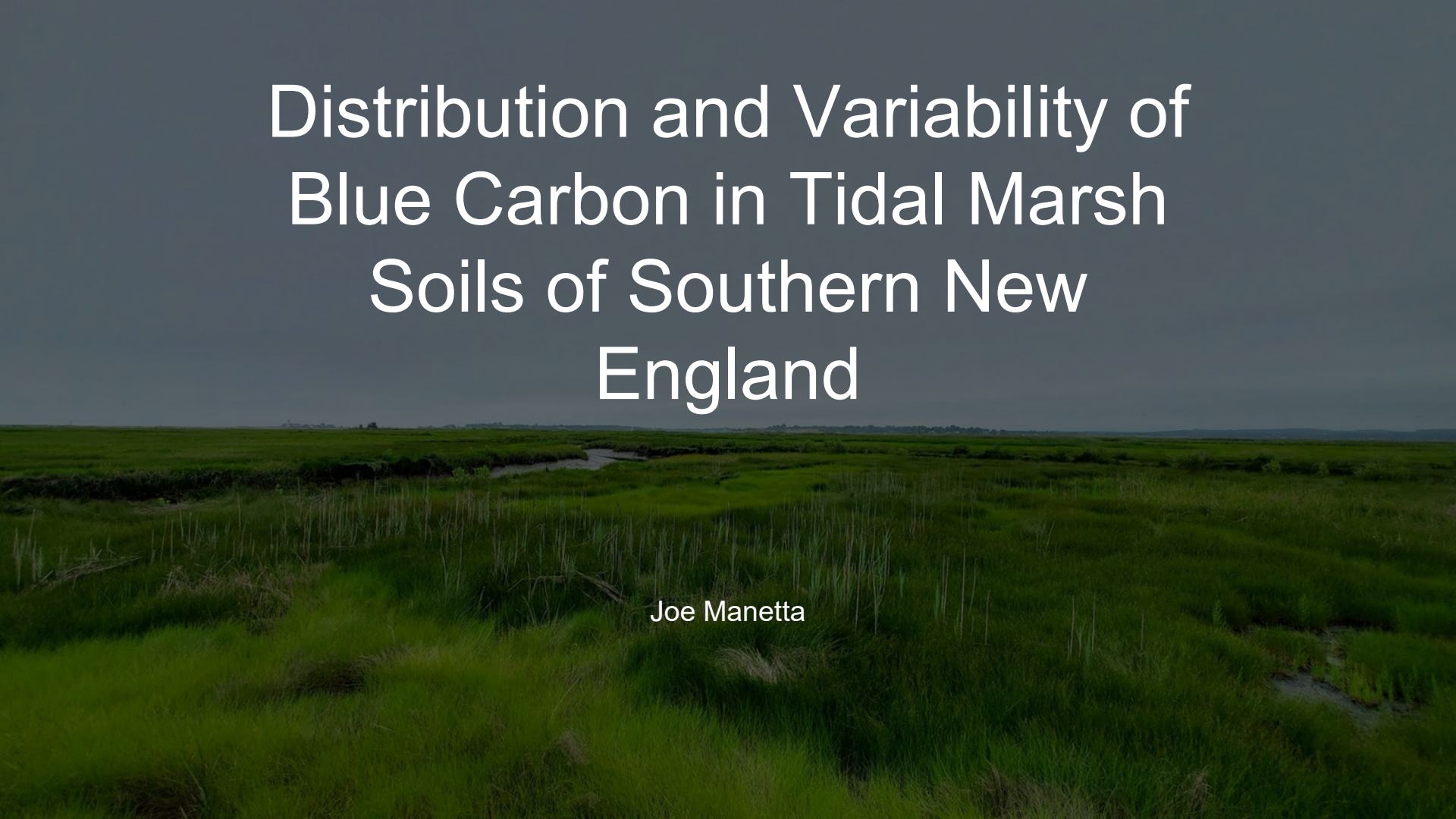
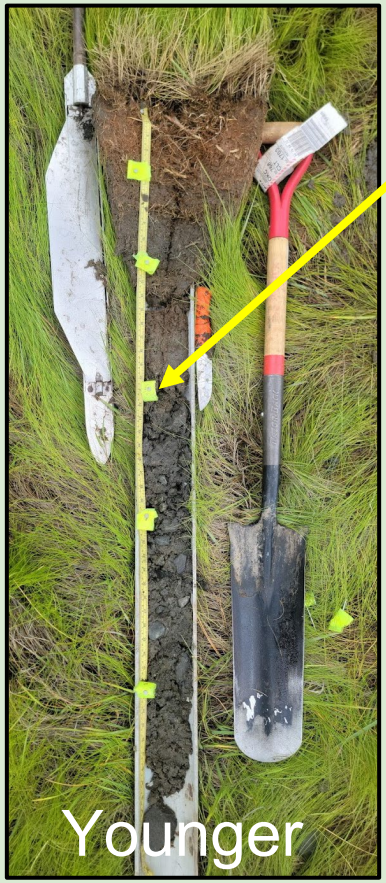
Distribution and Variability of Blue Carbon in Tidal Marsh Soils of Southern New England



