AGU
2023
Session
B53B-03

Blue Carbon Stock Estimation of US Coastal Marshes from New York to Georgia
How Much Do We Have to Lose?

Disappearing Pelham Marsh, New York City

(work in progress)

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BLUE CARBON

- Salt marshes, tidal marshes, mangroves, and seagrasses

- Greater than 46.9% of total carbon (C) burial in **ocean sediments**
- (Duarte et al., 2005; 2013)

- Bury C at a rate **30 to 50 times that of terrestrial forests** (McLeod et al., 2011; Duarte et al., 2013)

- Continued loss of these habitats at **critical rates..** Coastal wetlands in the eastern United States were lost at an average rate of **59,000 acres per year between 1998 and 2004 (EPA)**

- More than **25% of the estimated global area of salt marshes has been lost since the early 1800s**, and losses continue (Adam, 2002; Lotze et al., 2006).

- **From 2012-2020, only 6/20 S. Atlantic sites were gaining elevation at a rate that was equal to or greater than the long-term rates of sea-level rise and therefore considered resilient (Moorman et al. 2023)**

- **2,800 hectares** of tidal wetland in Hudson Estuary – **all at risk**

Why Care About Wetlands?

Sponges for aquifers

Nurseries for aquatic ecosystems

Support avian habitat

Protection of shorelines

Ecotone between rivers & uplands

***Archives of environmental history

***Carbon Storage –

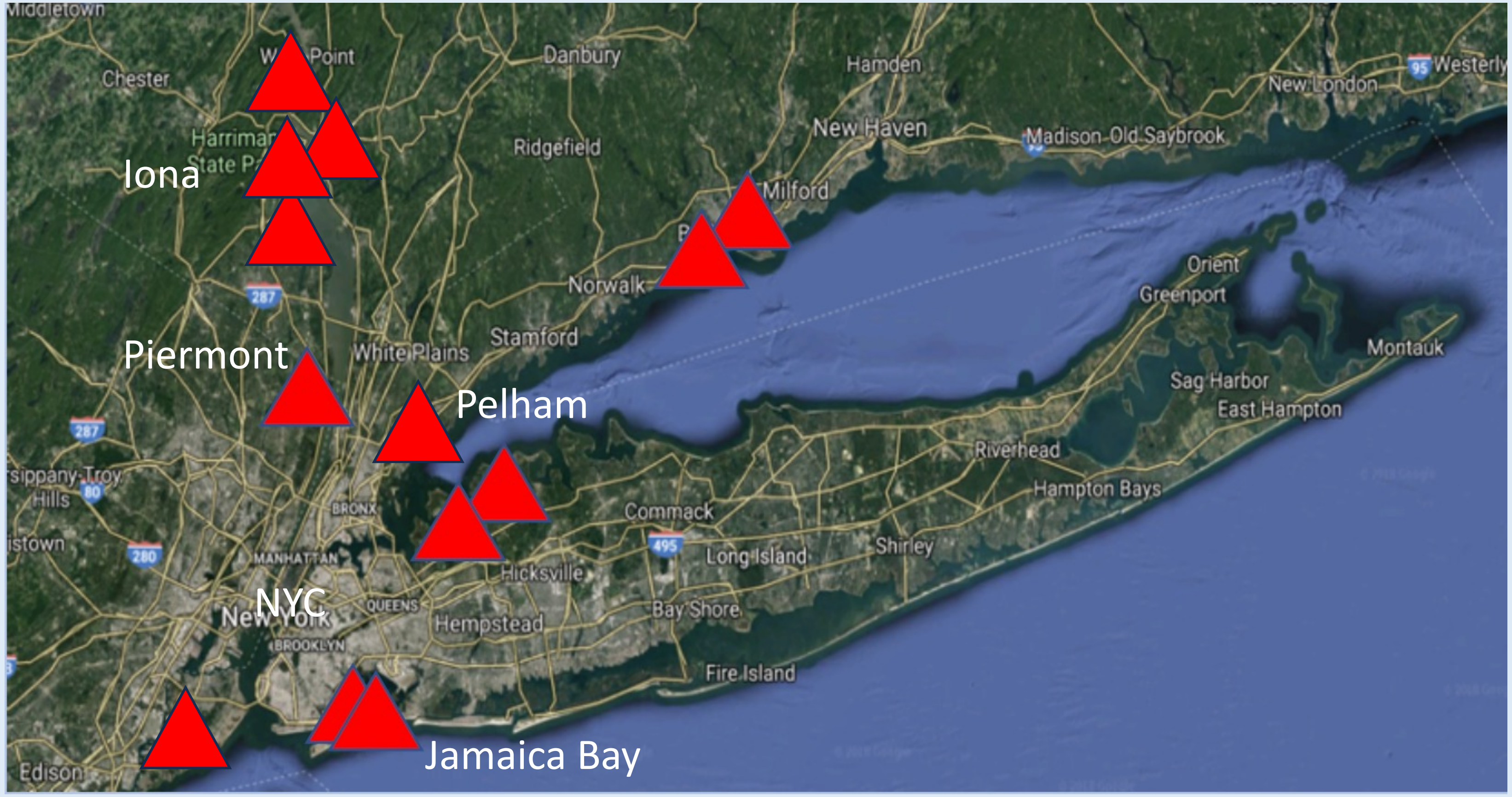
High sedimentation rate

Worldwide, huge losses in wetlands since 1970s!!..Ramsar report, 2018

NYC is hotspot for sea level rise

Below the water

Ongoing transect of marsh studies in
Hudson River, Long Island Sound
New York City



Full-depth peat accounting needed to measure carbon stocks

Thanks to all collaborators!

What does sediment tell us?

- Organics – marsh & upland history
  - -- *vegetation and climate*
  - -- *carbon and nitrogen history*
  - -- *chronology*

- Inorganics (sand, silt, clay) – depositional history
  - -- *upland weathering*
  - -- *contaminants*

**Needed for understanding best restoration practices*

Yellow Bar 2014 core, 0-1 m

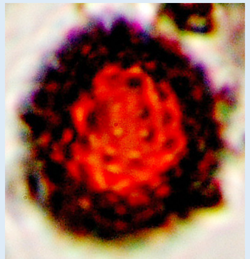
Methods

grass pollen

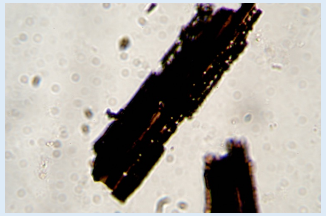
Spartina patens (high marsh grass)

- Pollen and Spore Analysis
  - 300 grains/sample…regional
- Macrofossil and Charcoal Analysis
  - Species-specific, fire history
- Foraminifera
  - High or low marsh, sea level…….droughts, floods
- C-14 Dating, Pb isotopes
  - AMS C-14 on macrofossils
- Sediment stratigraphy
  - Loss-on-ignition (LOI)…inorganic supply
  - Nitrogen isotopes, Carbon isotopes
- X-Ray Fluorescence Spectroscopy (XRF)
  - Lead, zinc, copper, titanium, potassium

