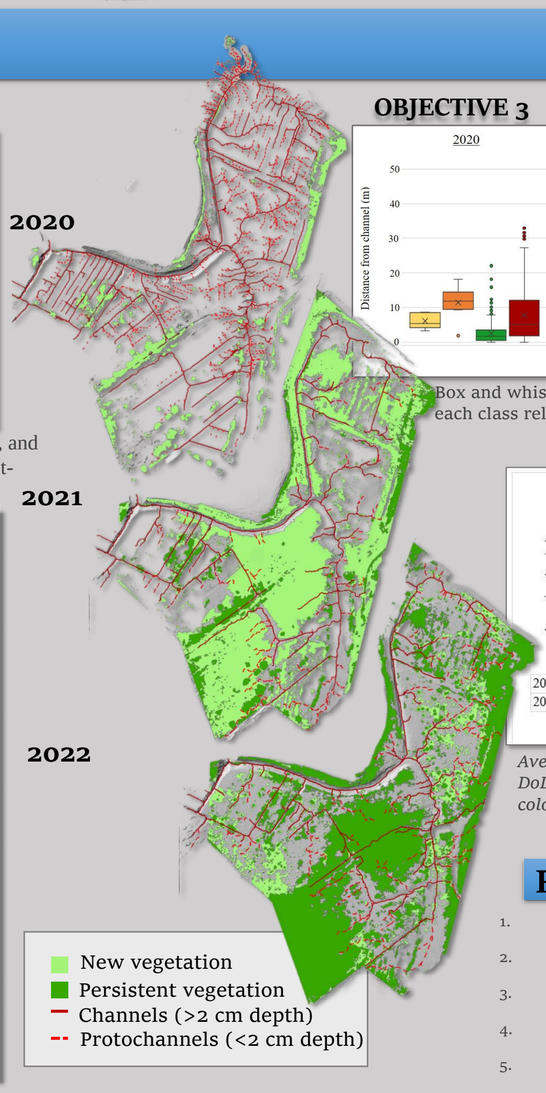
OBJECTIVE 2

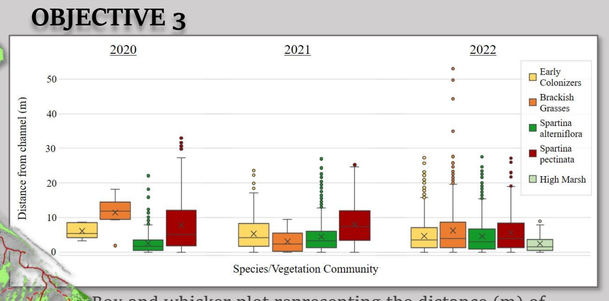


Abundance of bare ground, persistent halophytes, and new halophytes (new growth) from Year 1 post-restoration – Year 4 post-restoration.

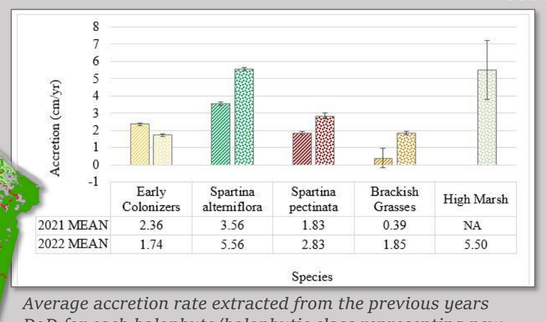


OBJECTIVE 3





Box and whisker plot representing the distance (m) of each class relative to channel networks from 2020-2022



	Early Colonizers	Spartina alterniflora	Spartina pectinata	Brackish Grasses	High Marsh
2021 MEAN	2.36	3.56	1.83	0.39	NA
2022 MEAN	1.74	5.56	2.83	1.85	5.50

Average accretion rate extracted from the previous years DoD for each halophyte/halophytic class representing new colonization in 2021 (hashed fill) and 2022 (dotted fill).

KEY FINDINGS

1. Highly successional process with year 3 appearing to be a pivotal year in the trajectory. Year 1 had agricultural vegetation persisting, with halophytic colonization appearing in consecutive years.
2. Colonization of target species, *Spartina alterniflora* was dominantly from seed early on, followed by clonal spread in later years. Evident from the rings of new colonization exhibited in the shapefile[4]
3. Year 1 demonstrated stronger relationships between vegetation colonization and channel networks than consecutive years but *S. alterniflora* and early colonizers (e.g. *Suaeda sp.*) are consistently close to channels. This is likely highly influenced by their tolerance for high saline environments
4. Greater variability (outliers) with DoDs and vegetation colonization each consecutive year, potentially due to ice influence[5]

TAKEAWAY MESSAGES

Managed realignment can be successful when the restoration initiative is properly designed and GIS is a highly effective way to monitor the trajectory of restoration sites.

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3. Pontee, N. (2014). Factors Influencing the Long-Term Sustainability of Managed Realignment. In *Managed Realignment : A Viable Long-Term Coastal Management Strategy?* (SpringerBriefs in Environmental Science, pp. 95-107). Dordrecht: Springer Netherlands.
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5. Van Proosdij, D., Townsend, S. (2006) Spatial and temporal patterns of salt marsh colonization following causeway construction in the Bay of Fundy. *Coast. Res.*, 3:1859–1863.