Blue Carbon Opportunities and Challenges in the Chesapeake Bay

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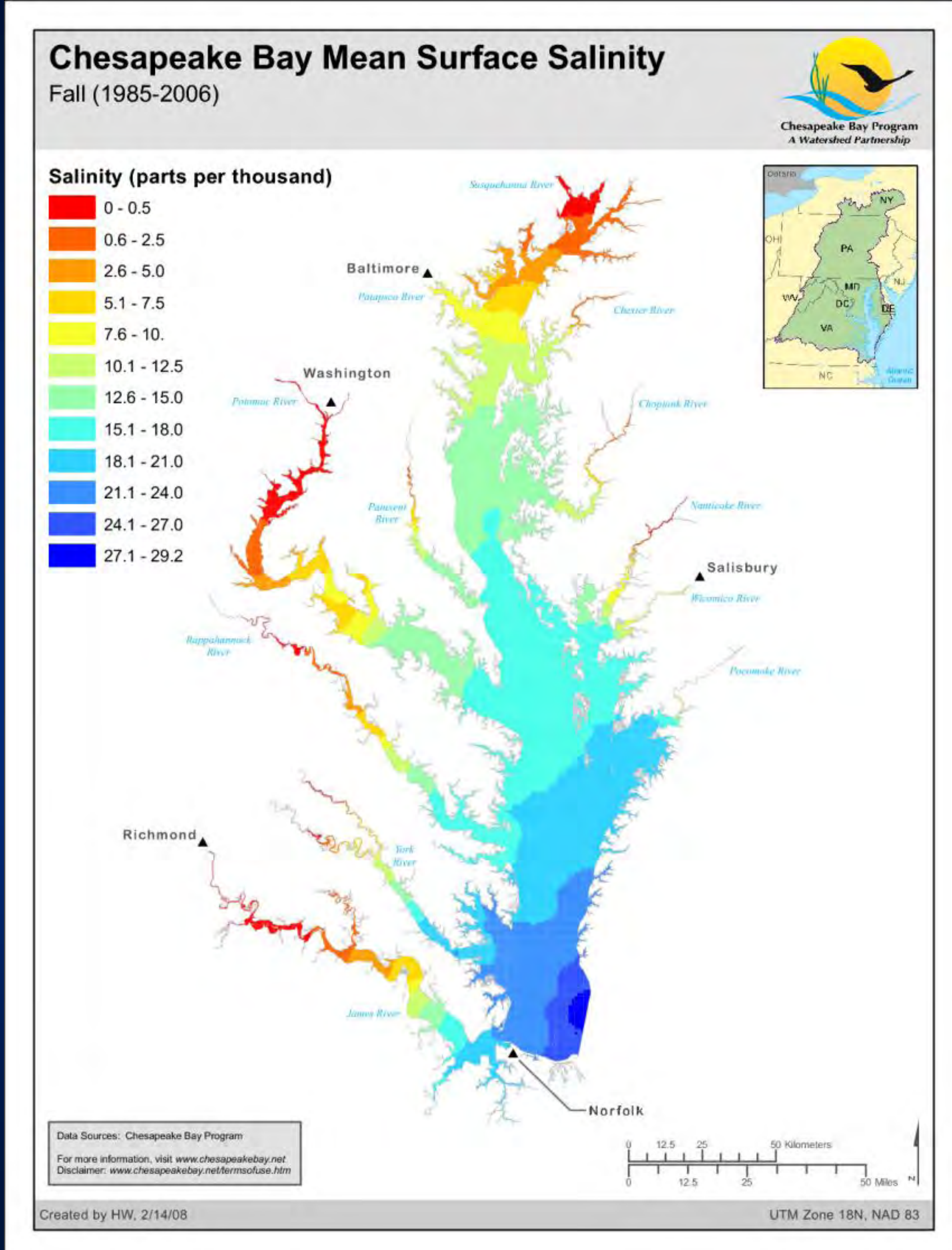
INTERNATIONAL BLUE CARBON SCIENTIFIC WORKING GROUP
4th WORKSHOP, 9-11 OCTOBER 2012, ANNAPOLIS, MARYLAND, USA

Chesapeake Bay coastal wetlands

Over 120,000 ha of estuarine wetlands in Maryland

http://www.chesapeakebay.net/maps/map/land_cover_chesapeake_bay_watershe



http://www.ncnr.nist.gov/programs/CHRNS/pdf/salinity_fall.png

U.S. Climate Change Science Program Synthesis and Assessment 4.1: Coastal Sensitivity to Sea Level Rise

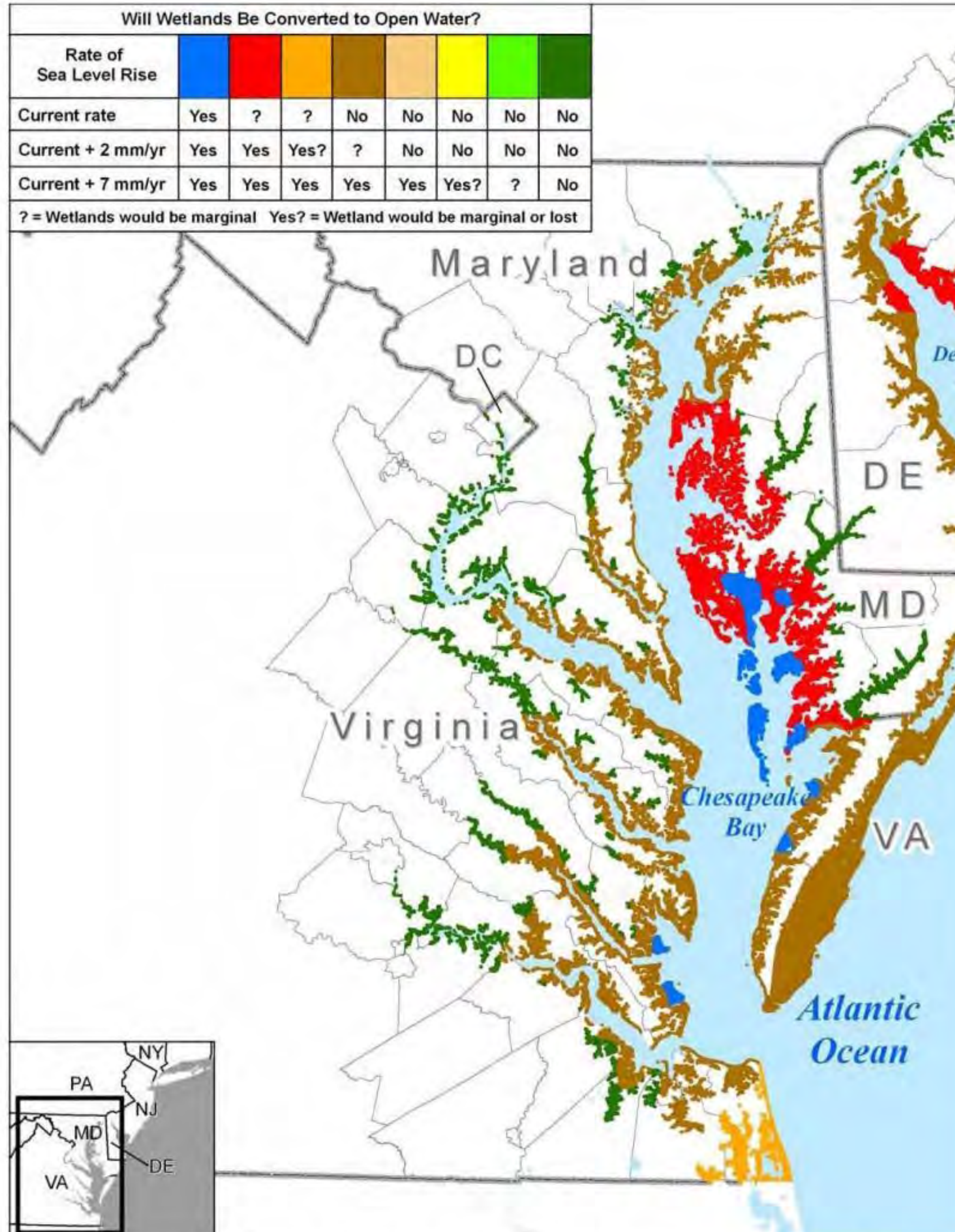
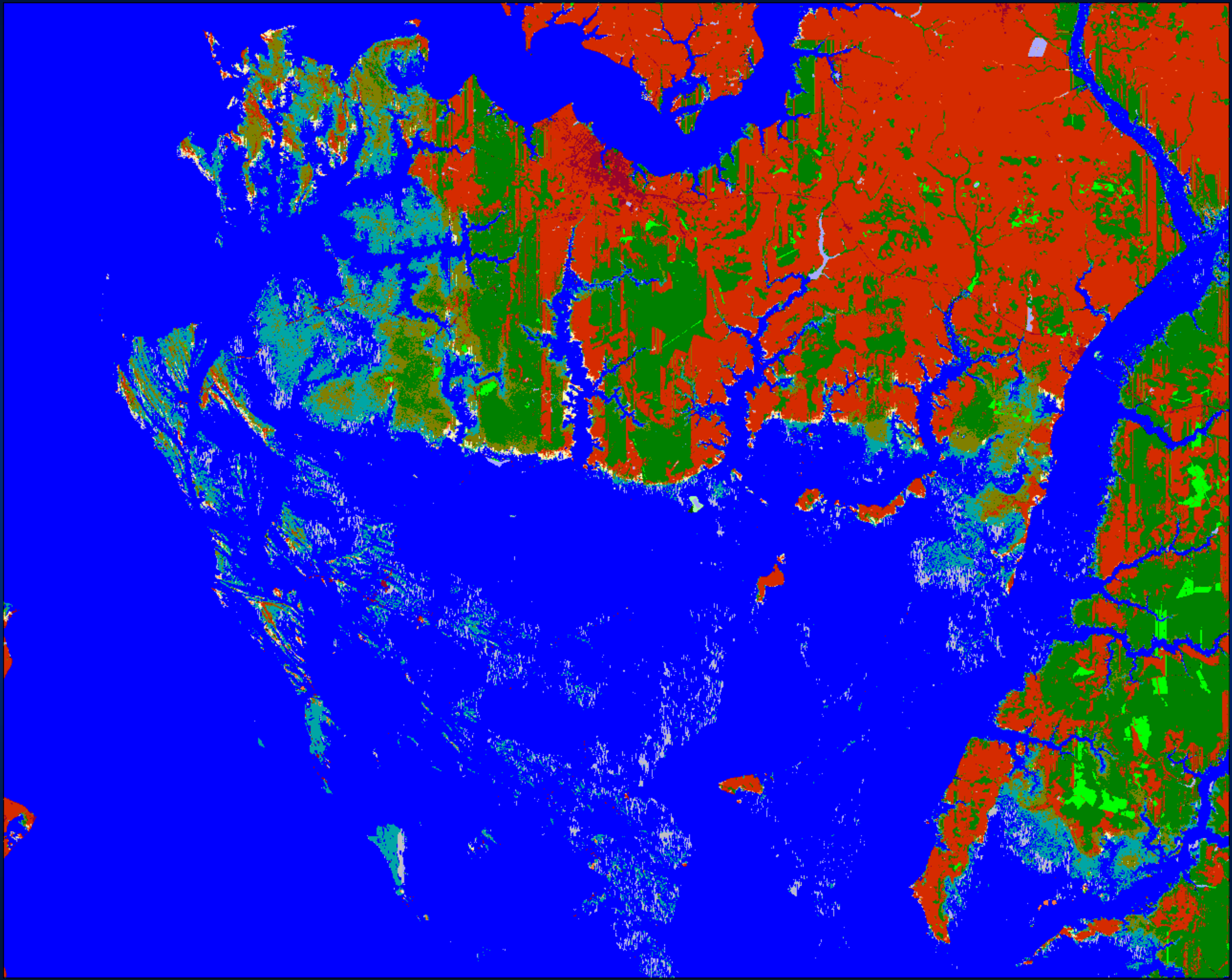


Figure 2.1.12. Wetland Response Map for the Chesapeake Bay Region. Note that the Lower Maryland Eastern Shore Region is considered separately. Source: Titus et al. (Section 2.2).

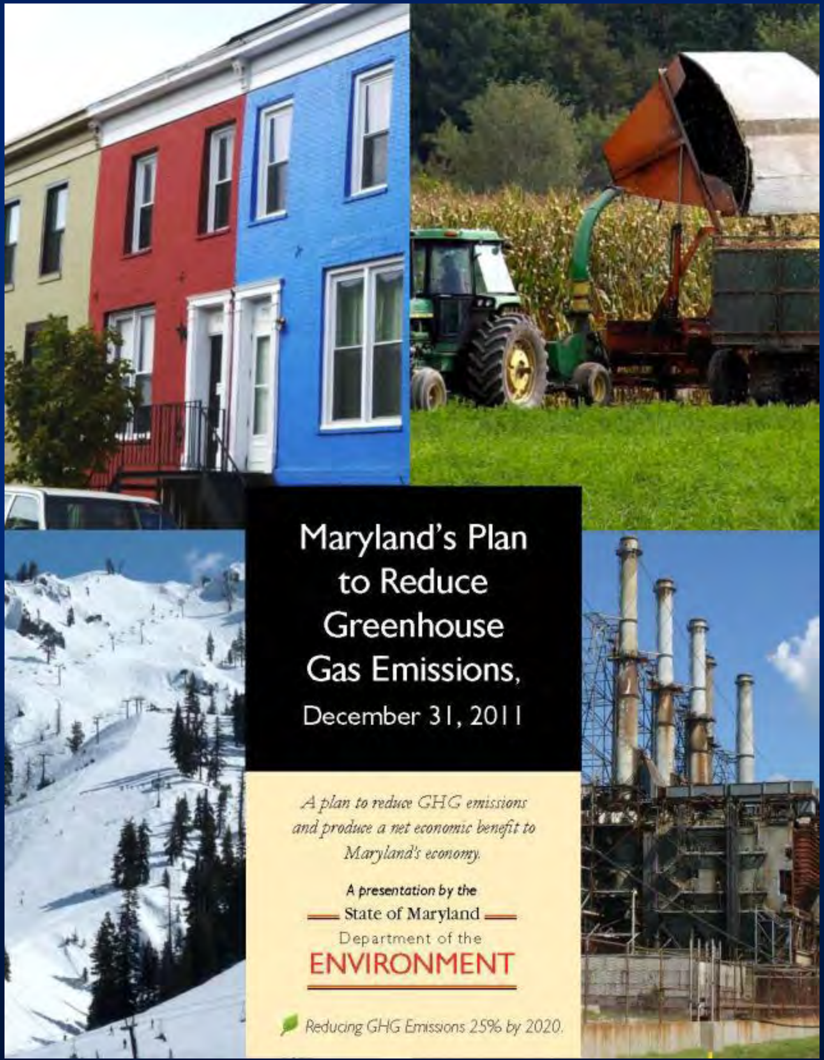
Initial Condition Cambridge MD, & Surrounding Peninsula

Year 2100,1 meter of global sea level rise



Greenhouse Gas Emissions Reduction Act of 2009

- 25% reduction by 2020
- "Creating and Protecting Wetlands and Waterway Borders to Capture Carbon"



AG AND FORESTRY

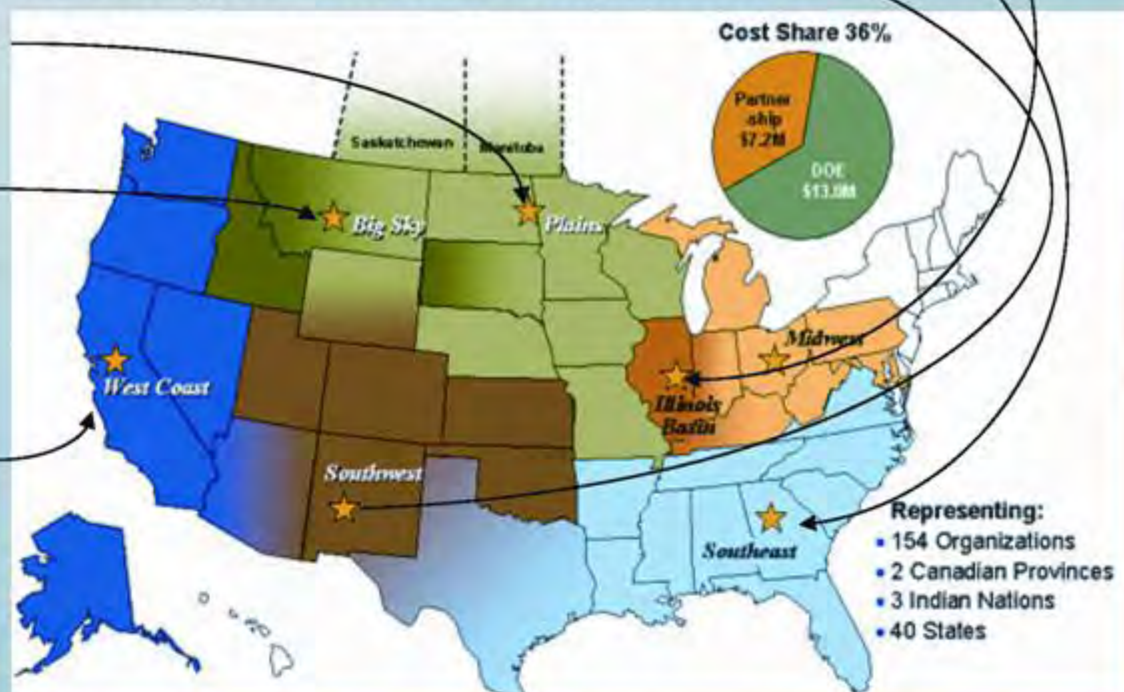
Program Number	Program	Potential GHG Reductions (million metric tons of CO_2-equivalent)
A&F-1	Managing Forests to Capture Carbon	2.70
A&F-2	Creating Ecosystems Markets to Encourage GHG Emissions Reductions	0.82
A&F-3	Increasing Urban Trees to Capture Carbon	1.32
A&F-4	Creating and Protecting Wetlands and Waterway Borders to Capture Carbon	0.65
A&F-5	Geological Opportunities to Store Carbon	Not Quantified
A&F-6	Planting Forests in Maryland	0.62
A&F-7	Expanded Use of Forests and Feedstocks for Energy Production	3.07
A&F-8	Conservation of Ag Land for GHG Benefits	0.28
A&F-9	Buy Local for GHG Benefits	0.05
A&F-10	Nutrient Trading for GHG Benefits	0.21
Total		**9.72**

Midwest Regional Carbon Sequestration Partnership

The MRCSP is One of Seven DOE Regional Partnerships Across the U. S.