ragweed

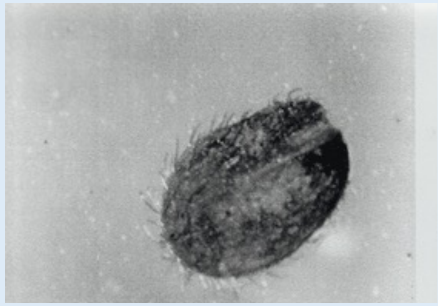


Ragweed (*Ambrosia*) pollen

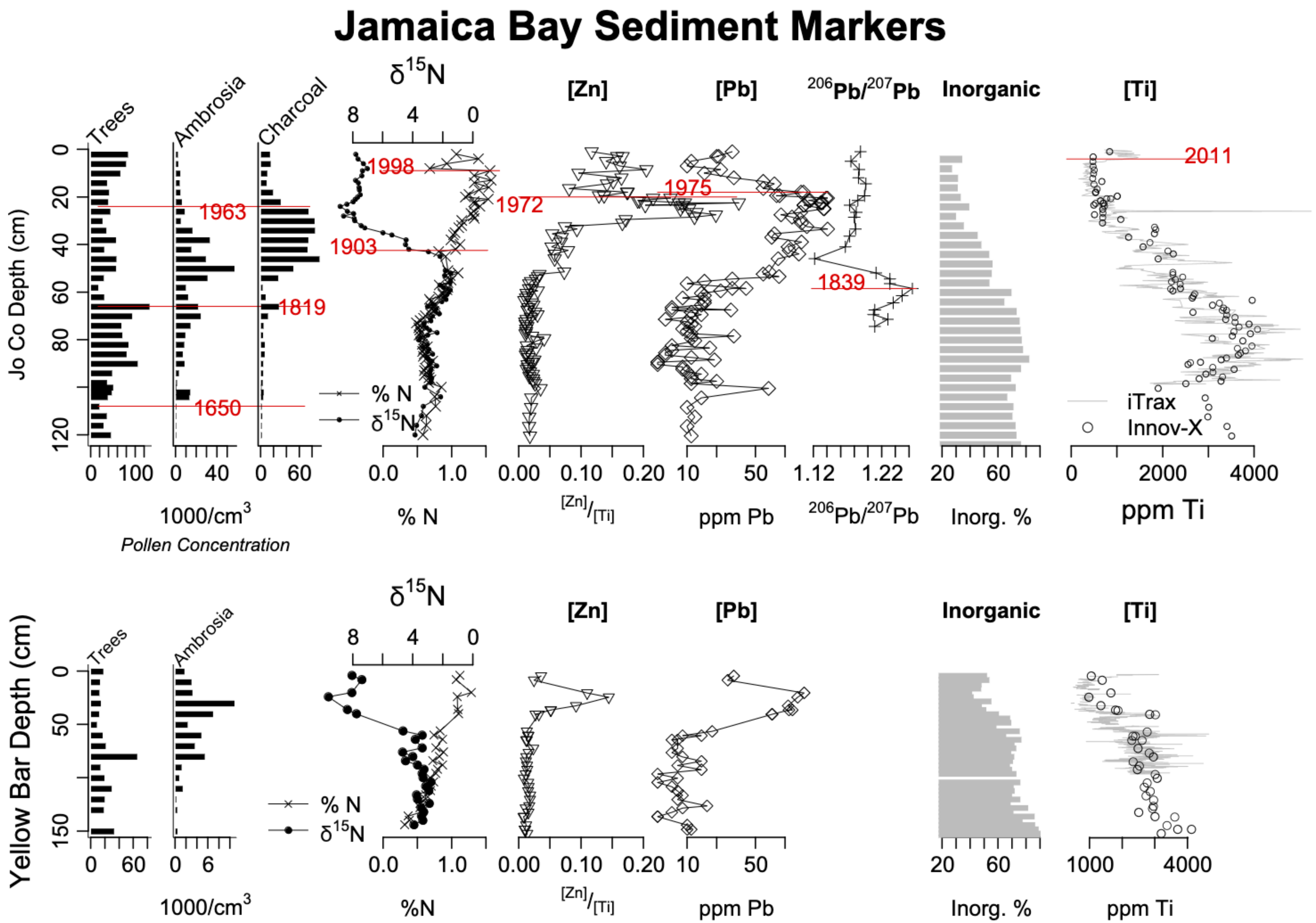


charcoal

foraminifera



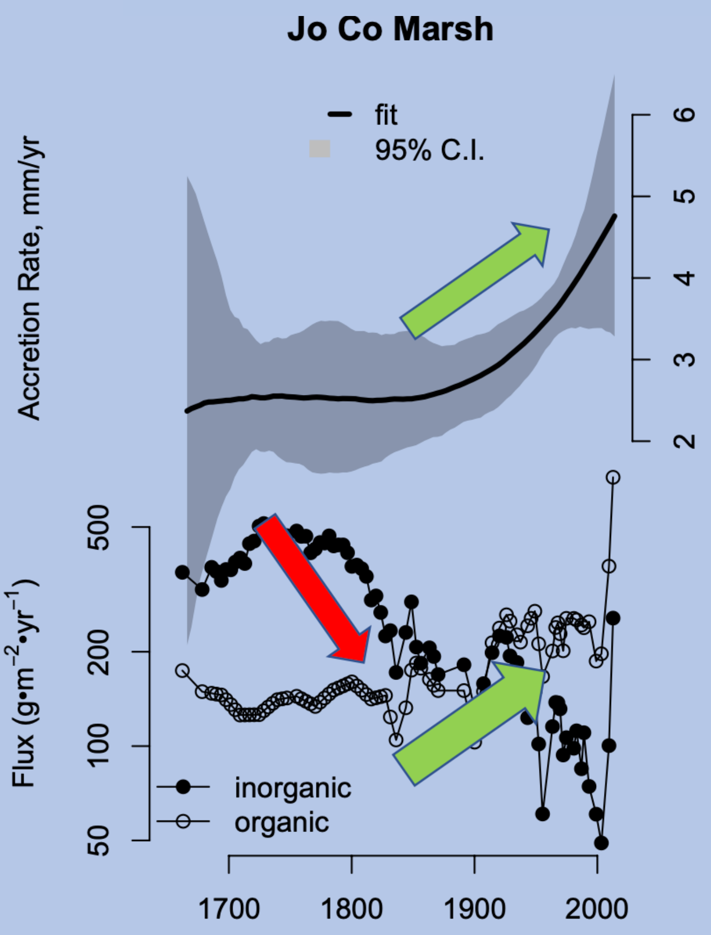
Salicornia seed



Jamaica Bay Sediment Markers
Trees
Ambrosia
Charcoal
δ15N
[Zn]
[Pb]
206Pb/207Pb
Inorganic
[Ti]
Jo Co Depth (cm)
1998
1963
1972
1975
1903
1819
1839
1650
2011
% N
δ15N
iTrax
Innov-X
1000/cm3
Pollen Concentration
% N
[Zn]/[Ti]
ppm Pb
206Pb/207Pb
Inorg. %
ppm Ti
Yellow Bar Depth (cm)
%N

Jamaica Bay Result:

Accretion rate in this urban estuary shows increase despite the mineral sediment decline…



Higher production or less decomposition due to increased nitrogen fertilization?

…Yet marsh falls apart

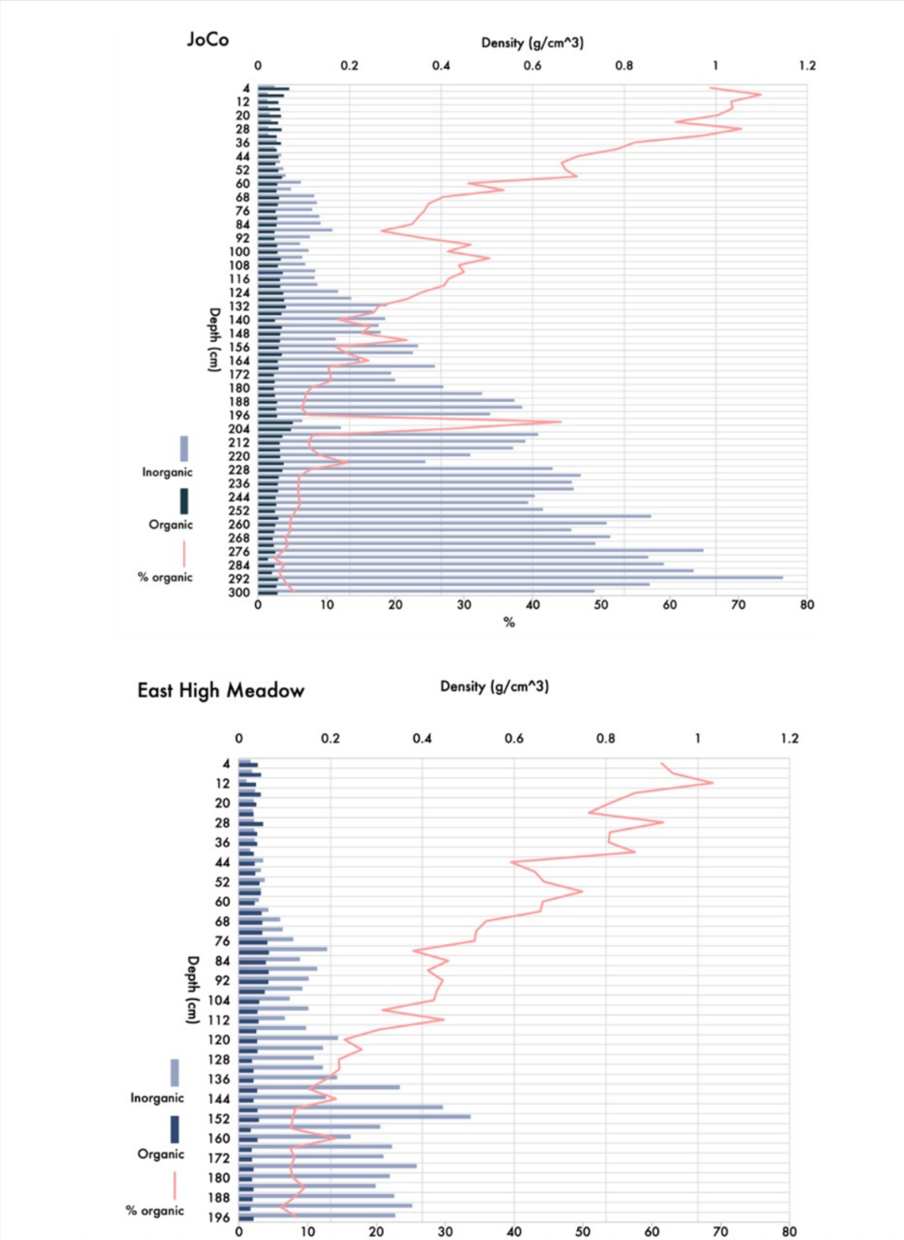
Peteet, D.M., Nichols, J., Kenna, T., Chang, C., Browne, J., Reza, M., Kovari, S., Liberman, L., and Stern-Protz, S. 2018. Sediment starvation destroys New York City's marshes' resistance to sea level rise. *Proceedings of the National Academy of Sciences (PNAS)* 115 (41): 10281-10286

