Mapping Coastal Marsh Erosion and Migration to Estimate Blue Carbon Fluxes

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Background & Research Objective

- Coastal marshes have declined by approx. 20,000 acres (0.9%) along the Atlantic coast and 140,000 (4%) along the Gulf coast in the past two decades [1].
- Sea level rise, projected as 50 cm to 100 cm by 2100, is expected to accelerate this loss, with global loss estimates ranging from 50% to 78% [2].
- Coastal marshes are estimated to account for 17TgC (or 10%) of the coastal carbon uptake, the majority of which is buried in sediments [3].
- Accurate estimates of marsh depth and carbon and consistent multi-decadal maps of coastal land cover change currently do not exist, limiting our ability to quantify this coastal carbon flux in the past, present, and future.

Fig 1: Illustration of coastal marsh erosion in Pelham Marsh, NY (taken by Dorothy Peteet).

Overarching Research Objective:

Produce new coastal marsh datasets that will enable the estimation of carbon fluxes associated with eroded marshes, and assess the relative significance of this flux in the carbon cycle.

Research Tasks

1. Quantify historical areas of coastal marsh loss along the Atlantic and Gulf Coast over the past 40 years using satellite imagery.
2. Study patterns of change and identify relationships between areal losses and drivers of loss (including relative sea-level rise, storm events, spatial inundation patterns, and land elevation changes) for 5 representative sites.
3. Using models from Task 2, quantify future areas of coastal marsh loss for 5 representative sites under alternative climate change scenarios.
4. Develop marsh depth and carbon maps that can be combined with the coastal marsh change maps (from Task 1) to quantify the carbon fluxes that have entered and will enter coastal ecosystems over time.
5. Compare carbon fluxes that enter the ocean from coastal marshes to those that enter from rivers to assess the relative significance of these coastal marsh fluxes.

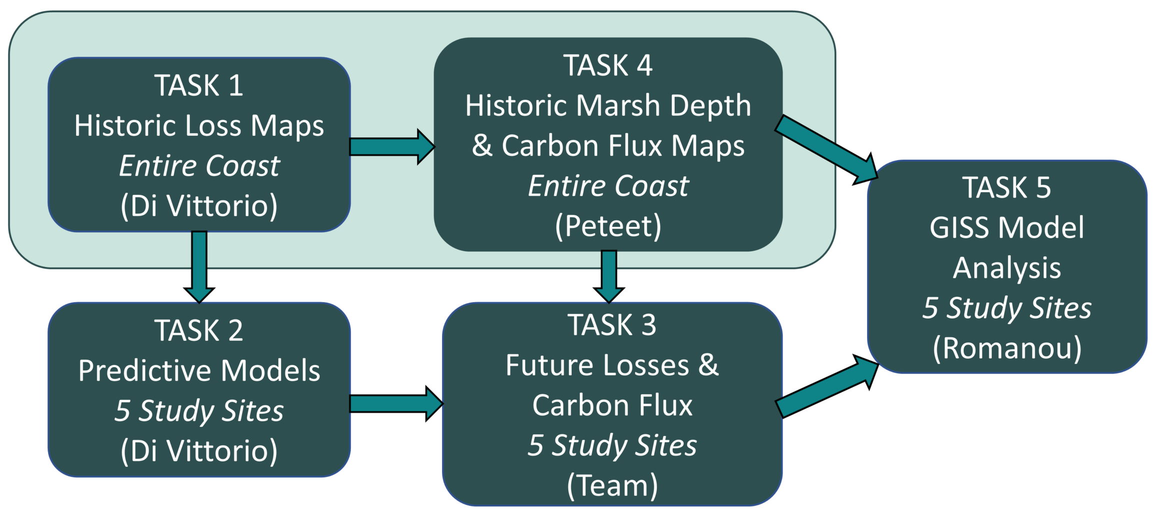

Fig 2: Flow chart illustrating the research tasks and their dependencies. The content presented below focuses on Tasks 1 and 4, which involve the creation of new coastal marsh datasets.