The other six are:

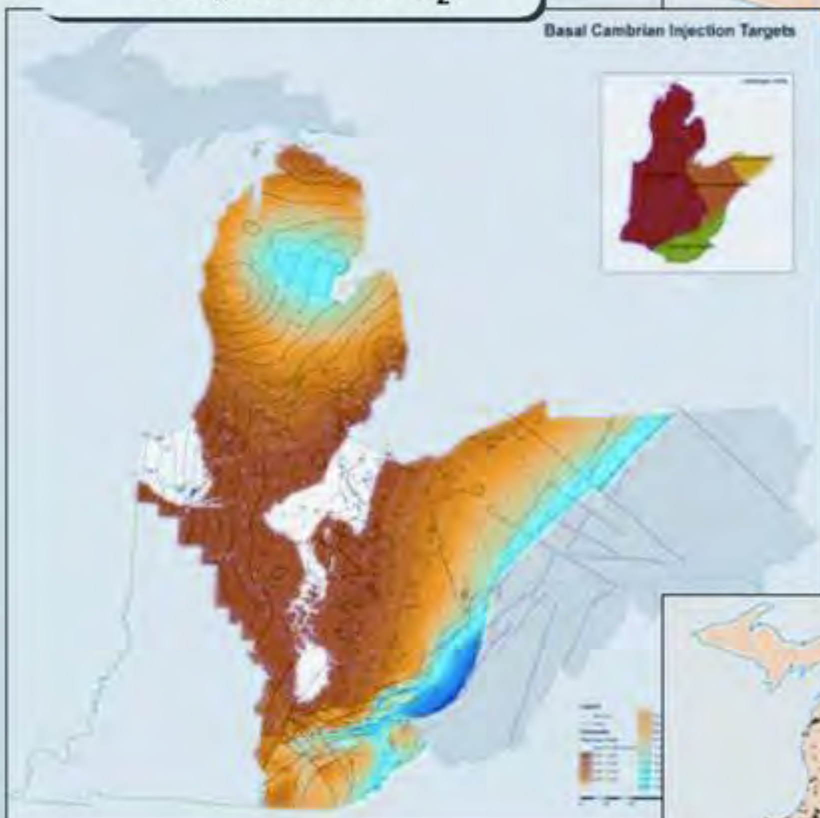
- Geological Carbon Sequestration Options in the **Illinois Basin**
- **Southeast** Regional Carbon Sequestration Partnership
- **Southwest** Regional Partnership for Carbon Sequestration
- **Plains** CO_2 Reduction Partnership
- **Big Sky** Regional Carbon Sequestration Partnership
- **West Coast** Regional Carbon Sequestration Partnership



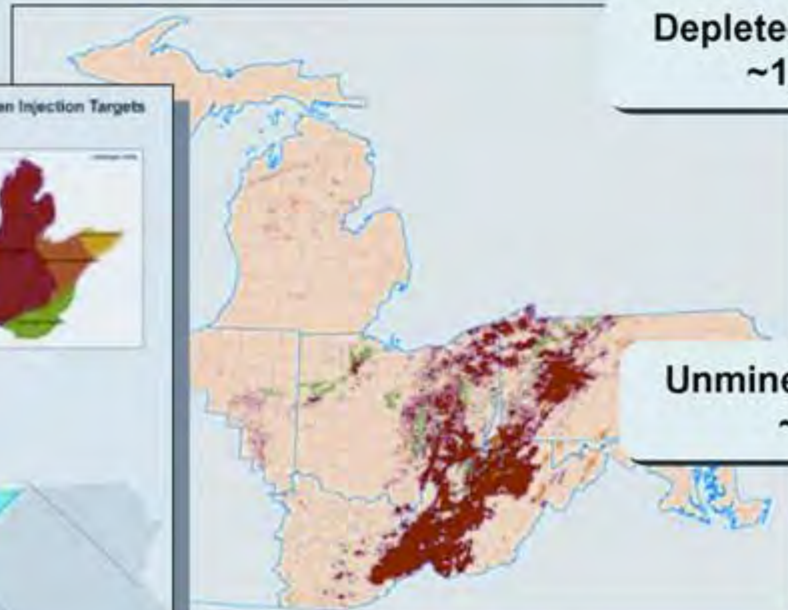
See http://www.netl.doe.gov/coal/Carbon%20Sequestration/partnerships/index.htm for more information from NETL on the seven partnerships.

The geological potential of the region is vast and well positioned relative to sources

Deep saline formations:
~475,000 $MMTCO_2$



Depleted oil and gas fields
~1,400 $MMTCO_2$



Unmineable coal and shale
~350 $MMTCO_2$

Data from over 40,000 wells have been analyzed

Battelle
The Business of Innovation

MRCSP

Regional Greenhouse Gas Initiative (RGGI or "Reggie")

- Nine Northeast and Mid-Atlantic states
- Cap-and-trade program for power plants in the region
  - Compliance began 2009
  - Regional emissions capped at ~1990 levels
  - Cap reduced 10% in 2018

Carbon offsets in RGGI

- None sold to date
- Performing 2012 mandatory review
- Discussing additional offset categories
  - 2015 – wetlands
- Process options
  - Independent RGGI protocol
  - Accept other protocols (e.g. VCS)
  - Accept offsets from other markets
- North America 2050 Initiative (NA 2050)

Blue carbon restoration and conservation opportunities

- Conservation through erosion protection
- Agriculture to wetland conversion
- Facilitated migration
- Dredged material placement
- Increased accretion through restoration and management

Restoration opportunities: Conservation through erosion protection

- 2100 m Eastern Red Cedar
- 140 ha marsh conserved
- ~$60K

Matt Whitbeck

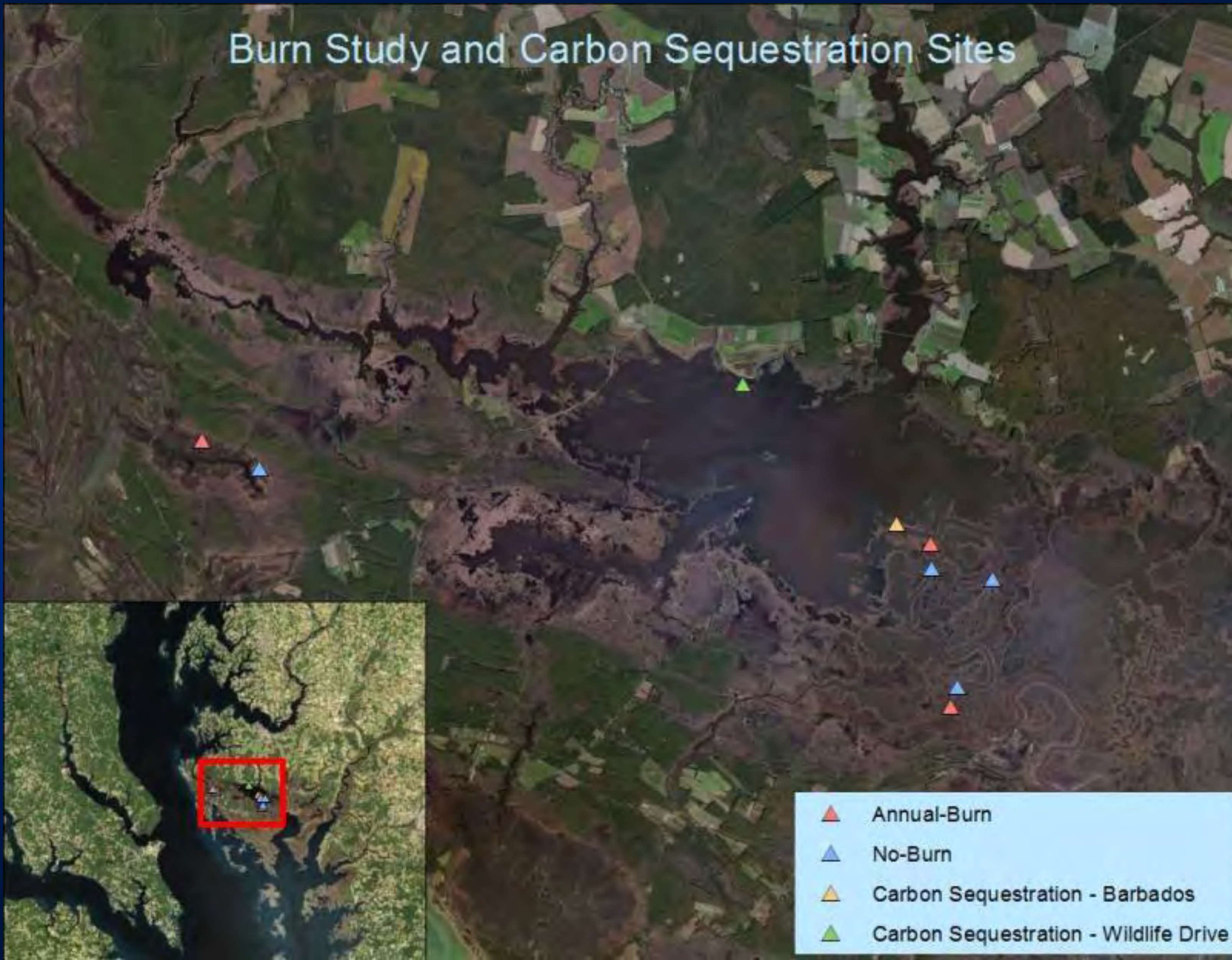
Restoration opportunities: Agriculture to wetland conversion

Restoration opportunities: Facilitated migration

Dredged material placement: Poplar Island

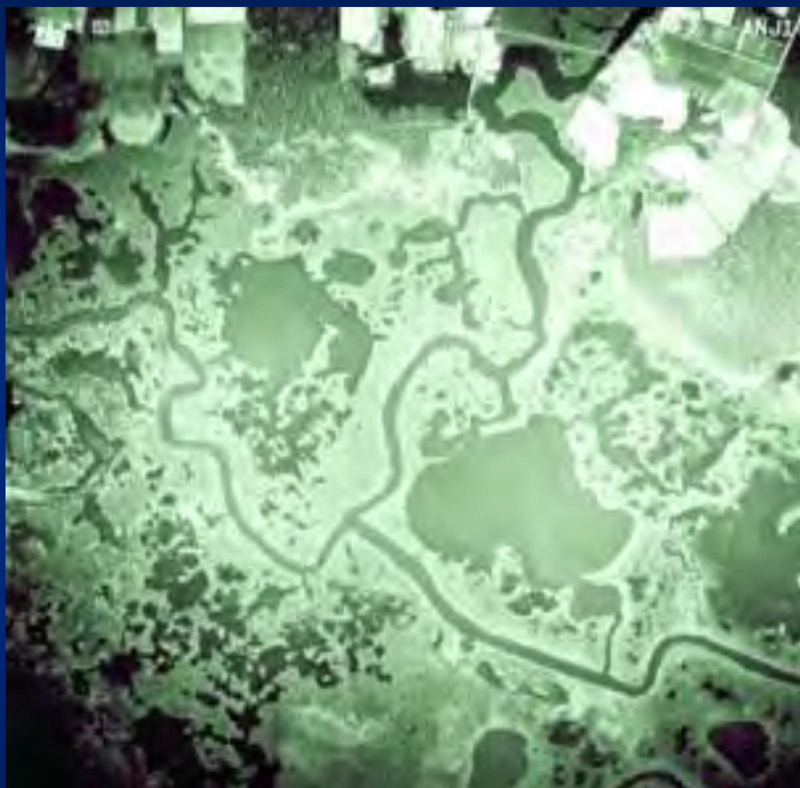
- 230 ha marsh restoration
- Varying success (problems related to excess nutrients in dredge material)

Blackwater National Wildlife Refuge

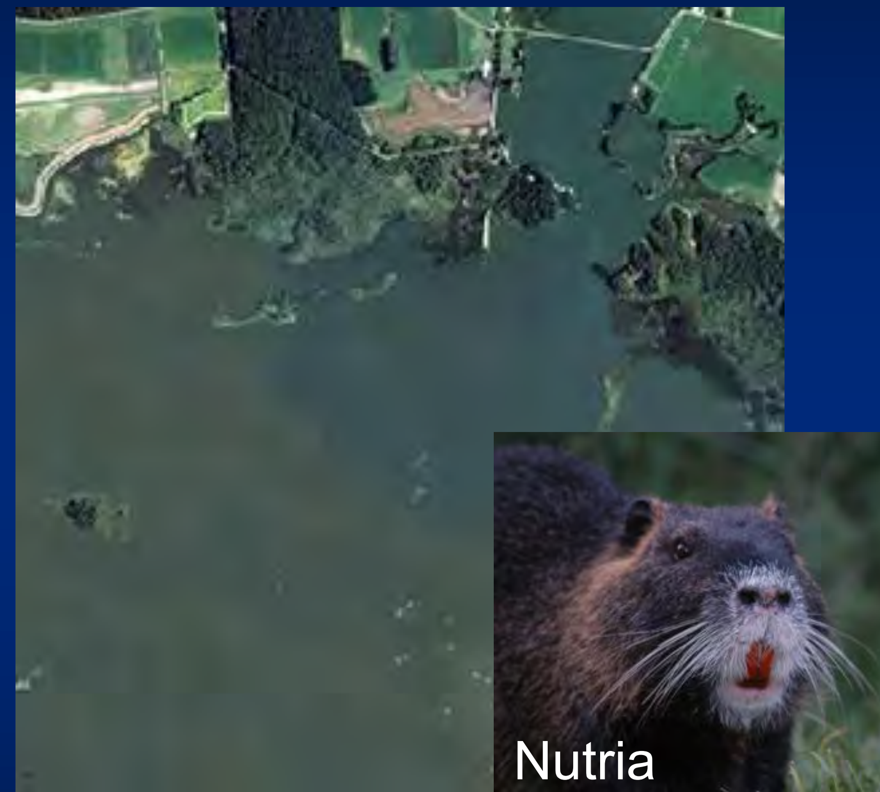


Blackwater National Wildlife Refuge

1938

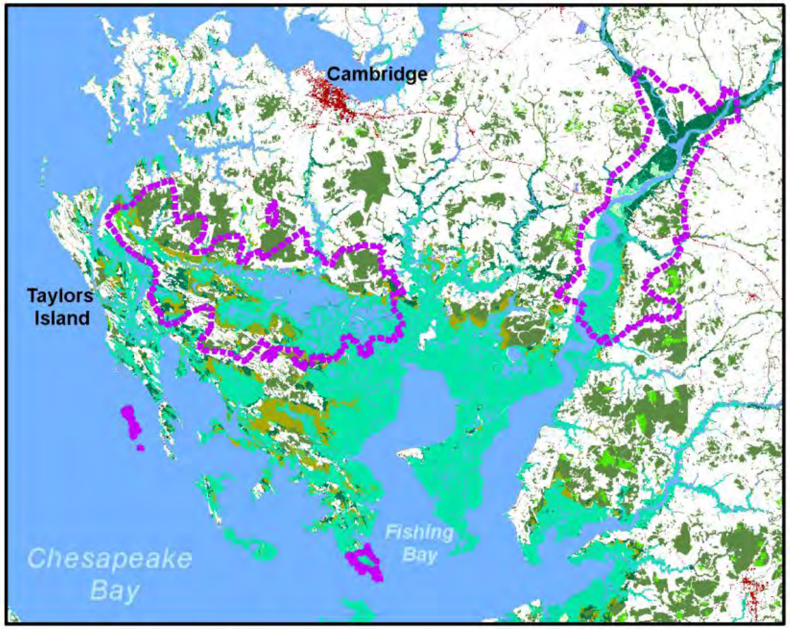


2005

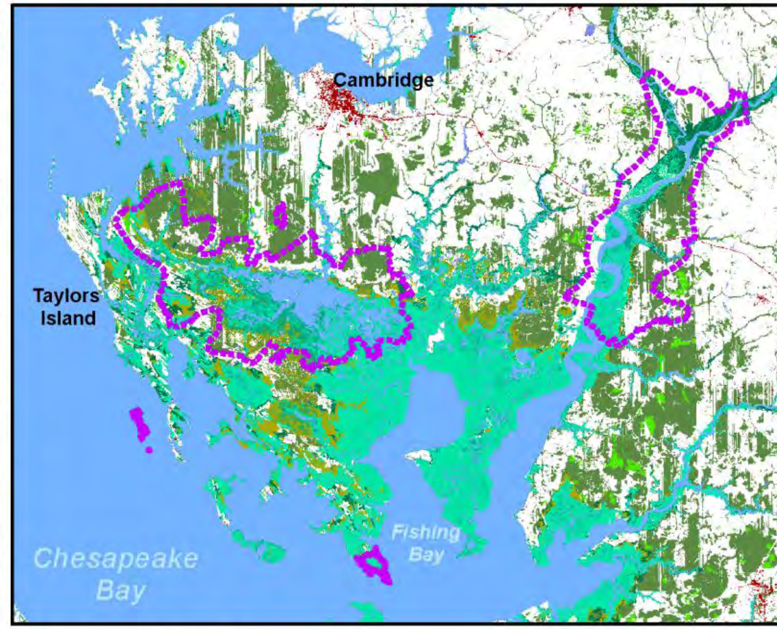


- Drowned river valley, wind-driven, microtidal
- Sediment-starved, brackish

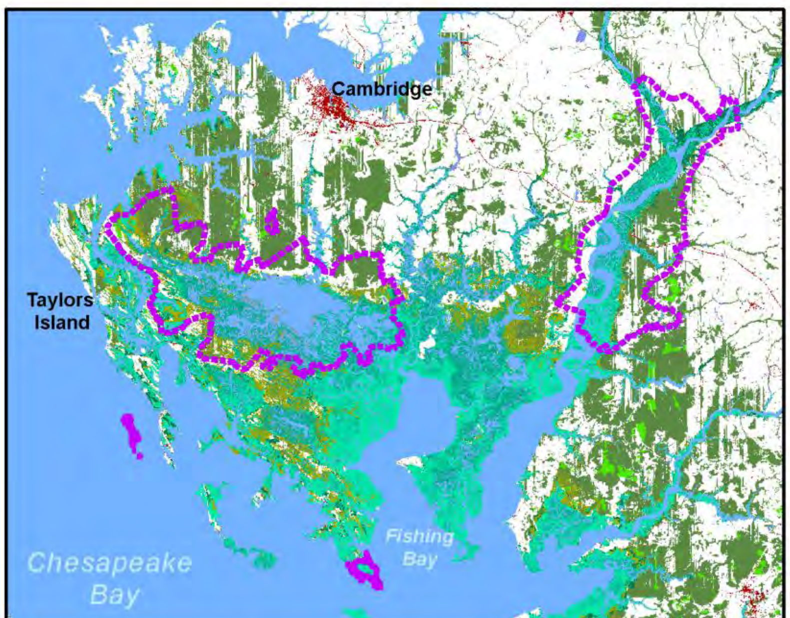
Early photo – scanned NAPP photos provided by Dixie Birch USFW – 2005 True Color Orthophotographs