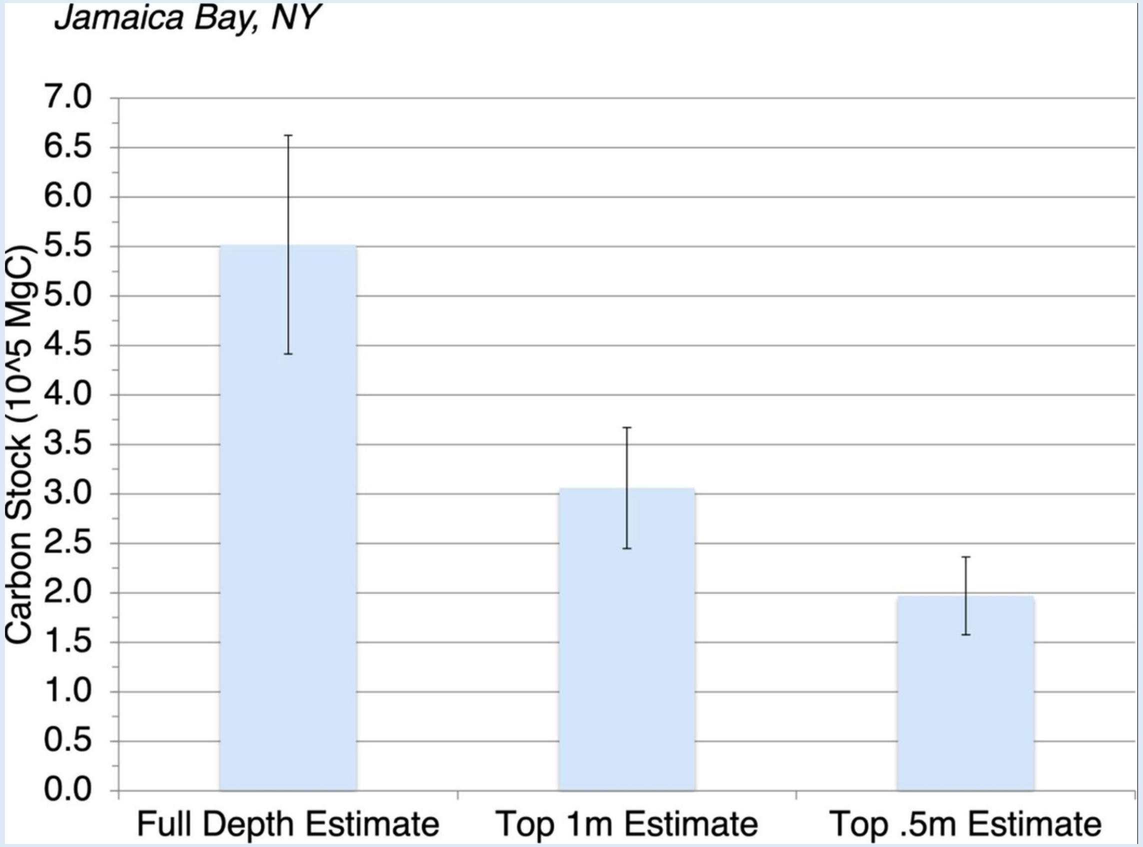
Calculating Blue Carbon Content:

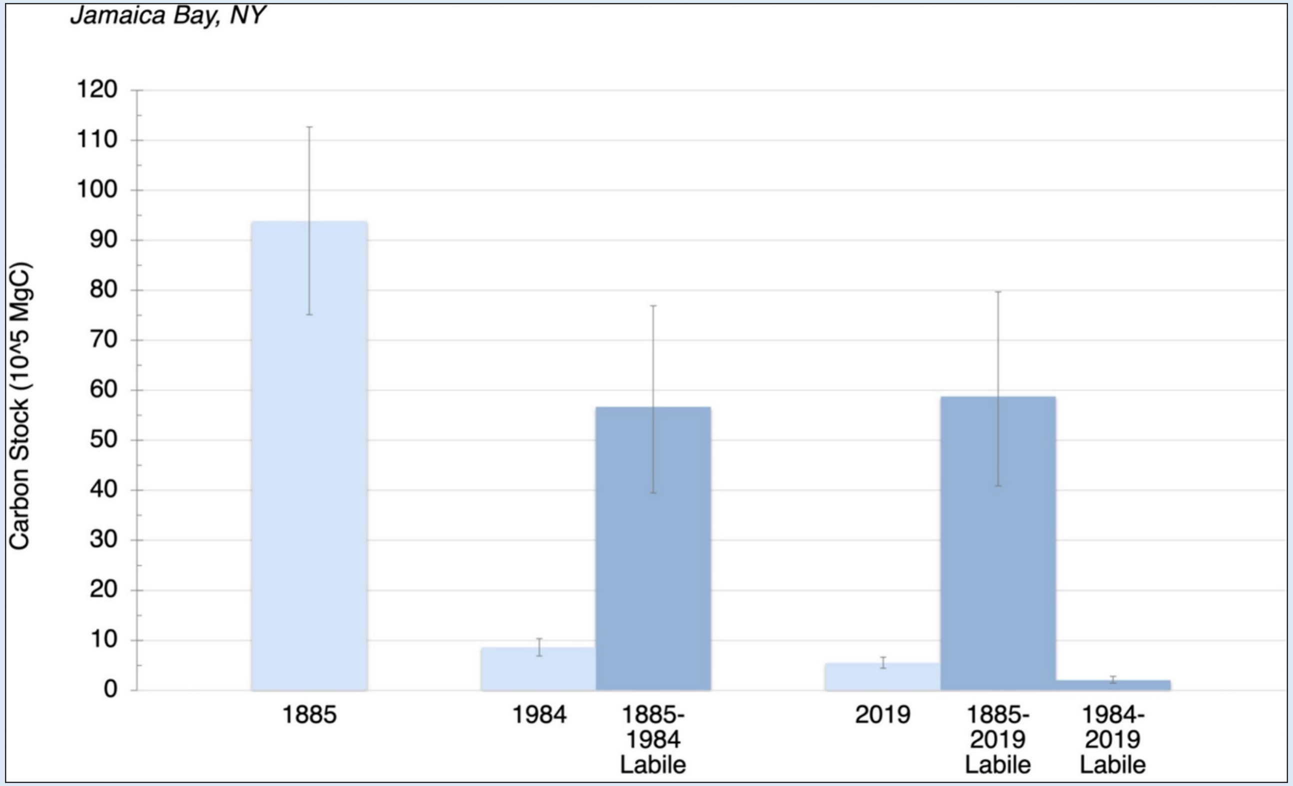
$$CS = CC * A * D \tag{1}$$

CS is the total carbon stock (kgC) and CC is the carbon content ($kgCm^{-3}$) calculated from LOI and soil bulk density data from the sediment cores and a regression Eq. [11] (see Eq. (2)). A is the area of the marsh (m^2) and D is the depth (m).