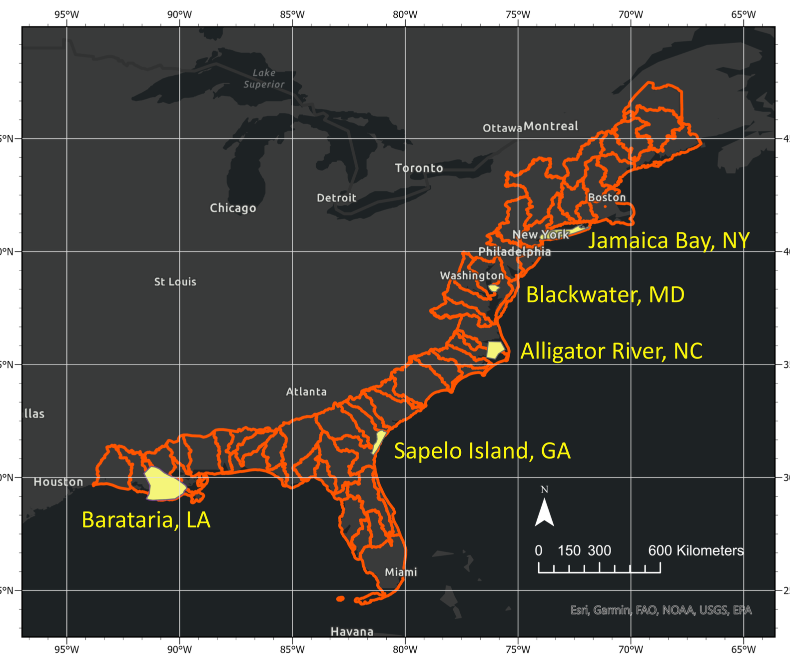

Fig 3: Map of US Atlantic and Gulf coast showing HUC-6 delineations (orange) and 5 representative sites (yellow) in LA, GA, NC, MD, and NY

Mapping Wetland LULC Changes from 1982 to 2021

1. Training Data & Comparing Existing Inventories

- Training data was derived from the National Wetland Inventory (NWI) and NOAA Coastal Change Analysis Program (CCAP).
- Changed and unchanged pixels were selected and manually checked in Google Earth.
- Compared NWI, CCAP, and DECODE [4] products for representative sites and submitted manuscript (under review).

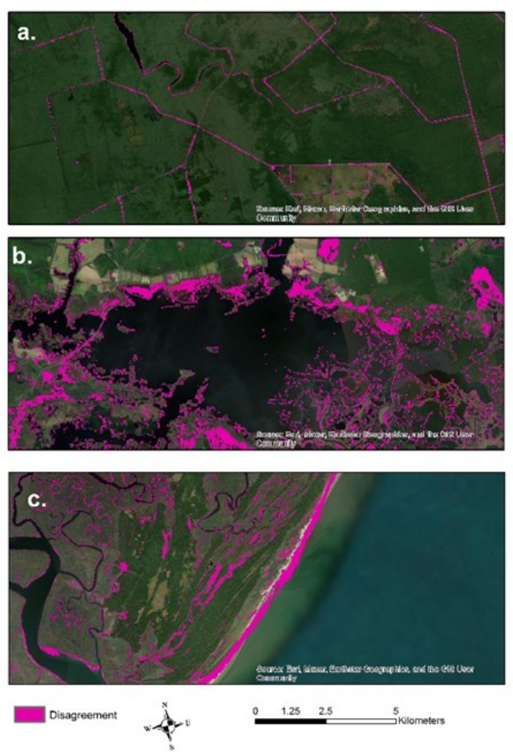

Fig 4: Close-up view of the class-level spatial disagreements between NWI and C-CAP, where: a. highlights differences along the road network in Alligator River, NC, b. shows differences concentrated around water bodies in Blackwater, MD, and c. shows differences concentrated along the boundaries of open water and vegetated wetland systems in Sapelo Island, GA.