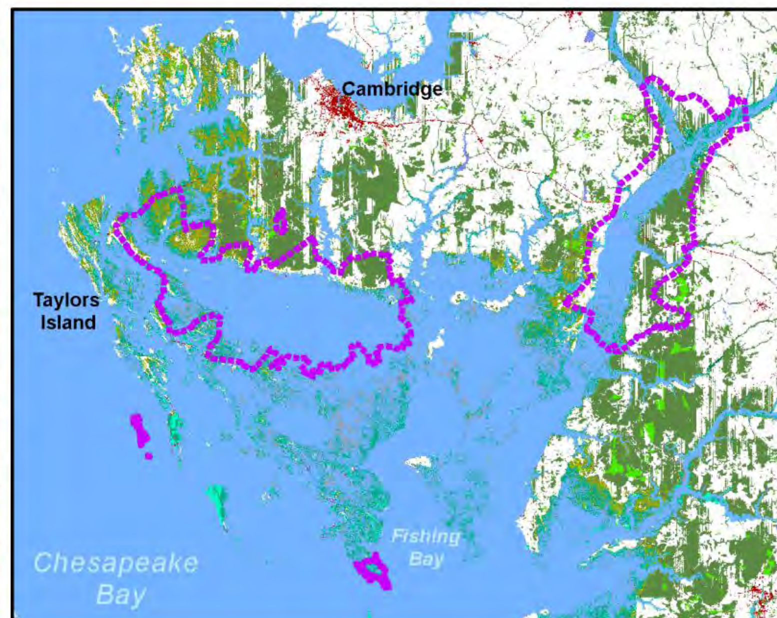
Initial Condition



2025 - A1B Max



2050 - A1B Max



2100 - A1B Max

Marsh restoration using local dredged material

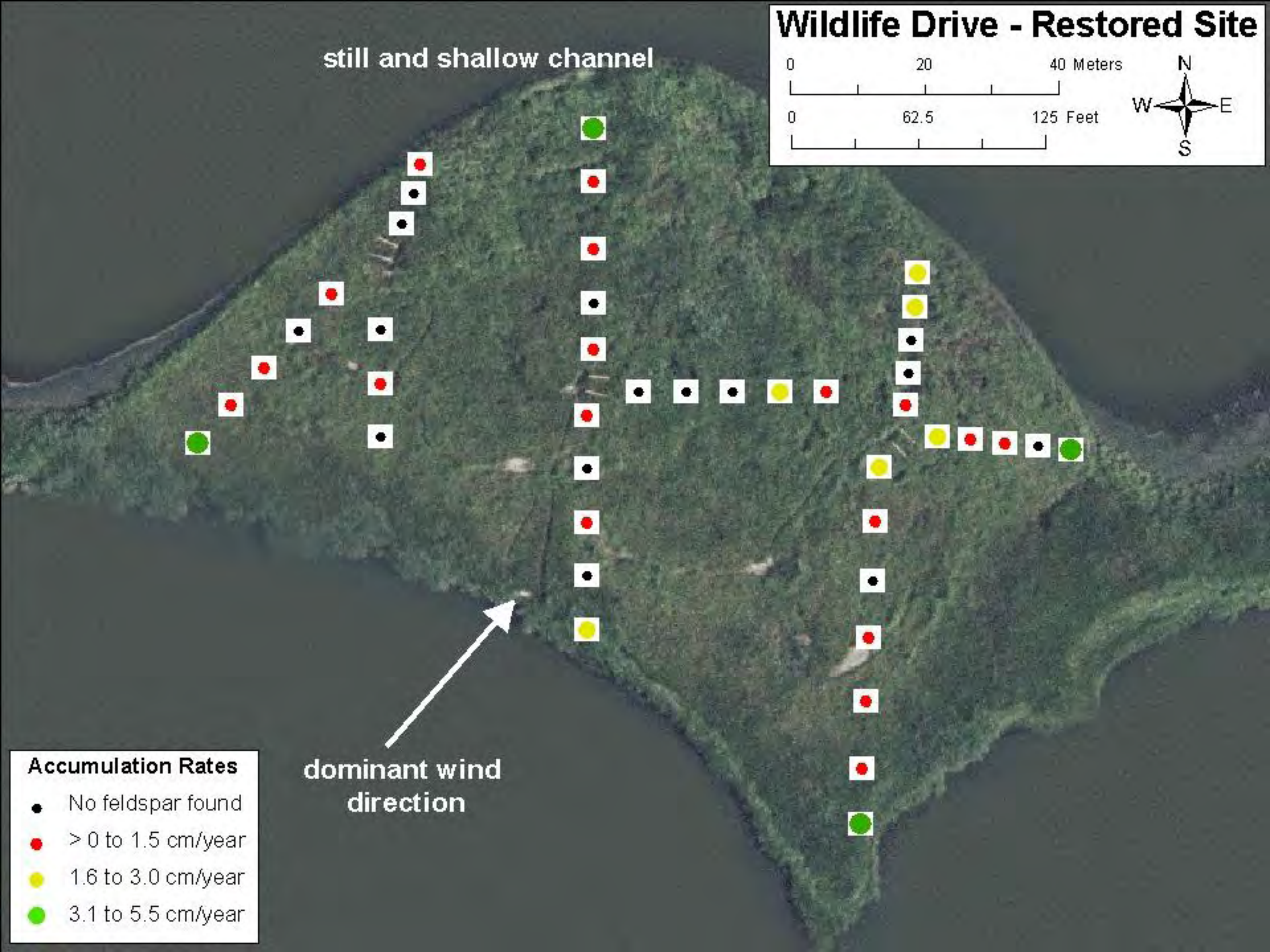

August 2003

Restored Marsh Cell Plot Locations

Carbon sequestration rates

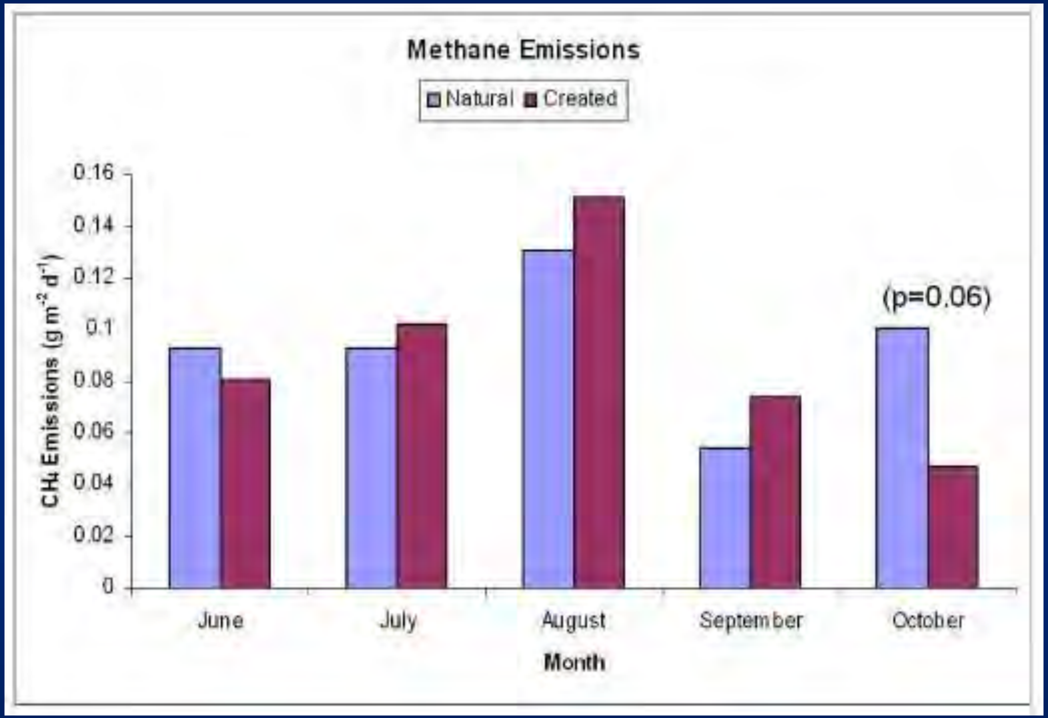
- **Natural site**
  - **3.4 to 5.7 Mg/ha/yr**
  - **Mean 4.4 Mg/ha/yr**
- **Restored site:**
  - **0.9 to 5.9 Mg/ha/yr**
  - **Mean 3.4 Mg/ha/yr**
  - **Standard deviation 1.3 Mg/ha/yr**

-> 6-10 sampling plots



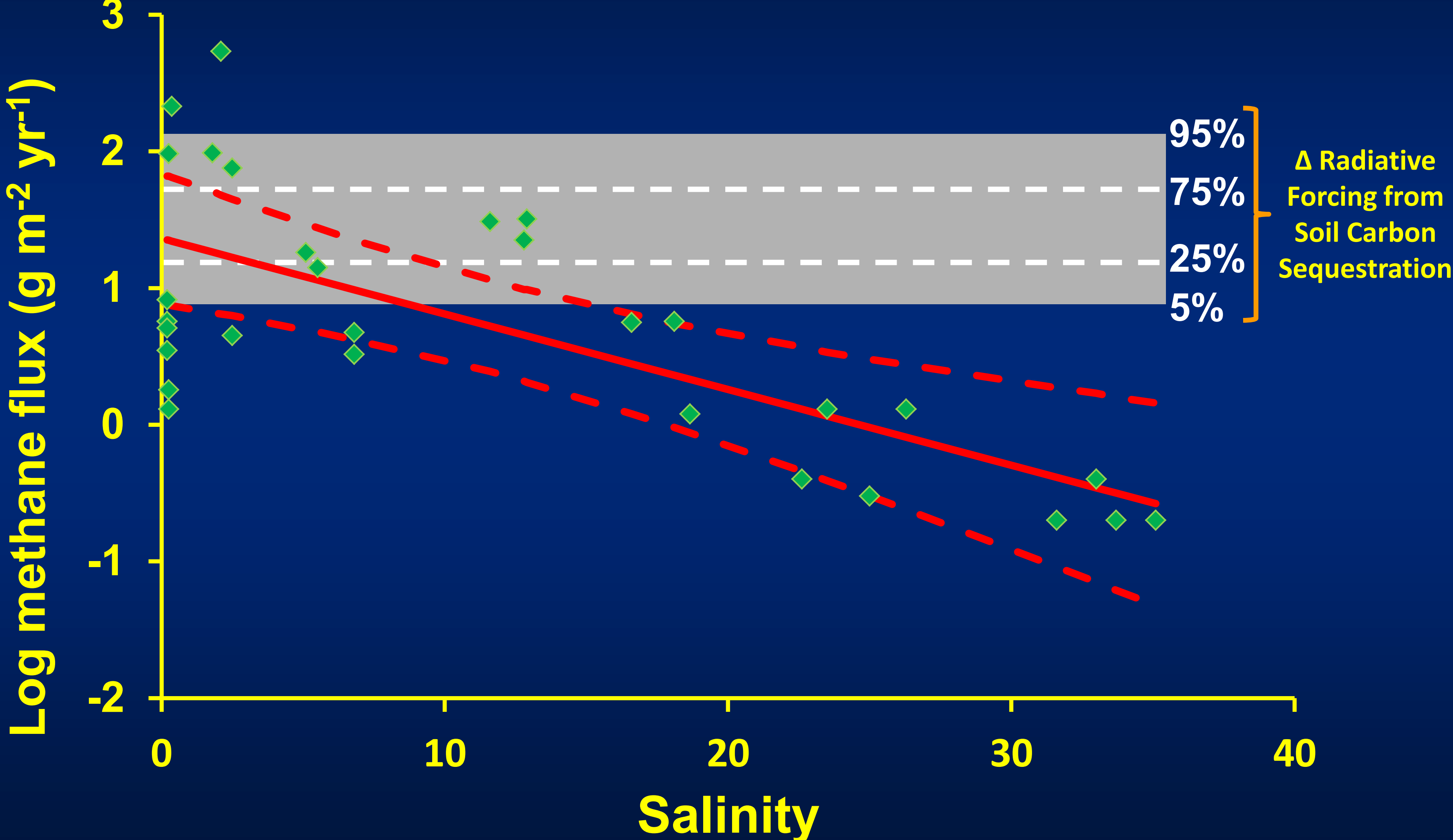
Wildlife Drive - Restored Site
0
20
40 Meters
0
62.5
125 Feet
N
W
E
S
still and shallow channel
dominant wind
direction
Accumulation Rates
No feldspar found
> 0 to 1.5 cm/year
1.6 to 3.0 cm/year
3.1 to 5.5 cm/year

Methane emissions at Blackwater



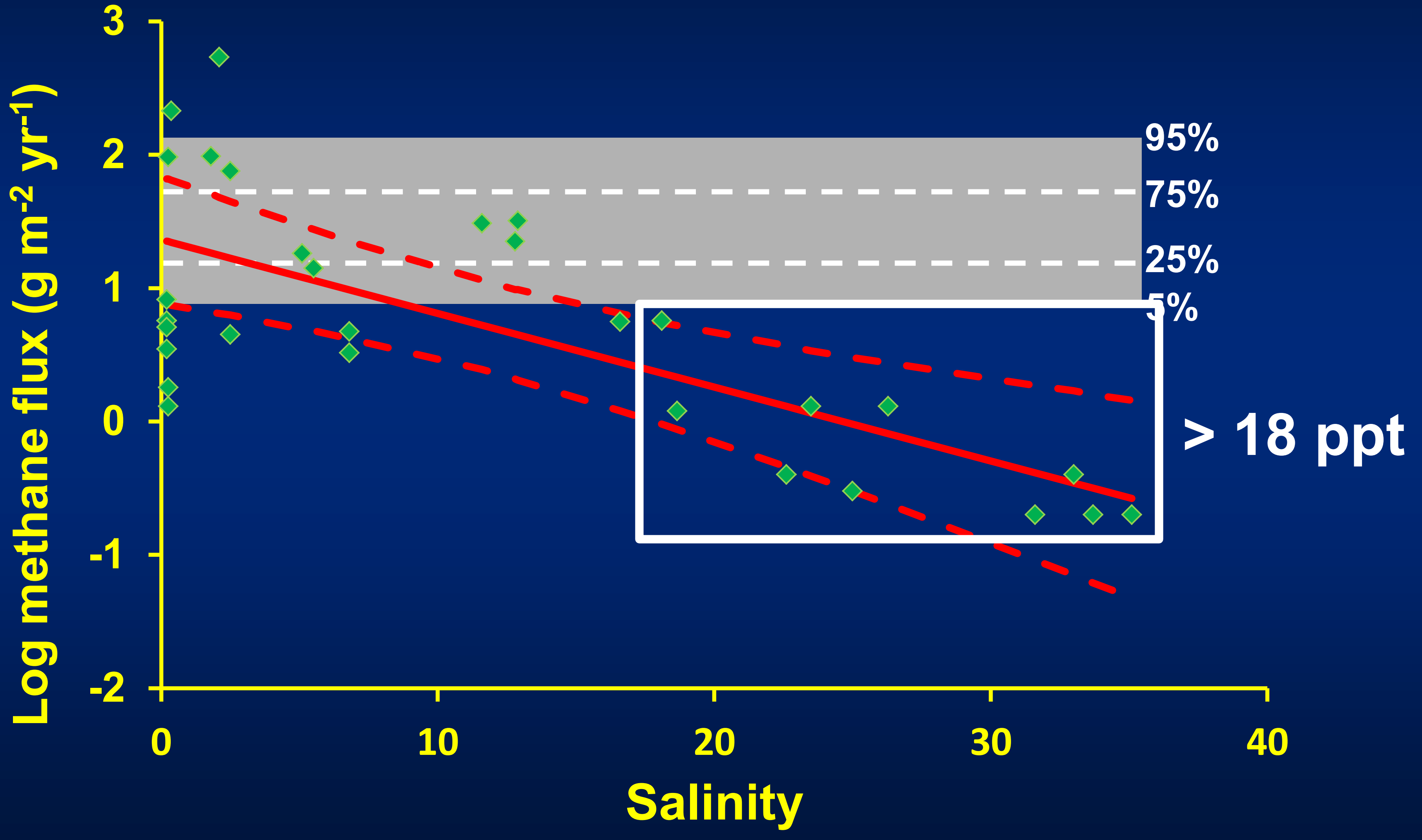
Megonigal, unpublished data

Climate Benefits of Sequestration Offset by Methane

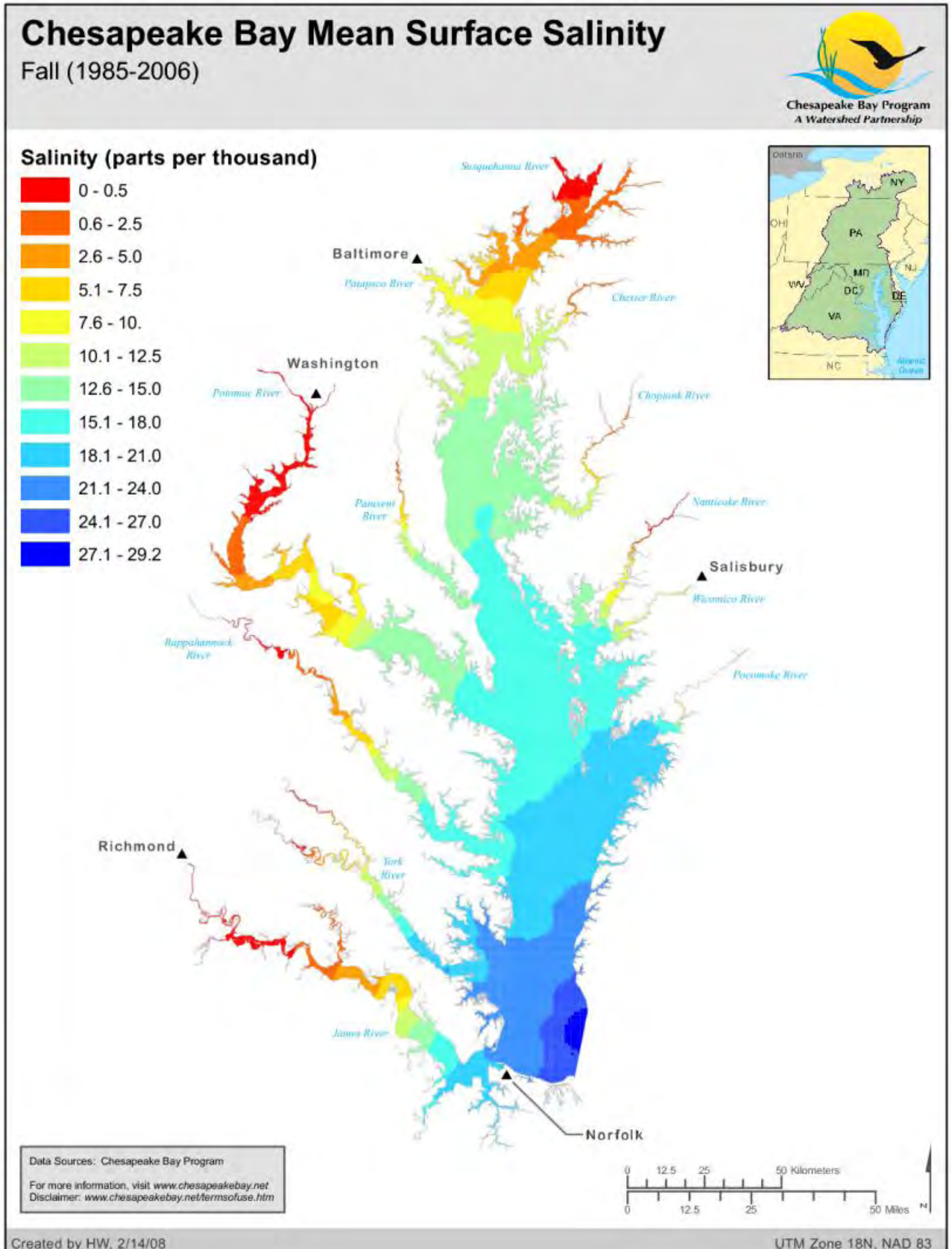


Poffenbarger, Needelman & Megonigal. 2011. Salinity Influence on Methane Emissions from Tidal Marshes. Wetlands.