$$CC = CF * LOI * BD \tag{2}$$





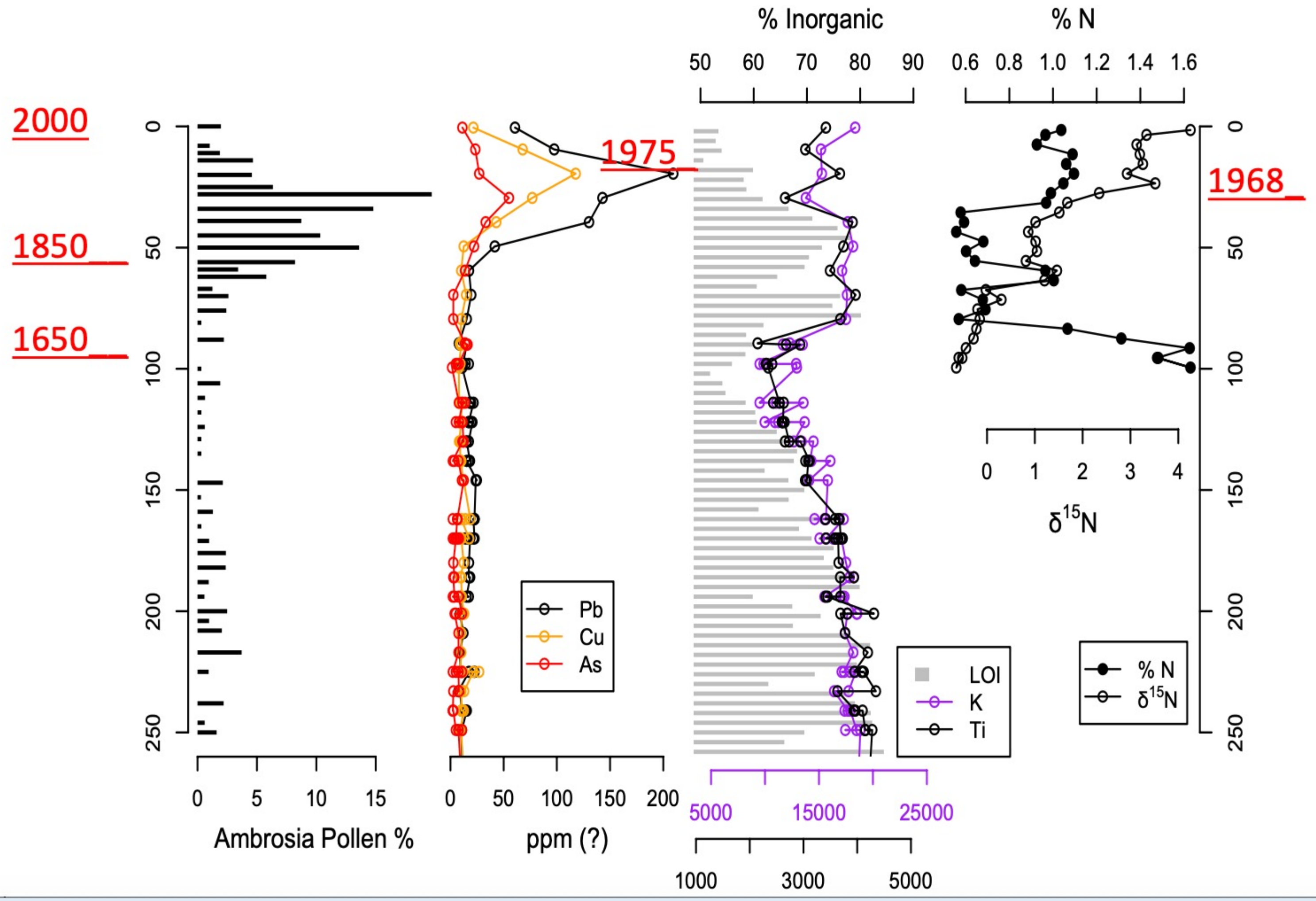


*The carbon stock estimates presented here show a 95% carbon stock loss between 1885 and 2019 in Jamaica Bay

*Highlight the severe underestimation of carbon stocks without full-depth calculations.

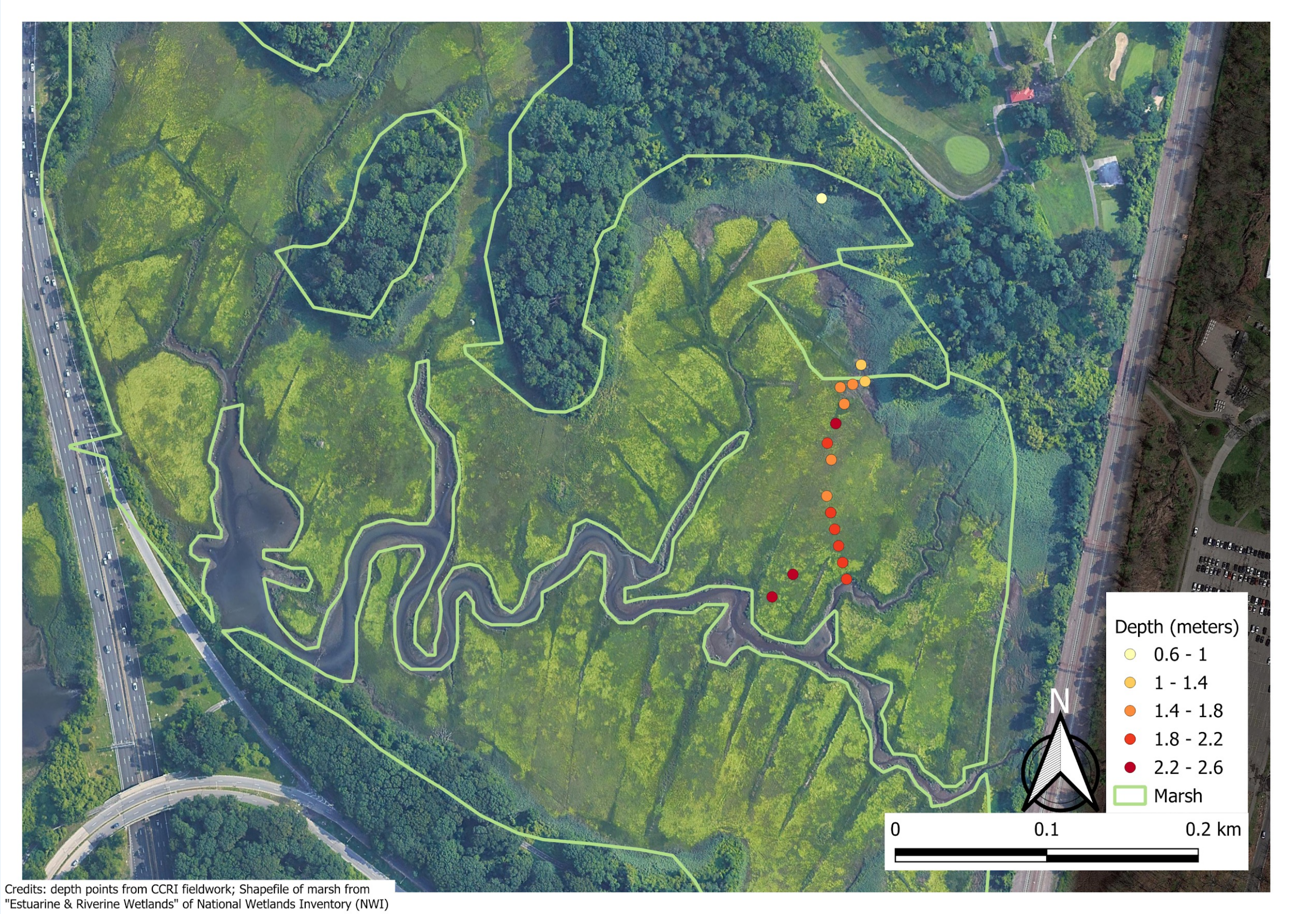
Pace, G., D. Peteet, M. Dunton, C. Wang-Mondaca, S. Ismail, J. Supino, and J. Nichols, 2021: Importance of quantifying the full-depth carbon reservoir of Jama
Bay Salt Marshes, New York. *City Environ. Interact.*, **12**, 100073, doi:10.1016/j.cacint.2021.1000

Piermont Marsh show human impact: ragweed rise, inorganic increase with disturbance, heavy metals with industry, and N shifts