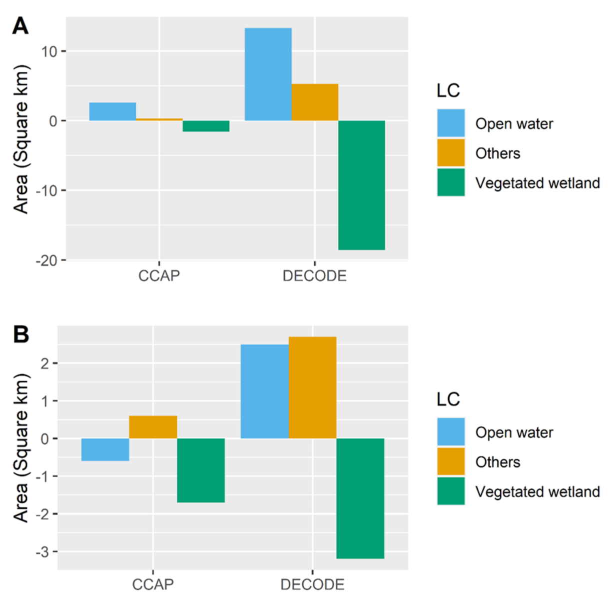

Fig 5: A. Areal Change of Land Cover Types in Blackwater, MD (1996-2016); B. Areal Change of Land Cover Types in Jamaica Bay, NY (1996-2016).

2. New Algorithm Development (Blackwater, MD)

- Extracted time series of 6 bands from all Landsat 4—8 images and calculated 7 indices.
- Identified break points using *ecp* [5] change point algorithm.
- Split time series into stable and unstable segments .

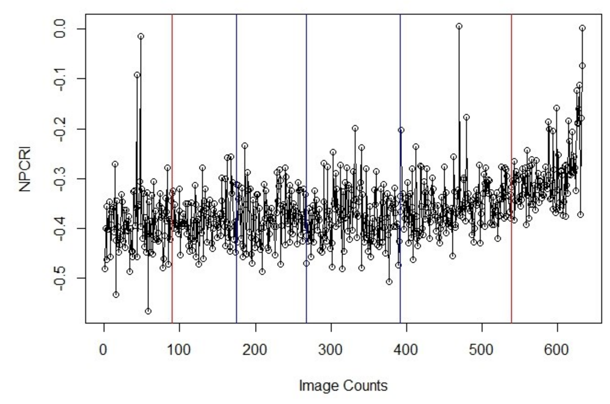

Fig 6: Example of implementing *ecp* change point algorithm and splitting time series into stable and unstable segments, which are assumed to be the middle segments.

- Trained random forest model using all observations of stable segments.
- Used classification percentages from each segment to determine stability thresholds and then classified study site on segment-basis to produce annual wetland LULC maps.

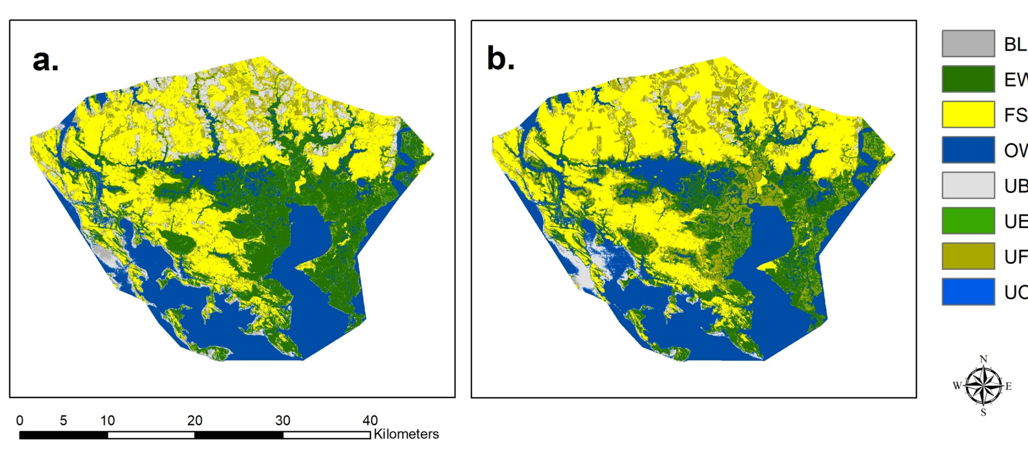

Fig 7: Final classified maps of Blackwater, MD in (a) 1982 and (b) 2021

3. Google Earth Engine (GEE) Implementation

- Using GEE enables coast-wide implementation.
- We are adapting and parameterizing the Continuous Change Detection and Classification (CCDC) temporal segmentation tool [6] and random forest classifier.