Climate Benefits of Sequestration Offset by Methane



Poffenbarger, Needelman & Megonigal, Wetlands, 2011



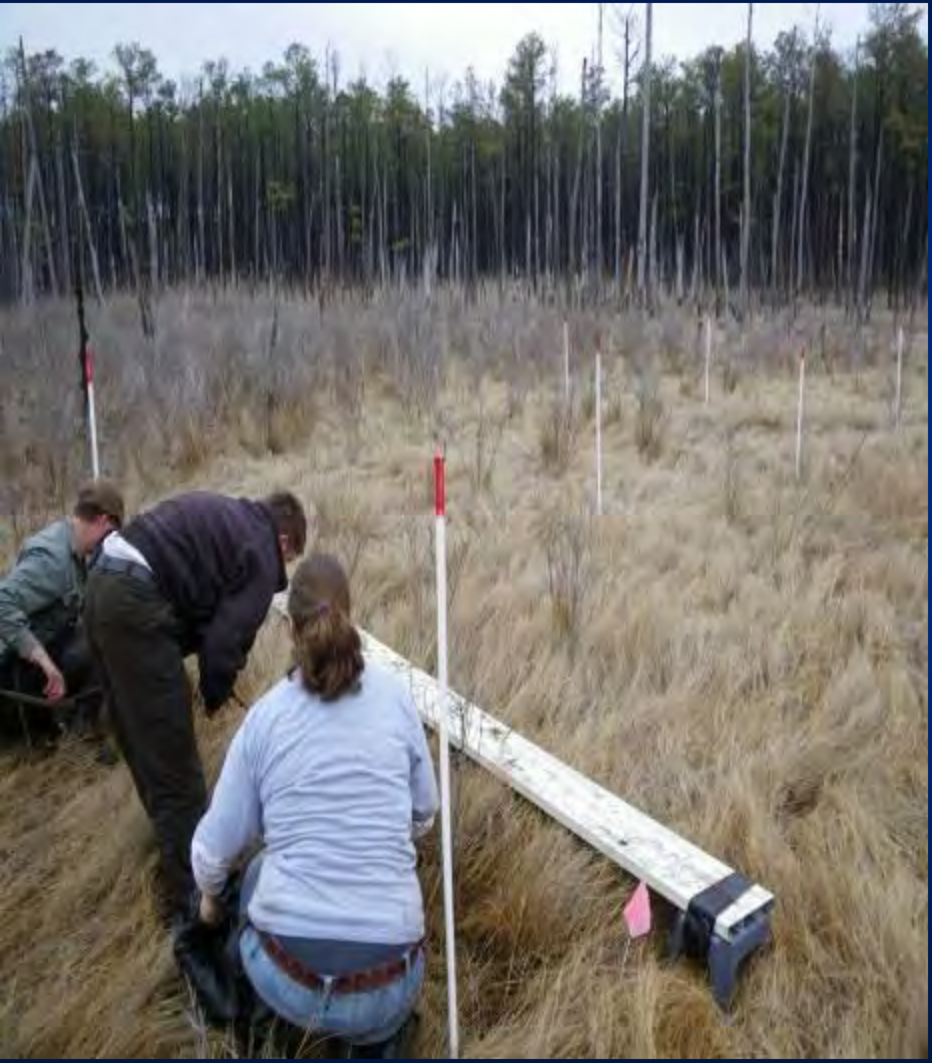
http://www.ncnr.nist.gov/programs/CHRNS/pdf/salinity_fall.png

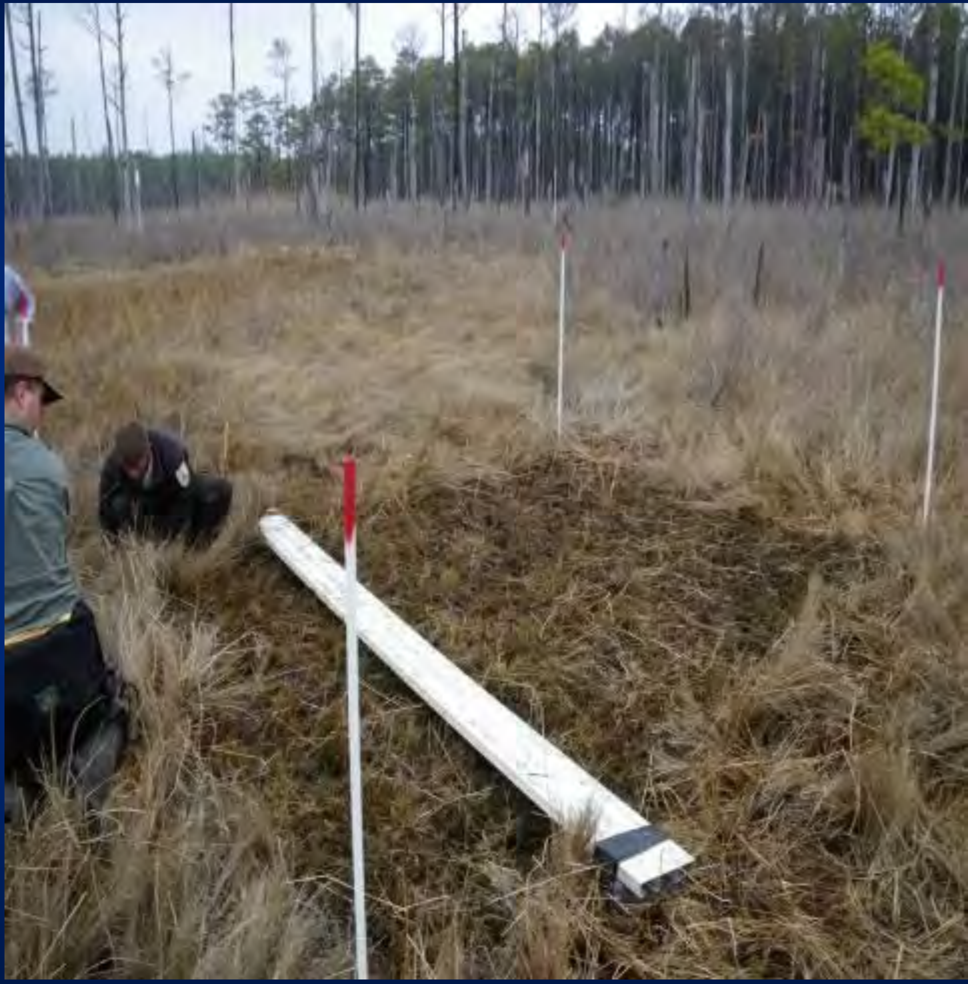
Restoration opportunities: Increased accretion through restoration and management

Restoration of ditch-drained marshes

Prescribed fire and blue carbon

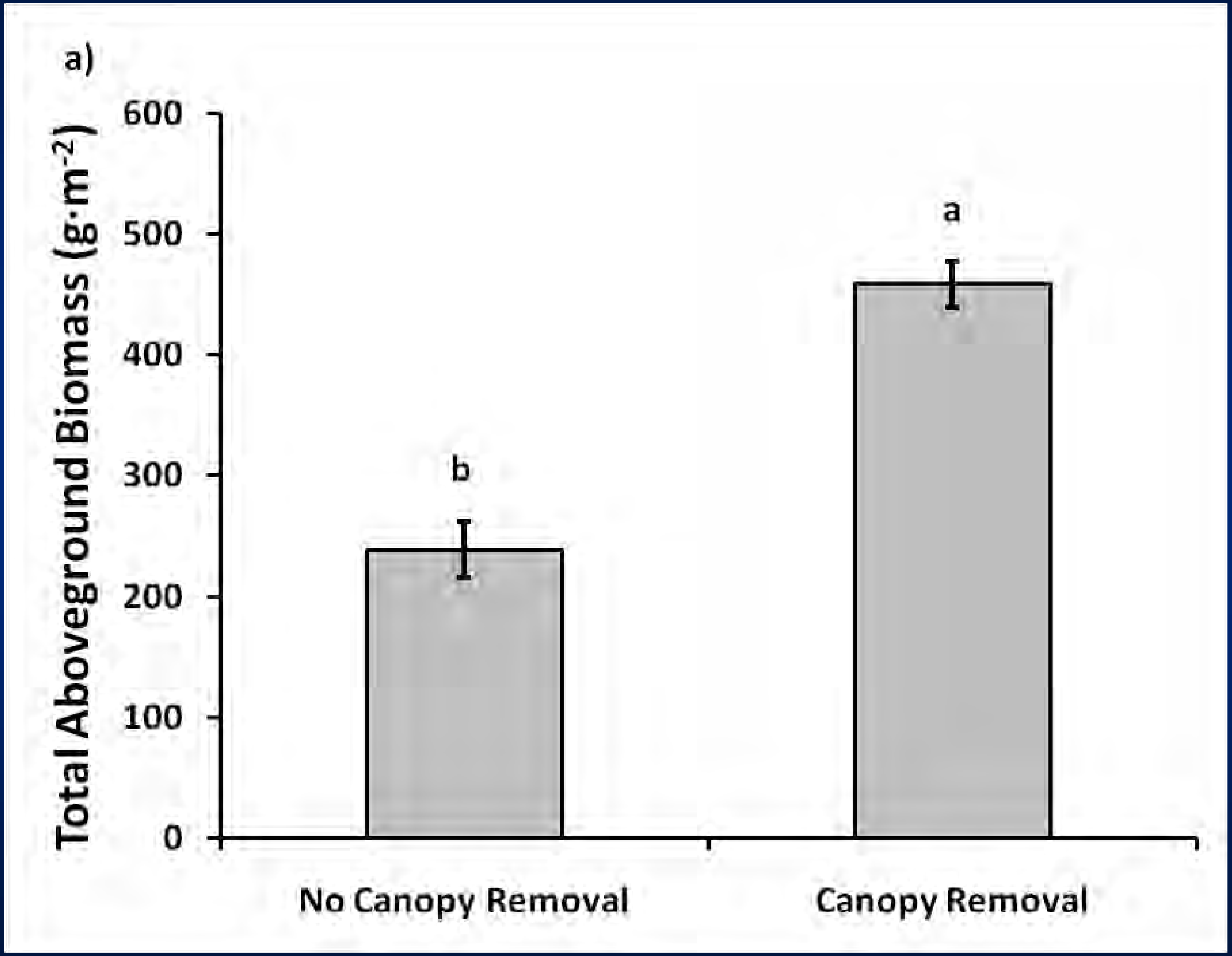
Canopy removal





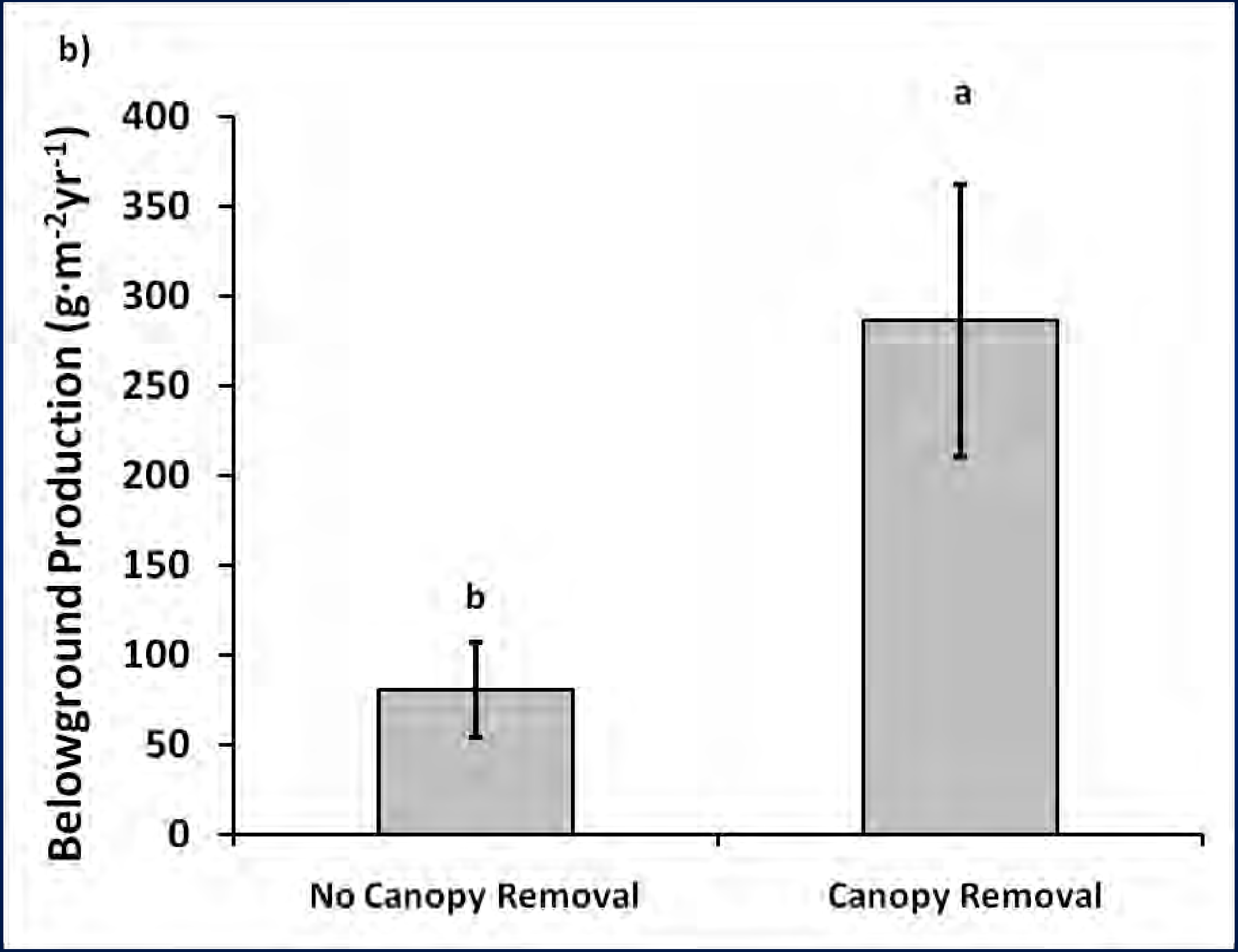
Canopy replacement

Sedge-dominated sites



Bickford, Needelman, Weil, & Baldwin. 2012. Estuaries and Coasts.

Sedge-dominated sites



Bickford, Needelman, Weil, & Baldwin. 2012. Estuaries and Coasts.

Prescribed fire and accretion/elevation

(From Cahoon et al. 2010)

	Annual Burn	No Burn	Significance
Surface accretion ($mm \cdot yr^{-1}$)	5.9 ± 1.5	9.7 ± 1.8	NS
Root zone subsidence ($mm \cdot yr^{-1}$)	-0.4 ± 1.2	-6.2 ± 1.0	NS

N_2O and CH_4 emissions from burn ~0.1 Mg CO_{2eq}

Thank you

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Funding
Maryland Department of Natural Resources Power Plant Research Program
Maryland Sea Grant
Department of Energy

Value of carbon sequestration for marsh restoration (3 Mg CO_2/yr; 50 years)

Price per Mg CO_2	40 ha	400 ha
$5.00	$75,000	$750,000
$10.00	$150,000	$1,500,000
$40.00	$600,000	$6,000,000
$80.00	$1,200,000	$12,000,000

Before subtracting baseline, methane, uncertainty, insurance, verification, …

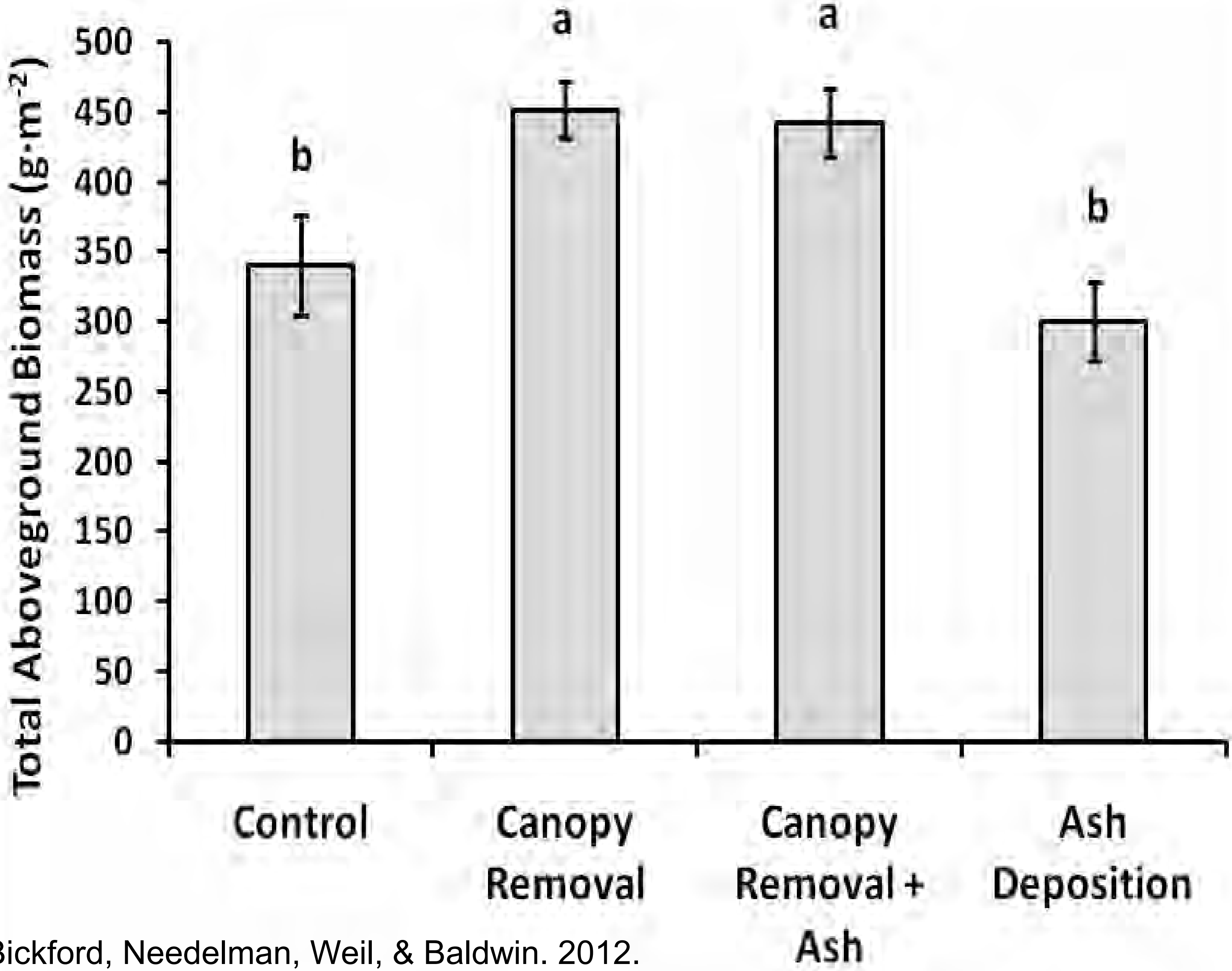
Restoration opportunities: Increased accretion through restoration and management

