ASSESMENT OF BLUE CARBON STOCK IN DELAWARE BAY SALT MARSH

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ABSTRACT

Coastal salt marshes have been recognized as reservoirs for blue carbon sequestration and storage. Despite their environmental services, coastal carbon ecosystems are experiencing dramatic losses. It was estimated that 35% of tidal salt marshes have been lost worldwide (Murray et al. 2011). If this trend continues at a current rate, another 30-40% of tidal marshes could be lost in the next 100 years (Pendleton et al. 2012). Estimates of global blue carbon stock have a high degree of uncertainty; variations in carbon stock and rates of salt marsh losses are poorly documented.

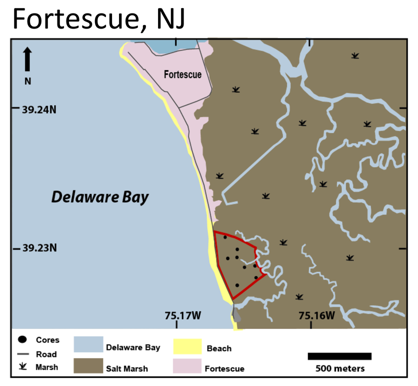
We estimated current total carbon stock of the Fortescue (New Jersey) salt marsh. We compiled historical shoreline change along a 20 km stretch of the Delaware Bay coast for the past 85 years. We documented that the rate of shoreline erosion varies between 0.04 and ~ 8.0 m/year depending on geomorphologic setting.

The stratigraphy of the Fortescue salt marsh documents several episodes of salt marsh erosion related to major storms. We estimated a volume of carbon repository sediments that were lost due to storms during the last century.

We present an estimate of carbon loss due to rising sea level and storm erosion. Our results contribute to the assessment of salt marsh carbon storage and provide a better understanding of the possible extent of carbon release when carbon reservoirs are impacted by erosional events.

STUDY AREA

Fortescue, NJ



The 15 hectare study area is a salt marsh platform that is part of the Fortescue Glades Wildlife Refuge, located near Fortescue, NJ, along the norther shore of the Delaware Bay. The salt marshes in this region have been developing for the last 2,000 years (Nikitina et al. 2014). The coast line experienced relative sea level (RSL) rise at a rate of ~1.3 mm/yr. throughout the late Holocene (Kemp et al. 2013). The RSL rise created an accommodation space for the deposition of tidal sediments that include four depositional environments based on plant tolerance to salt inundation: tidal flats characterized by gray muds, low marsh vegetated by *Spartina alterniflora*, high marsh vegetated by *Spartina patens*, *Distichlis spicata* and stunted *Spartina alterniflora*, mixed marsh vegetated by all of the above species, and the uplands vegetated by *Phragmites australis*.

The mean tidal range is 1.783 meters (NOAA). The surface of the marsh is dissected by tidal creeks and is underlain by 2-4 meters of salt marsh and tidal flat sediments. The salt marsh sediments of the Delaware Bay are highly organic with silt being the most dominant size (Nikitina et al. 2003). The salt marsh sediments within the study area have an average thickness of 2.3 m. The salt marsh platform is protected by a narrow fetch-limited barrier island.