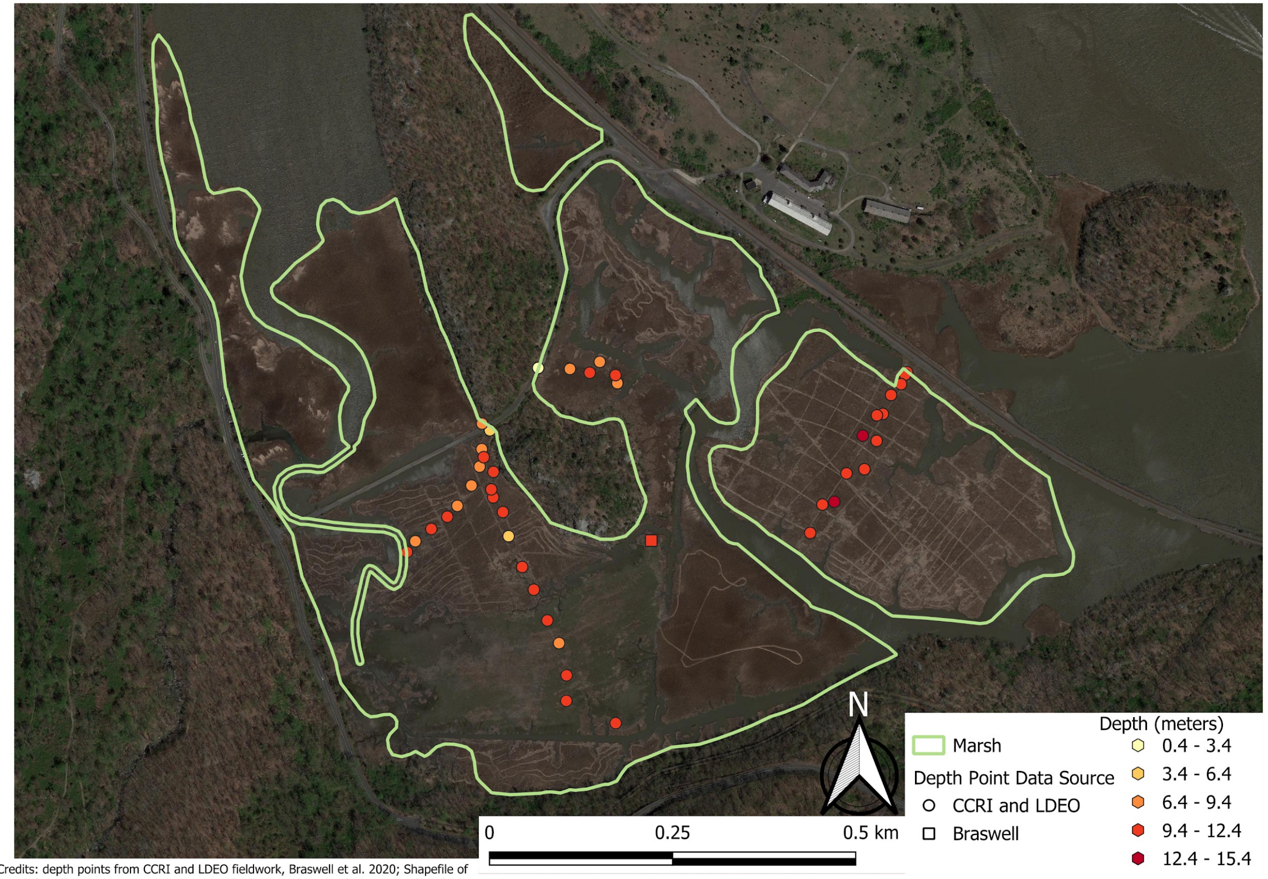
Peteet et al., 2020

Case Study 1: Pelham Marsh, NYC



Pelham	
Number of Depth Points	20
Average Marsh Depth (m)	1.79
Total Marsh Area (m²)	742,312.85
Total Marsh Volume (m³)	1,328,740.00
Carbon Content (kg C/m³)	27
Carbon Stock (tonnes C)	35,875.98
Carbon Stock (car-years)	7,799.13

Case Study 2: Iona Marsh, Hudson River

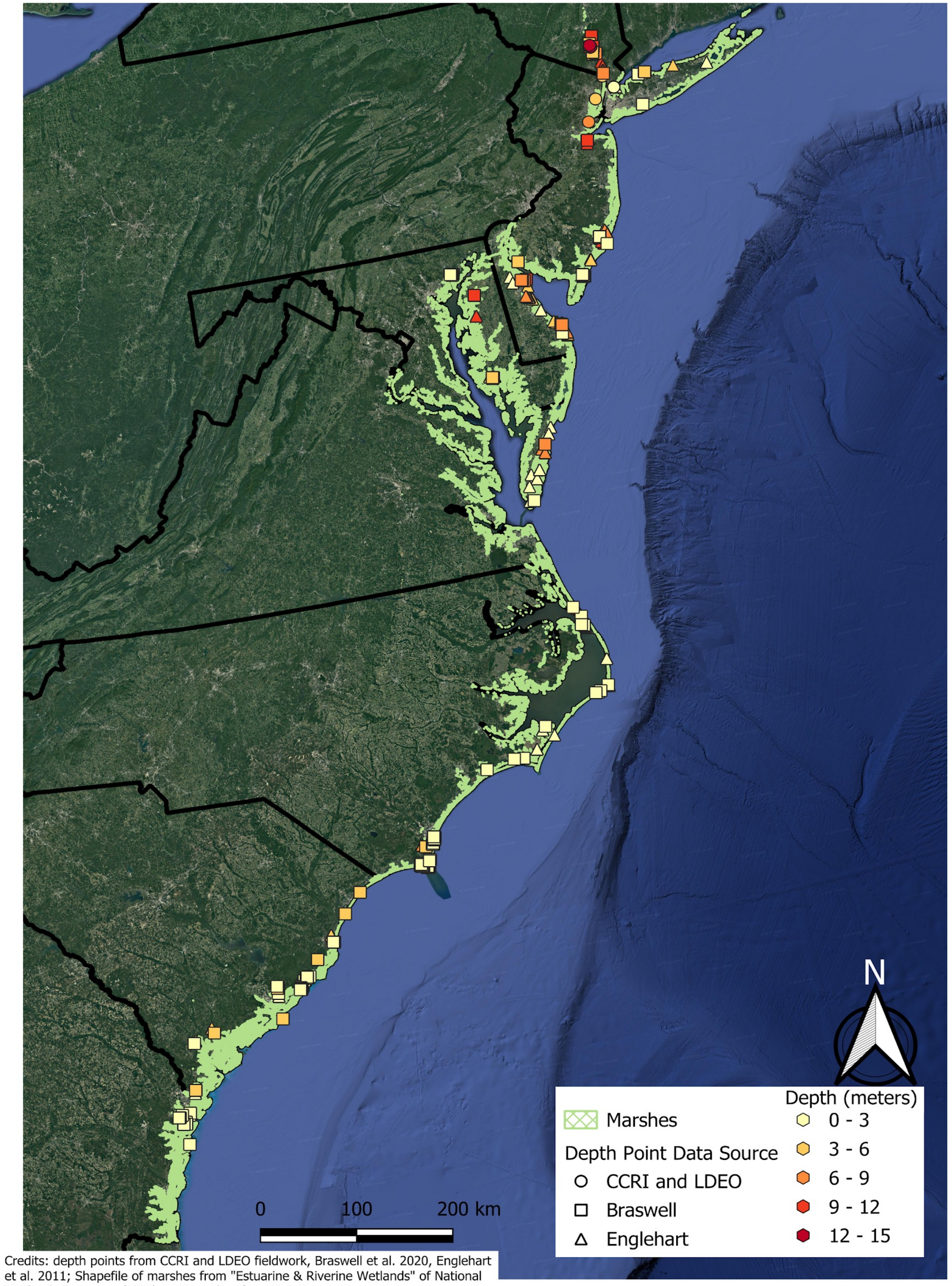


Credits: depth points from CCRI and LDEO fieldwork, Braswell et al. 2020; Shapefile of marsh from "Estuarine & Riverine Wetlands" of National Wetlands Inventory (NWI)

Iona	
Number of Depth Points	74
Average Marsh Depth (m)	8.3116
Total Marsh Area (m^2)	553,711.92
Total Marsh Volume (m^3)	4,602,221.52
Carbon Content (kg C/m^3)	29.85
Carbon Stock (tonnes C)	137,376.31
Carbon Stock (car-years)	29,864.42

Riverine (Iona) vs. Coastal (Pelham)

<u>**Statistic**</u>	<u>**Iona**</u>	<u>**Pelham**</u>
Number of Depth Points	52	20
Average Marsh Depth (m)	10.0	1.79
Total Marsh Area (m^2)	550,000	740,000
Estimated Total Marsh Volume (m^3) *Average Marsh Depth * Total Marsh Area*	5,500,000	1,300,000
Estimated Carbon Stock (metric tons C) *Average Estimated Total Marsh Volume **	170,000,000	36,000,000



Credits: depth points from CCRI and LDEO fieldwork, Braswell et al. 2020, Englehart et al. 2011; Shapefile of marshes from "Estuarine & Riverine Wetlands" of National Wetlands Inventory (NWI); state outline from U.S. Census Bureau

Carbon content = LOI (loss-on-ignition) * bulk density (g/cm^3) * 0.5

or use 27 kg C/m^3 (Holmquist et al, 2018)

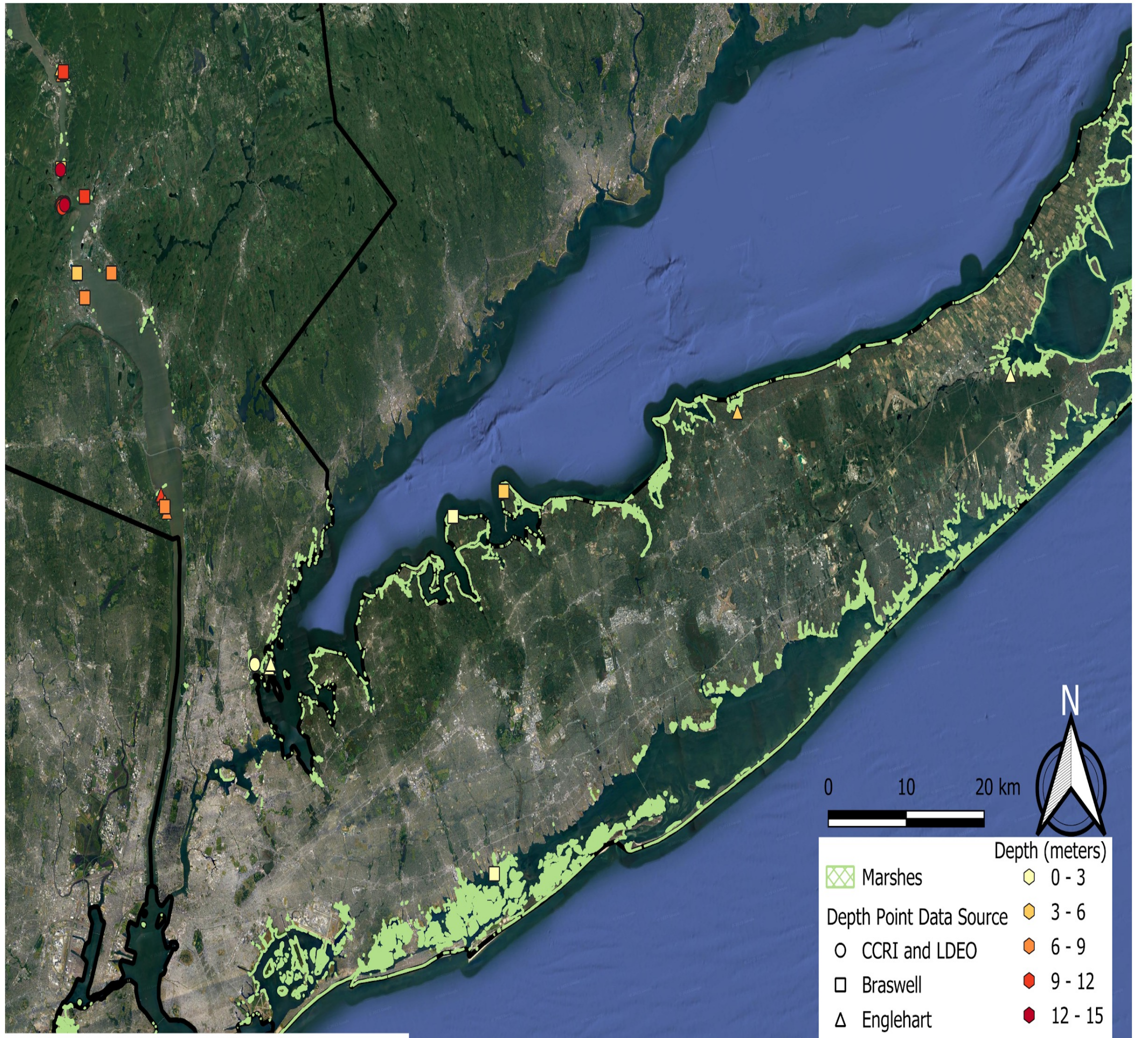
Carbon stored = carbon content * Area * Depth