Joe Manetta

Speaker Background

A look at marsh soil development

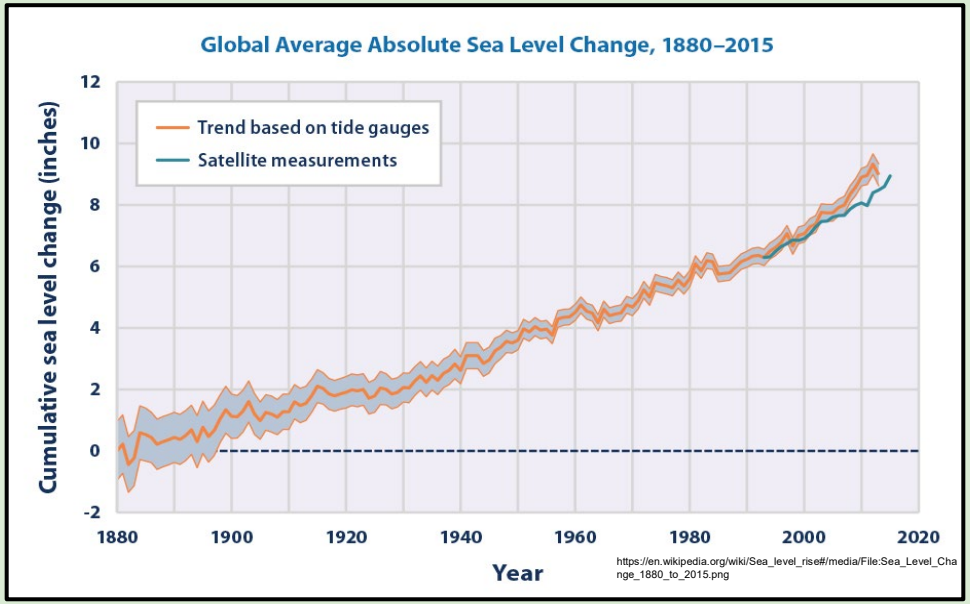


54 cm organics

Time

86 cm organics

Why blue carbon accounting matters



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Global carbon markets value hit record $909 bln last year

REUTERS®

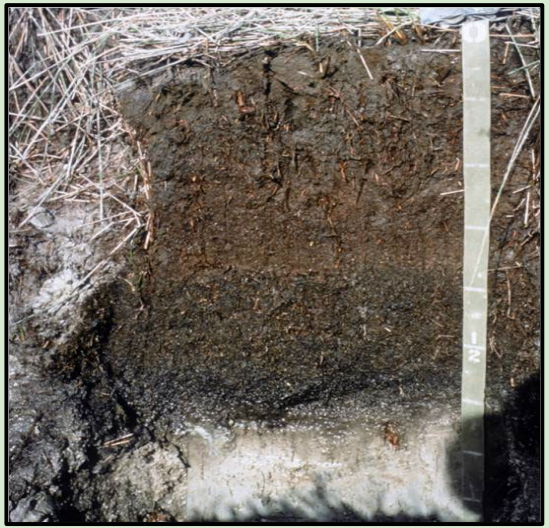
By Swati Verma and Nina Chestney

Previous studies

- Many marshes mapped using only a peat probe
- Previous studies suggest using a singular values for all marshes across the US.
  - Assumes C density does not vary with depth
  - This does not account for regional or landscape variability
  - Effectively 27 kg C m^{-2}
- Our study presents an alternative

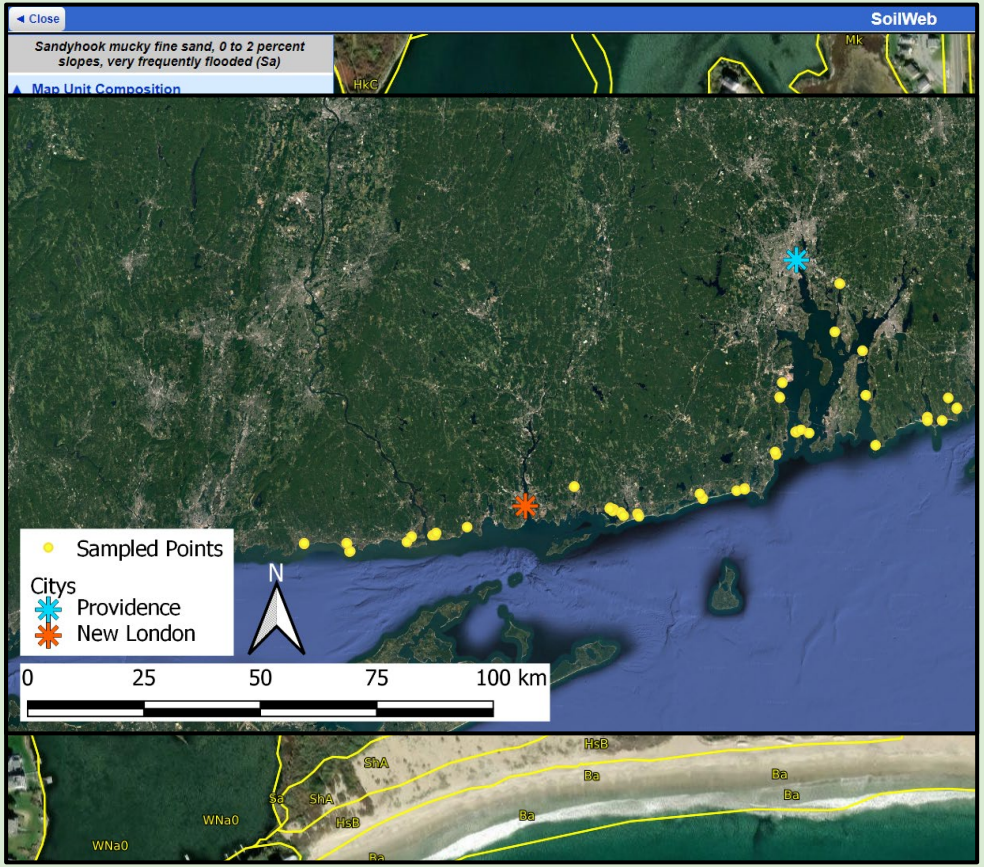
Objectives

- Relate landscape-level variables in tidal marshes to model carbon stocks
  - Useful in regional carbon accounting
- Relate pedon-level morphological characteristics in tidal marsh soils to model carbon stocks
  - Useful in putting valuing specific marshes



