Mapping and modeling blue carbon storage in Delaware coastal wetlands

Daniel L Warner, Ph.D.   Co-PIs: John Callahan, Ph.D., Tom McKenna, Ph.D.

Blue Carbon

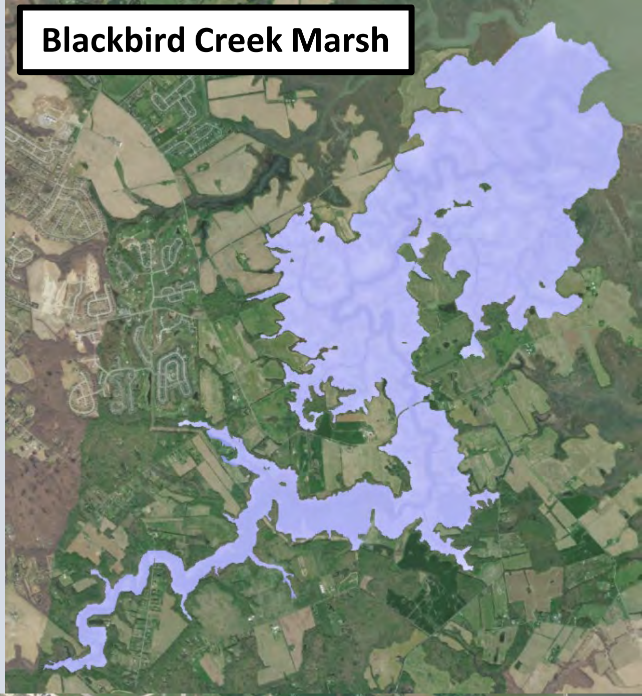
- Coastal wetlands accumulate and store carbon at much higher levels than other ecosystems
- High plant productivity + slow decomposition
- Storage is difficult to estimate
  - Variable sediment thickness
  - Storage varies in space both horizontally and vertically

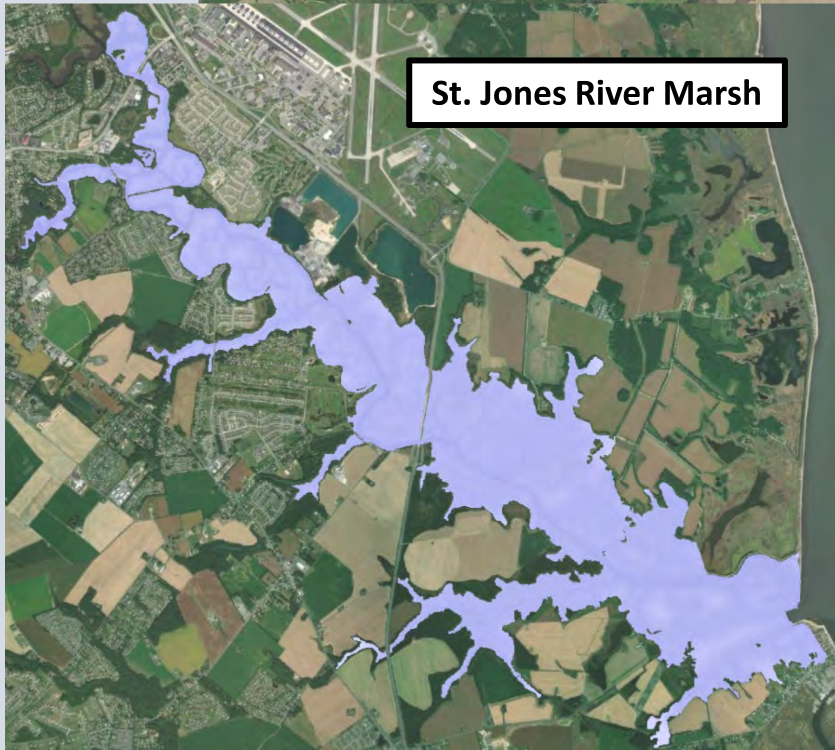
Spatial variability within marshes

- Hydrology: variable flow paths and flooding patterns
- Vegetation: different species and growth forms
- Chemical/Sediment inputs: uplands, marine, and within-system transfers

Key questions

- Can we map organic matter storage on the marsh platform using field observations and remote sensing products?
- How much organic carbon is stored in our study areas (Blackbird Creek and St. Jones River marshes)?
- What can we infer on the vulnerability of carbon storage in these marshes based on its spatial patterns?