Thin-layering

Ditch-drained marsh restoration

Invasive species control

Prescribed fire



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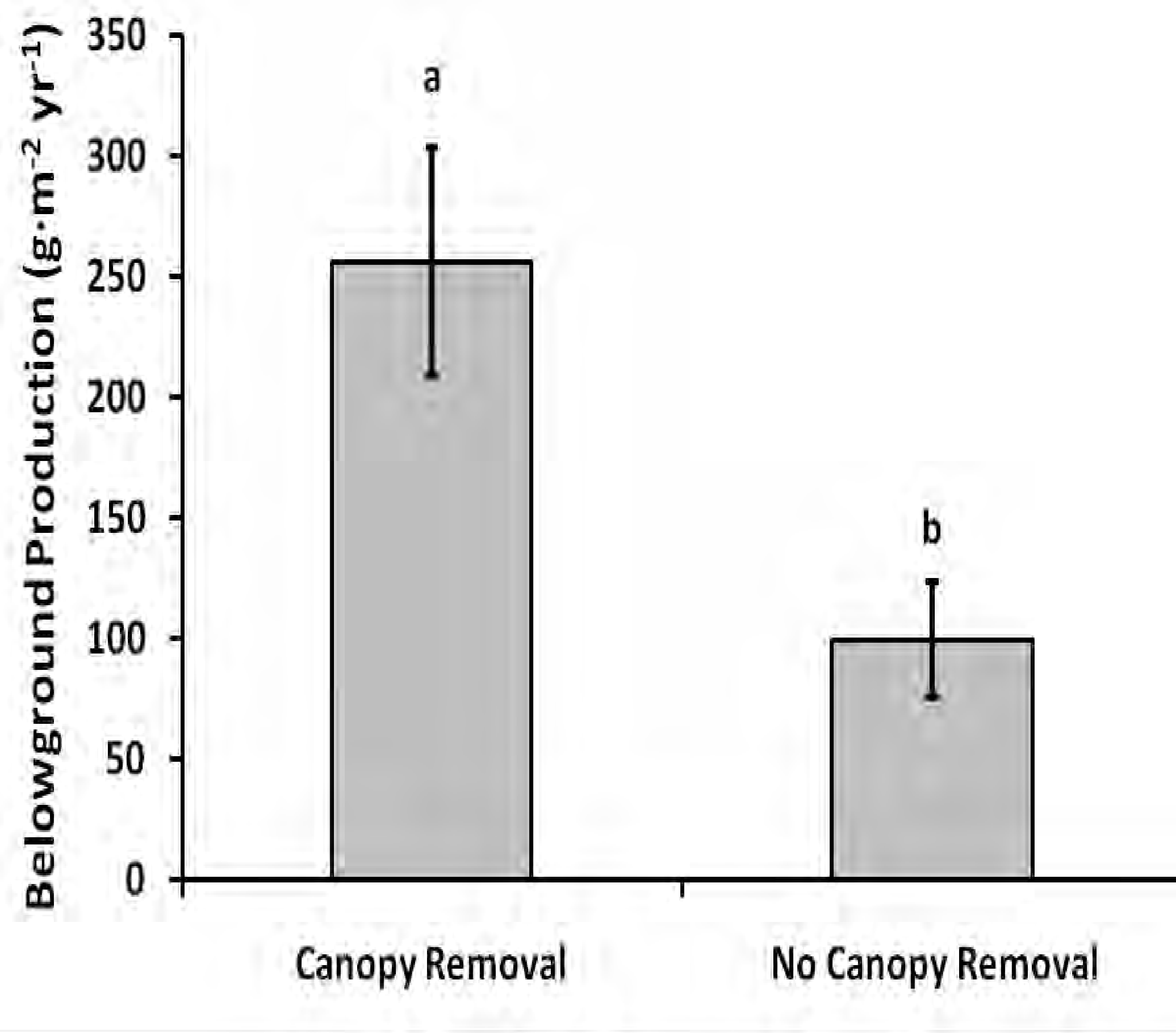
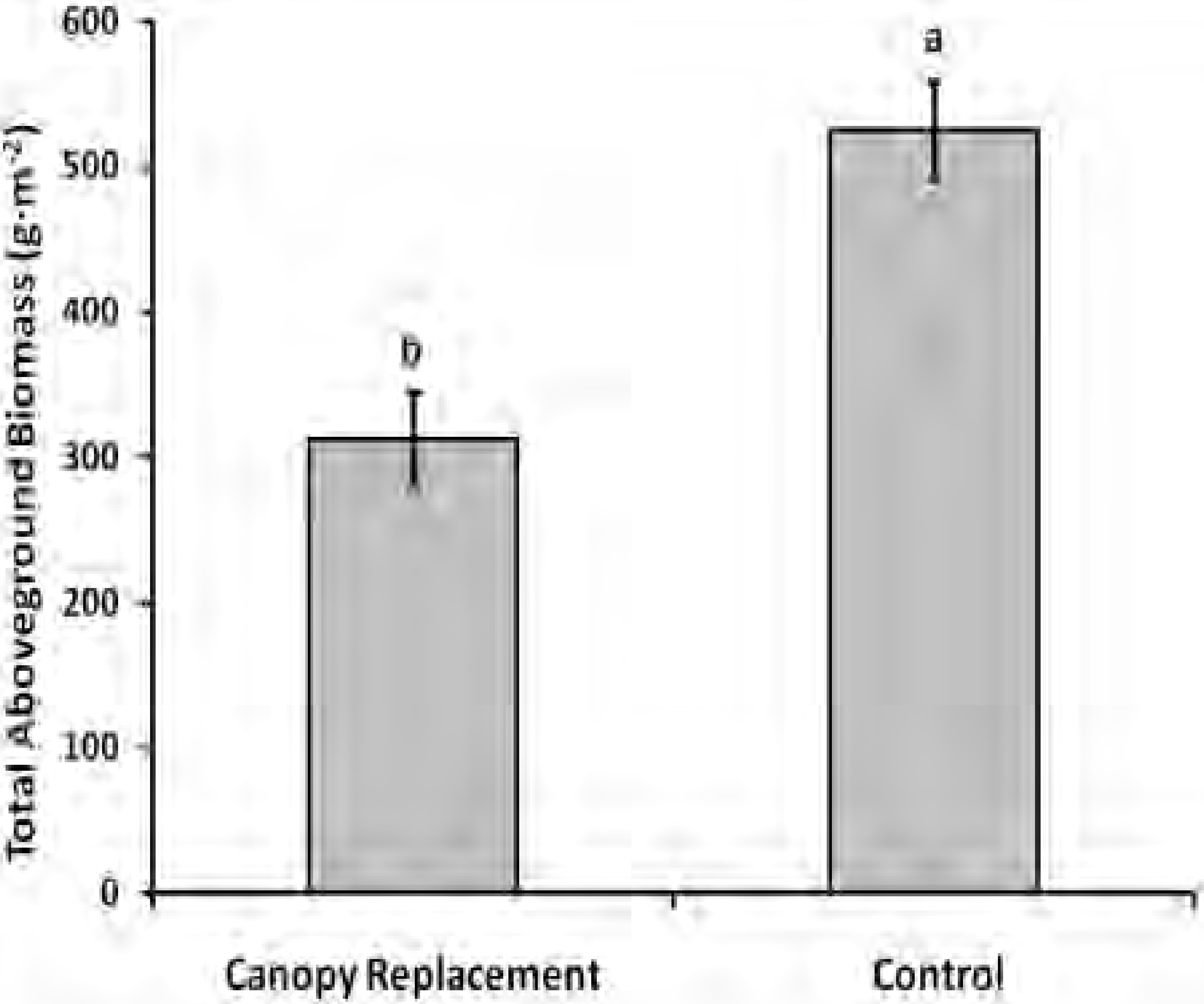


Bickford, Needelman, Weil, &
Baldwin. 2012. Estuaries and Coasts.


Total Aboveground Biomass (g·m⁻²)
600
500
400
300
200
100
0
a
b
Canopy Replacement
Control

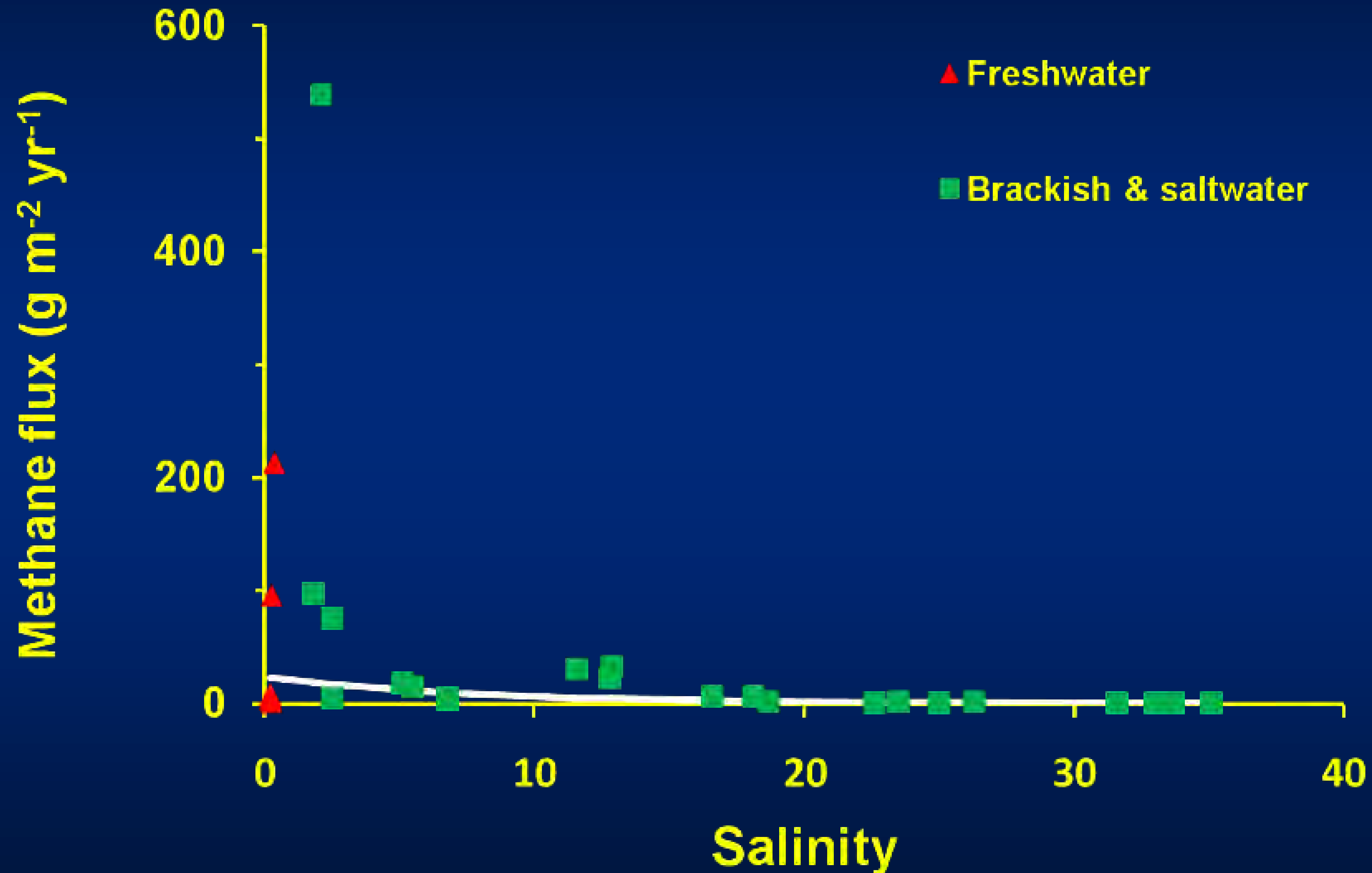
Dominant Plant Species

Sedge: Schoenoplectus americanus

Grass: Distichlis spicata

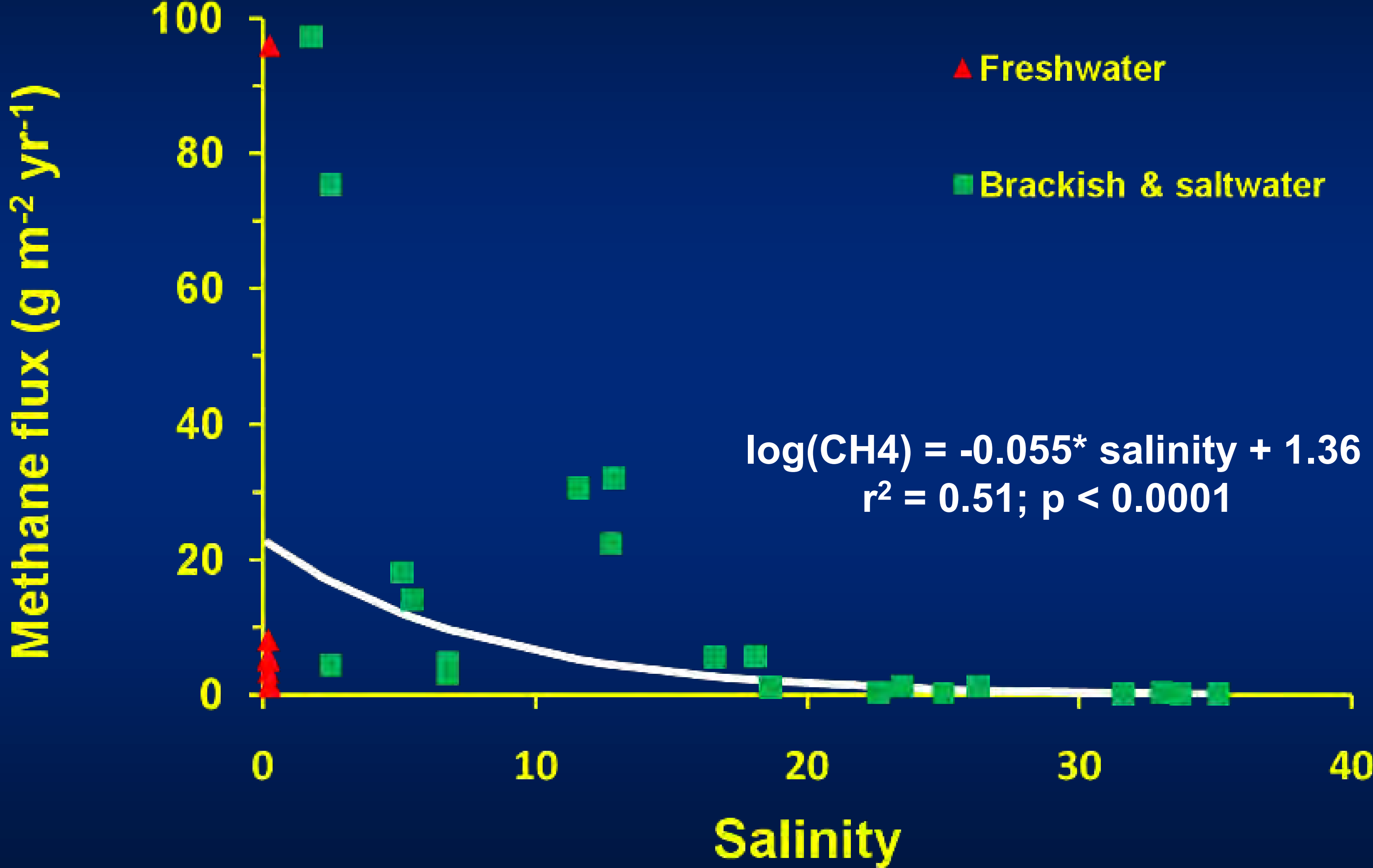
Grass: Spartina patens

Salinity versus methane flux



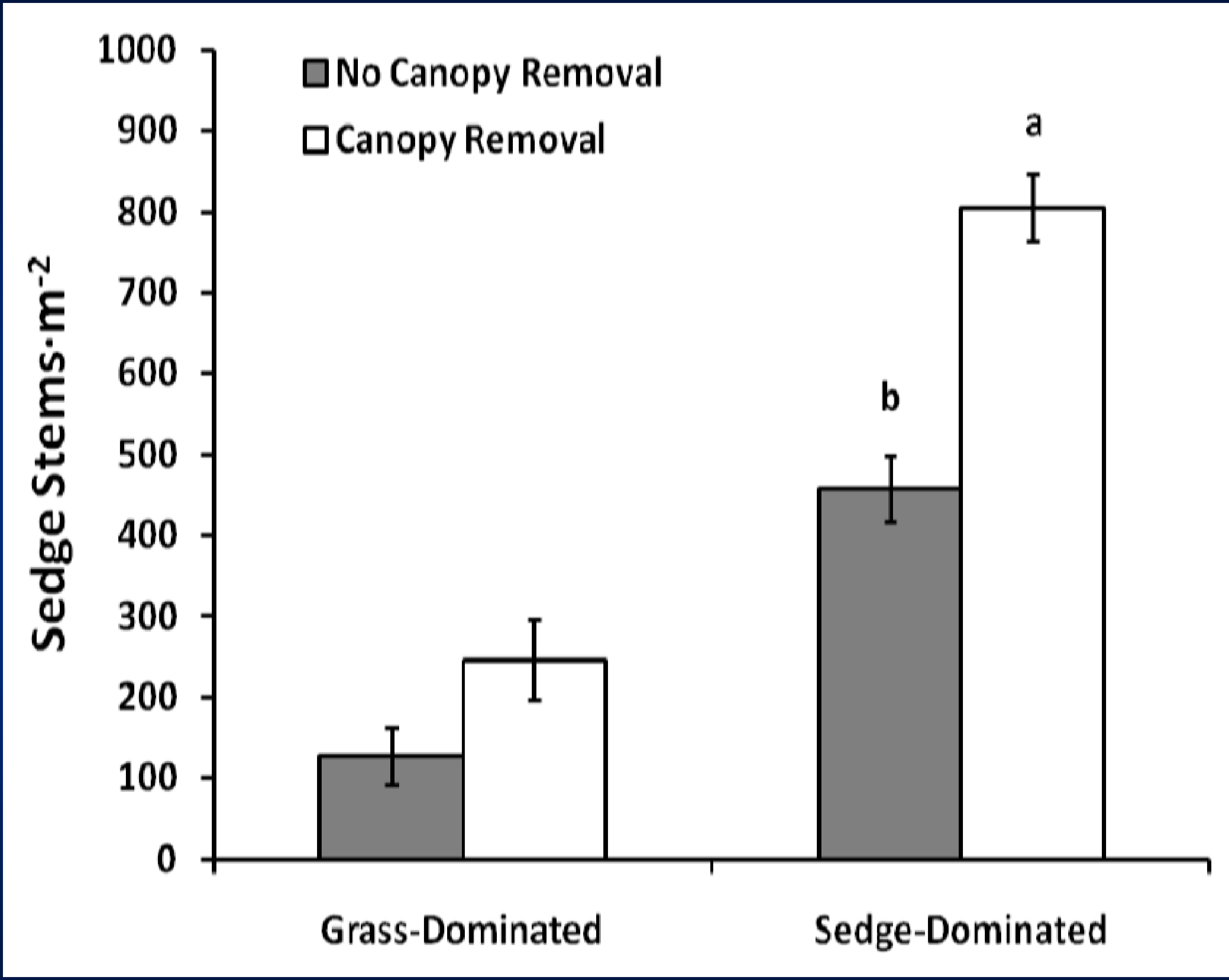
Poffenbarger, Needelman & Megonigal. 2011. Salinity Influence on Methane Emissions from Tidal Marshes. Wetlands.