Site selection

- 146 pedons from 37 marshes described
  - 570 samples
- Soil survey used to identify potential study sites
- 4 distinct pedogeomorphic units (PGUs) identified
  - Back barriers, coves, tidal creeks, and tidal rivers



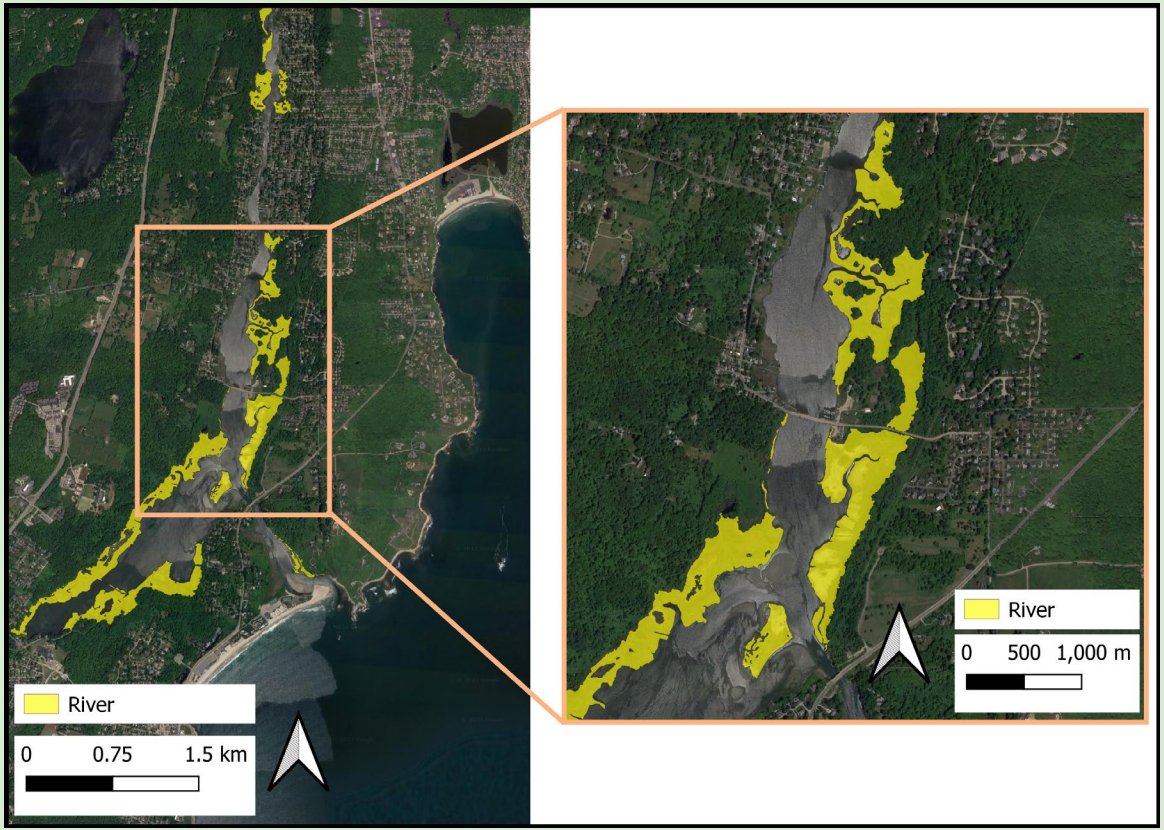
Back Barriers

Back barrier marsh, Westerly, RI

Coves

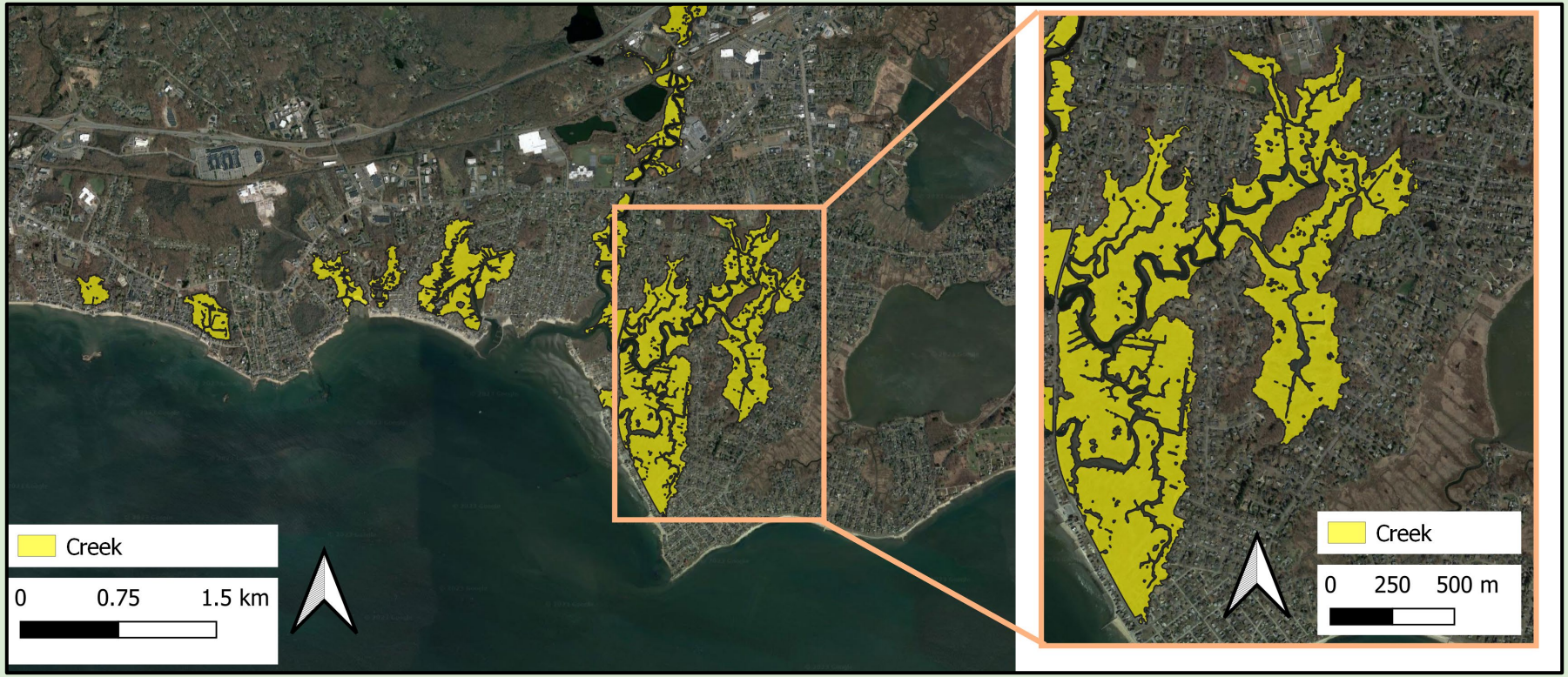
Cove marshes, Jamestown, RI

Tidal Rivers



Tidal river marshes, Kingston and Narragansett, RI

Tidal Creeks