METHODS

Sample Collection and Analysis

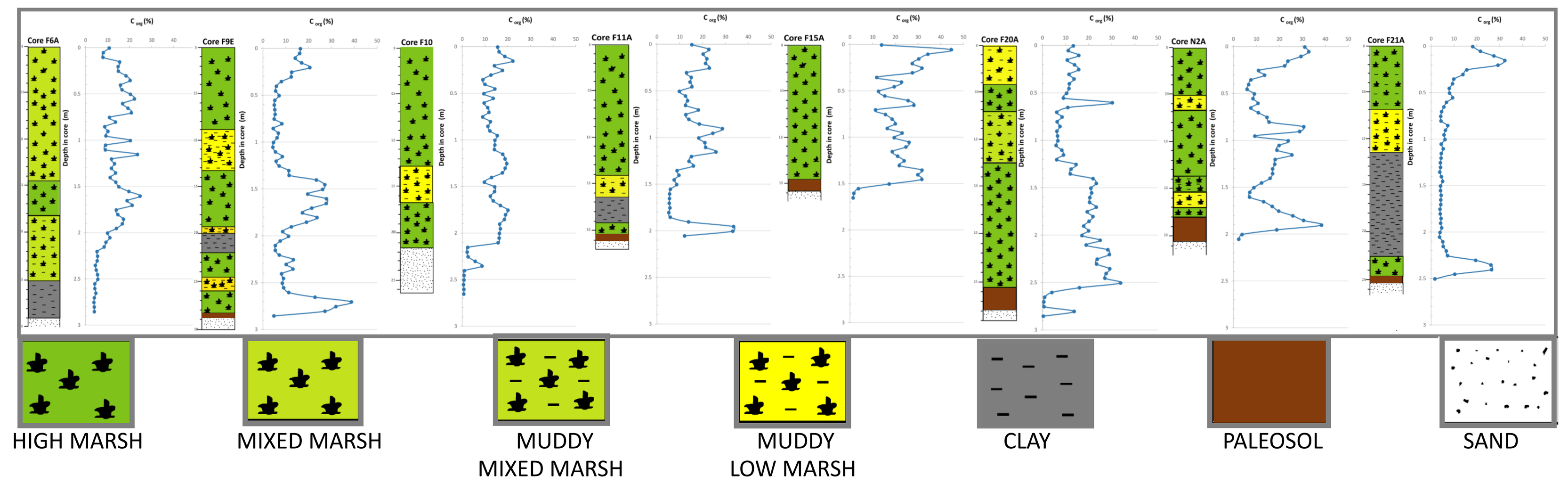
- Lithostratigraphy of the Fortescue salt marsh was completed from 42 hand-driven gouge cores.
- Sediments in the cores were described using Troels Smith Field Classification.
- Depositional environments of salt-marsh sediments were established based on plant micro-fossils in the core and compared to roots, rhizomes, and plants stems in the modern environment.
- Core locations were recorded using GPS.
- Surface elevation was measured using a Sokkia Total Station and referenced to North American Vertical Datum 1988 (NAVD88).
- Eight randomly selected cores were recovered in 50 cm segments with a 5 cm diameter Russian peat auger, placed into PVC pipes, wrapped, and transported to the lab.
- In the lab ~ 10 cm^3 of sediment were sampled in 5 cm intervals for Loss On Ignition (%) (LOI) and dry bulk density (g/cm^3) (DBD).

Organic Carbon (C_{org}) Content

- Samples were weighed, dried in the oven at 250°C for 24 hours, and reweighed for DBD values.
- Dry samples were placed in muffle furnace for 24 hours at 550°C.
- Organic content was measured by LOI.
- % C_{org} for each sample was calculated using: $\%C_{org} = 0.04\,[LOI] + 0.0025\,[LOI]^2$ (Craft et al. 1991).
- Salt-marsh sediment carbon density was estimated by: DBD (g/cm^3) * (%C_{org} /100).
- Total C_{org} (TOC) for each 5 cm interval was estimated by: salt-marsh sediment carbon density * 5.
- TOC for each core was estimated by summing %C_{org} for each 5 cm interval through the depth of the core.
- TOC for the study area was calculated as the average %C_{org} for all the cores to the average depth of 2.3 m.

RESULTS

Lithostratigraphy and % C_{org}



- The carbon pool includes highly organic heterogeneous salt-marsh sediments (%C_{org} 4-45), underground plant biomass %C_{org} as high as 45, macro-organic matter, and paleosol (%C_{org} 2-67).
- The average clay content derived from core analysis is low: <9%
- %C_{org} of clay is 4—11

TOC for each core (g/cm^2)

