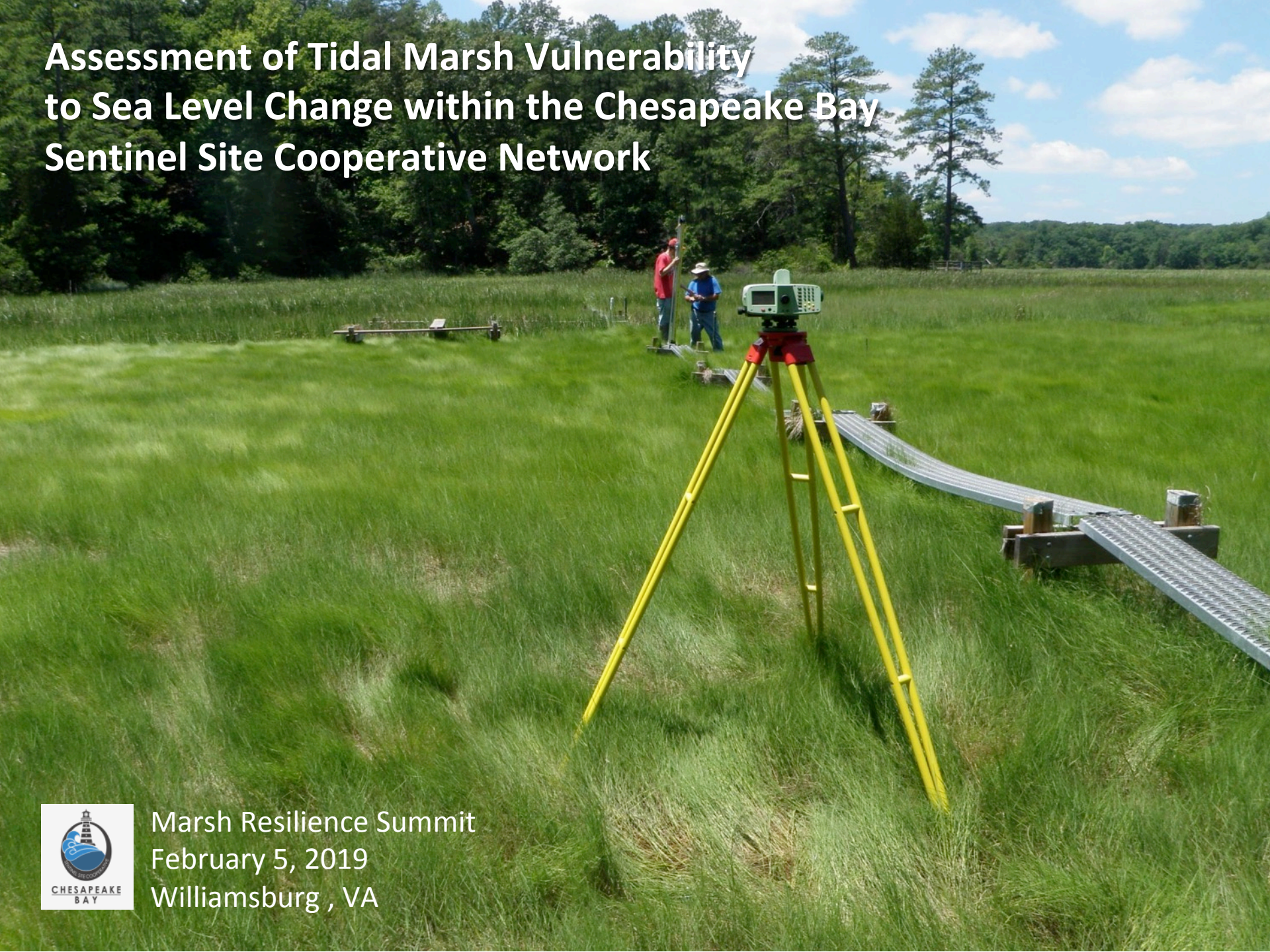
Assessment of Tidal Marsh Vulnerability to Sea Level Change within the Chesapeake Bay Sentinel Site Cooperative Network



Marsh Resilience Summit
February 5, 2019
Williamsburg , VA

CBSSC Network Data Contributors

- **Maryland Sea Grant**
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- **NOAA National Geodetic Survey**
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CHESAPEAKE BAY

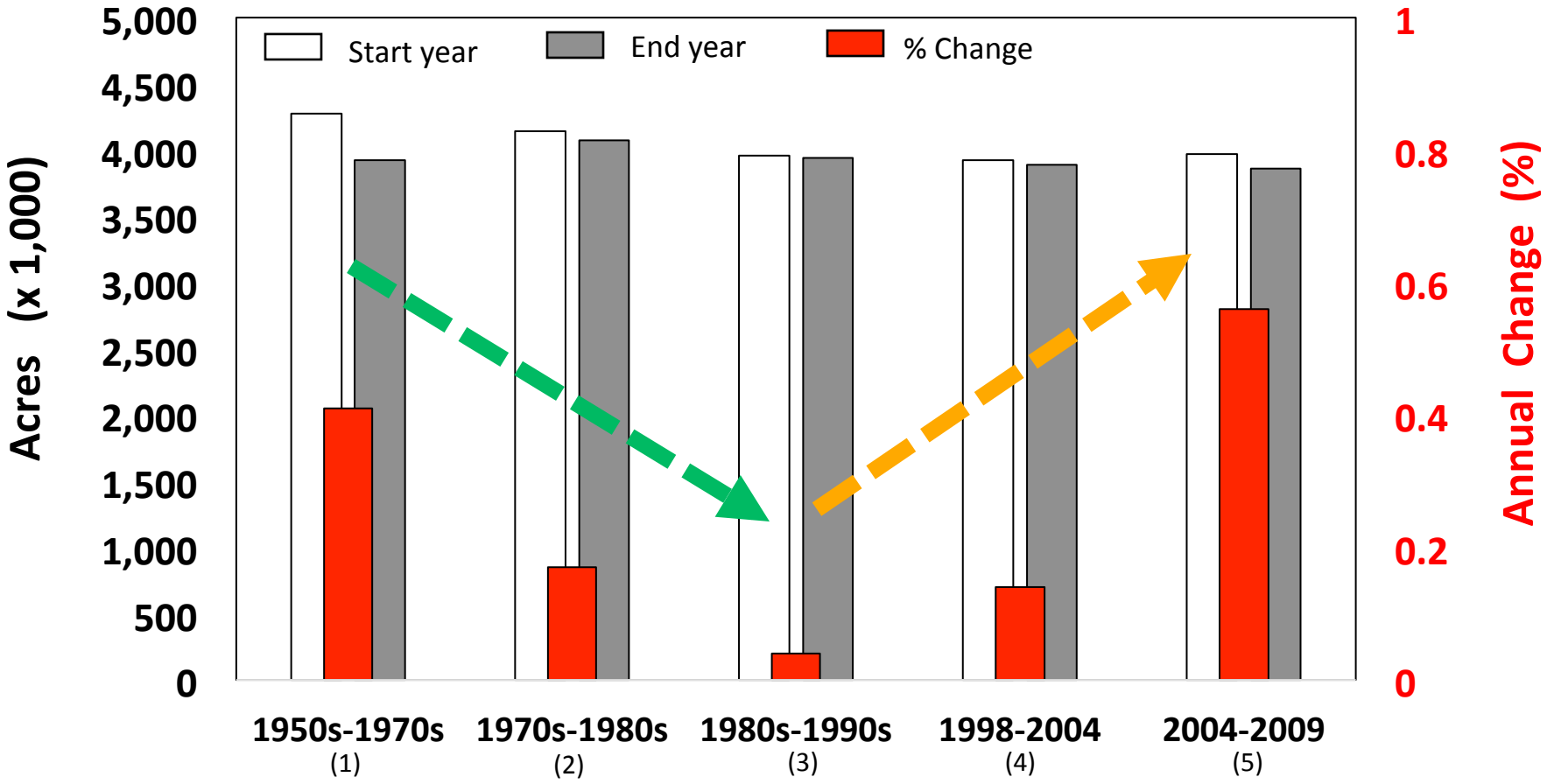
Presentation Overview

- Cooperative Assets and Capabilities
- Background and Sentinel Site Concept
- Vertical Marsh Movement - SET
- Lateral Marsh Movement – DSAS and Slope

Conterminous United States – Estuarine Emergent Wetlands: Status and Change

Hydrology modifications and land conversion slowed due to Wetlands Protection Regulations (Clean Water Act 1977, Sec. 404)

More Indirect Human Activity
No Net Loss Policy (1st adopted by Bush in 1989)



Data Sources: (1) Frayer et al. 1983, (2) Dahl and Johnson 1991, (3) Dahl 2000, (4) Dahl 2006, (5) Dahl 2011, (6) Dahl and Stedman 2013.

