Mitigating Marshes Against Sea Level Rise: Thin-Layer Placement Experiment


What do we know already know about marshes?

Ecosystem Services of Coastal Marshes

- Buffering wave energy to protect coastlines
- Trapping sediments and filtering runoff to improve water quality
- Reducing impacts of flooding
- Recreational opportunities
- Fish nursery areas and wildlife habitat

Zonation

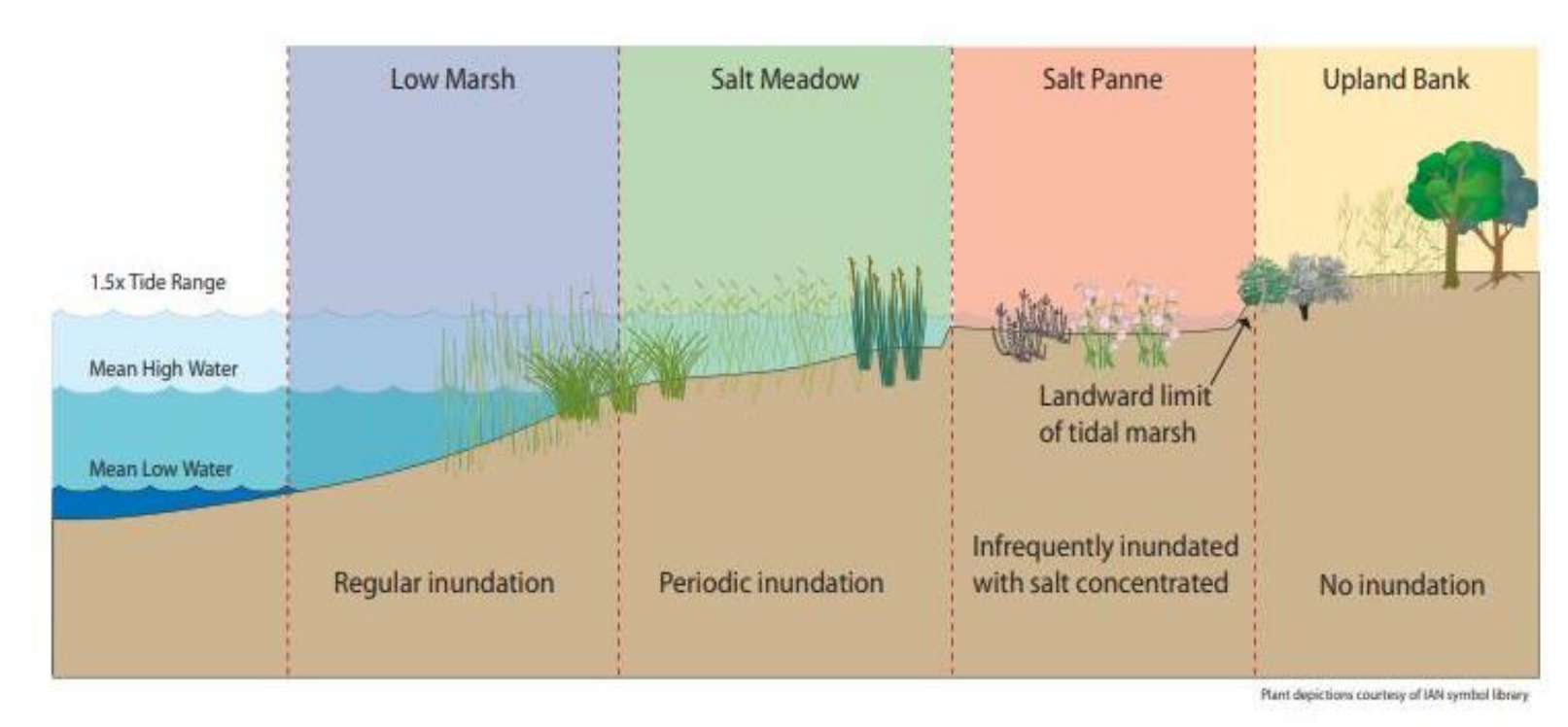


Image: CCRM at VIMS

Species

Low Marsh Species

Smooth cordgrass (*Spartina alterniflora/Sporobolus alterniflorus*)

High Marsh Species

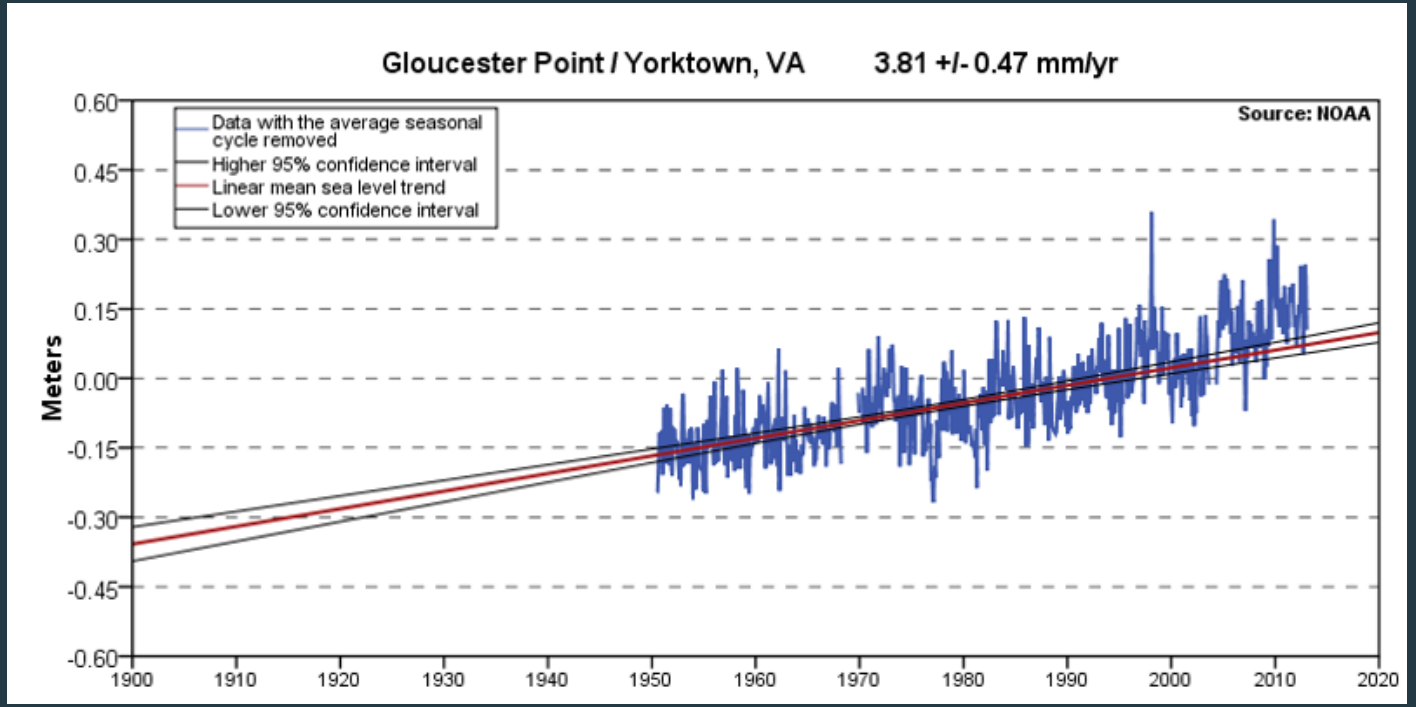
Salt grass (*Distichlis spicata*)