Carbon data

- Sediment cores collected with hand augers
  - DNERR set – mostly near major channels
  - DGS set – mostly interior and marsh fringe
- Cores segmented: 0-30 cm, 40-60 cm, 70-90 cm
- Organic matter content measured via loss-on-ignition (LOI)
- Carbon content via CNS elemental analysis
- Bulk density based on core volume and dry weight

Spatial data

Many variables considered

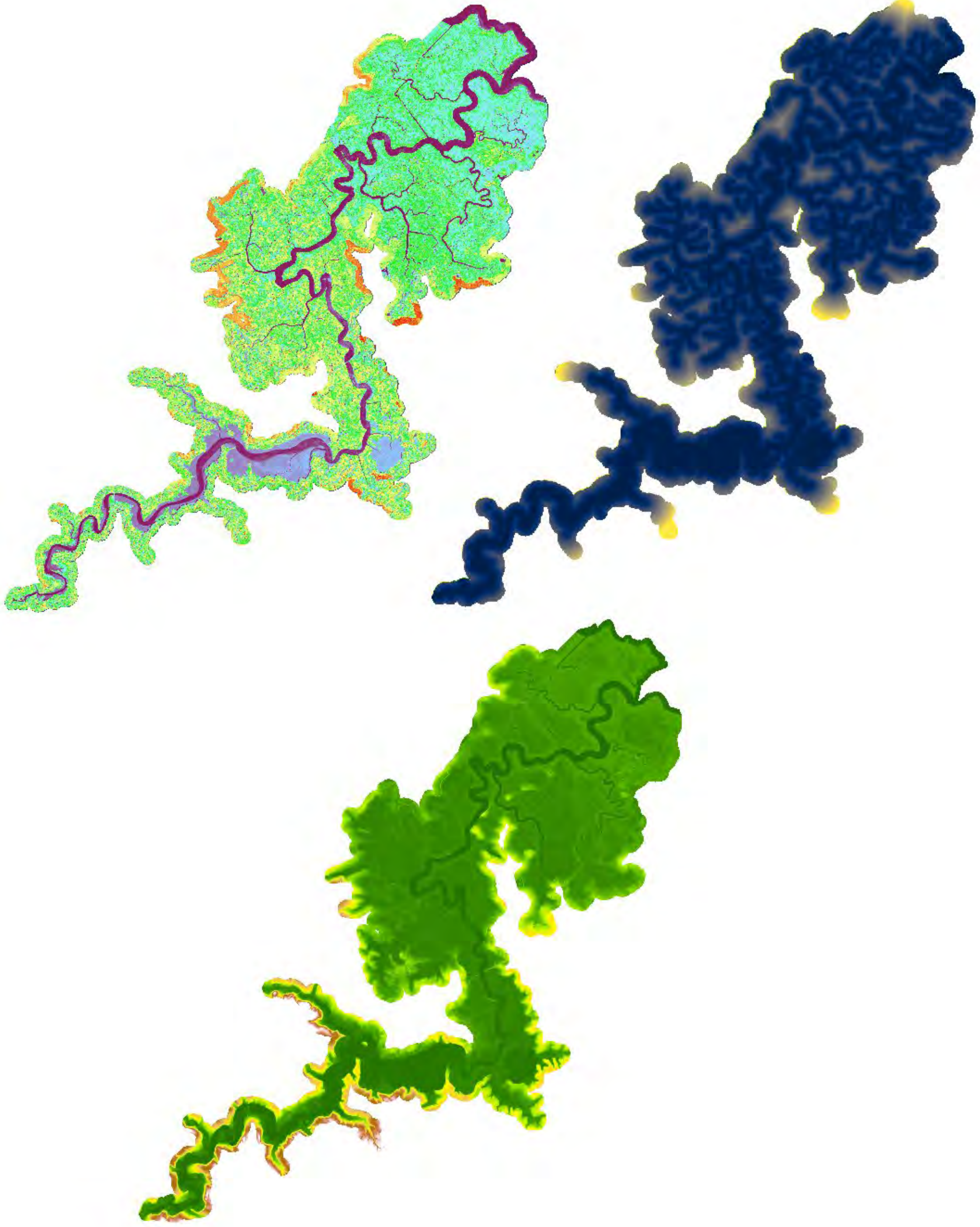
- Terrain: Elevation, slope, ruggedness, detrended DEM, Euclidean distance to channel
- Vegetation: NAIP data – NDVI, GCI, and SIPI

Final Predictors:

Elevation

Euclidean distance to channel

NDVI



Modeling

- All soil cores had GPS coordinates associated
  - Spatial data extracted at each core location

- Models examined for fitting spatial variables to observations of organic matter density (OMd kg m^{-2}) in upper 30 cm of marsh
  - General linear model
  - Random Forests
  - K-Nearest Neighbors
  - Neural Network

- Final predictors were chosen based on contribution to preliminary model performance and limited autocorrelation

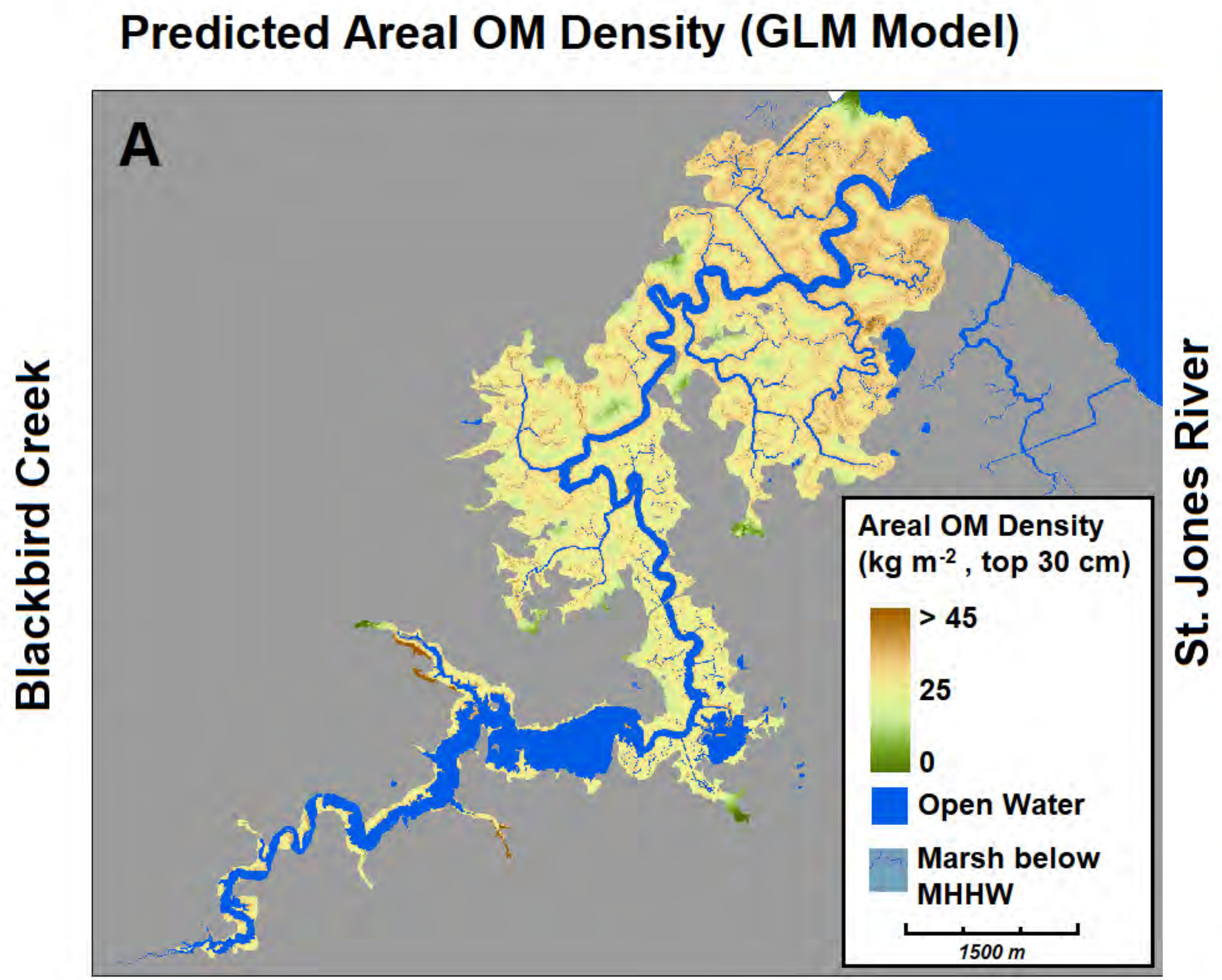
Final Model

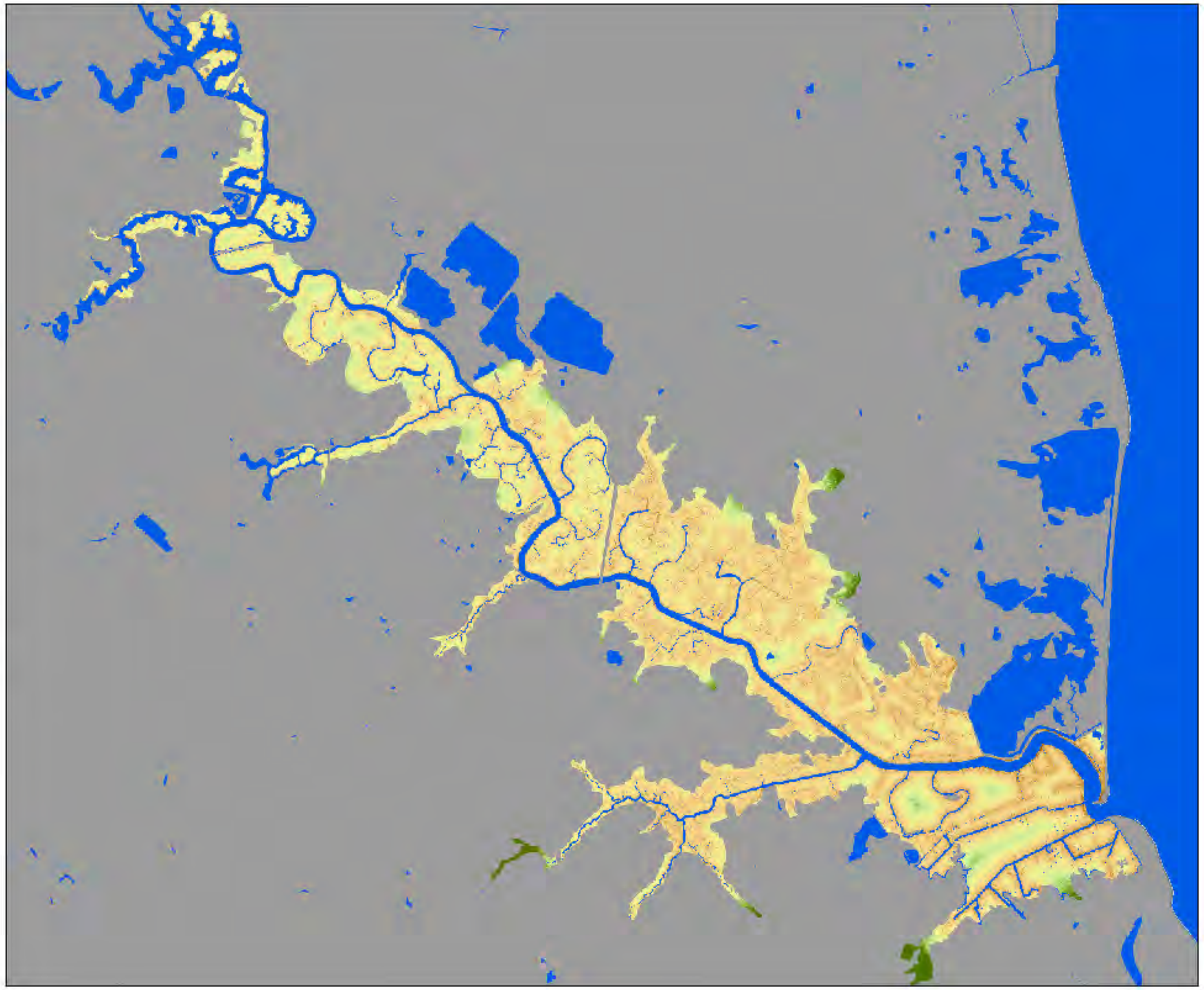
- Final model selected was multiple linear regression
  - MAE: 6.1 kg m^{-2}
  - R^2: 0.28

- Random Forest performed slightly better but was heavily weighted towards the Euclidean distance predictor
  - Strange artifacts in extrapolated maps

- Carbon density estimated based on observed % carbon in organic matter
  - 41.5% of OM was carbon on average