Salinity versus methane flux



Poffenbarger, Needelman & Megonigal, Wetlands, 2011

Sedge stem density



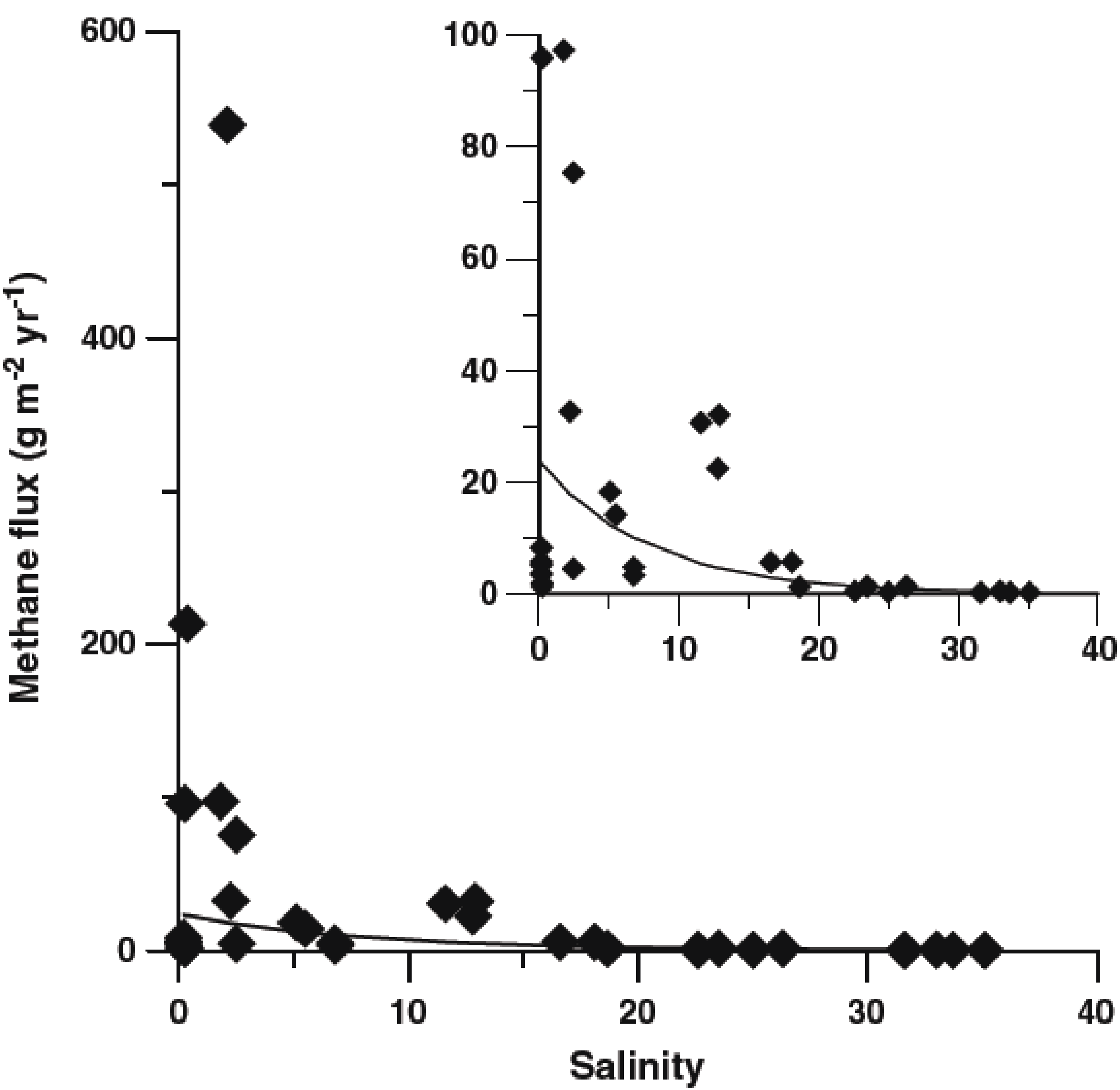
Bickford, Needelman, Weil, & Baldwin. 2012. Estuaries and Coasts.

Volunteers planted 70,000 units combined of Olney's 3-square (*Schoenoplectus americanus*), salt marsh bulrush (*Schoenoplectus robustus*), and smooth cordgrass (*Spartina alterniflora*)

Literature (methane flux)

- DeLaune et al. 1983
- Bartlett et al. 1985
- Bartlett et al. 1987
- Kelley et al. 1995
- Magenheimer et al. 1996
- Van der Nat and Middelburg 2000
- Neubauer et al. 2000
- Megonigal and Schlesinger 2002
- Nedwell et al. 2004
- Marsh et al. 2005
- Hirota et al. 2007
- Wang et al. 2009
- Field sites at the Blackwater National Wildlife Refuge

Poffenbarger, Needleman & Megonigal, *Wetlands* 2011



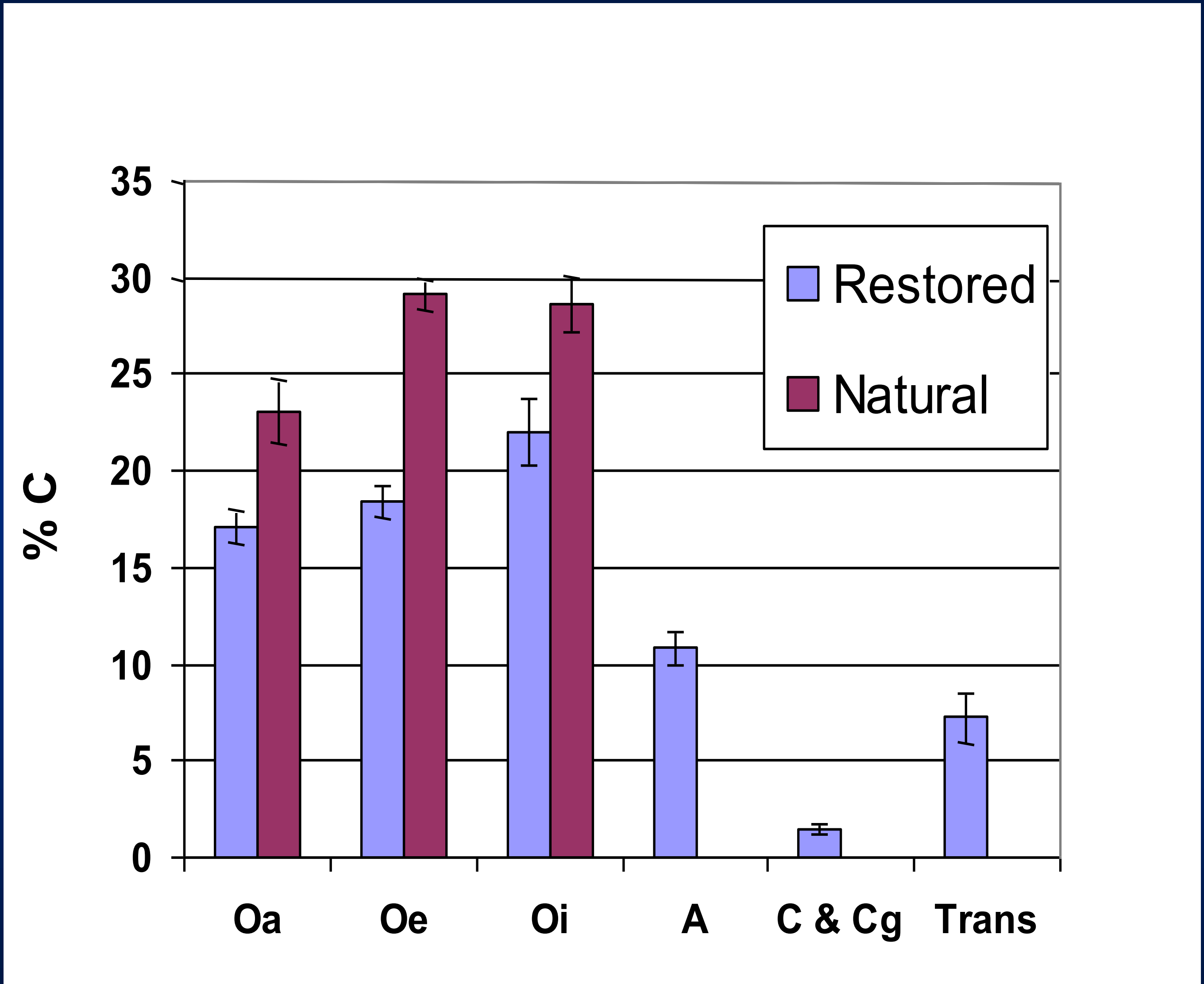
Methane emissions and carbon sequestration equivalents

Salinity Class	Salinity Range	Methane emissions ($g\ m^{-2}\ yr^{-1}$)				N	Carbon sequestration equivalent of methane emissions ($Mg\ C\ ha^{-1}\ yr^{-1}$)*		
	ppt	Mean	Min	Max	Std Dev	N	Mean	Min	Max
Fresh	<0.5	42[a]	1	213	76	8	2	0.1	12
Oligohaline	0.5-5	179[ab]	5	539	243	4	10	0.3	31
Mesohaline	5-18	16[bc]	3	32	11	8	0.9	0.2	2
Polyhaline	>18	1[c]	0.2	6	2	10	0.1	0.0	0.3

*Calculated based on a methane global warming potential of 21 (100-year time horizon).

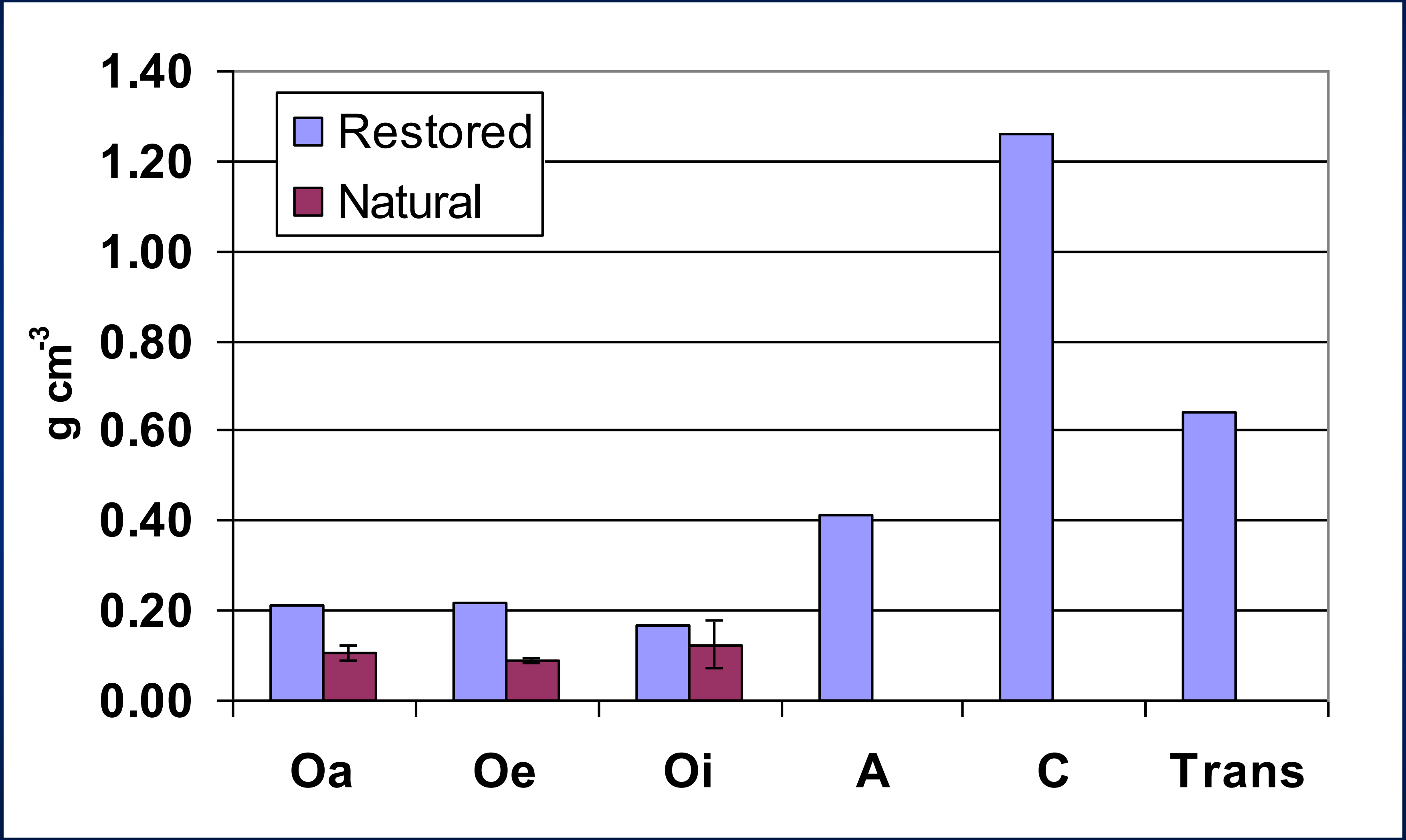
Hoffenbarger, Needelman & Megonigal, Wetlands, 2011

Mean Carbon Concentration



Wills, S.A., B.A. Needelman, and R.W. Weil. Carbon distribution in restored and reference marshes at Blackwater National Wildlife Refuge. Archives of Agronomy and Soil Science. (In press)