High Marsh Species

Saltmeadow cordgrass (*Spartina patens*)

Global Sea Level Rise (SLR)

SLR is affecting many coastlines in areas such as the Chesapeake Bay Estuary



Subsidence

Sinking of the land is a major factor contributing to local sea level rise which varies throughout the Bay

Possible causes:

- Retreat of glaciers from the previous ice age
- Sediment loading adding too much weight on the wetlands
- Sediment compaction after groundwater removal

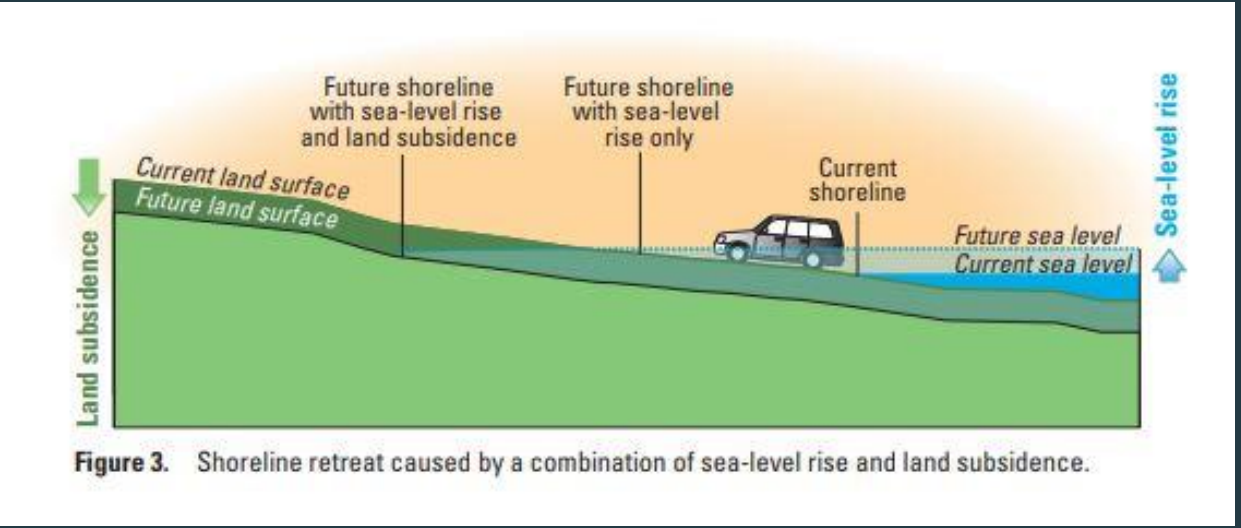
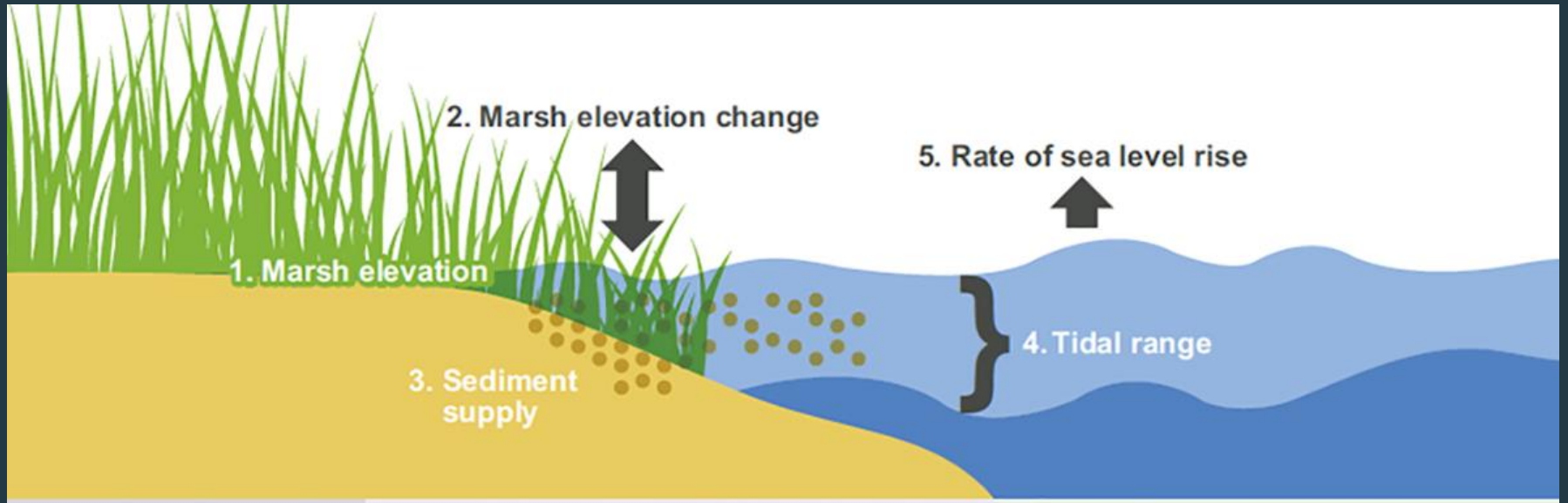


Figure 3. Shoreline retreat caused by a combination of sea-level rise and land subsidence.