Area: National Wetlands Inventory database

Depth: Engelhart et al. 2011 database
Braswell et al. 2020 database

..future…Coastal Carbon Atlas

**most salt marsh carbon stock estimates only go to 1 meter depth (Ardenne et al., 2018)



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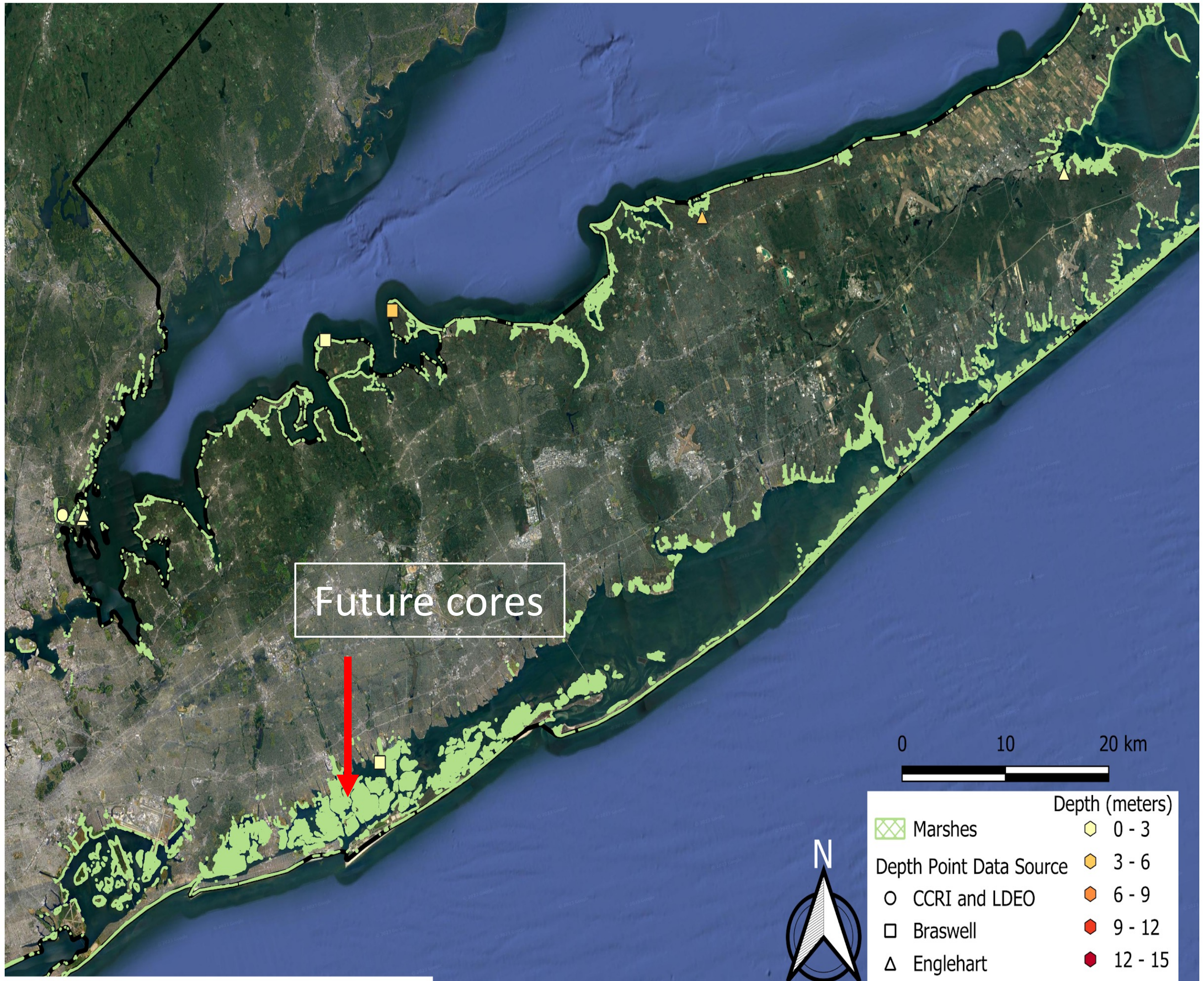