(6) **Atlantic (0.1%)**
Gulf (1.0%)
Pacific (0.0%)

A Roadmap to Developing Adaptation Strategies

- Species
- Habitats
- Ecosystems

1. Identify Targets

2. Assess Vulnerability

Monitor
Review
Revise

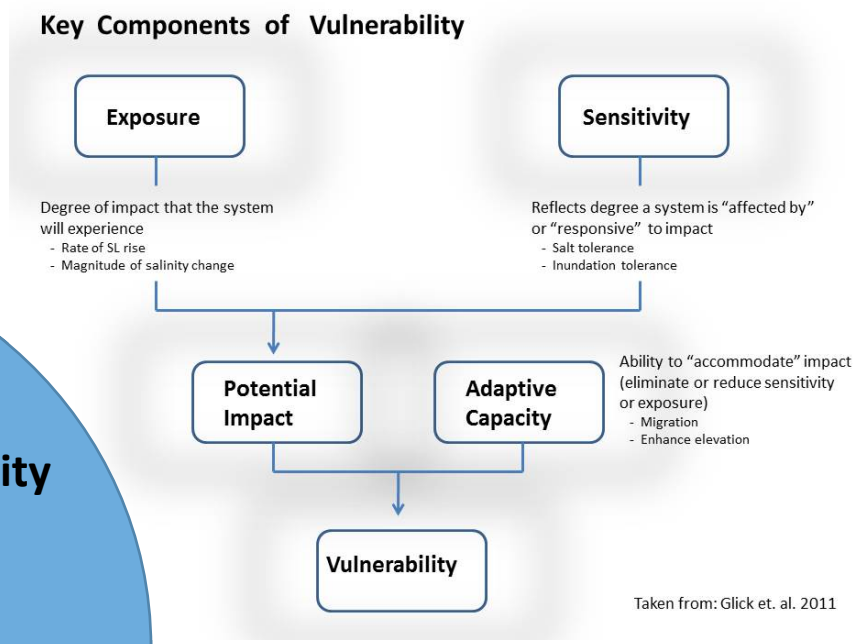
3. Identify Options

- ↓ Sensitivity
- ↓ Exposure
- ↑ Adaptive Capacity

4. Implement Options

- △ Policies
- △ Practices
- Institutional △

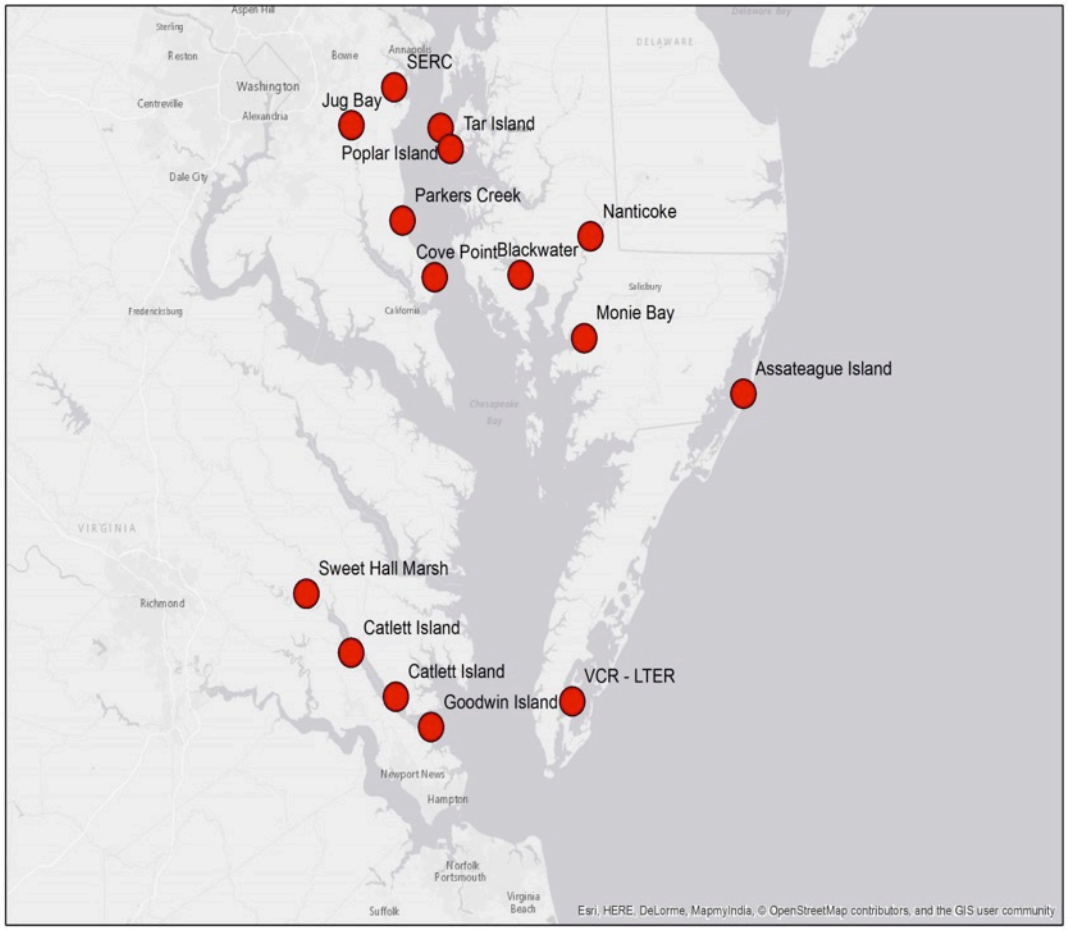
Adapted from: Glick et. al. 2011



Sentinel Site – Defined

Sentinel Site Criteria

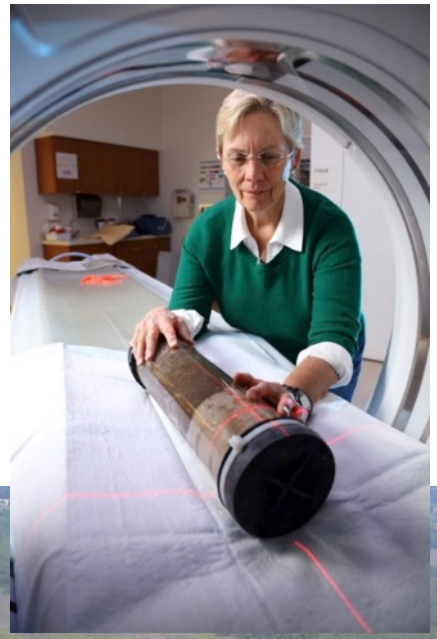
- **Managed area that is representative of regional ecosystem types;**
- **Operational capacity for intensive and sustained study** (high-frequency and multivariate measures; historical data record);
- **Physical, chemical and biological monitoring referenced to accurate geospatial infrastructure;**
- **Network or subset of network must encounter the stressor of interest and be responsive to that stressor;**
- **Monitoring leads to an understanding of the nature of variability and underlying forces;**