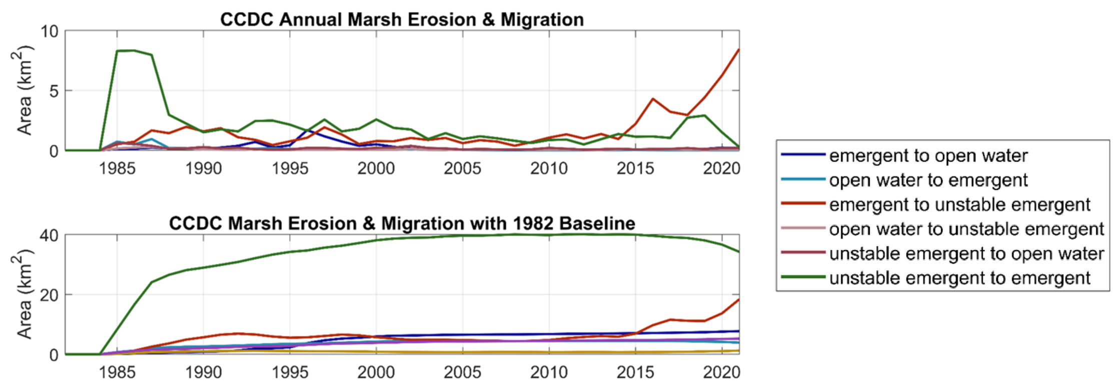

Fig 8: Time series of coastal marsh erosion and migration rates, derived using the GEE CCDC tool. The top plot shows annual change each year and the bottom plot shows cumulative change, using 1982 as a baseline for measuring change.

- To accommodate GEE memory limits, we split large study sites into smaller grids.
- We are parameterizing models on 5 representative sites, and will delineate the Atlantic and Gulf coasts using HUC-6 watersheds.

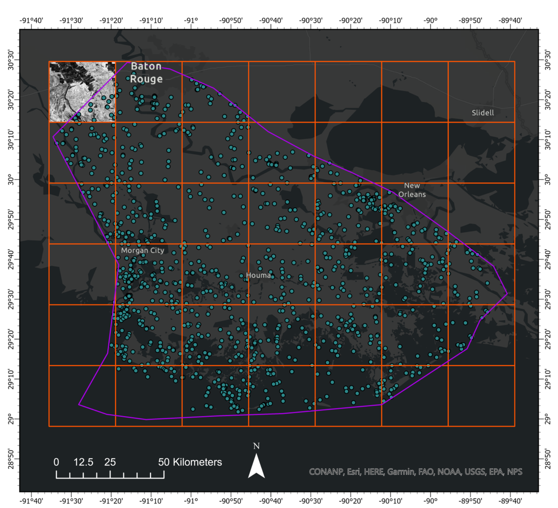

Fig 9: Barataria, LA area (purple) split into grids (orange) with training points (teal).

Mapping Marsh Depth and Estimating Carbon Fluxes

Aggregating Marsh Depth and Carbon Inventories

We have been aggregating and refining the Englehart and Horton [7], Braswell et al. [8], and Hudson River/ NYC coastal marsh databases to produce a marsh depth map for the Atlantic and Gulf coast.