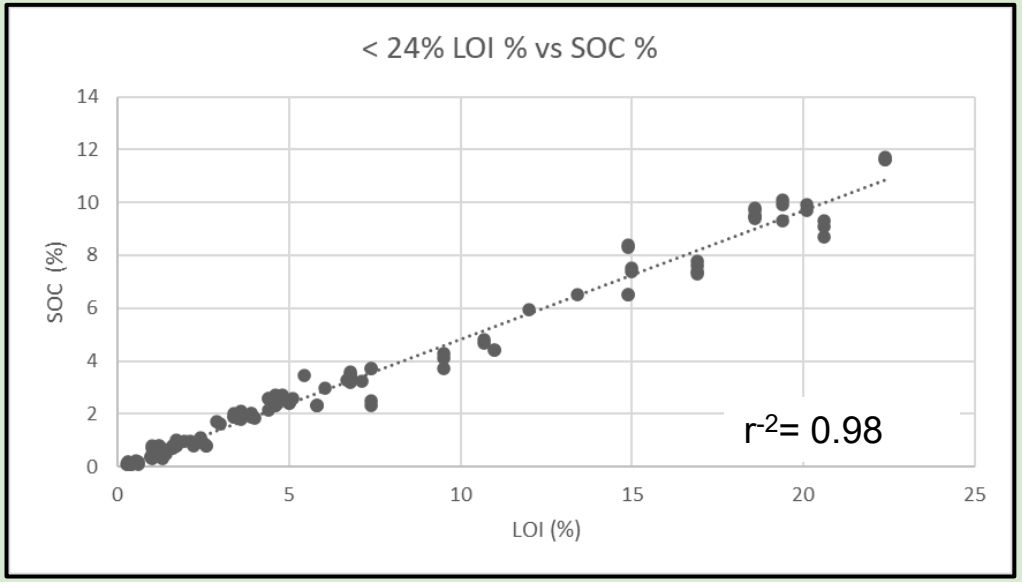
Tidal creek marshes, Old Saybrook, CT

Field sampling

- Transects run perpendicular to upland and open water
- 3-6 pedons described per site
  - According to standard methods
- Representative pedons sampled

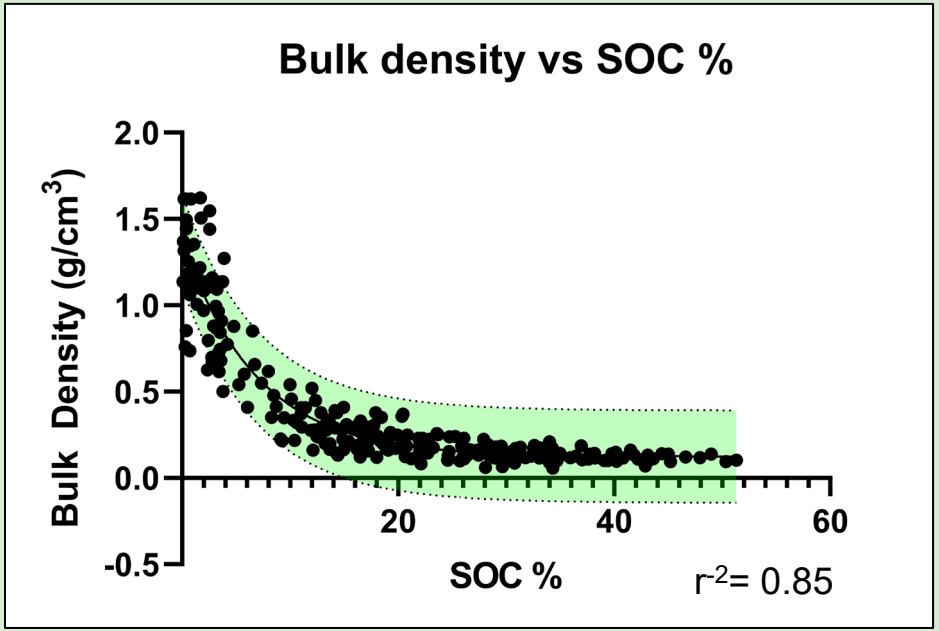
Laboratory Analysis

- Samples analyzed for the following:
  - Electrical conductivity
  - pH
  - Bulk density
  - Particle size distribution
  - Loss on ignition
  - Soil organic carbon (150 total)