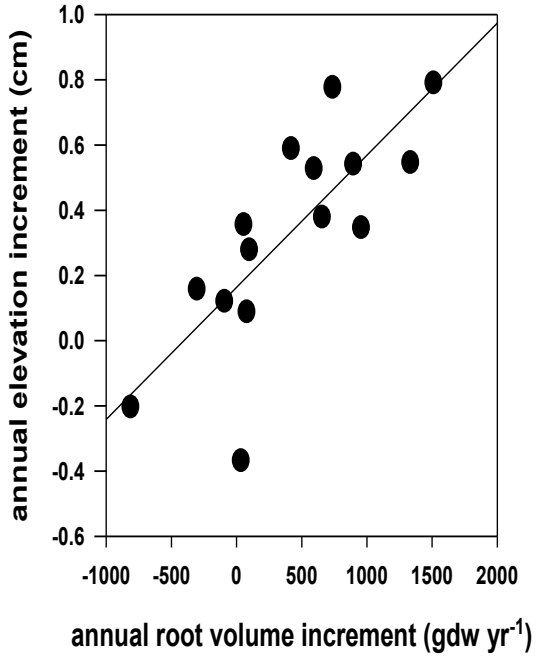


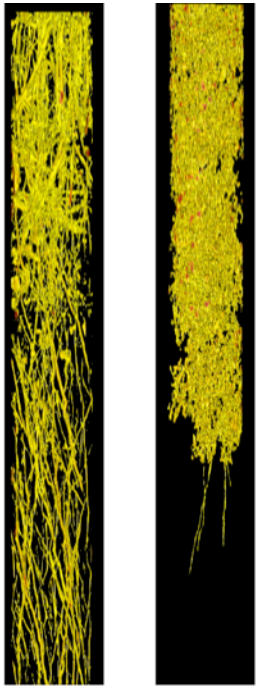
- **Detection of change or trends should be possible** (heightened sensitivity to stressors and/or low background variability); and
- **Be of a size that is practical for testing adaptive management approaches and for education and outreach.**

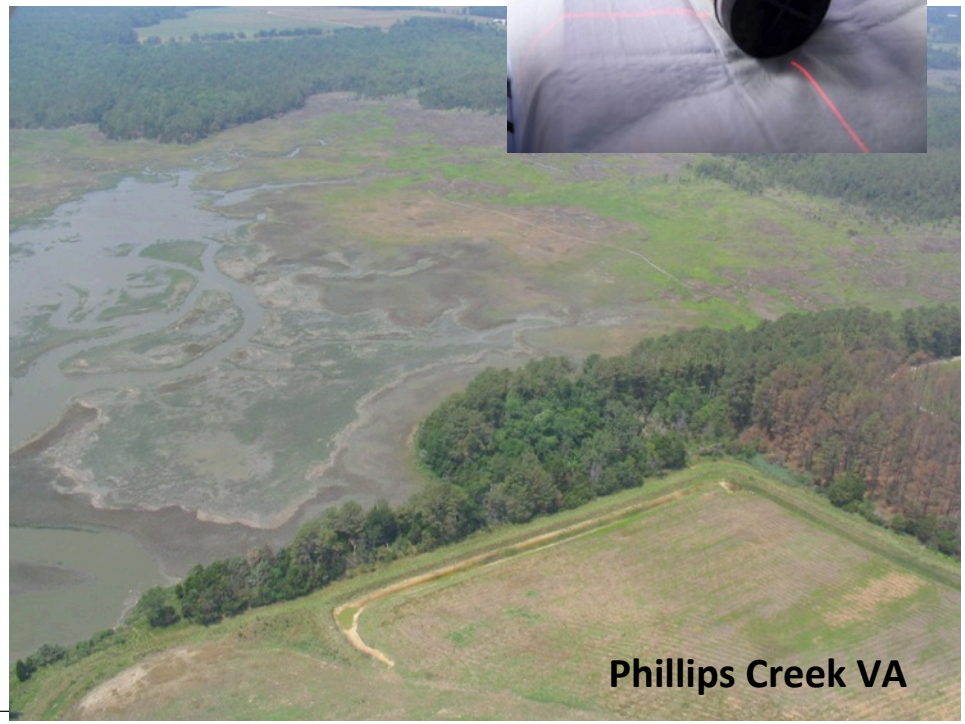
CBSSC Network Capacity – Soil Processes

- Soil and plant processes facilitating marsh migration into forest and agricultural lands.
- Sediment and organic matter contributions to marsh surface elevation change.



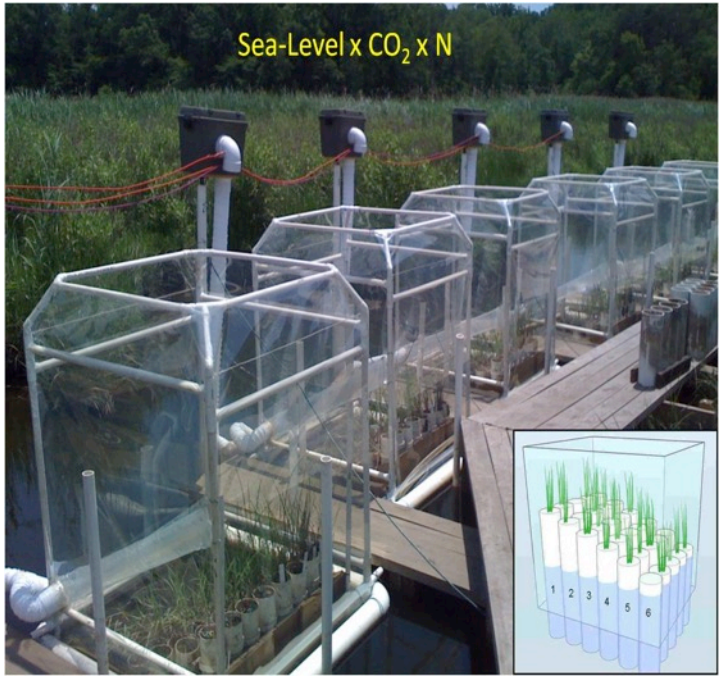


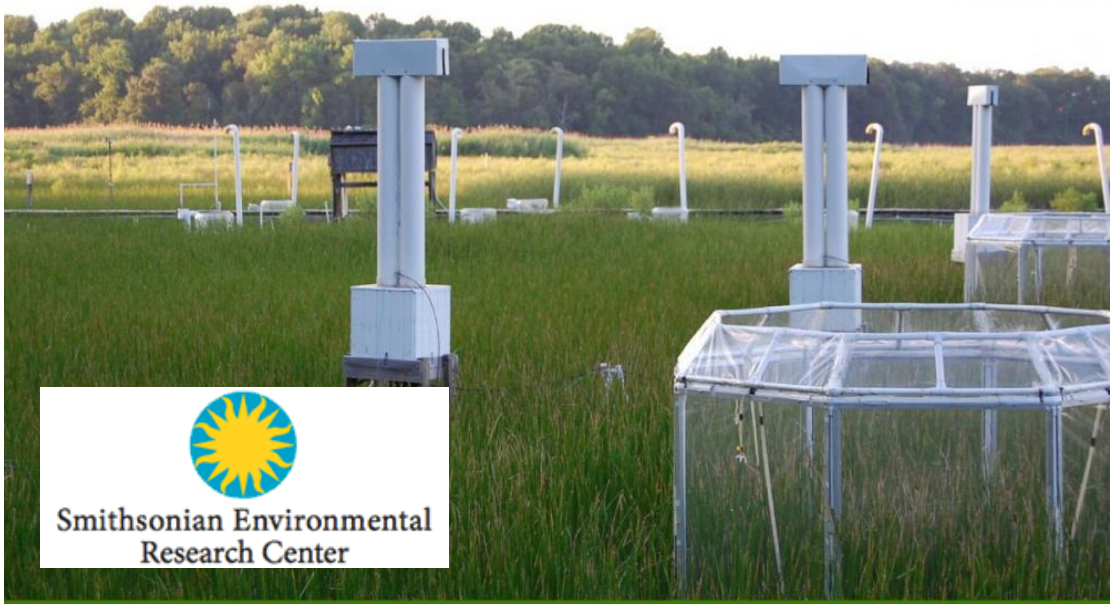




CBSSC Network Capacity – Climate Experimentation

- Marsh elevation response to manipulated levels of temperature, CO_2, nutrients, and sea level.
- Forecast invasion rates of *Phragmites* in response to global change factors - elevated CO_2 and nutrient loadings.