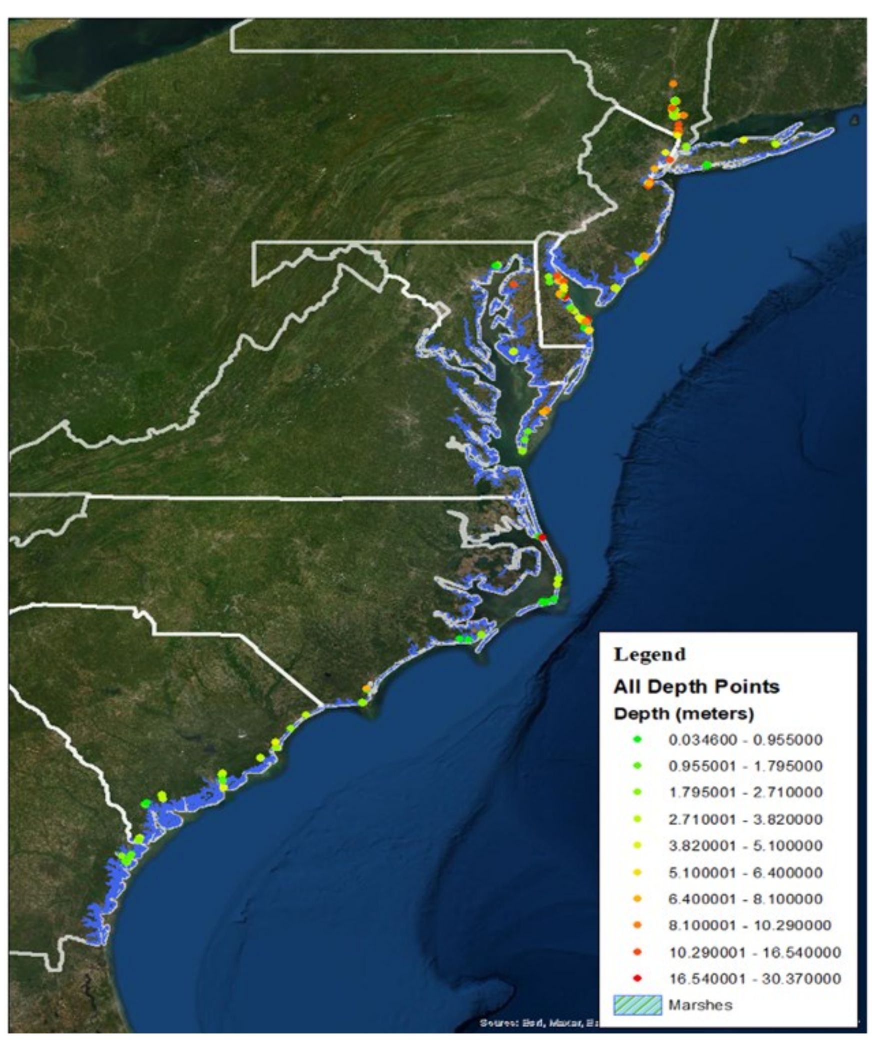

Fig. 10: Current aggregated marsh depth map for the Atlantic coast, showing locations where in-situ data is available.

Marsh Carbon Stock Estimates by State

The figures below illustrate how the new marsh depth database can be combined with marsh area estimates to quantify carbon stocks. Later we will combine this depth database with the annual wetland LULC maps produced in Task 1 to estimate carbon fluxes into coastal ecosystems, allow us to assess the significance of this flux relative to those currently included in the GISS model.