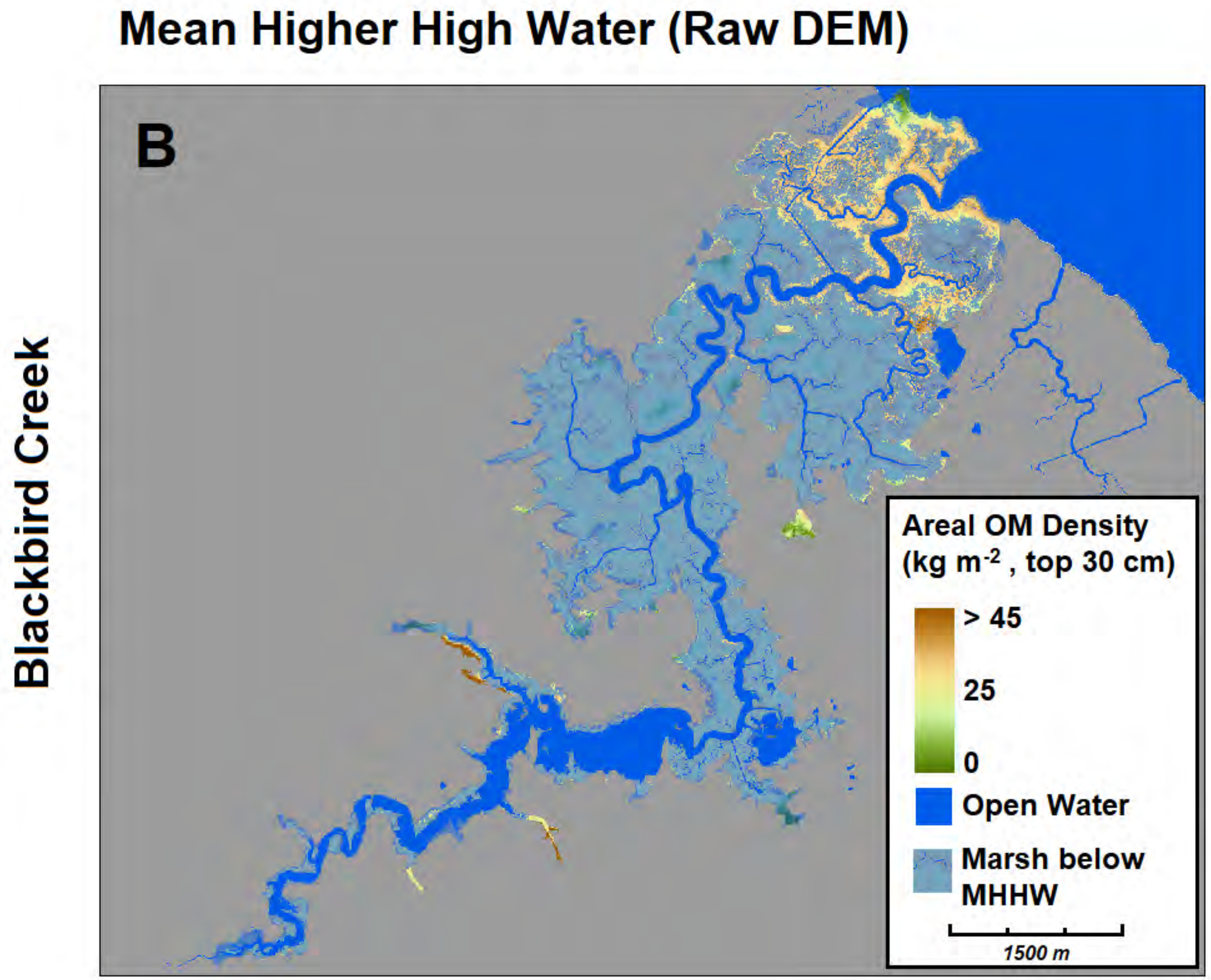
Extrapolating models

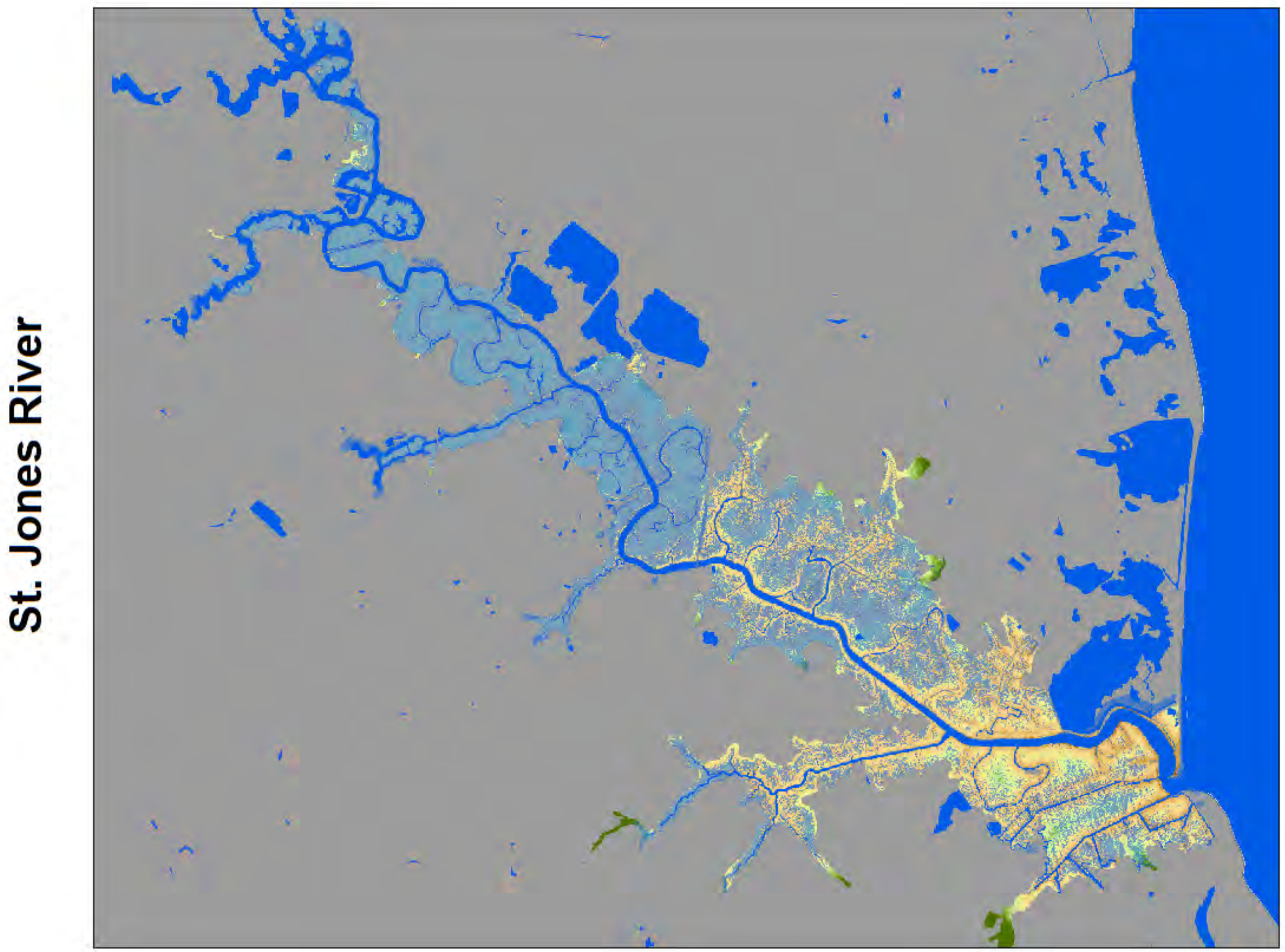




Where is the tide?

- A simple bathtub model estimates the extent of tide at MHHW
- Suggests much more inundation at Blackbird





Key findings

- We estimate that Blackbird and St. Jones marsh store 70 and 79 gigagrams (1000 metric tons) of organic carbon in the top 30 cm of sediment, respectively

- Storage is certainly much higher
  - Difficult to know variability with depth and in sediment thickness
  - We found no correlations between spatial data and deeper core segment C

- Carbon storage was highest in high marshes near shore and near channels
  - High marshes may be less frequently inundated
  - Vulnerability to erosion from boat wakes and tidal waves?

Future steps

- Leverage new potential predictor data from a different new project
  - Recent work looking at LIDAR DEM corrections in salt marshes identified some promising predictors for removing vegetation structure.
- Investigate more sophisticated inundation models
  - Bathtub models are based on a single tide gauge, does not reflect tide propagation across vegetated marsh surface and channel network
- Investigate 3-dimensional structure of marsh sediments
  - Can we estimate sediment thickness using upland terrain and historical sea levels?
  - Is carbon storage in deep layers consistent enough to make reliable estimates?

Acknowledgements

- Special thanks to the DE Estuarine Research Reserves, DNREC, and City of Dover, who gave us permission to sample on managed lands.
- Please direct questions to:

Daniel L Warner – Delaware Geological Survey

warnerdl@udel.edu