Carbon accounting

- Carbon stocks are calculated to 1 and 2 meters
- Undisturbed sample needed for bulk density
  - Often impossible to collect deep undisturbed sand samples



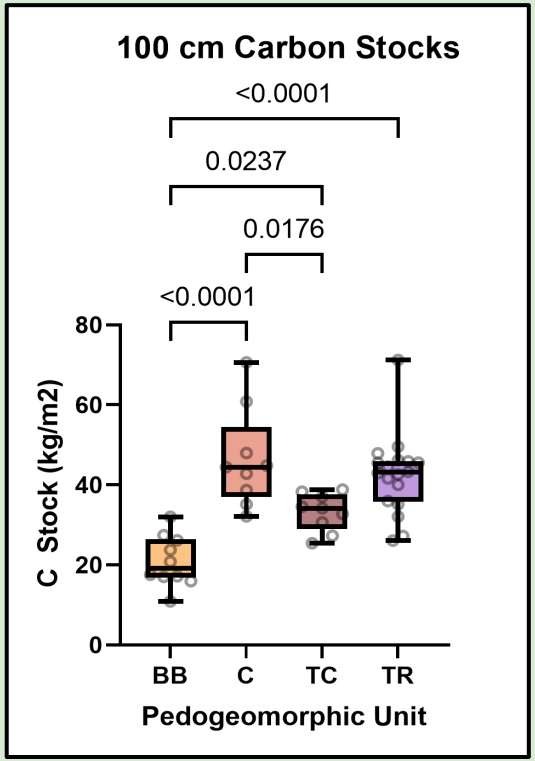
Carbon density

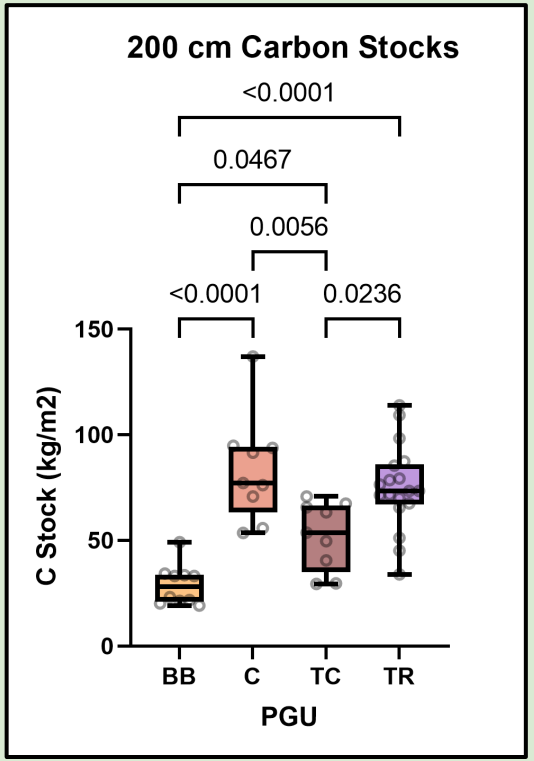
$$Horizon\ C\ Stock = Bulk\ Density \times Soil\ Organic\ Carbon \times Horizon\ Depth$$

$$Pedon\ C\ Stock = \sum All\ horizon\ C\ stocks\ to\ 1\ or\ 2\ meters$$

C stocks across PGUs

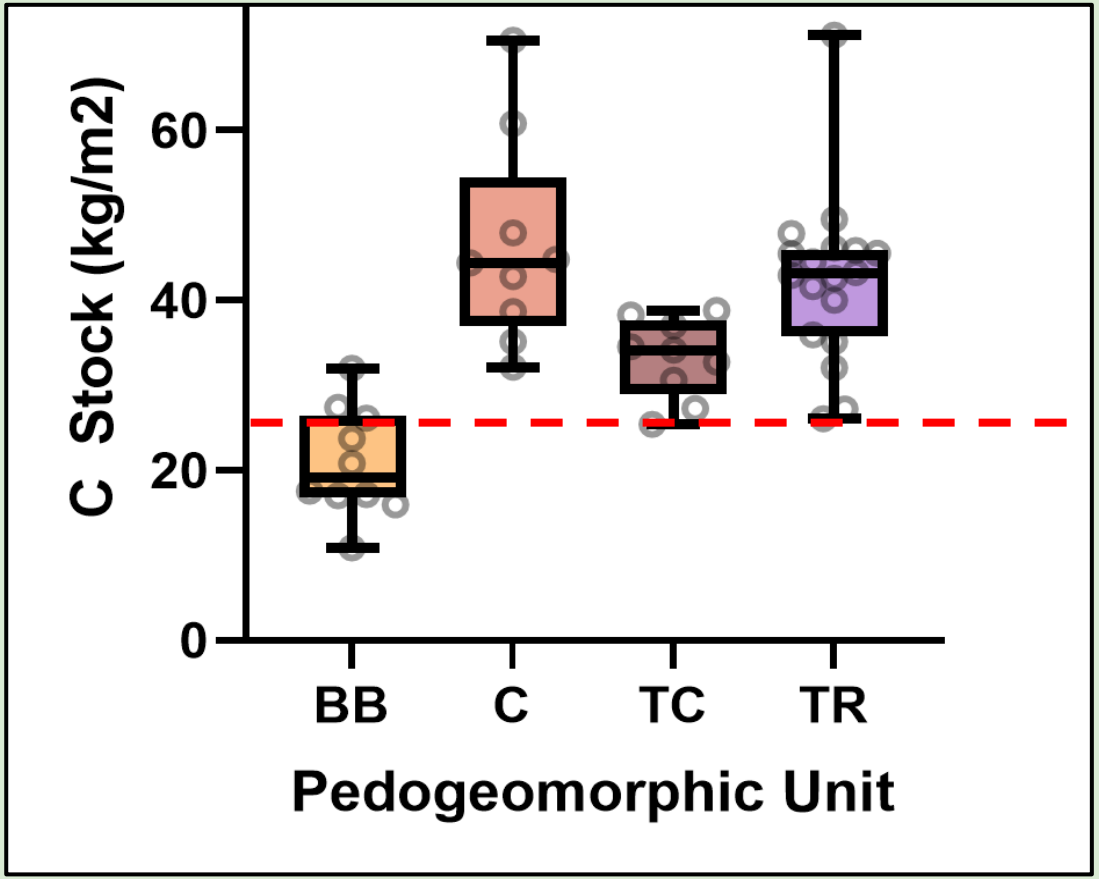
- Coves hold the most carbon
  - Deep organic materials
  - Well protected
  - 46 kg C m^{-2} @ 100 cm
  - 83 kg C m^{-2} @ 200 cm
- Barriers hold the least carbon
  - Shallow depth to C-poor sands
  - Subject to overwash events
  - 21 kg C m^{-2} @ 100 cm
  - 31 kg C m^{-2} @ 200 cm