Image: Eggleston, Jack, and Pope, Jason, 2013, Land subsidence and relative sea-level rise in the southern Chesapeake Bay region: U.S. Geological Survey Circular 1392, 30 p., http://dx.doi.org/10.3133/cir1392.

Erosion

Shoreline erosion causing loss of the marsh land



CATEGORIES OF MARSH RESILIENCE TO SEA LEVEL RISE

1. **Marsh elevation:** Are the plants located at the high end of their tolerance to flooding so they are initially protected from inundation by rising seas?
2. **Change in elevation:** Is the marsh rising fast enough to keep pace with rising seas?
3. **Sediment supply:** Is there sufficient sediment to help build up the marsh?
4. **Tidal range:** Does the tidal range allow marsh plants to occupy a broad range of elevations so they are buffered against the effects of sea level rise?
5. **Rate of sea level rise:** Is the marsh more resilient because it has not yet been exposed to rapid local sea level rise or high water levels?

Image: Kerstin Wasson, ESNERR

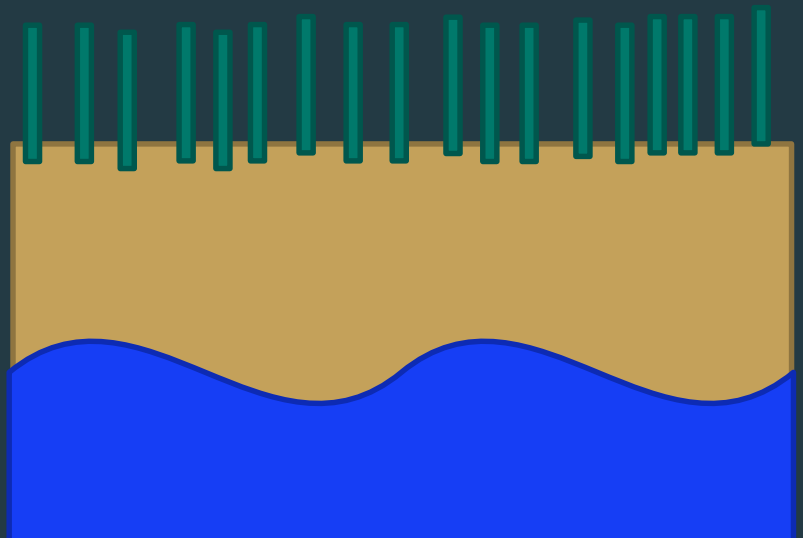
How do the marshes respond?

1) Vertical Accretion

Marshes build vertically by

accumulating sediments and

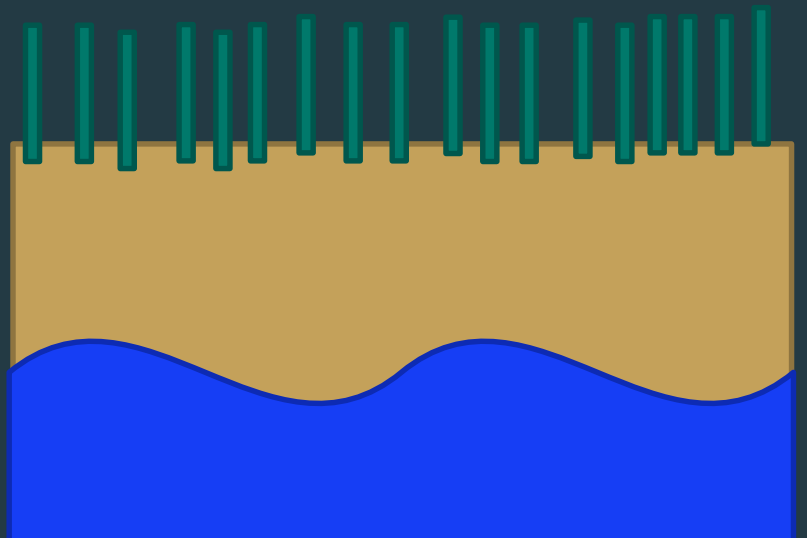
organic matter



1) Vertical Accretion

This vertical development is

referred to as accretion



2) Horizontal Migration

Salt marshes are able to migrate towards higher elevation and further inland to try and survive, but they may not be able to keep up with the rate of SLR and can drown