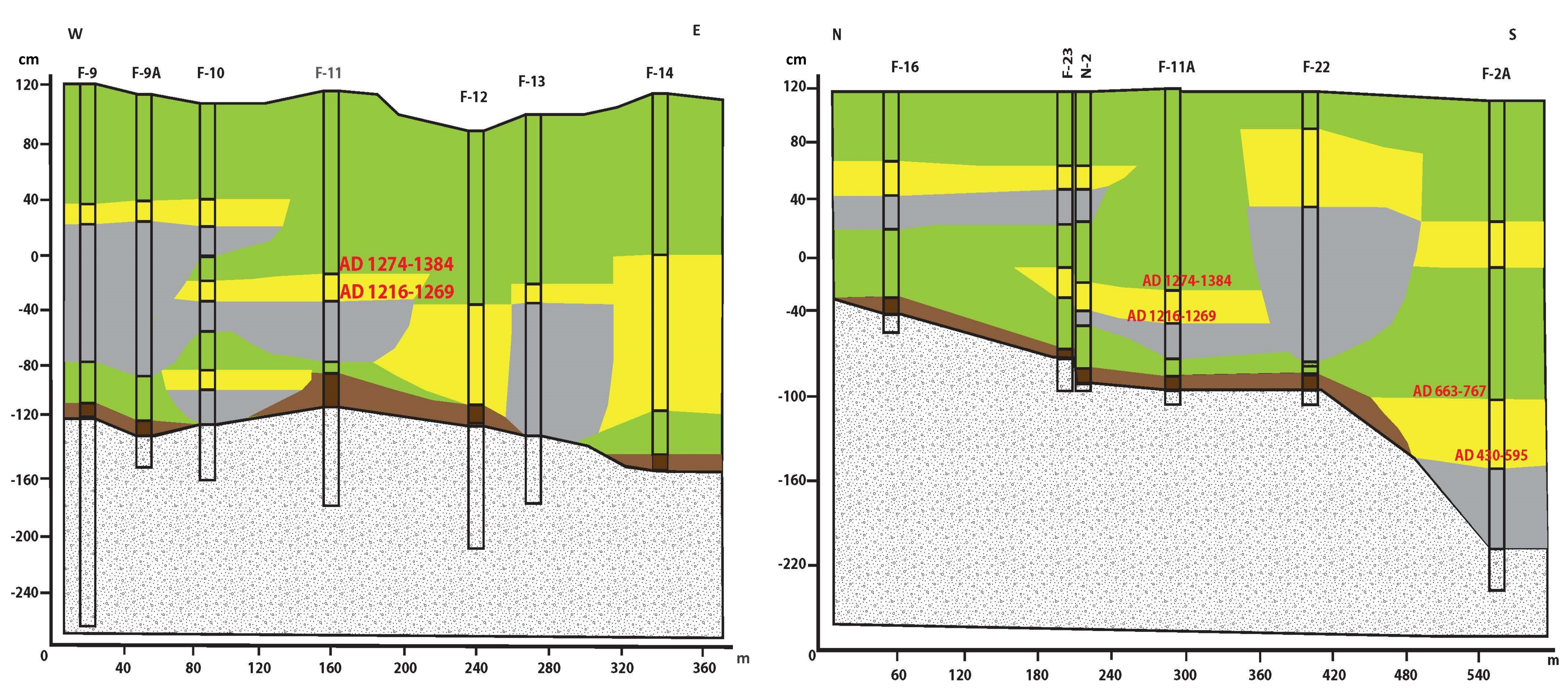
Core	Depth of core to sand (m)	TOC (g/cm^2)
F6A	2.90	9.90
F9E	2.90	5.58
F10	2.15	8.05
F11A	2.10	8.43
F15A	1.60	6.97
F20A	2.80	12.31
F21A	2.55	8.42
N2A	2.05	8.60

Depositional Environment	Average % C_{org}		
	Depth		
	0 - 1 m	1-2.3 m	0-2.3 m
HM	16.06	19.27	17.49
MM	12.93	11.32	12.16
LM	9.34	9.25	9.29
CL	0	4.99	4.99
PS	0	22.28	22.28

Organic Carbon Stock (TOC)

Depth Interval	Surface to -1m	-1m to -2m	-1m to -2.3m	Surface to -2.3m
Sampled Interval (m)	1.00	1.00	1.30	2.30
Average TOC per hectare	351.14	378.87	478.48	829.62
Standard Deviation	0.0220	0.0155	0.0172	0.0197
TOC for Study Area (MgC)	5,267.10	5,683.01	7,177.14	12,444.31
Standard Deviation	0.33	0.23	0.26	0.30

Stratigraphy



- 0-1 m: accumulation of salt-marsh sediments.
- 1-2.3 m: sedimentary environment changed from clay to low/high salt-marsh peats probably due to salt marsh erosion.
- 1-2.3 m sedimentary unit corresponds to AD 550-1800 time interval (Kemp et al. 2013).
- Eroded salt-marsh sediments were replaced with low % C_{org} clay.
- Paleosol unit ~ 20 cm thick, and characterized by highest % C_{org}, was documented above pre-Holocene surface.
- Highest % C_{org} and TOC are documented in the lower stratigraphic sections probably due to sediment compaction.
- The modern salt-marsh sediments continuously accumulated for ~200 years and experienced minor surface erosion.