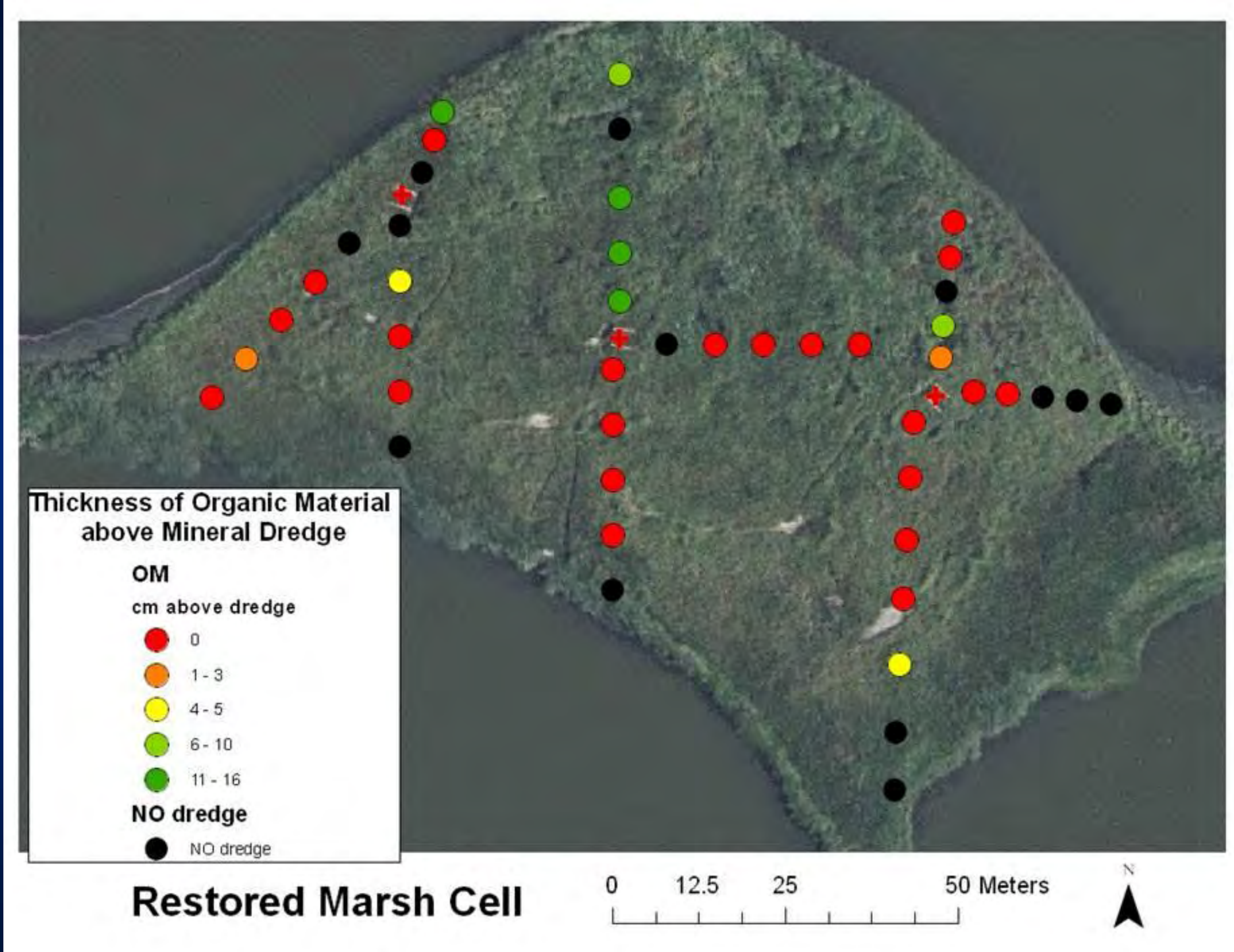
Bulk Density

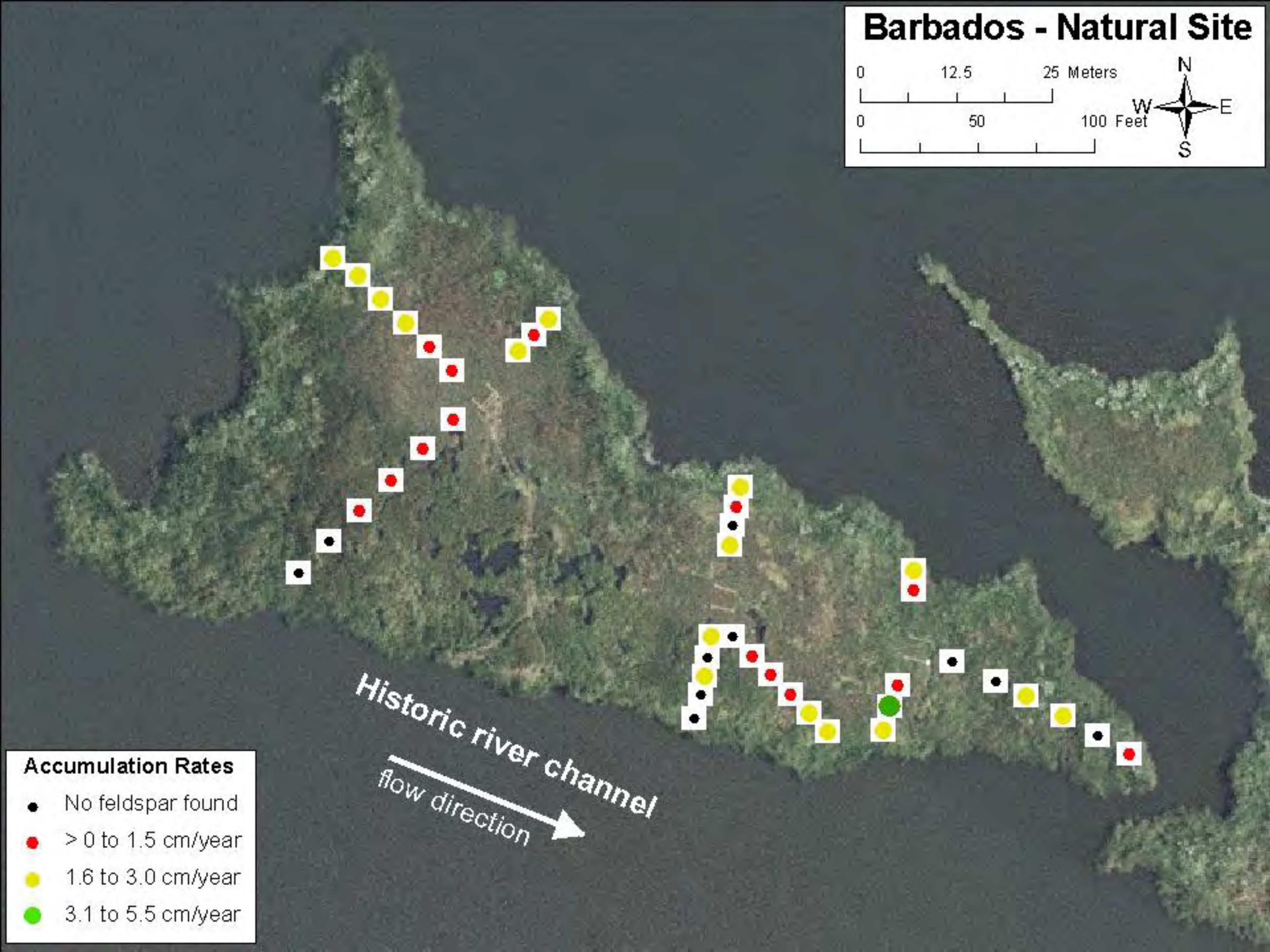


Organic ("O") horizons

Mineral organic-rich ("A") horizons

Mineral organic-poor ("C") horizons


Thickness of Organic Material above Mineral Dredge
OM
cm above dredge
0
1 - 3
4 - 5
6 - 10
11 - 16
NO dredge
NO dredge
Restored Marsh Cell
0
12.5
25
50 Meters
N

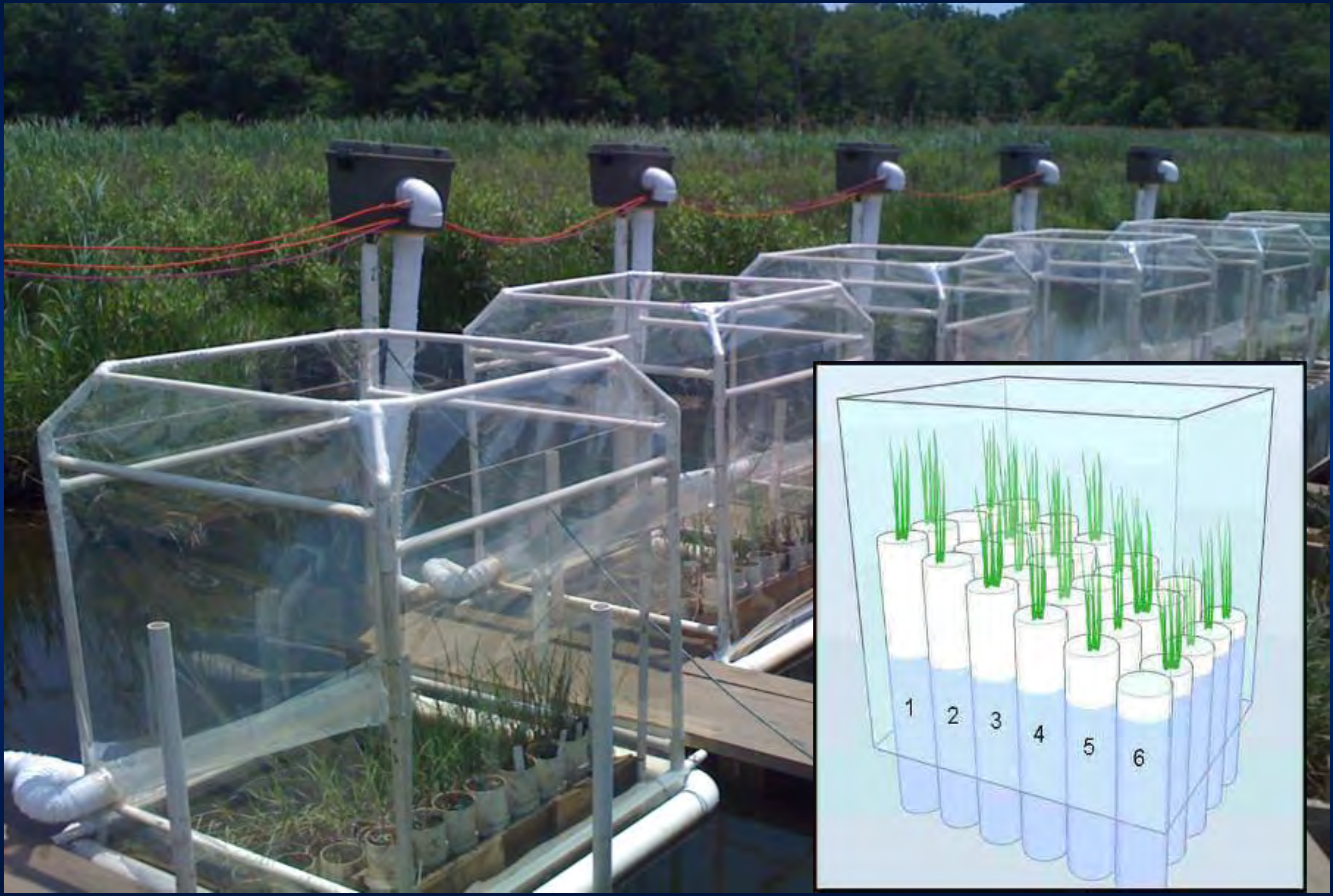

Barbados - Natural Site
0 12.5 25 Meters
0 50 100 Feet
N
W
E
S
Historic river channel
flow direction
Accumulation Rates
No feldspar found
> 0 to 1.5 cm/year
1.6 to 3.0 cm/year
3.1 to 5.5 cm/year

Wildlife habitat

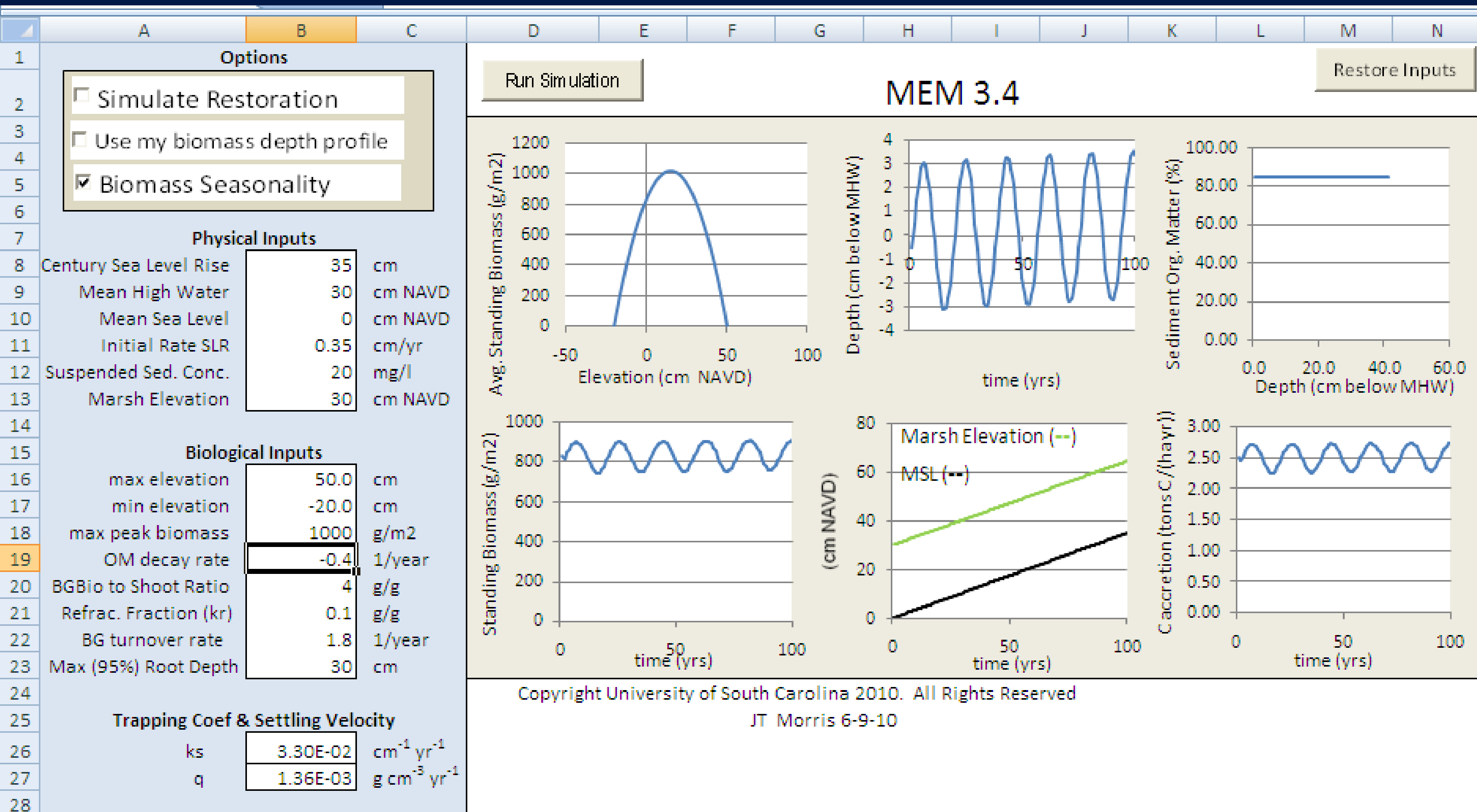
Wildland-urban interface

Stimulate the marsh

SERC Global Change Research Wetland Marsh Organ Facility



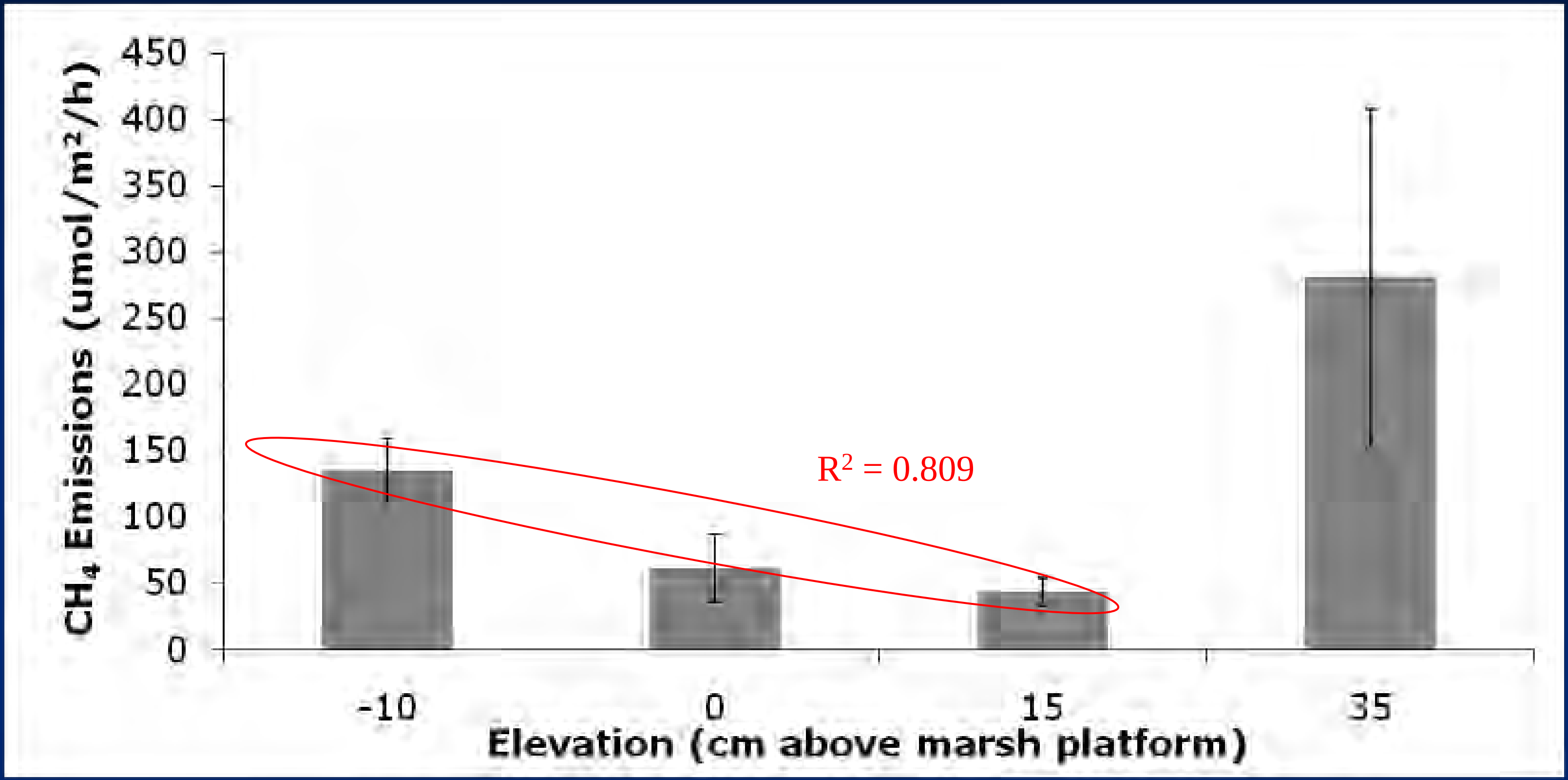
Marsh Equilibrium Model (MEM)



Morris, in preparation

Measuring methane emissions

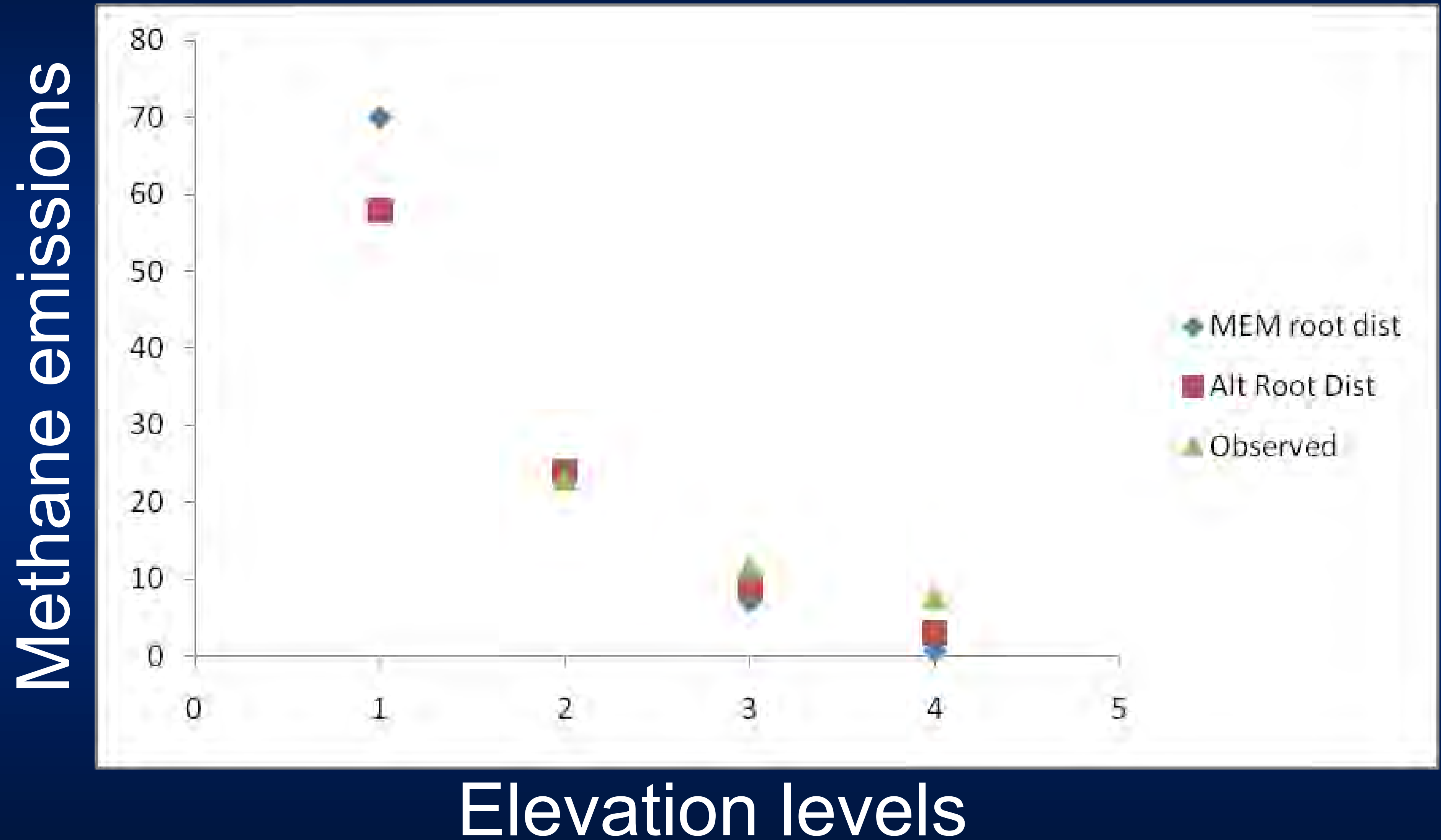
Methane Emissions from Marsh Organ Experiments



wet ← rising sea level ← dry

- *Spartina patens & Schoenoplectus americanus* Community
- Elevated CO_2 and N Fertilized Treatments Pooled