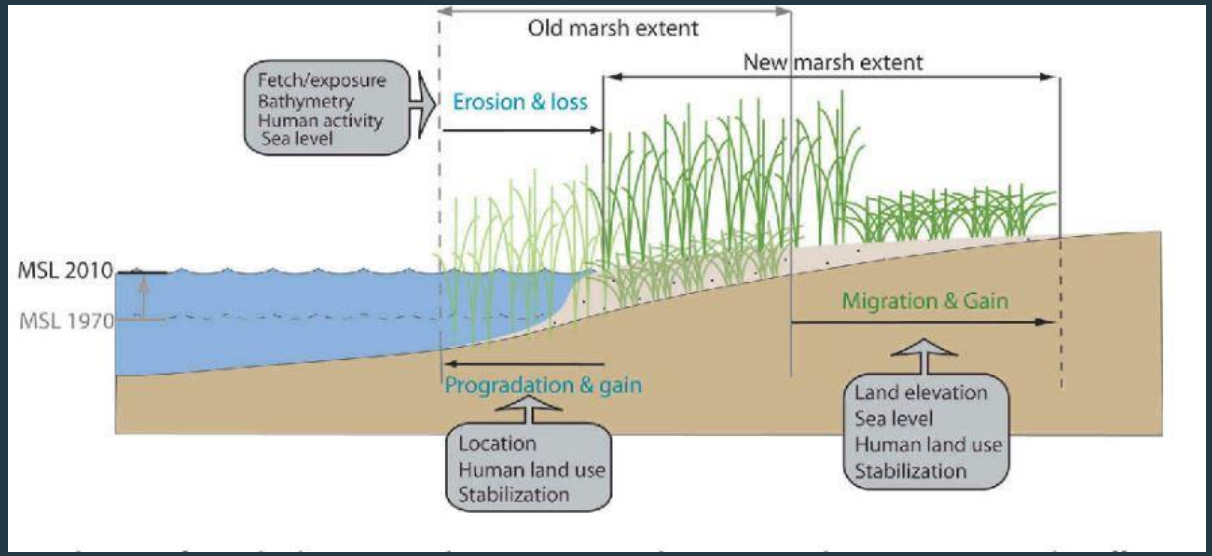


Image: Mitchell, Molly & Herman, J & Bilkovic, Donna Marie & Hershner, C. (2017). Marsh persistence under sea-level rise is controlled by multiple, geologically variable stressors. Ecosystem Health and Sustainability. 3. 1379888. 10.1080/20964129.2017.1396009.

Scientists are trying to improve marsh resilience

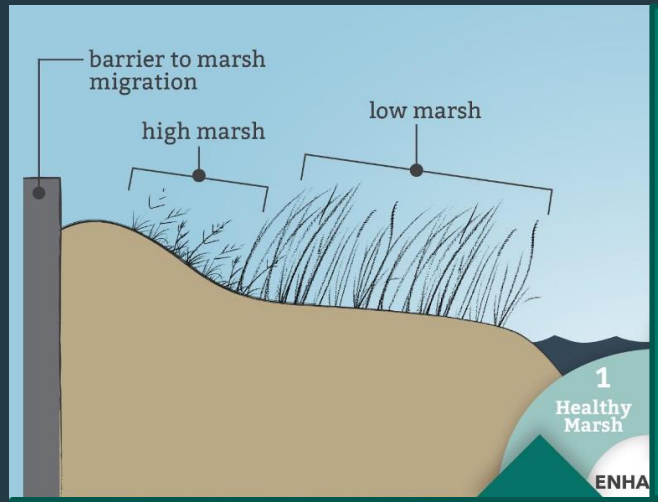
Thin-Layer Placement (TLP)

TLP can be defined by the US Army Corps of Engineers as:

"Purposeful placement of thin layers of sediment (e.g., dredged material) in an environmentally acceptable manner to achieve a target elevation or thickness. Thin layer placement projects may include efforts to support infrastructure and/or create, maintain, enhance, or restore ecological function" (Berkowitz et al., 2019, p. 6).

In other words, the goal is to increase marsh elevations for maximum vegetation growth and to keep marshes from eroding away

Healthy



Degraded

Regrowth

TLP in action!

Image: NERRS Science Collaborative TLP Project

National Estuarine Research Reserve (NERR) System

- Researchers evaluating different strategies and treatments for TLP across the nation
  - NERR System Science Collaborative has funded a **two-year** experiment at 8 different NERR sites
  - One more year of monitoring left!

Core research questions the collaborative aims to answer:

- Is sediment addition an effective adaptation strategy for marshes in the face of sea level rise?
- How does marsh resilience respond to different levels of sediment addition?
- How do low versus high marsh habitats differ in their response to this restoration strategy?

Chesapeake Bay National Estuarine Research Reserve in Virginia (CBNERR-VA)

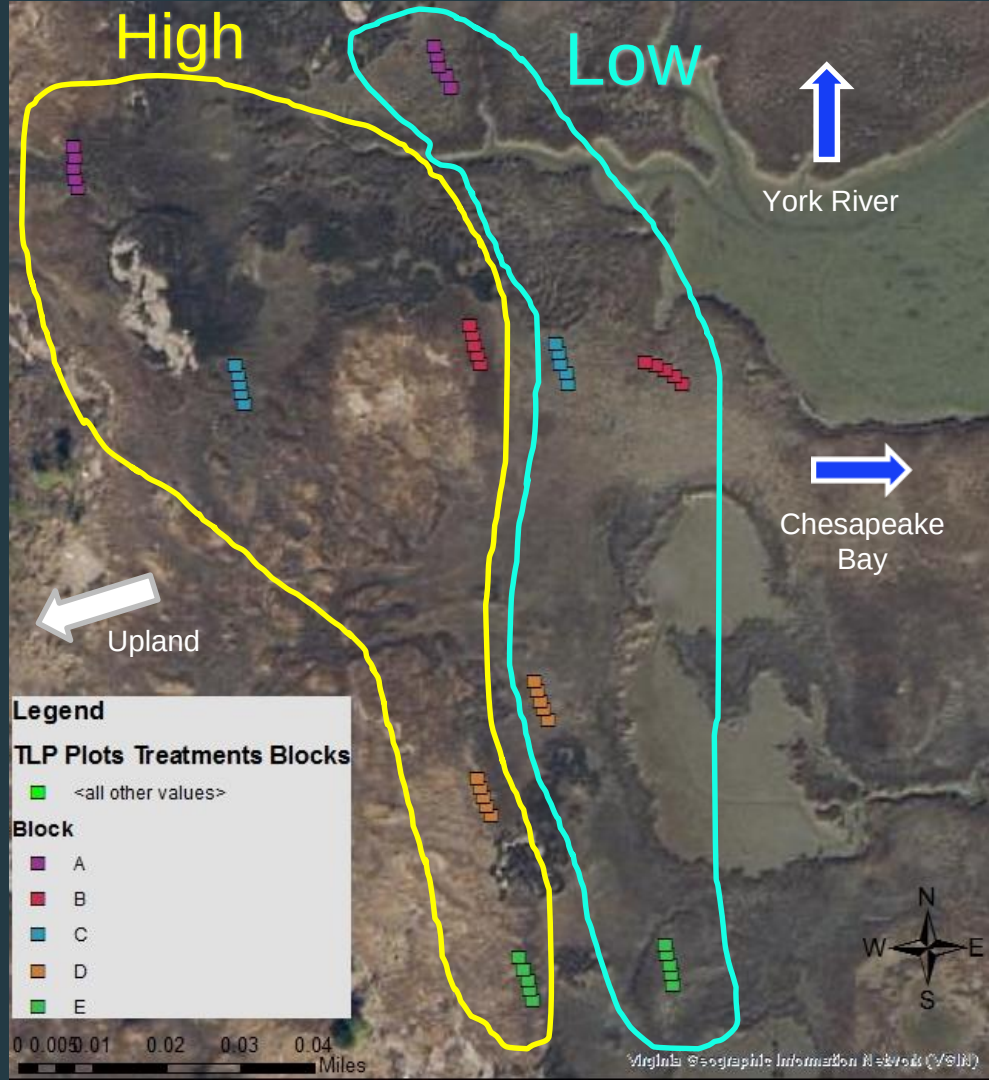
- At CBNERR-VA:
  - Study design answers a secondary question
  - Extra treatment using local dredge material from a recent shoreline enhancement project
  - “Win-win” situation