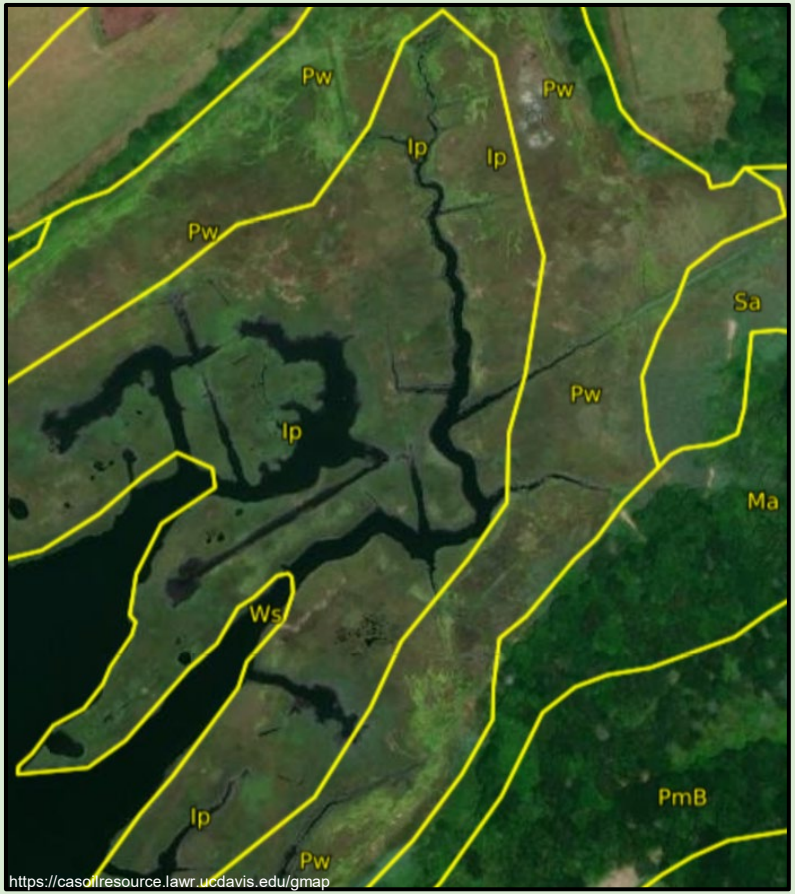
PGUs versus universal carbon density

- Most marshes hold more carbon in upper meter compared to universal value of 27 kg C m^{-2}