CBSSC Network Capacity – Numerical Modeling

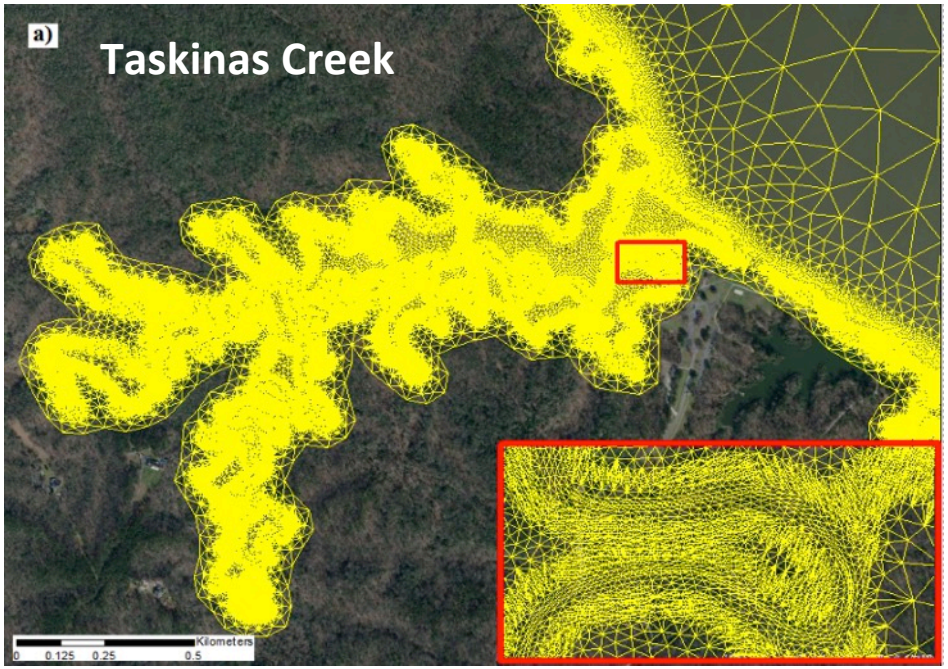
VIMS | William & Mary
Virginia Institute of Marine Science

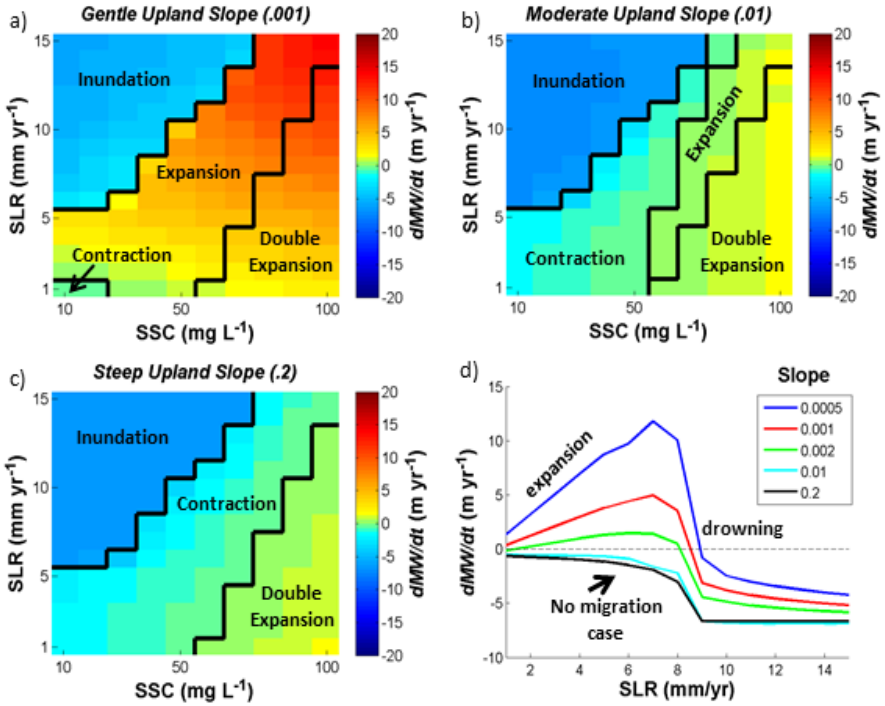
- Coupled Geomorphic & Ecological Marsh Evolution Model

M. Kirwan et al. 2016. Geophys. Res. Lett., 43, doi: 10.1002/2016GL068507.

- SCHISM based Tidal Marsh Model

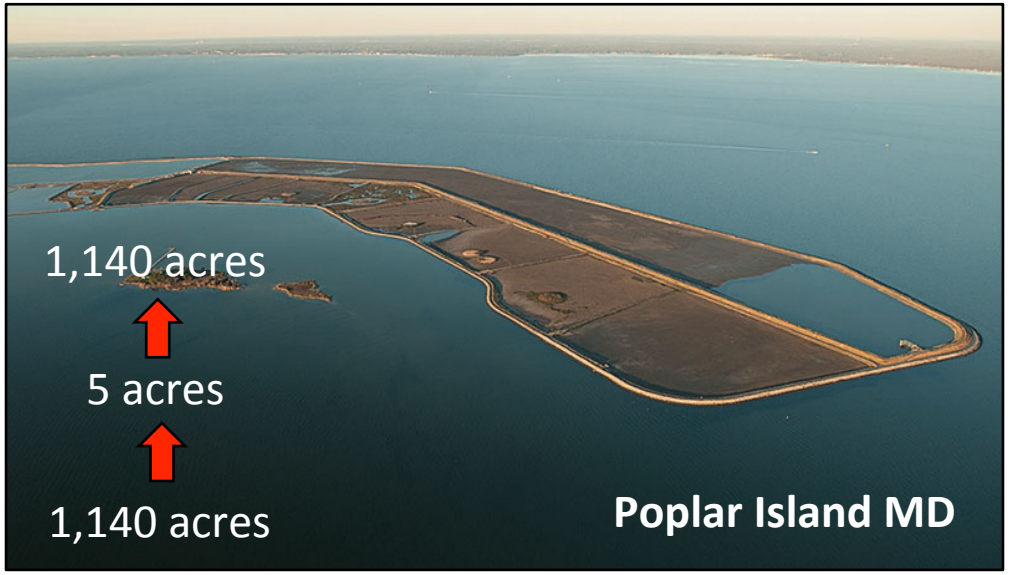
K. Nunez et al. 2019. Submitted Estuaries and Coasts





CBSSC Network Capacity – Restoration Approaches

- Effectiveness of planting methods (grid vs group) in varying soil types.
- Impacts of initial elevation, vegetation type and proximity to tidal inlets on marsh surface elevation dynamics.



CBSSC Network Capacity – Elevation Change

Chesapeake Bay National Estuarine Research Reserve Maryland

- Spatial, seasonal and episodic event influences on marsh elevation dynamics.
- Vegetation responses to changing trends in groundwater salinity.

National MARS Analysis

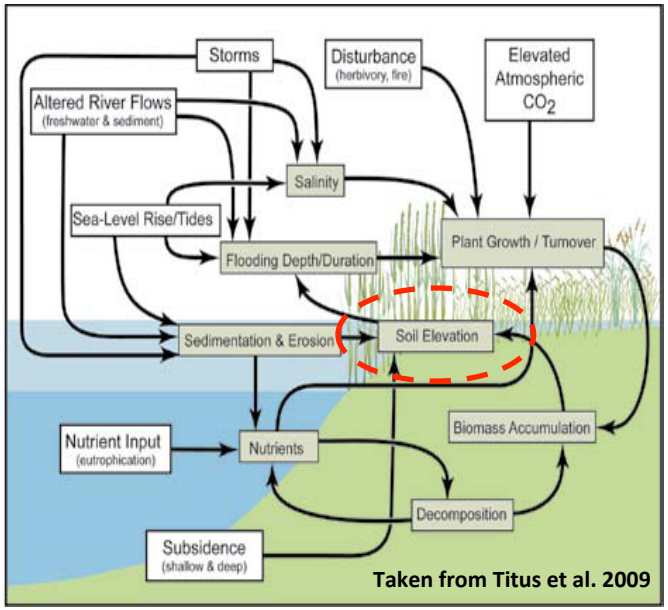
MArsh **R**esiliency to **S**ea level Indices (MARS) Raposa et al. 2016.