CBNERR-VA Study Site: Goodwin Island, VA


CBNERR-VA Study Site:
Goodwin Island, VA
York River
Chesapeake
Bay
0 0.1 0.2 0.4 0.6 0.8
Miles
N
W
E
S

Experimental Design

- 5 study sites in both high and low marsh habitats
  - Plot treatments within sites include:
    - Control plot with no wooden frame
    - Control plot with wooden frame
    - Thin standard sediment layer
    - Thick standard sediment layer
  - Some reserves, like CBNERR-VA, use dredged material in 5th plot



Goodwin Island, VA

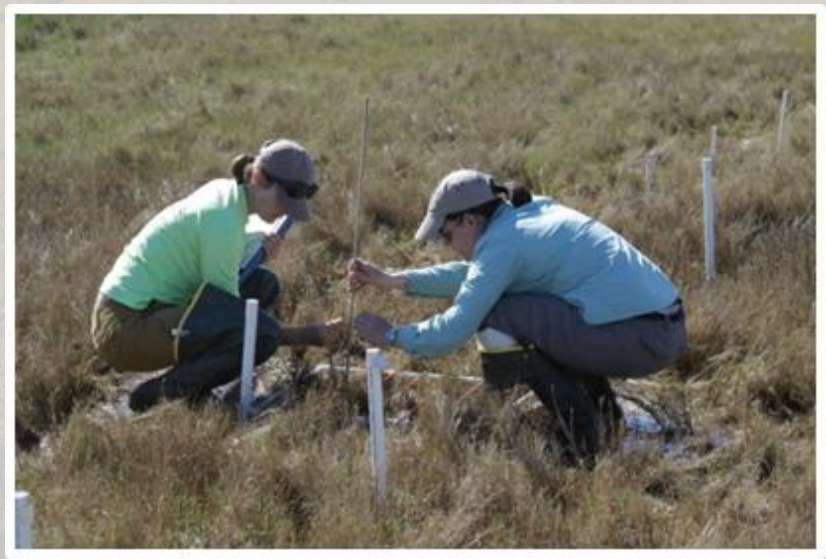
(5 treatment plots)

The Beginning: Transportation

The Beginning: Creation

Monitoring

- Researchers at the reserves monitor changes over the two years by evaluating:
  - Marsh vegetation
    - Cover, composition, and canopy height
  - Elevation

