University of Massachusetts Amherst – Tidal Marsh Soil Properties for the Northeast

- **Quantify blue carbon stocks for marshes within the Northeast US**
- **Estimate mineral sediment demand for marsh units prior to planned restoration efforts**

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1. Introduction

Raster-based models of Northeast US salt marsh soil properties were created as part of a collaborative soil science project by scientists at the NRCS and University of Massachusetts Amherst.

This dataset includes four raster files that can be used to calculate blue carbon stocks. When paired with estimates of vertical accumulation rates, these datasets can also be used to estimate blue carbon sequestration or mineral sediment demand of tidal marshes.

These are the rasters (and associated units):

1. NortheastSaltmarsh_SOM (Soil Organic Matter, percent)
2. NortheastSaltmarsh_BD (dry bulk density, g cm^{-3})
3. NortheastSaltmarsh_CD (mass of carbon per unit volume, gC cm^{-3})
4. NortheastSaltmarsh_MinD (mass of mineral material per unit volume, gM cm^{-3})

Methods

We used 10 cm deep soil samples roughly 418 cm^3 in volume to characterize the dry bulk density and soil organic matter at 19 tidal marsh sites spanning New York to Maine during the summer of 2021. A total of 400 samples were collected. Data from these samples were used to calibrate a remote sensing-based model to predict soil characteristics across all Northeast US tidal marshes, New York to Maine. The model relies on the the normalized difference water index (NDWI) (McFEETERS, 1996) (McFeeters, 1996) from Sentinel 2, which is provided at 10 m resolution, matching those of our rasters. Full model development is discussed in Teng et al. (in review), and error and applications of the model described in Yellen et al. (in review) and decribed briefly below.

Marshes across the region were catgorized as barrier marshes, formed within embayments created by barrier beaches, or fluvial marshes, formed along major river estuaries. The percent soil organic matter (SOM) was predicted as a function of the NDWI and a global variable to account for differences between sites. Global variables were chosen for each geomorphoic class (barrier vs fluvial) based on minimiziation of model R^2 values. We found that tidal range for barrier systems, and suspended particulate matter in the offshore water column for fluvial marshes resulted in better model fits with observational data. Full model equations are shown below:

$$SOM_{barrier} = -1.05 \cdot NDWI_{jun,\ h} - 0.12 \cdot TR + 0.16 \qquad \textit{Eqn. 1}$$

$$SOM_{fluvial} = -0.95 \cdot NDWI_{dec,\ h} - 0.03 \cdot SPM + 0.04 \qquad \textit{Eqn. 2}$$

Where TR refers to the tidal range at the closest NOAA tide gauge, and SPM is suspended particulate matter from MODIS satellite system at the closest ocean pixel.

From SOM rasters, we derived the three other rasters. Soil bulk density (BD), calculated as the total dry mass of a soil sample divided by its volume was derived from SOM at each pixel using the relationship presented in Morris et al. (2016). Total organic carbon (TOC) was derived from SOM using the conversion published in Ouyang and Lee (2020). TOC was then multiplied by BD to estimate the carbon density (CD) of the marsh soil at each pixel in units gC cm^{-3}. Mineral sediment density (MinD) described the mass of inorganic or mineral material per unit volume and, when paired with a vertical accumulation rate, can be used to constrain how much sediment must be delivered to a marsh. MD was calculated as (1-SOM)*BD. We used our 430 marsh surface samples to constrain model error and summarize error below as the mean absolute percent error (MAPE). Raster values are representative of the top 10 cm of the marsh soil, which is equivalent to roughly 25 years of accumulation based on recent accumulation rates (Hill and Anisfeld, 2015; O'Keefe Suttles et al., 2021).

Table 1 – Mean absolute percent error (MAPE) for each raster model is presented in the table below. The value for each raster represents the average of the percent difference between the observed and modeled value at 430 field observation points distributed across 19 salt marshes in the Northeast US. Field data can be downloaded from NRCS's Ag Data Commons. See Data Availability below.

LOI	BD	MinD	CD
32.4	27.0	18.0	15.5

Data Availability:

1. Field data used to calibrate raster models for this project were archived at the NRCS's Ag Data Commons:

Northeast US Tidal Marsh Sediment Soil Properties - UMass-NRCS

   a. UMass-NRCS_blue_carbon_surface_samples.csv

   b. UMass_BlueCarbonCores_LOI.csv

c. UMass_BlueCarbonCores_BD.csv

d. README_Northeast_blue_carbon_samples.txt

Yellen, Brian (2023). Northeast US Tidal Marsh Sediment Soil Properties - UMass-NRCS. Ag Data Commons. https://doi.org/10.15482/USDA.ADC/1529276.

Raster data are available for download from NRCS's Ag Data Commons.

2. Northeast US Blue Carbon Rasters (pending embargo)

e. Northeast_marsh_LOI.7z

f. Northeast_marsh_BD.7z

g. README_Northeast_BlueCarbon_rasters.txt

Yellen, Brian; Yu, Qian; Teng, Wenxiu (2023). Northeast US Blue Carbon Rasters. Ag Data Commons. https://doi.org/10.15482/USDA.ADC/1529275.

CITATIONS

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