Site	Marsh Elevation	Elevation Change	Sediment Accretion	Tidal Range	Sea-level Rise		MARS Risk	MARS Average	MARS Ratio
Great Bay NH	4.3	4.0	3.0	5.0	4.0		5	4.1	2.4
Waquoit Bay MA	3.0	1.0	1.0	1.0	2.0		1	1.6	0.6
Narragansett Bay RI	3.3	1.0	1.3	1.0	2.0		1	1.7	0.7
Hudson River NY	3.7	5.0	4.3	3.0	1.5		4	3.5	4.8
Delaware DE	4.3	4.0	5.0	3.0	1.5		4	3.6	1.2
Chesapeake Bay MD	4.7	2.0	4.0	2.0	1.0		2	2.7	0.7
Chesapeake Bay VA	4.0	5.0	3.0	2.0	1.0		3	3.1	1.1
VCR/LTER VA	3.2	3.7	2.7	2.0	2.0		2	2.9	1.0
North Carolina NC	3.0	1.0	2.0	2.0	3.5		2	2.3	-.09
NI-WB SC	3.3	2.0	2.0	3.0	3.0		3	2.7	0.8
ACE Basin SC	3.0	1.0	3.0	4.0	3.0		4	2.8	0.6
Grand Bay MS	3.3	4.0	1.5	1.0	3.0		3	2.6	1.3
Padilla Bay WA	2.3	N/A	2.5	5.0	4.0		2	3.5	N/A
South Slough OR	4.3	1.0	1.3	4.0	5.0		3	3.1	-0.2
San Francisco Bay CA	4.3	3.0	3.7	3.0	4.0		5	3.6	2.0
Elkhorn Slough CA	3.0	1.0	3.0	3.0	4.5		4	2.9	0.5
Tijuana River CA	3.3	5.0	3.5	2.0	3.5		4	3.5	2.9