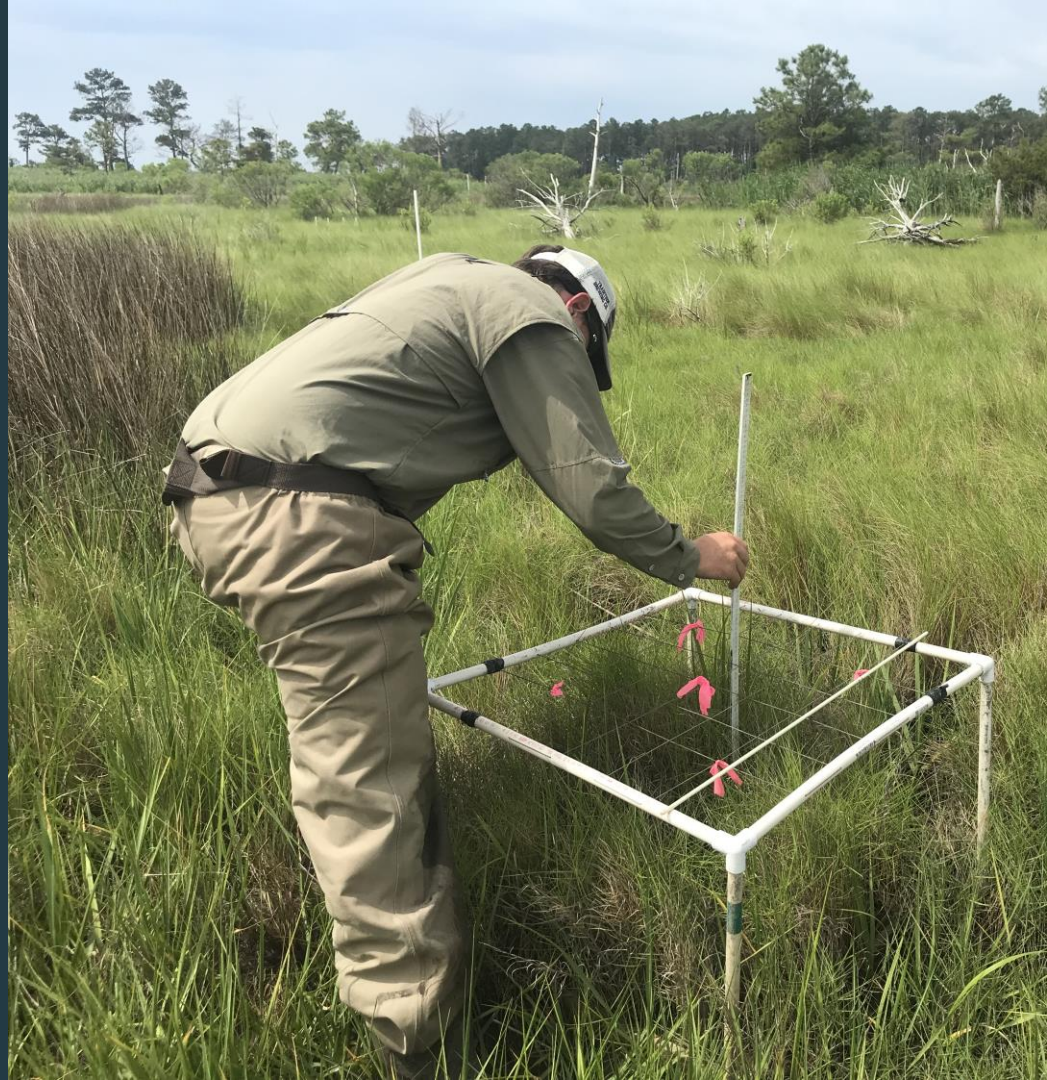


Idealized Trajectory

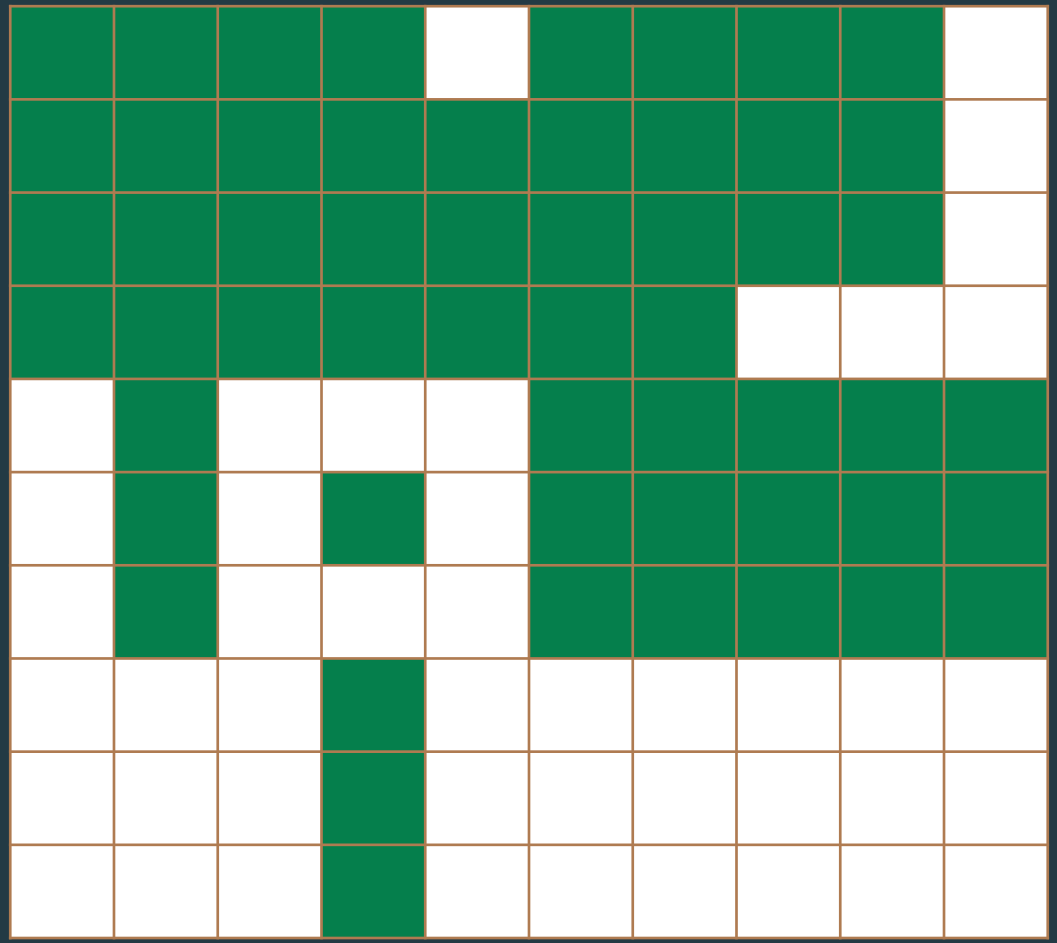
	Before - degraded	Sediment addition	Goal
HIGH			
LOW			

Percent Cover

- Measuring how much of an area is covered with vegetation
- Using quadrats helps visualize the area in grids for easy & fast estimation