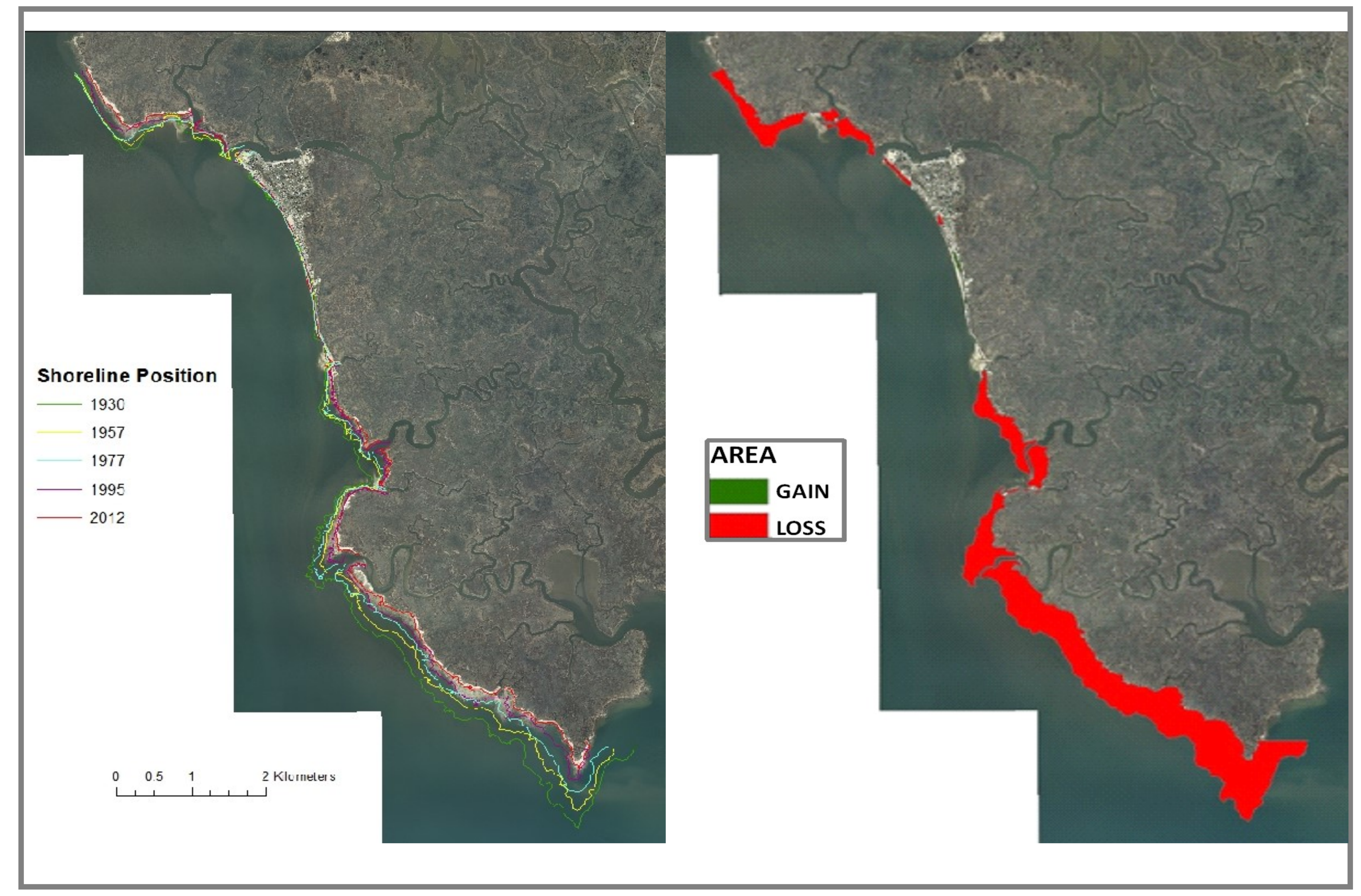
APPLICATIONS

Shoreline Regression

- Historical aerial photos from 1930, 1957, 1977, 1995, and 2012, - obtained from USGS EarthExplorer and the New Jersey Geographic Information Network (NJGIN) - were georeferenced, and inputted into ArcGIS 10.3.
- Digital Shoreline Analysis System (DSAS) Version 4.0 was used to calculate coastal area loss due to shoreline erosion following Boak and Turner (2005), and Himmelstoss (2009).
- The loss of salt marsh area from 1930—2012 was estimated by subtracting beach area from total coastal area loss.

Coastal Erosion from 1930 to 2012

- The rate of erosion is between 0.04 and ~8.0 m/year
- The area of salt marsh lost to shoreline erosion is 325.2 hectares.
- Assuming that the average thickness of the salt marsh sediments is 2.3 m and remained consistent through time, the TOC lost due to shoreline erosion could be as large as 269,792.42 Mg.



CONCLUSION

- The average thickness of organic rich sediments in the study area is 2.3 m.
- TOC is 12,444.31 MgC (to the depth of 2.3 m).
- TOC in salt marsh deposits which accumulated between 1800's to present day equals 5,267 Mg.
- During AD 550 to 1800's salt-marsh sediments in the study area were replaced by clay due to surface erosion.
- TOC in 1m to 2.3 m below the surface of the marsh platform equals 7,177 Mg.
- The higher amount TOC within the eroded stratigraphic sequence is most likely due to marsh aging, sediment compaction, and reduced O_2 levels at depth.
- The highest %C_{org} is documented in ~20 cm of paleosol immediately above the pre-Holocene surface.
- Total estimated area of salt marsh loss along 20 km shoreline due to erosion between 1930 to 2012 is 325.2 hectares.
- The TOC lost to shoreline erosion in the last century is ~ 269,792 Mg.

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