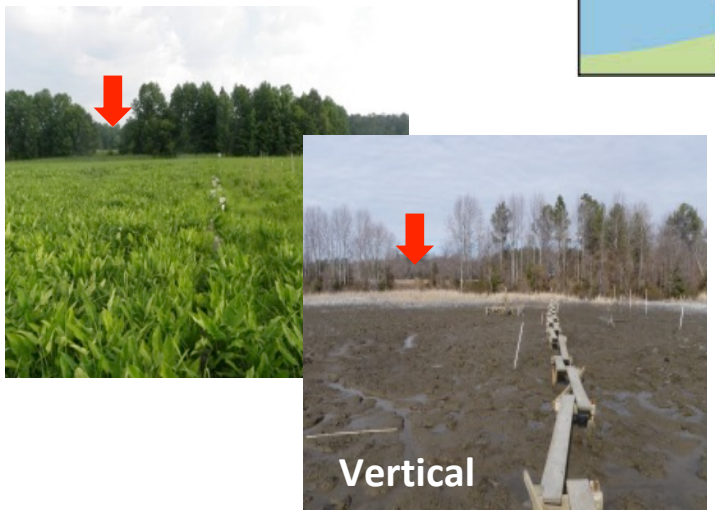
Marshes on the Move

(-) Erosion

(±) Vertical Maintenance



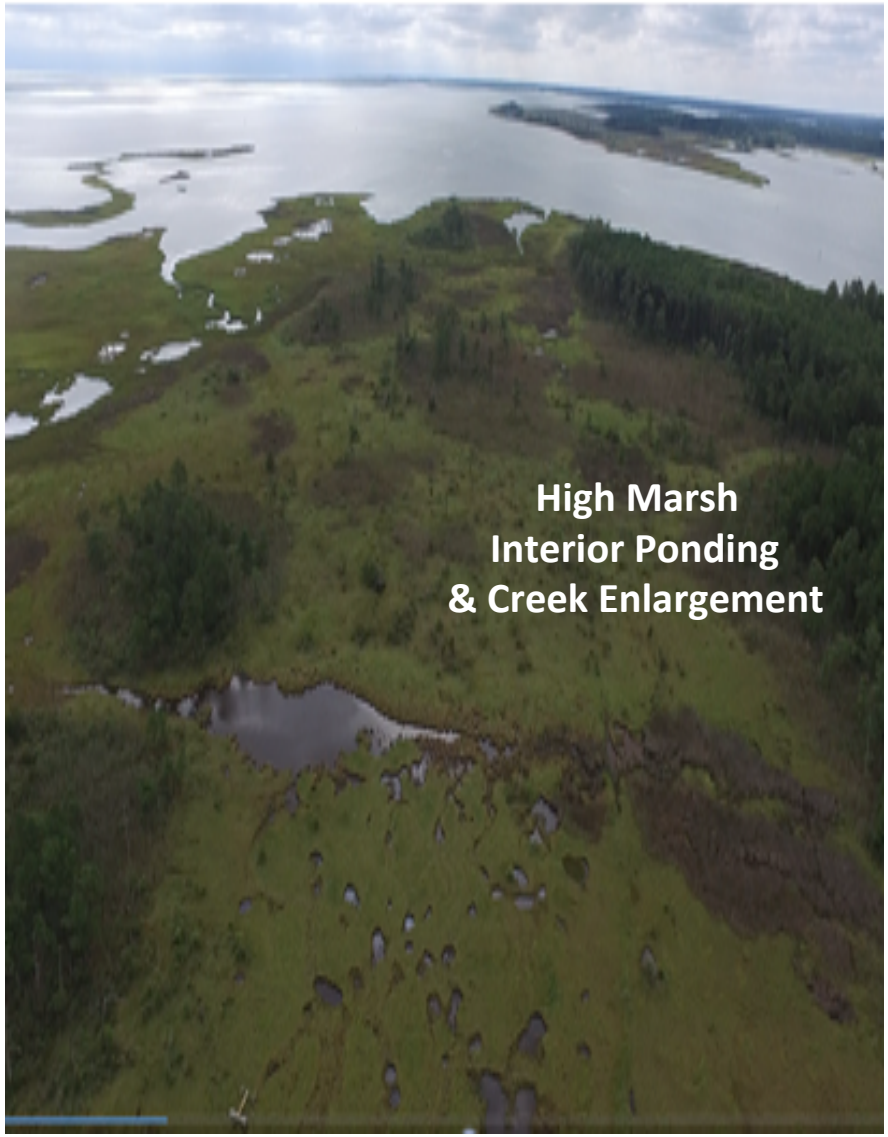
(+) Upland Transgression

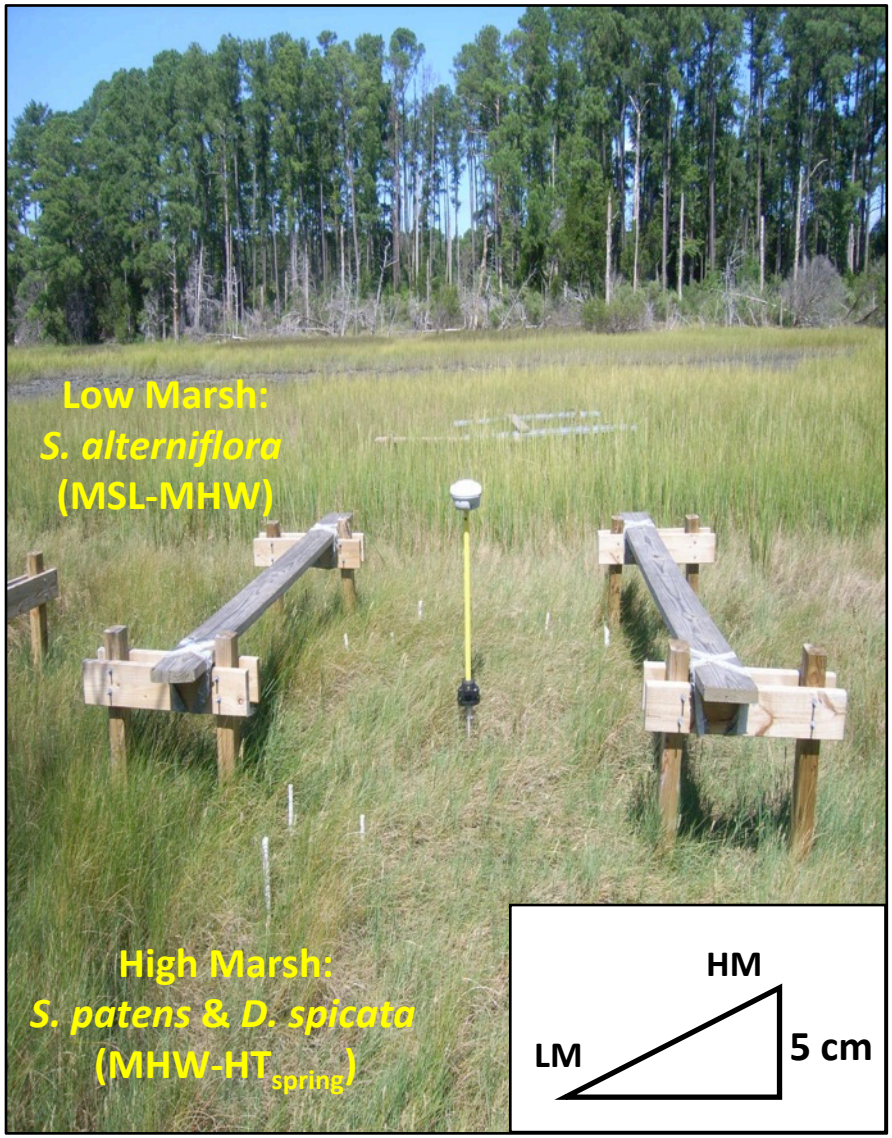


Environmental Drivers

Accretion Processes

Low and High Marsh – Vertical Accretion





Sediment Elevation Table – Just the Basics

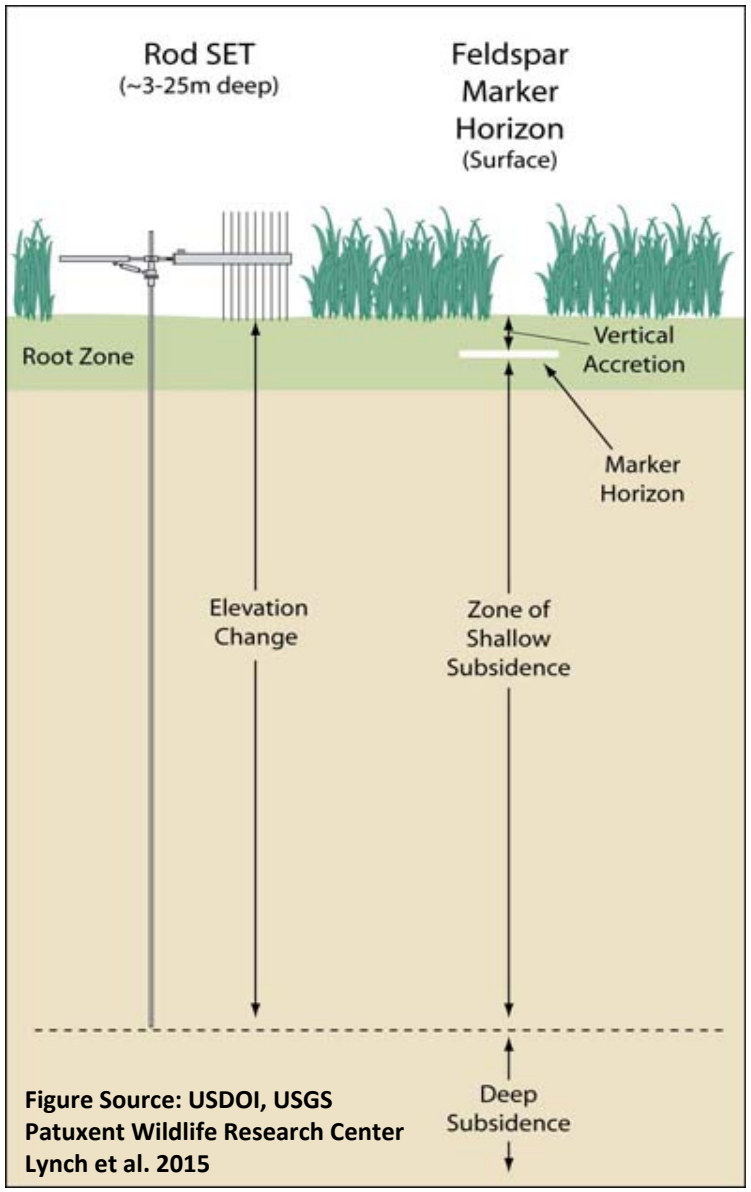
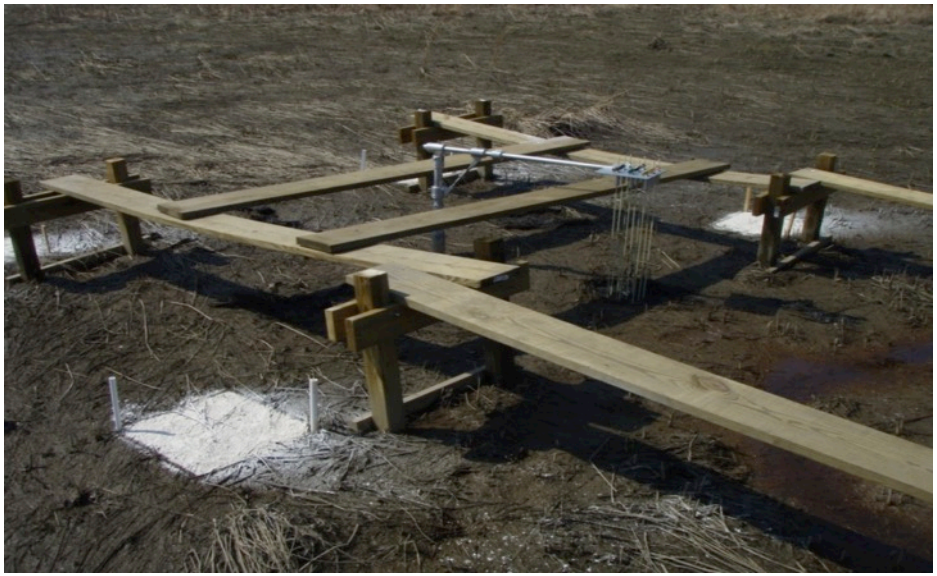
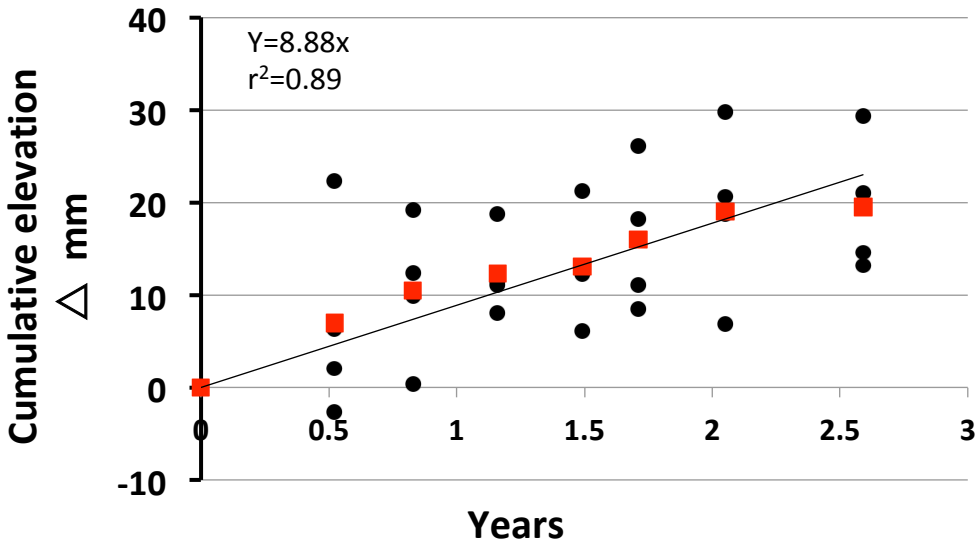