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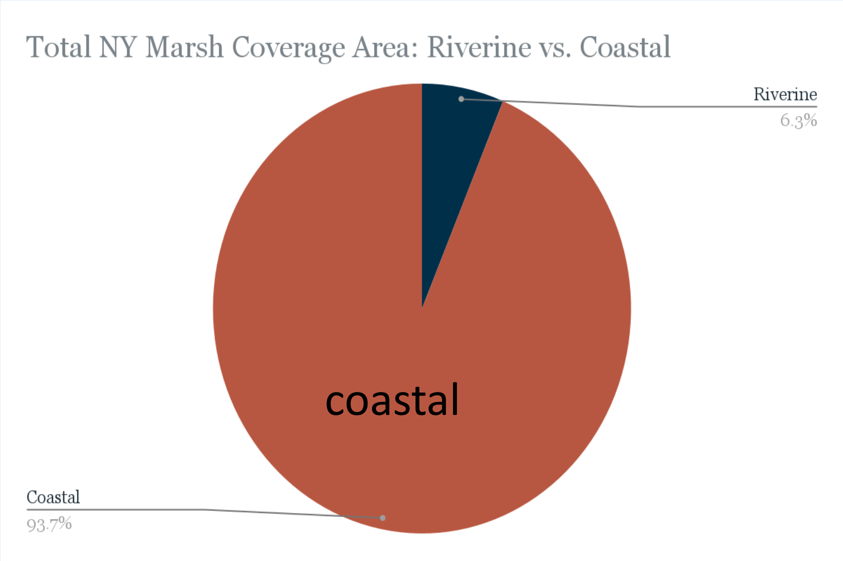
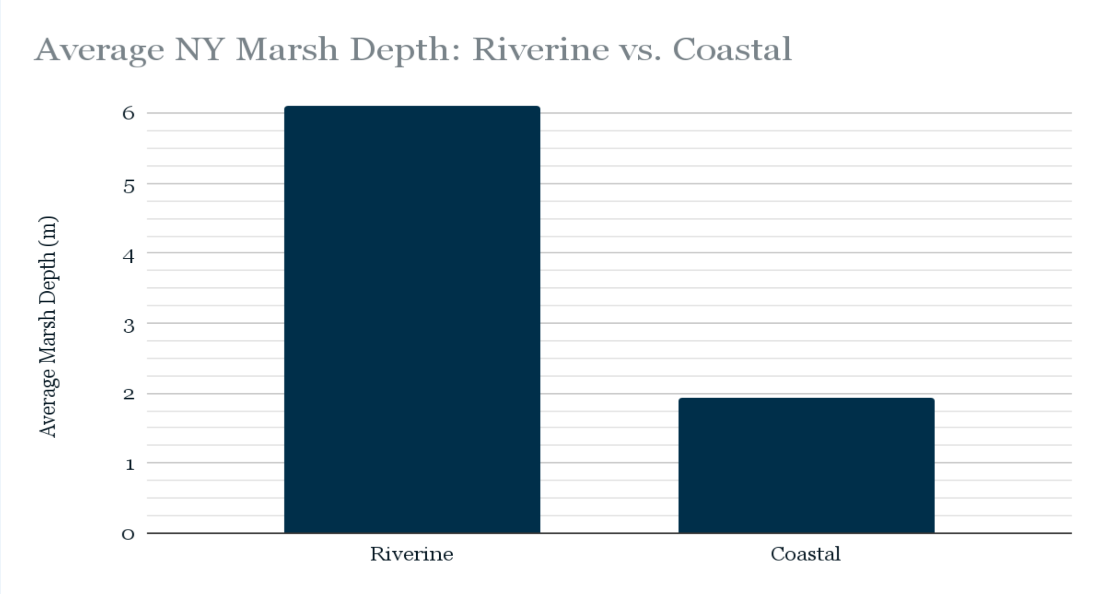
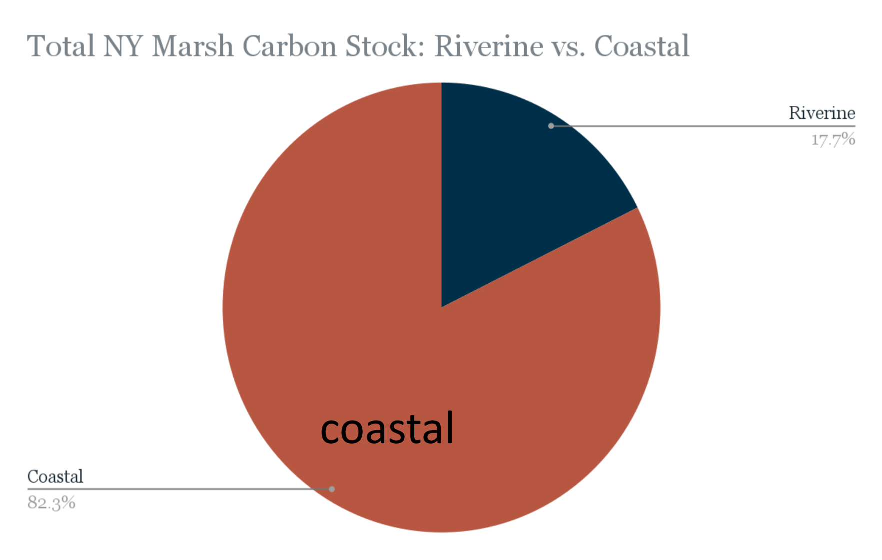
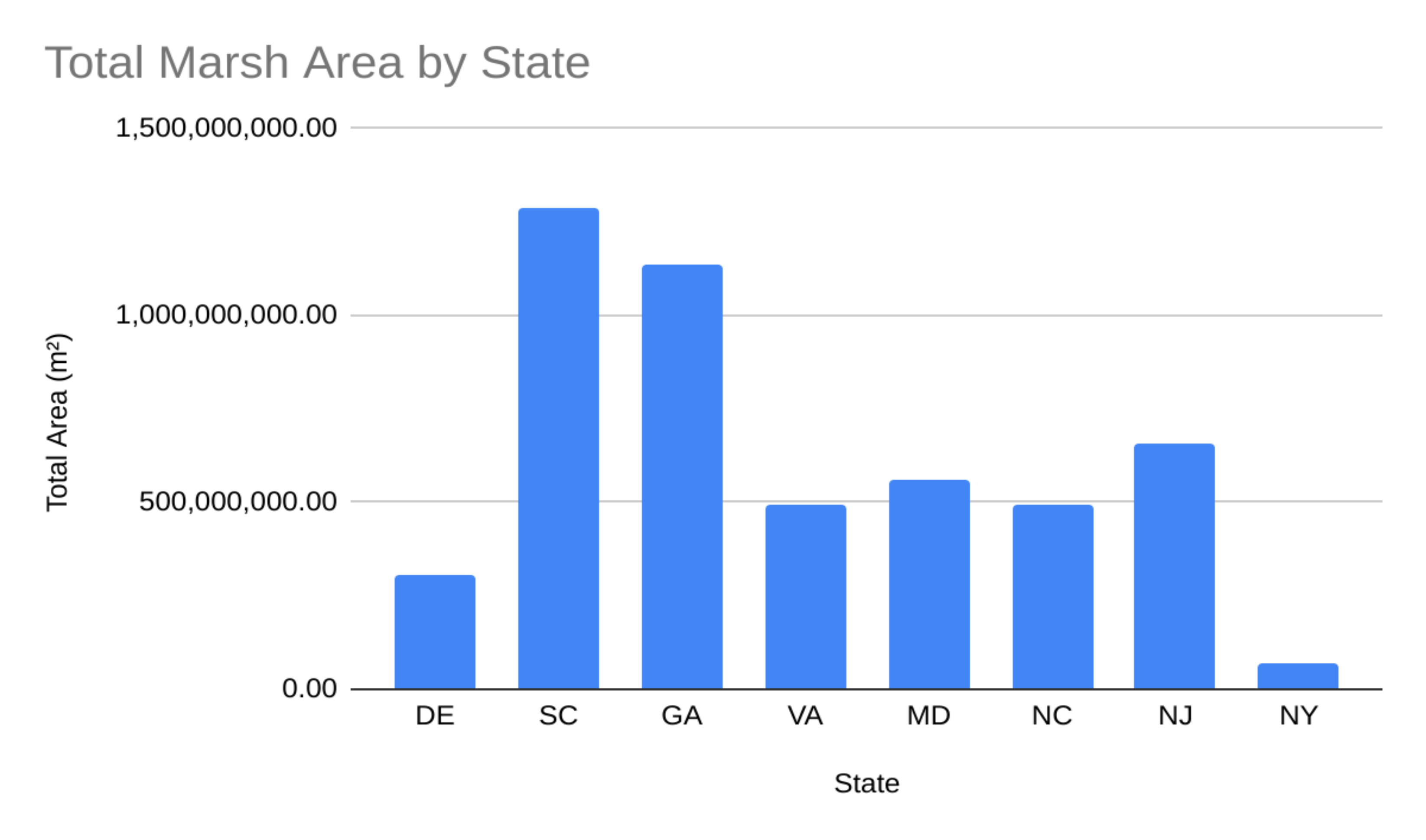




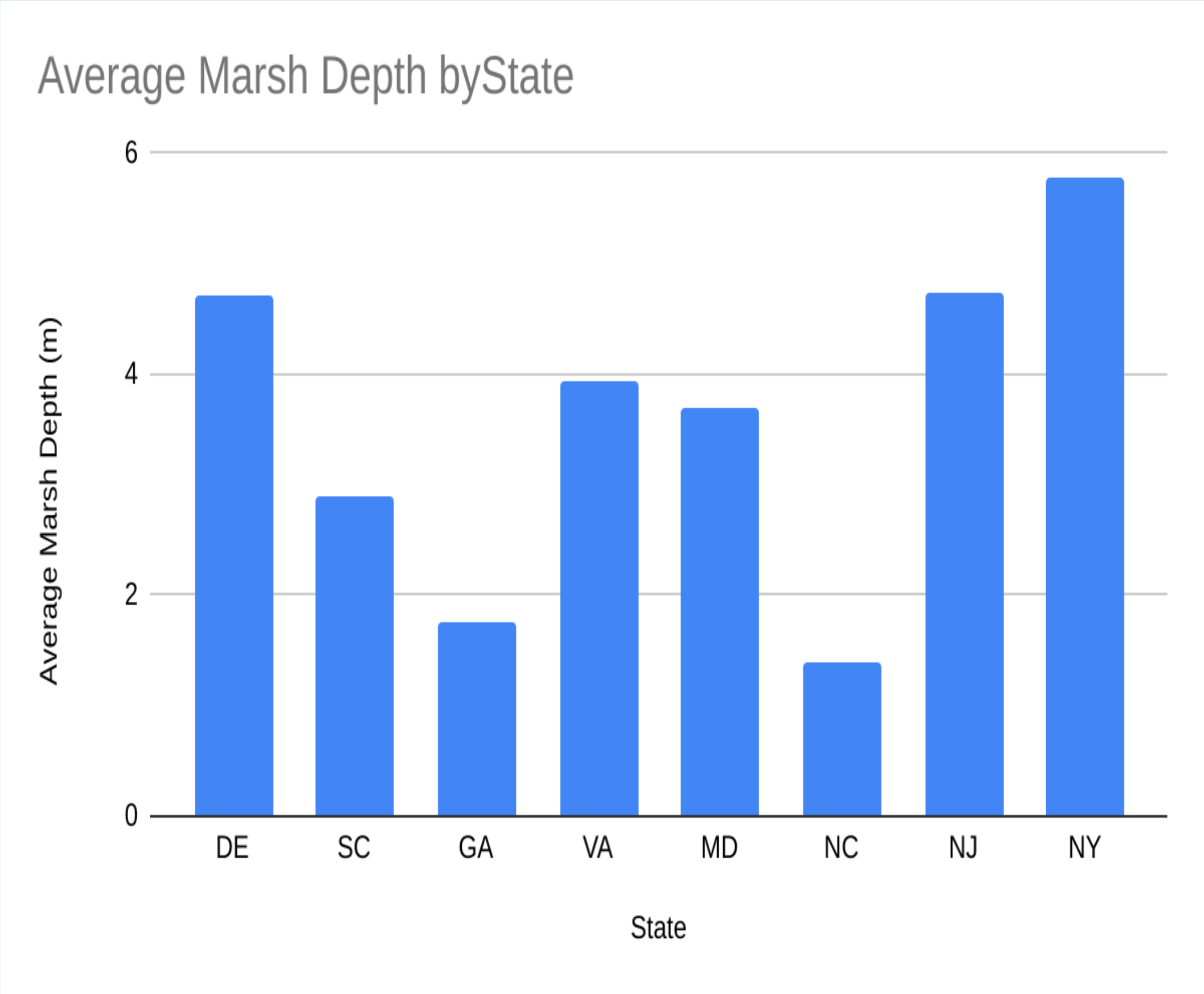


** NY Riverine marshes are deeper but NY coastal area is greater so contains more carbon



NATIONAL WETLANDS INVENTORY…all marsh?