Estimating carbon stocks at the pedon level

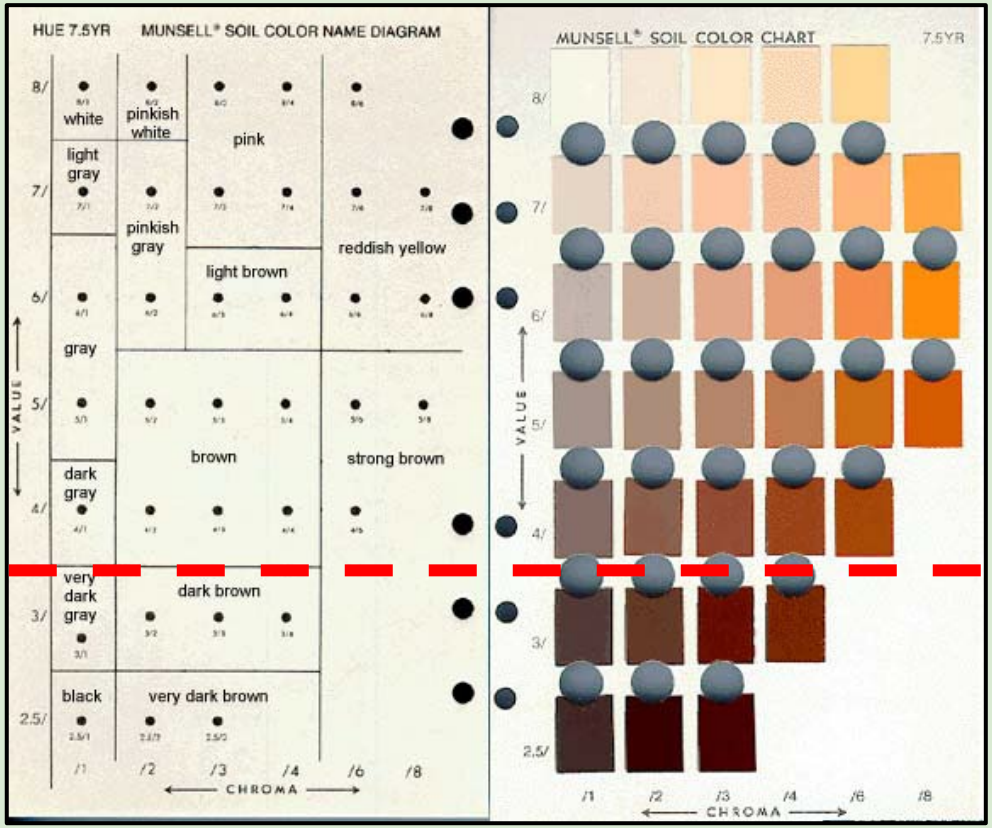
- PGUs offer simple carbon modeling, but some marshes have multiple soils mapped
  - Ip: Ipswitch
  - Pw: Pawcatuck
  - Sa: Sandyhook
- Different soils hold different amounts of carbon
- How do we capture carbon stocks at the pedon level?



Soil material group (SMG) creation

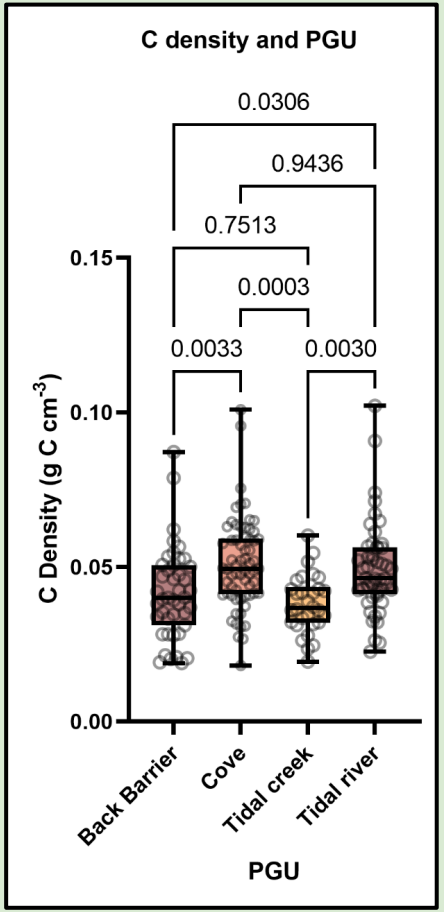
- Soils broken into organic and mineral
- PCA and correlation matrix to identify effective SMGs
  - Munsell color
  - PGU
  - Fluidity
  - Texture
  - Pore water salinity
  - Electrical conductivity
- ANOVA used to compare groups and cross-validation used to validate models

Munsell color



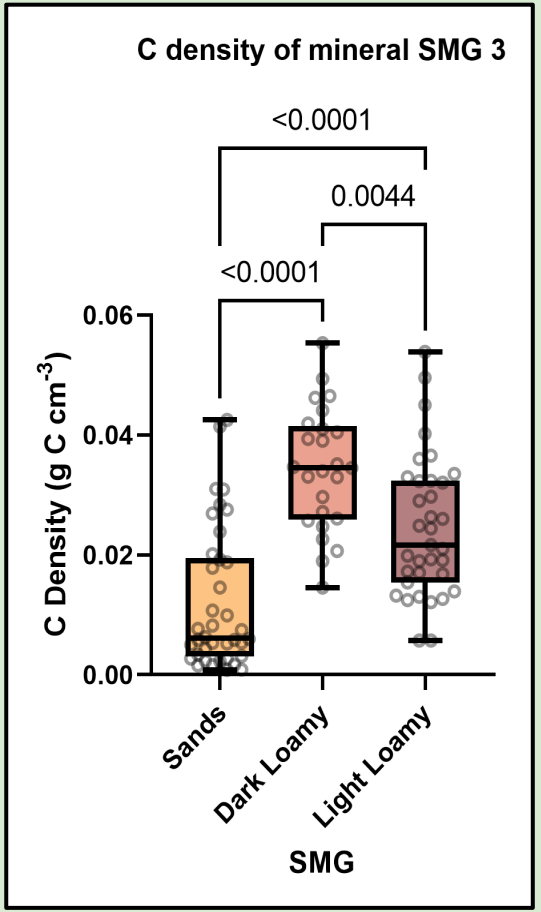
Organic SMGs

- Degree of humification and chroma do not correlate with carbon density
- Two distinct groups of PGUs
  - A: Back barriers and tidal creeks
    - 0.040 g C cm^{-3}
  - B: Tidal rivers and coves
    - 0.050 g C cm^{-3}