Figure Source: USDOI, USGS
Patuxent Wildlife Research Center
Lynch et al. 2015

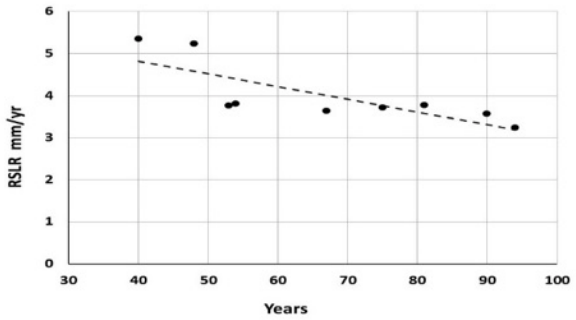




METHODS: RSLR RATES

- **Historical RSLR Rates**

- Source: NWLON reported RSL trends
- Nearest 3 Neighbors
- Range 3.5 to 4.6 mm/yr

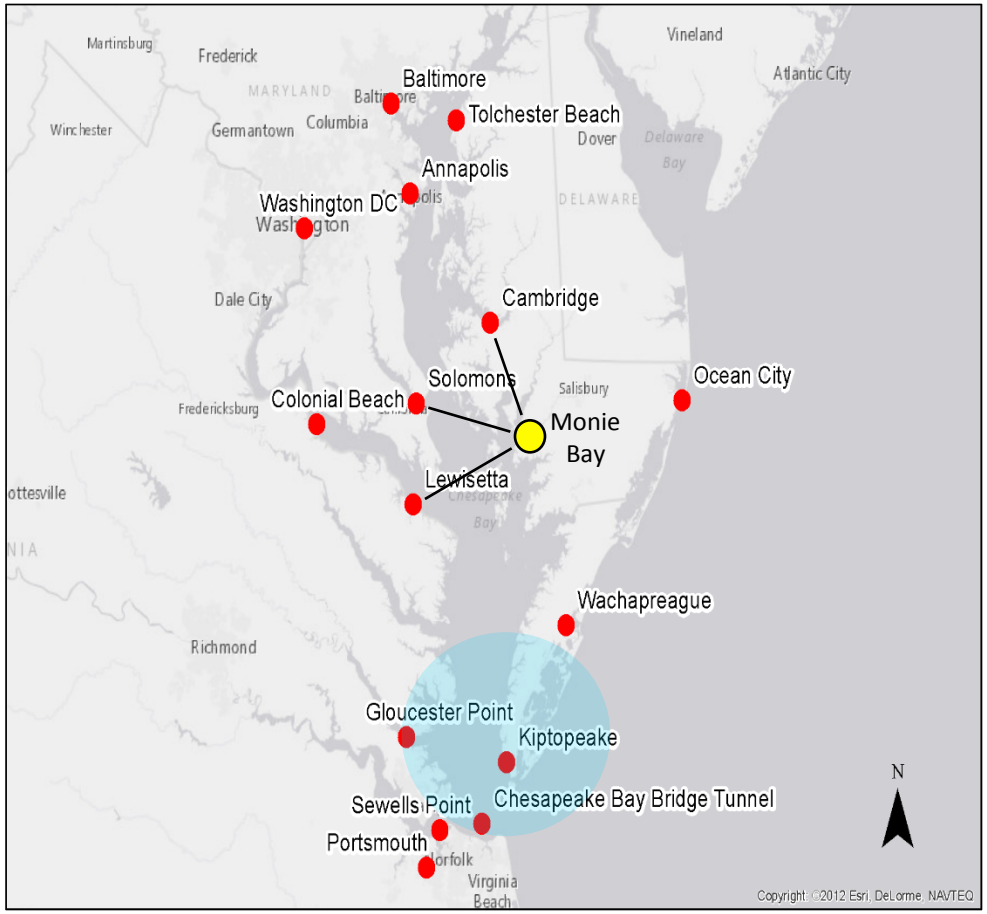


- **Current RSLR Rates**

- USCOE Sea Level Rise Calculator
- 2006 NOAA RSLR slopes, adj. for recent IPCC/NRC projections (intermediate curve RCP4.5) and local subsidence.
- Range 3.7 to 5.8 mm/yr

- **2050 RSLR Rates**

- Source: Boesch et al. 2018 (SLR Projection for MD; RCP4.5)
- Range 7.3 to 8.2 mm/yr



Vertical Elevation Change – Salt Marshes

Site (L/H: Low/High Marsh, N)	Median SET Slope mm/yr	RSLR Rate (mm/yr) Historic	Current	2050	(SET Slope – RSLR) (mm/yr) Historic	Current	2050
Prospect Bay MD (L,2)	11.9	3.2	4.0	7.3	8.7	7.9	4.6
Poplar Island 3D MD (L,6)	7.0	3.7	4.2	7.3	3.3	2.8	-0.3
Poplar Island 1C MD (L,3)	8.6	3.7	4.2	7.3	4.9	4.4	1.3
Tar Island MD (L,3)	3.1	3.7	4.2	7.9	-0.6	-1.1	-4.8
Parkers Creek MD (L,4)	7.9	4.2	4.2	7.3	3.7	3.7	0.6
Cove Point MD (L,2)	3	4.2	4.7	7.3	-1.2	-1.7	-4.3
Monie Bay MD (L,12)	1.9	4.2	4.7	7.9	-2.3	-2.8	-6.0
Phillips Creek VA (L,3)	4.7	4.3	4.9	8.2	0.4	-0.2	-3.5
Goodwin Island VA (L,4)	7.3	4.4	4.7	8.2	2.9	2.6	-0.9
Prospect Bay MD (H,2)	5.2	3.2	4.0	7.3	2.0	1.2	-2.1
Nanticoke River (H,6)	1.6	4.2	4.7	7.9	-2.6	-3.1	-6.3
Monie Bay (H,6)	1.7	4.2	4.7	7.9	-2.5	-3.0	-6.2
Phillips Creek (H,6)	4.1	4.3	4.9	8.2	-0.2	-0.8	-4.1
Goodwin Island (H,6)	2.2	4.4	4.7	8.2	-2.2	-2.5	-6.0

Vertical Elevation Change – Oligohaline and TFW Marshes

Site (L/H: Low/High Marsh, N)	Median SET Slope mm/yr	RSLR Rate (mm/yr) Historic	Current	2050	(SET Slope – RSLR) (mm/yr) Historic	Current	2050
Jug Bay NERR MD (L,6)	-9.8	3.5	4.0	7.3	-13.3	-13.8	-17.1
Sweet Hall Marsh VA (L,4)	7.6	4.7	5.0	8.2	2.9	2.6	-0.6
Jug Bay NERR (H,6)	2.0	3.5	4.0	7.3	-1.5	-2.0	-5.3
Jug Bay USF&WS (H,6)	0.9	3.5	4.0	7.3	-2.6	-3.1	-6.4
Nanticoke River (H,9)	-1.1	4.2	4.7	7.9	-5.3	-5.8	-9.0
Sweet Hall Marsh (H,8)	1.4	4.7	5.0	8.2	-3.3	-3.6	-6.8