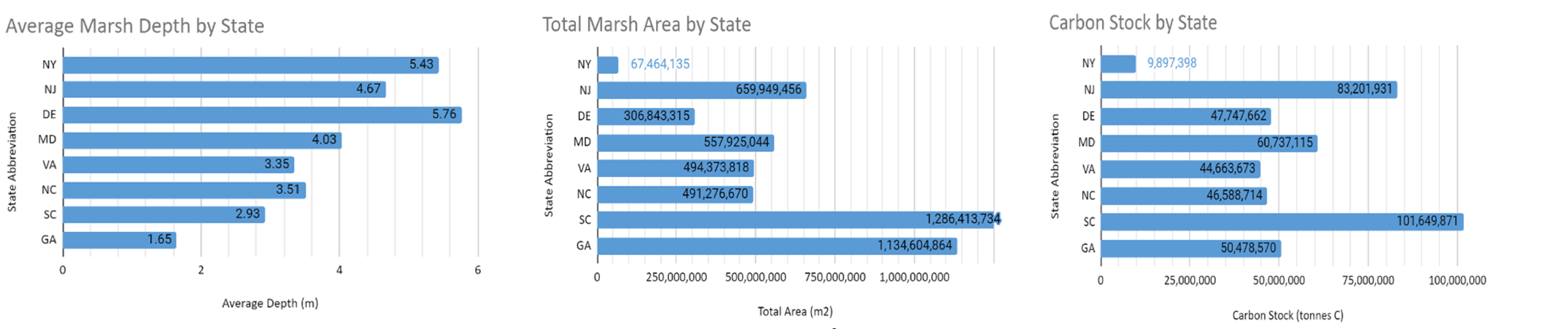

Fig. 11: Marsh depth, area, and carbon stocks summarized by state. We used a standard value of 27Kg C/m^3 suggested by Holmquist [9] to convert marsh volume to carbon stock.

In-situ Marsh Transects Collected in NY

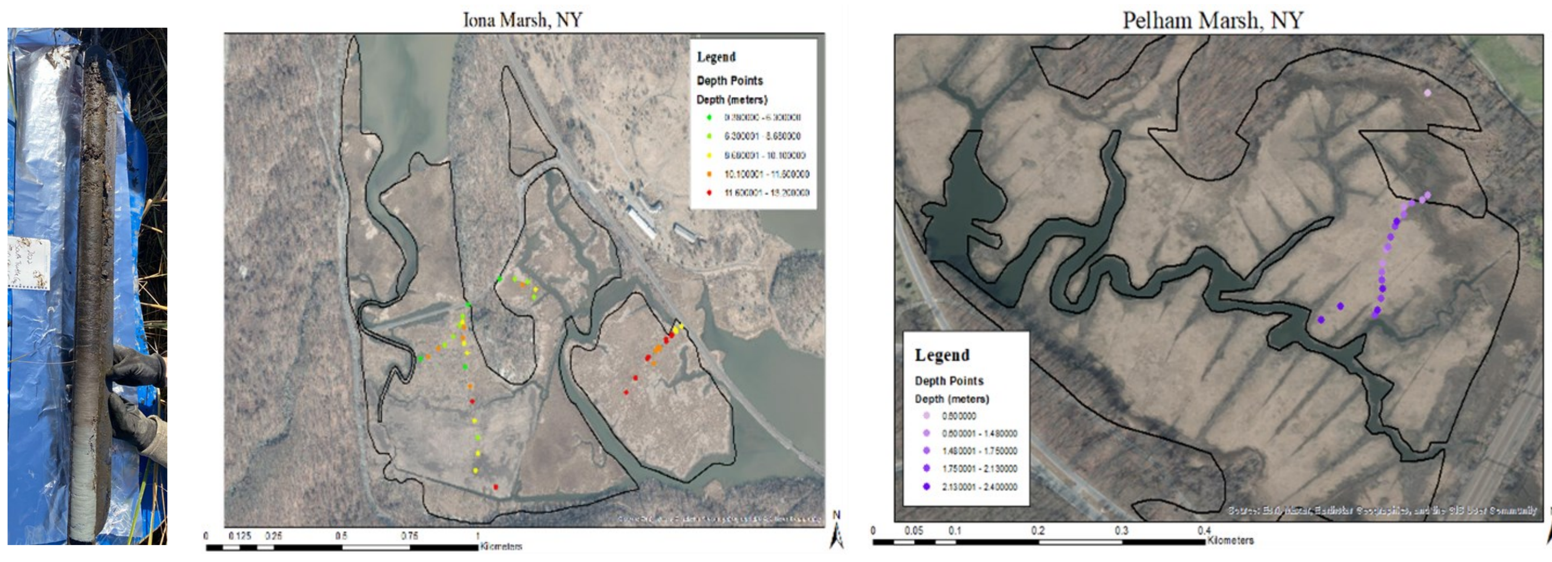

Fig. 12: Picture of soil core sample (left), and maps of transect data collected in NY marshes. The average depth of the Iona marsh is 10.0 meters, and the average depth of the Pelham marsh is 1.79 meters.

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Acknowledgements

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