Mineral SMGs

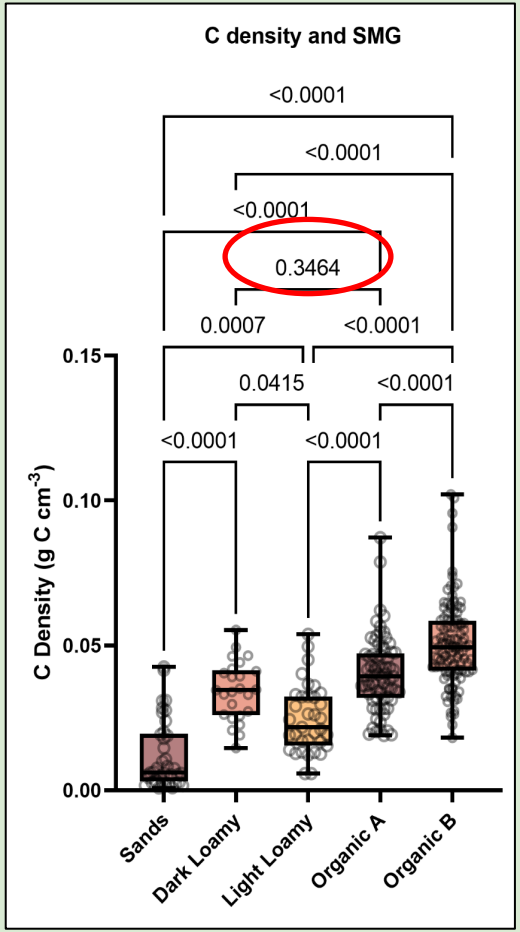
- Final mineral grouping is simple, but effective
  - Easy to apply
- Sands have low C density (0.011 g C cm^{-3})
- Finer particles are better able to trap carbon
  - Dark loamy C density = 0.035 g C cm^{-3}
  - Light loamy C density = 0.021 g C cm^{-3}



Final SMG Grouping

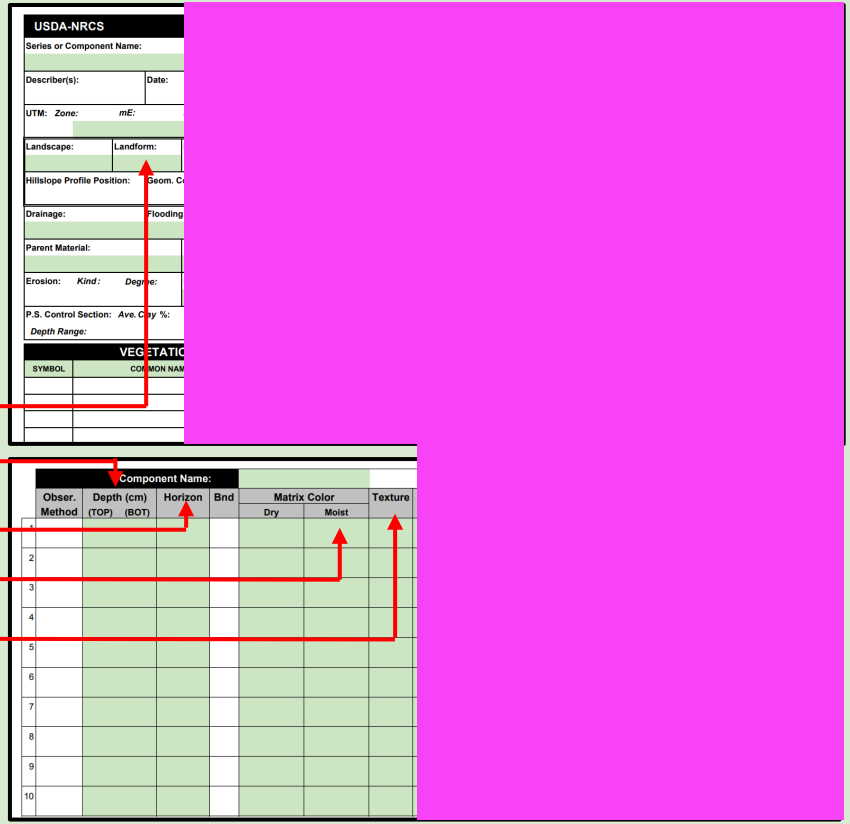
- Dark loamy (0.035 g C cm^{-3}) and organic A not significantly different
  - Loamy materials have higher BD than organic materials
- 5 total SMGs
  - Simple and accurate
    - Mean error < 2 kg C m^{-2}

Organic A	Organic B	Dark loamy	Light Loamy	Sands
0.040 g C cm^{-3}	0.050 g C cm^{-3}	0.035 g C cm^{-3}	0.021 g C cm^{-3}	0.011 g C cm^{-3}
Barriers, creeks	Coves, rivers	Value ≤ 3, loamy	Value > 3, loamy	Any value, sandy



How to apply SMGs to described pedons

- Start with a description
- Find relevant information
  - Pedogeomorphic unit (landform)
  - Horizon thickness
  - Horizon designation
  - Moist matrix color
  - Texture
- Ignore the rest!



Applying SMGs to an example pedons

Organic - A or B – 13 cm

Dark loamy – 35 cm

Sand – 52 cm

Calculating C stocks of marshes with SMGs

Carbon density

$$Horizon\ C\ Stock\ = bulk\ density\ \times soil\ organic\ carbon \times horizon\ depth$$

$$Horizon\ C\ Stock\ = SMG\ \text{C density} \times Horizon\ Depth$$

$$Pedon\ C\ Stock\ = \sum All\ horizon\ C\ stocks\ to\ 1\ or\ 2\ meters$$

$$Marsh\ C\ Stock\ = Pedon\ C\ \text{Stock} \times \text{Extent}$$

Conclusions

- PGUs and soil morphological characteristics can be used to model carbon stocks
  - Both provide more accurate carbon accounting than a universal carbon density value

- Use of SMGs can be used to accurately model carbon stocks of specific marshes in an accurate and timely manner
  - Can be used with little training or knowledge of soils

Acknowledgements

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Questions?