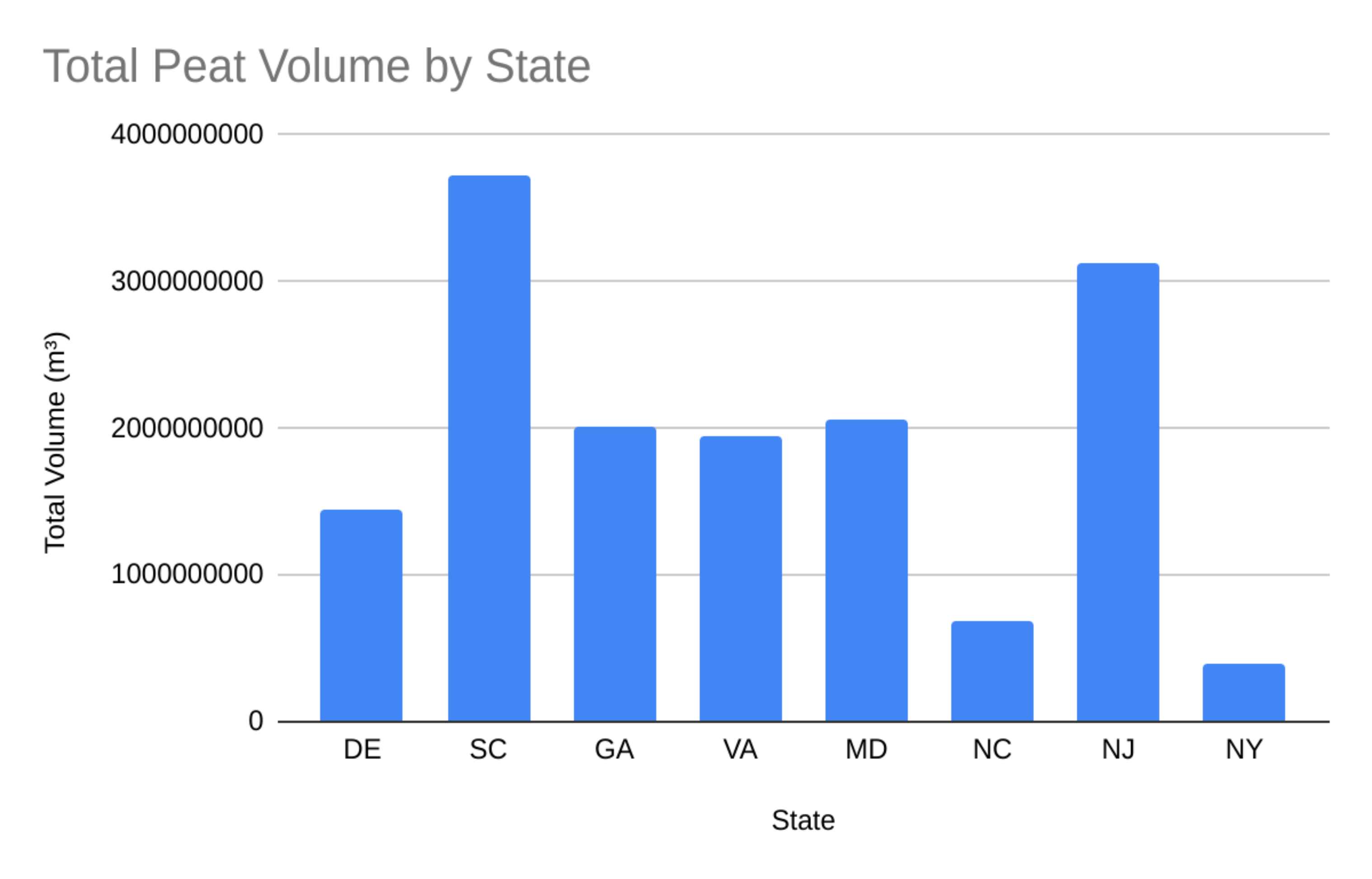
GREATEST MARSH AREA : South Carolina and Georgia



Average Depth ranges from 5.7 to 1.7 m

Greatest depths in NY, NJ, DE

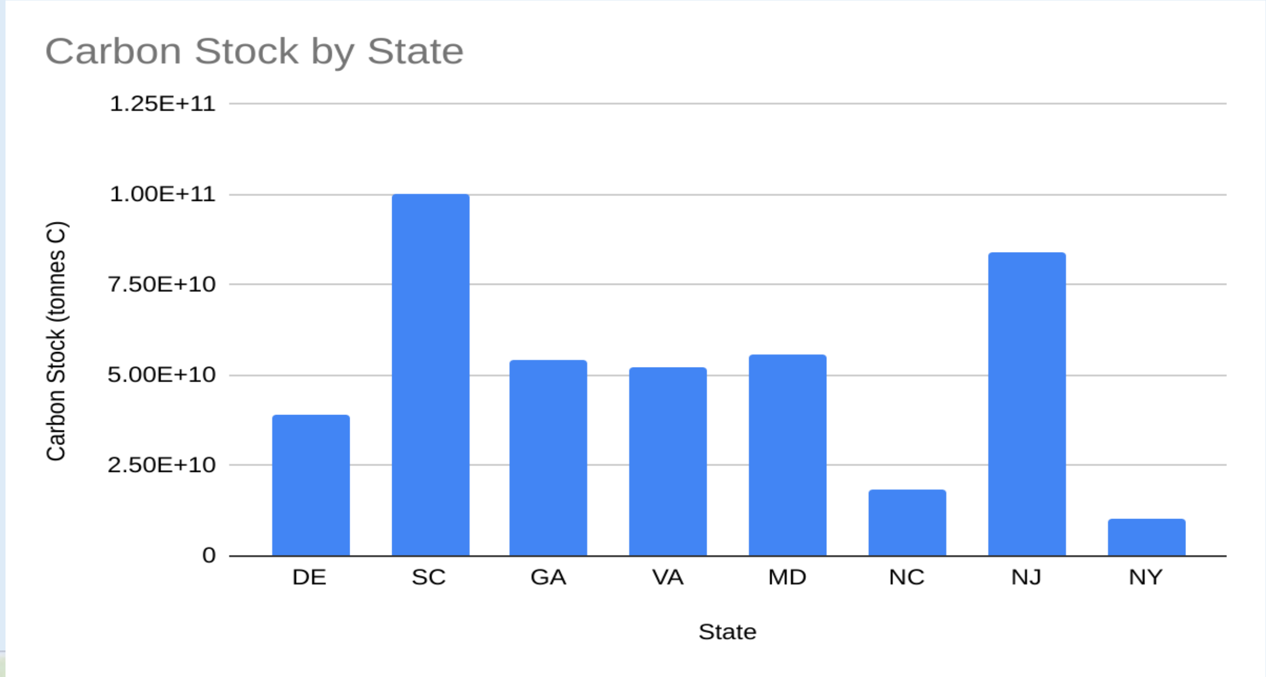
Is this really true?....RIVERINE vs COASTAL



Uncertainty:
Area – large, NWI, state data?
Depth – large, lack of data
Carbon density – better constrained

Almost 70% of the 512 data points in our database are for marshes in NY, DE, and NJ (n = 355), which also happen to be the three states with the greatest average marsh depth.

Further data collection needed



400 Million tons of carbon (large uncertainty)
BUT with sea level rise….

*Najjar et al. 2000…A case study for Delaware based on digital elevation models suggests that, by the end of the 21st century, 1.6% of its land area and 21% of its wetlands will be lost to an encroaching sea.

*Sapkota and White (2021)… with erosion….
75% of peat mineralized…ends up as CO^2 in atmosphere

Future Climate?

Expectations:

Warmer temperatures – drought, erosion

Greater storm frequency and intensity –

-more upland erosion & re-deposition?

Sea level rise

-marsh drought drowning, loss of peat strength

More dredging – remobilization of pollutants

Conclusions

Riverine marshes are deeper than coastal marshes

Organic matter increase - in last century with N pollution

Inorganic decline - in urban environments (hardening of shorelines)

NY – GA ….Marshes store greater than 400 million tons of carbon …

**Heavy metals (Pb, Cu, As, Zn) show huge increases in marsh sediment in industrial era.

***Blue carbon preservation important to keep heavy metals buried!!...
As well as all other important marsh functions