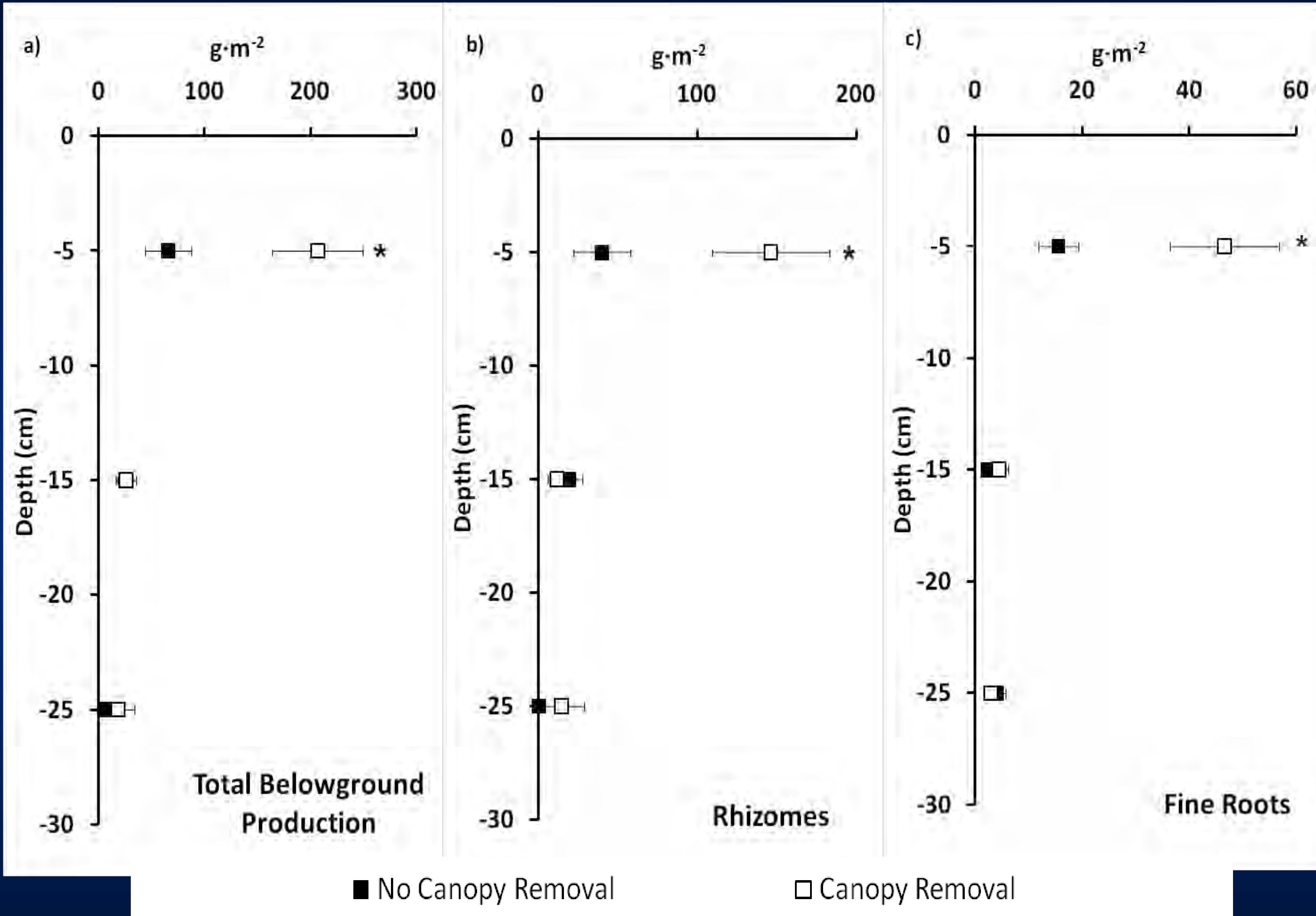
Marsh Equilibrium Model -- Methane (MEM-M)



Megonigal, unpublished

Restoration opportunities: Agriculture to wetland conversion

Restoration opportunities: Facilitated migration



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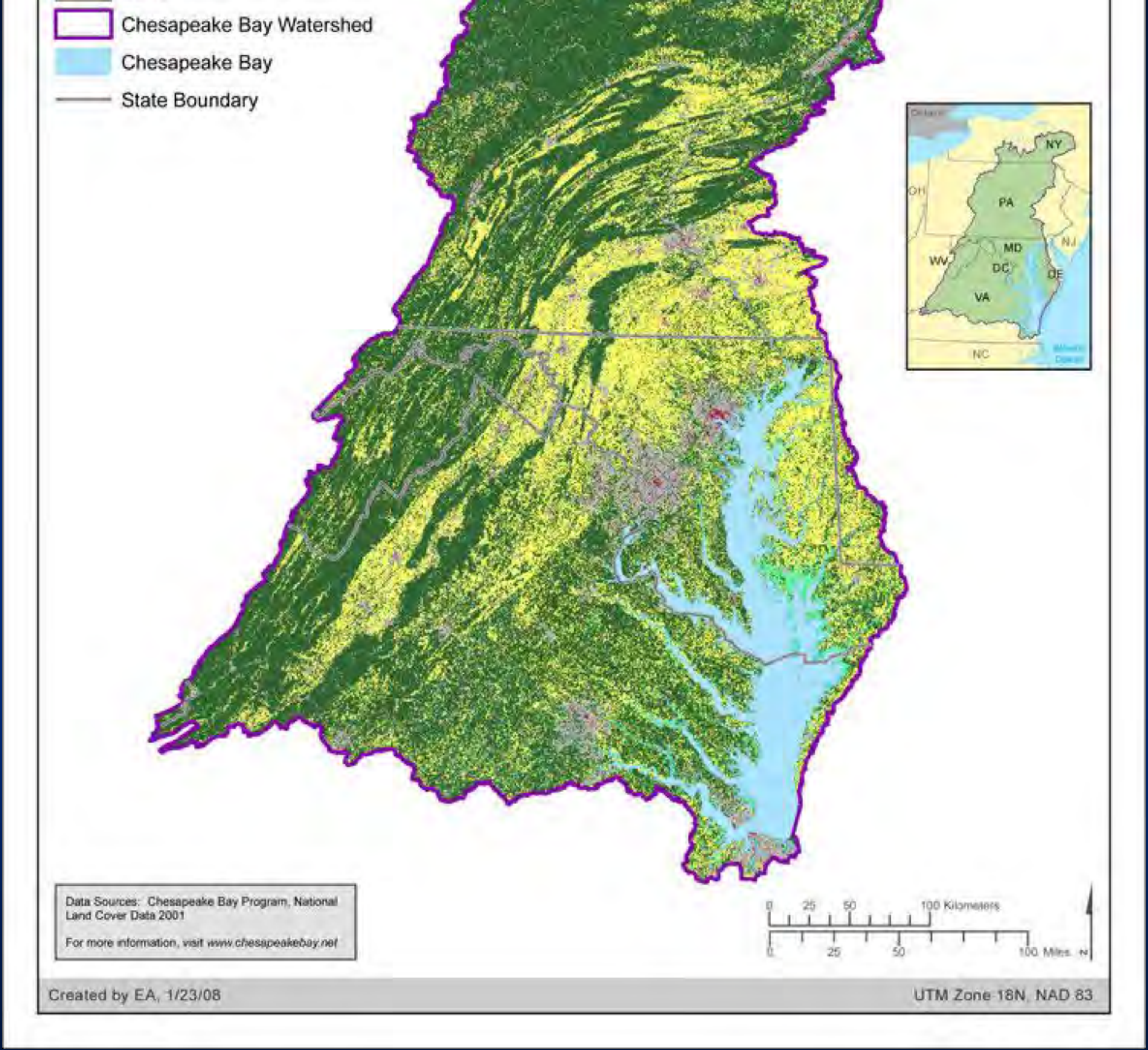
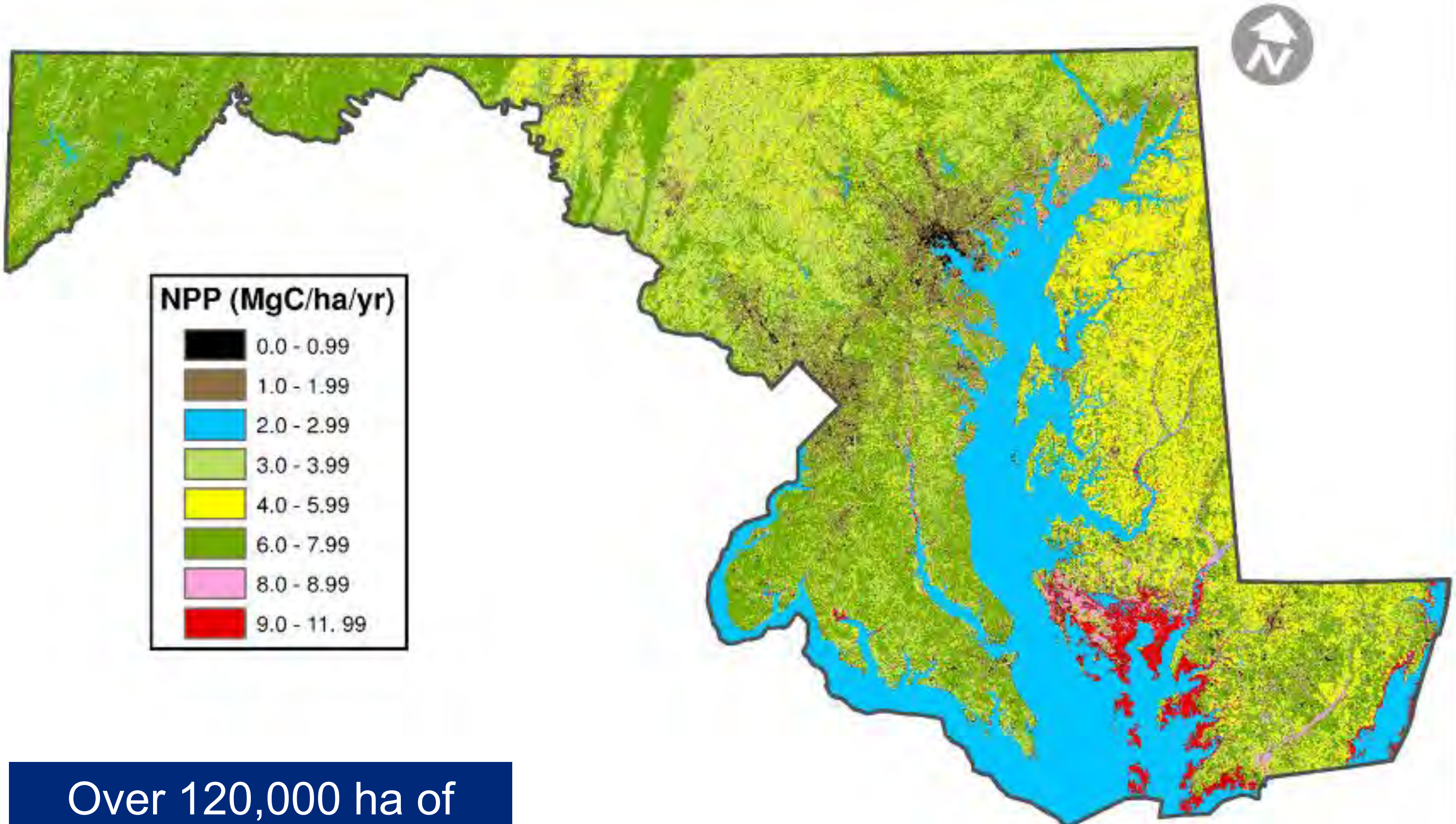


Chesapeake Bay Watershed
Chesapeake Bay
State Boundary
NY
PA
OH
NJ
MD
WV
DC
DE
VA
NC
Data Sources: Chesapeake Bay Program, National Land Cover Data 2001
For more information, visit www.chesapeakebay.net
0 25 50 100 Kilometers
0 25 50 100 Miles
N
Created by EA, 1/23/08
UTM Zone 18N, NAD 83

ha of
nds in
l

Maryland Net Primary Productivity estimates based on land use class and literature values



Over 120,000 ha of estuarine wetlands in Maryland

Strebel, 2007

Chapter 5: Mitigating Greenhouse Gases Through Coastal Habitat Restoration

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Janet E. Hawkes
HDI LLC

Chapter citation: Needelman, B.A., and J.E. Hawkes. 2012. Mitigating greenhouse gases through coastal habitat restoration. In: B.A. Needelman, J. Benoit, S. Bosak, and C. Lyons (eds.) Restore-Adapt-Mitigate: Responding to Climate Change Through Coastal Habitat Restoration. Restore America's Estuaries, Washington, DC, pp. 49-57.

Climate change is caused by increasing concentrations of greenhouse gases in the earth's atmosphere. Coastal habitats, like all of the earth's ecosystems, both release and remove greenhouse gases from the atmosphere. The role of coastal habitats and oceans in carbon sequestration has received increased attention since the recent publications of "Blue Carbon: A Rapid Response Assessment" by the United Nations Environment Programme (Nellemann, 2009) and "The Management of Natural Coastal Carbon Sinks" by the International Union for Conservation of Nature (Laffoley and Grimsditch, 2009). Habitat restoration projects will have a net positive or negative effect on greenhouse gases in the atmosphere depending on how they affect the release and removal of greenhouse gases. State, regional, and national greenhouse gas mitigation programs may use restoration projects that cause a net reduction in greenhouse gas concentrations. Restoration projects may also be eligible for funding through carbon credit or carbon offset programs. If a project leads to a net increase in greenhouse gases, however, this effect should be considered against other benefits of restoration.

Background on Greenhouse Gases

The earth's atmosphere provides a critical service of heat retention, acting as a blanket for the earth—without it the world would freeze. Sunlight warms the earth; the earth in turn radiates heat outward. Certain gases in the atmosphere trap most of this radiated heat—this is known as the greenhouse effect. The significant greenhouse gases, in order of decreasing impact, are water vapor, carbon dioxide, methane, ozone, nitrous oxide, and chlorofluorocarbons (CFCs). Human activities have increased the atmospheric concentration of many greenhouse gases, particularly carbon dioxide, methane, ozone, nitrous oxide, and chlorofluorocarbons.

Carbon dioxide (CO_2)

The carbon dioxide concentration in the atmosphere has risen from about 280 ppm (parts per million) prior to the industrial revolution to a current level above 390 ppm, an increase due largely to emissions from the burning of fossil fuels and from deforestation. The Intergovernmental Panel on Climate Change (IPCC) has estimated that the concentration of carbon dioxide will rise to between 450 and 1000 ppm over the next century (IPCC, 2007).

In a process called the carbon cycle, there is a constant exchange of carbon atoms present within carbon dioxide (CO_2) and carbon atoms in the inorganic and organic matter on the earth's surface. The quantity of carbon dioxide in the atmosphere represents a tiny percentage of the total carbon on earth; it is highly sensitive to changes in the larger, earth-bound

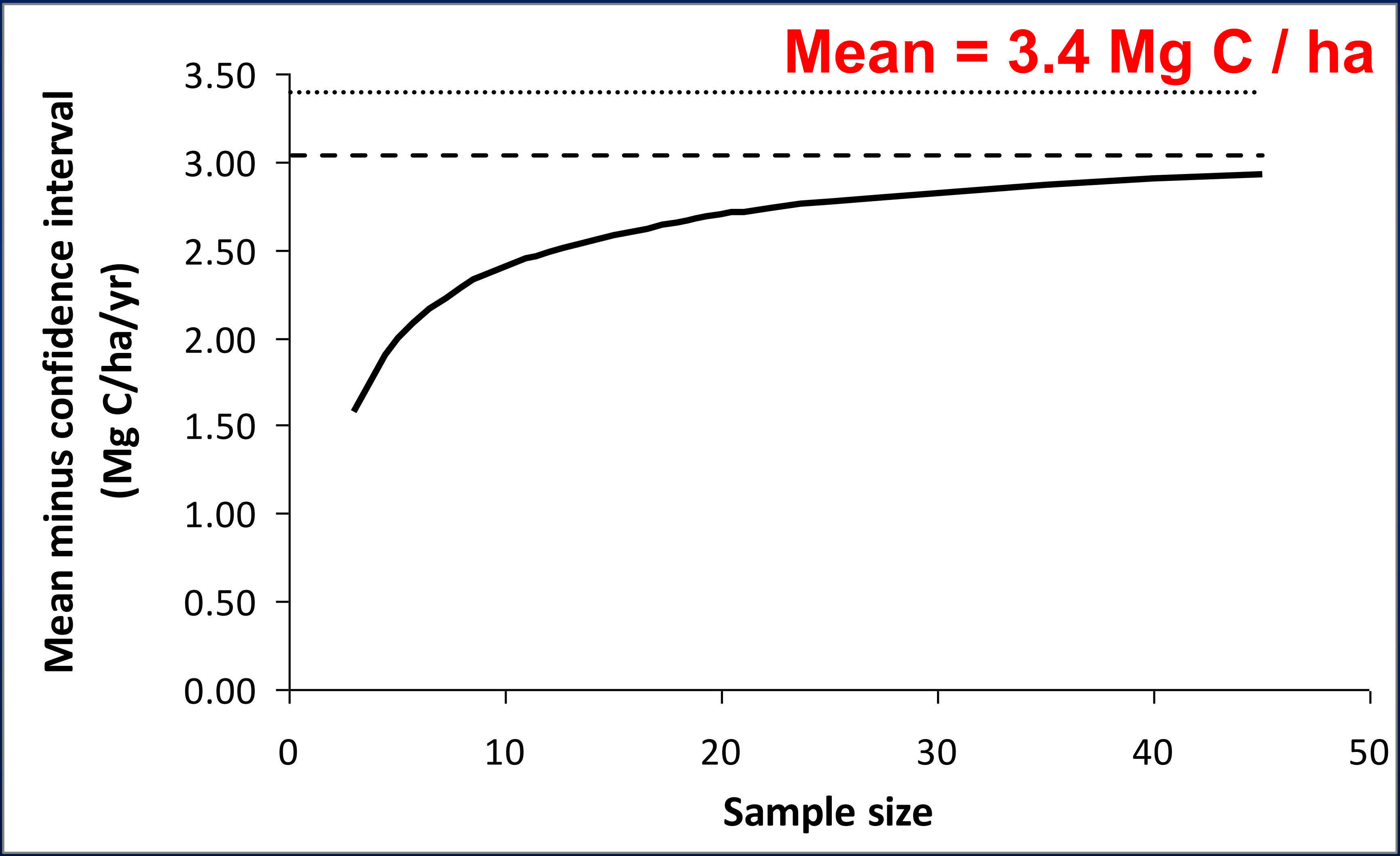
Restore-Adapt-Mitigate: Responding to Climate Change through Coastal Habitat Restoration

Download at http://www.estuaries.org/reports/

Marsh Loss at the Blackwater National Wildlife Refuge

- Drowned river valley, wind-driven microtidal
- Sediment-starved
- Brackish

Conservative quantification for carbon crediting



Cost-realistic, statistical estimation of carbon sequestration rates

- Traditional radionuclide methods often not applicable
  - Expensive
  - Don’t represent post-restoration rates
  - Limited spatial replication
- Challenges
  - Cost
  - Sampling depth
  - Spatial variability