Practice Percent Cover



Activity Time

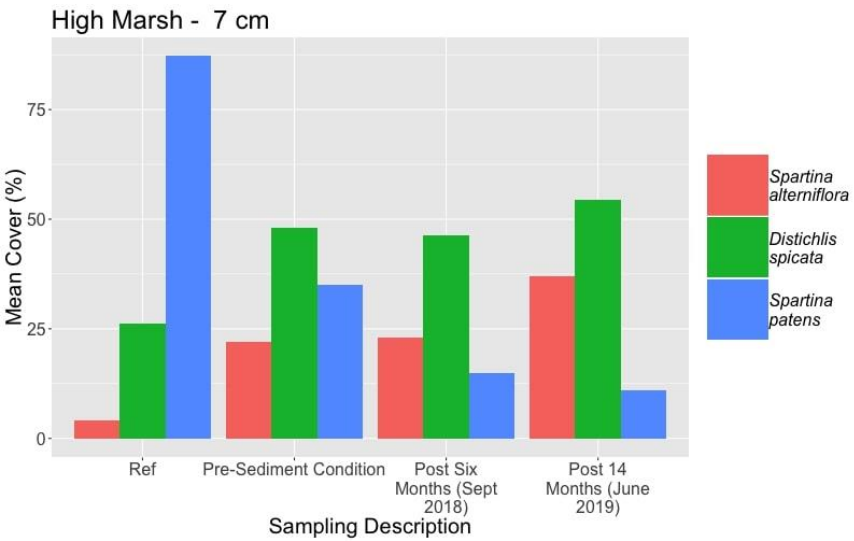
Help CBNERR-VA monitor the
1st year of the experiment

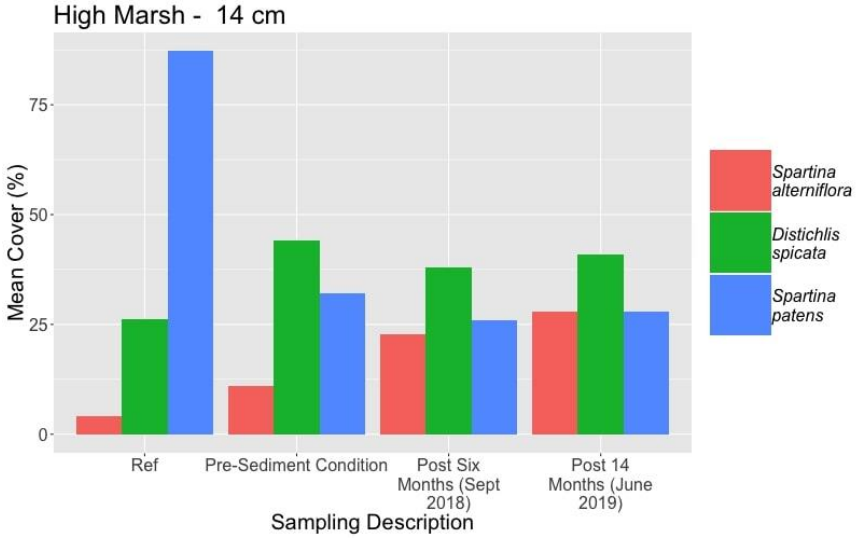
High Marsh

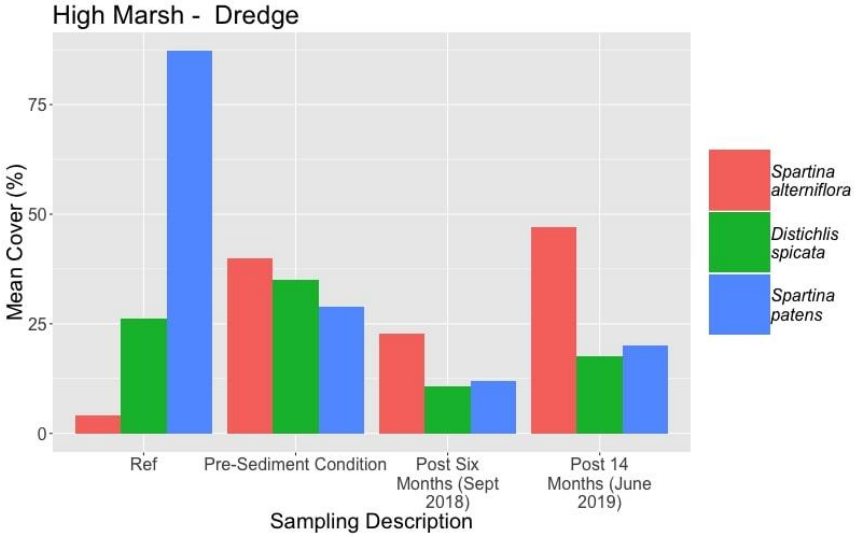
Goal: maximized growth of native high marsh vegetation and high elevation

Hint: The goal is represented by “Ref” (reference plot)

Individual Plots
vs.
Average of ALL Sites


High Marsh - 7 cm
Mean Cover (%)
0
25
50
75
Ref
Pre-Sediment Condition
Post Six Months (Sept 2018)
Post 14 Months (June 2019)
Sampling Description
Spartina alterniflora
Distichlis spicata
Spartina patens


High Marsh - 14 cm
Mean Cover (%)
0
25
50
75
Ref
Pre-Sediment Condition
Post Six Months (Sept 2018)
Post 14 Months (June 2019)
Sampling Description
Spartina alterniflora
Distichlis spicata
Spartina patens

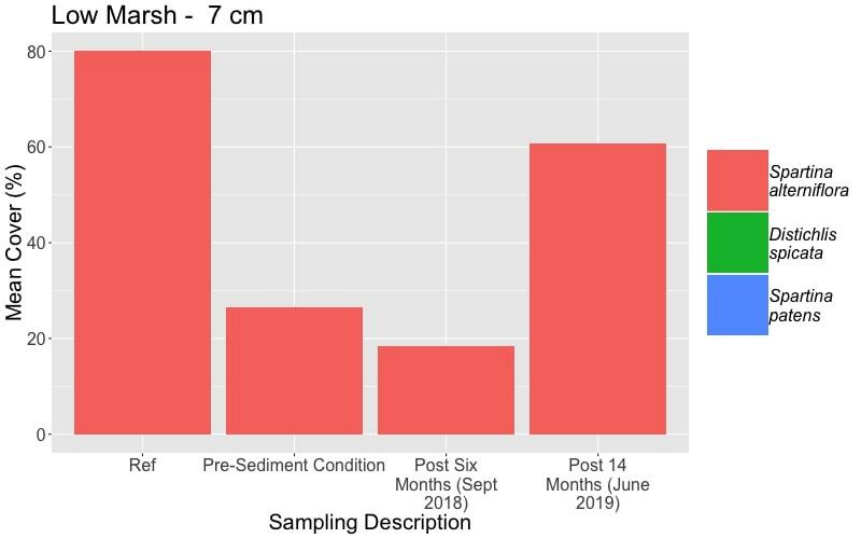

High Marsh - Dredge
Mean Cover (%)
0
25
50
75
Ref
Pre-Sediment Condition
Post Six Months (Sept 2018)
Post 14 Months (June 2019)
Sampling Description
Spartina alterniflora
Distichlis spicata
Spartina patens