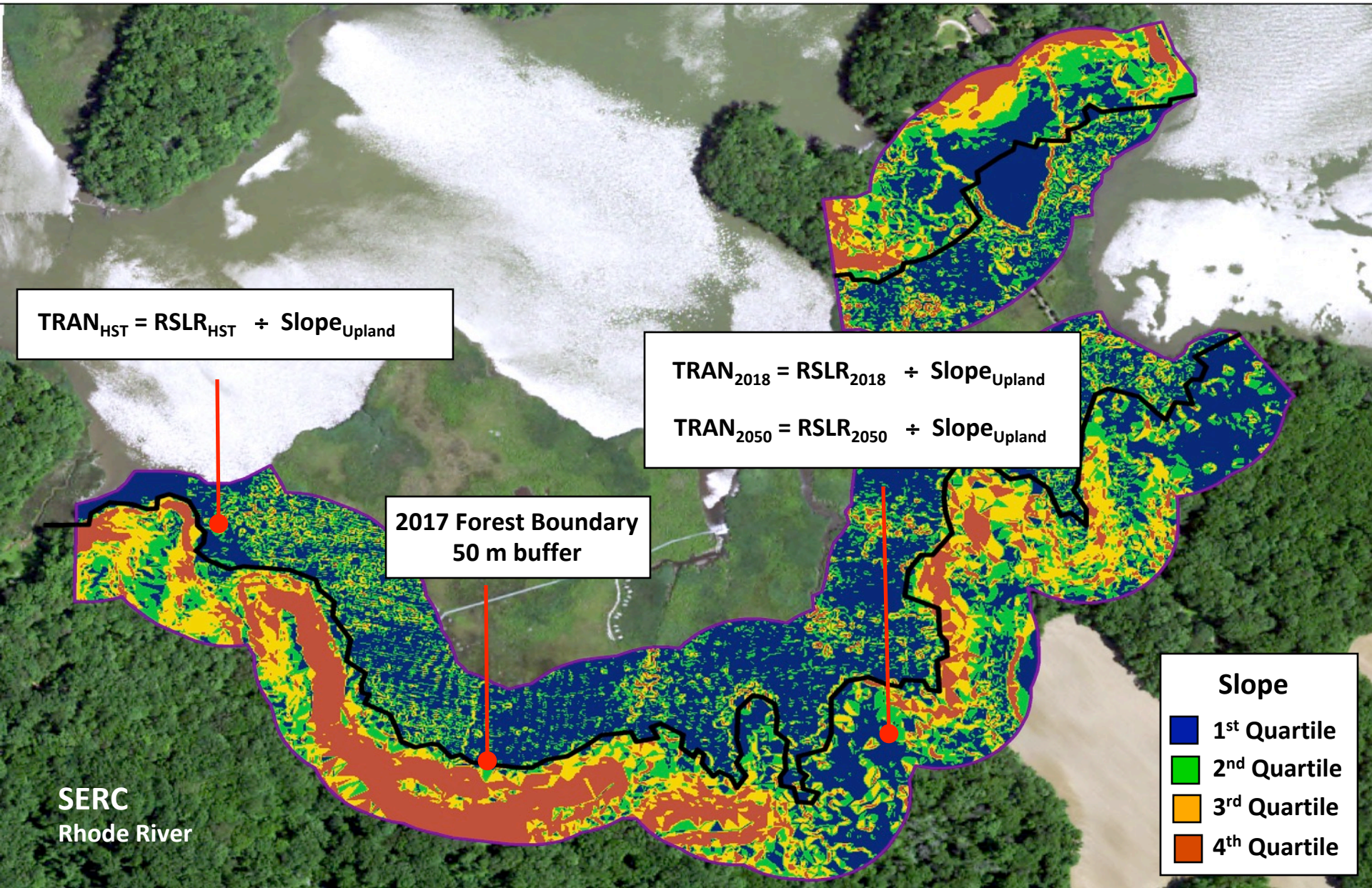
Net Lateral Change – DSAS Methodology

- **Digital Shoreline Analysis System (DSAS; Esri ArcGIS).**
- **10 m spaced perpendicular transects off shoreline and forest-marsh baselines.**
- **Change rates determined as mean transect distance differences between year images.**
- **Imagery: USDA National Agriculture Imagery Program (NAIP): 2004/2016 MD, 2005/2017 VA.**

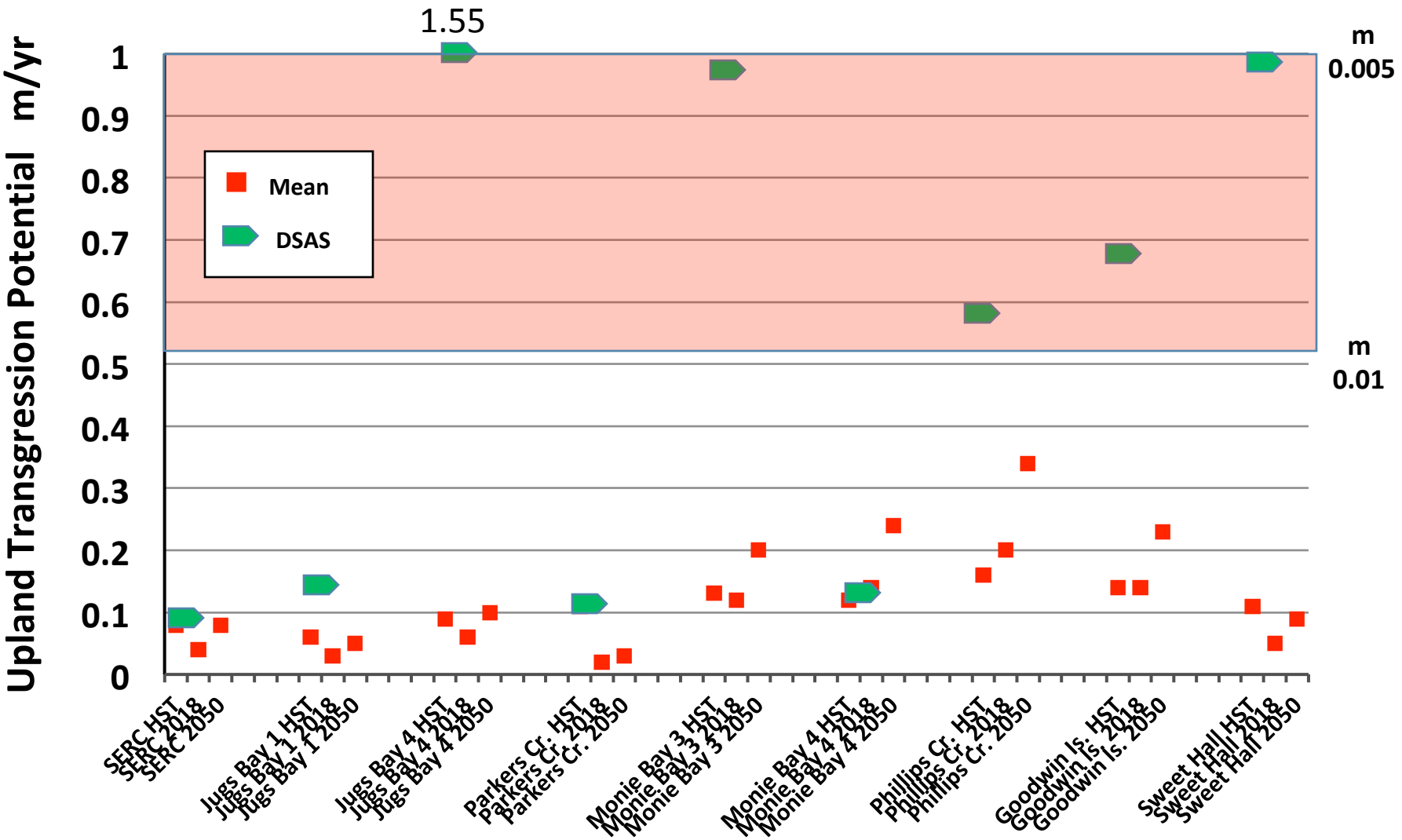
Net Lateral Change – DSAS

Site	Shoreline Erosion m/yr	Forest Retreat m/yr	NET Marsh Change m/yr
SERC, MD	.14	.03	-.11
Jug Bay 1 MD	.02	.10	.08
Jug Bay 4 MD	.12	1.55	1.43
Poplar Island 3D MD	.12		
Poplar Island 1C MD	.24		
Tar Island MD	.25		
Parkers Creek MD	.24	.07	-0.17
Cove Point MD	.50		
Monie Bay 3 MD	.29	.98	.69
Monie Bay 4D MD	.26	.08	-.18
Phillips Creek VA	-.16	.57	73
Sweet Hall Marsh VA	.44	.98	.54
Goodwin Island VA	.35	.67	.32

Marsh Transgression – Slope & RSLR



Marsh Transgression – Slope & RSLR



Presentation Summary

- Regarding Vertical Sediment Surface Elevation Changes:

  - Low TFW and saltmarsh zones have the potential to keep pace with current and 2050 RSLR rates but are vulnerable in regions of low sediment and tide range.

  - High TFW and saltmarsh zones appear vulnerable under current and 2050 RSLR rates.

- Regarding Lateral Marsh Changes:

  - Image based shoreline erosion rates varied between 0.02 and 0.50 m/yr.

  - Image based forest retreat rates varied between -0.02 and 1.55 m/yr.

  - Slope based forest retreat rates were generally reduced as compared to image based results and reflect leverage of elevated slope in buffer zones.

Thank You for Your Interest.

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