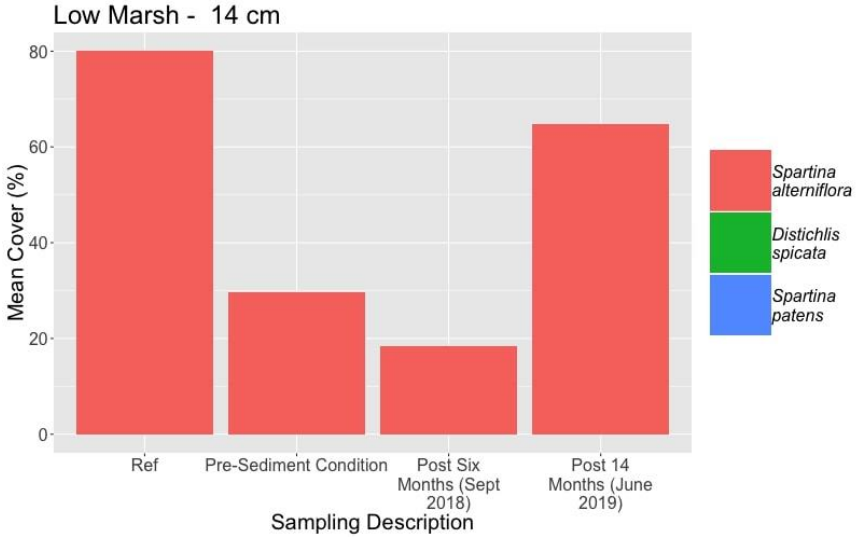
Low Marsh

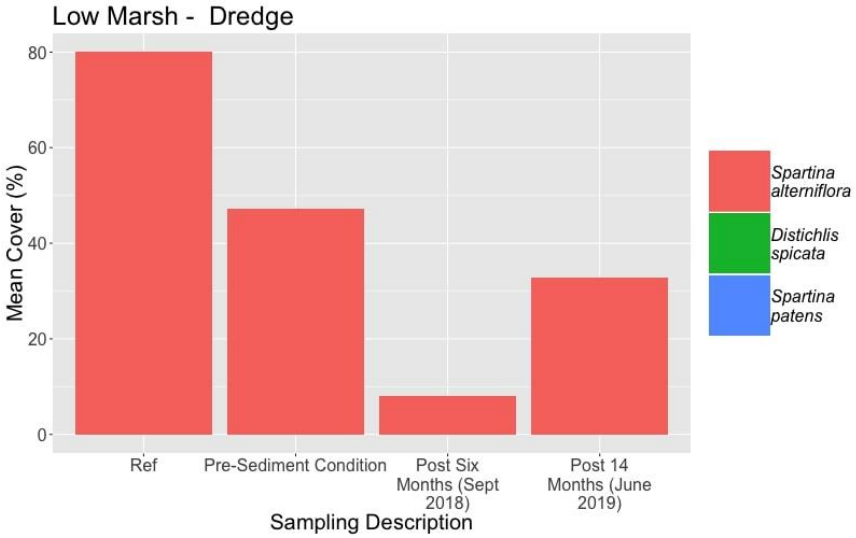
Goal: Higher percent cover of low marsh species and high elevation

Hint: The goal is represented by “Ref” (reference plot)

Individual Plots
vs.
Average of ALL Sites


Low Marsh - 7 cm
Mean Cover (%)
0
20
40
60
80
Ref
Pre-Sediment Condition
Post Six Months (Sept 2018)
Post 14 Months (June 2019)
Sampling Description
Spartina alterniflora
Distichlis spicata
Spartina patens


Low Marsh - 14 cm
Mean Cover (%)
0
20
40
60
80
Ref
Pre-Sediment Condition
Post Six Months (Sept 2018)
Post 14 Months (June 2019)
Sampling Description
Spartina alterniflora
Distichlis spicata
Spartina patens


Low Marsh - Dredge
Mean Cover (%)
0
20
40
60
80
Ref
Pre-Sediment Condition
Post Six Months (Sept 2018)
Post 14 Months (June 2019)
Sampling Description
Spartina alterniflora
Distichlis spicata
Spartina patens

Discussion

What Scientists Say: High Marsh

- Both the 7 cm and 14 cm treatments appear to be responding equally well
- Slightly more vegetation in the 7 cm treatments, but the 14 cm treatments have a higher percent cover of the more desirable high marsh species
  - In the 7 cm treatment, there is a presence of low marsh species in the high marsh habitat
  - This indicates the 7 cm might not be enough sediment to support high marsh conditions

What Scientists Say: Low Marsh

- 7 cm treatments have slightly better vegetation recovery compared to the 14 cm and dredge treatments
  - Important to remember:
    - This is only the **first year** from a 2-year study!!
    - Scientists expect the 14 cm treatments to continue to show recovery over time

Experimental Design Issues

Raccoons digging

Deer stepping

Crabs burrowing

...and hurricanes

Wrap-Up Discussion & Questions

Photo Credits

CBNERR-VA Staff: Slide 2, 3, 5, 8,

17, 18, 19, 20, 23, 24, 26, 27, 28,

31, 34, 38, 39

CBNERR-MD Staff: Slide 26

GBNERR Staff: Slide 25

ESNERR Staff: Slide 25

WBNERR Staff: Slide 24

NCNERR Staff: Slide 24, 40

David Harp: Slide 15 & 41

NBNERR: Slide 40