Collaborative Activities on Blue Carbon in Maryland

Webinar #3:

Living Shorelines in Practice - Enhancing Coastal Resilience

February 10, 2022

This workshop highlighted advances in Maryland around Living Shoreline and related restoration projects. The panel discussion highlighted tools available for visualization and modeling, approaches to assessment and monitoring as well as regulatory barriers and opportunities for advancement. The webinar included a discussion panel to address framing questions and the opportunities for blue carbon in restoration efforts.

Agenda

Welcome	Dr. Christine Conn, *Maryland Department of Natural Resources*
Presentations	"Implementation of Living Shorelines in Maryland", Wesley Gould *and* "Resiliency Through Restoration", Nicole Carlozo, *Maryland Department of Natural Resources*
	"Living Shorelines in Practice - Enhancing Coastal Resilience"
	"Holistic Ecosystems Tactics and Approaches," Albert McCullough, *Sustainable Solutions*
	"Living shoreline performance and impacts to adjacent nearshore benthic habitats: does age matter?," Dr. Cindy Palinkas, *Horn Point Laboratory, UMCES.*
	"Working with Communities to Balance Habitat Needs," Kevin Smith, *Maryland Coastal Bays*
	"Blue Carbon and Living Shorelines," Dr. Carolyn Currin, *EA*
	"Carbon Calculator for Restoration Projects," Dr. Peter May, *University of Maryland* and Dr. Elliott Campbell, *Maryland Department of Natural Resources*
Panel Discussion	Facilitator: Nicole Carlozo, *Maryland Department of Natural Resources*

Recording of the Webinar

Summary

Key Points

- "Living Shorelines are the result of applying erosion control measures that include a suite of techniques which can be used to minimize coastal erosion and maintain coastal process. The techniques are used to protect, restore, enhance, or create natural shoreline habitat" - 2008 Living Shorelines Protection Act
- Resiliency Through Restoration Initiative - effort to reduce Maryland's vulnerabilities to climate change impacts and enhance resiliency of local economies through the use of natural and nature-based solutions. Annual project solicitation through DNR Grants Gateway-Outcome 3.
- There are two license types for Living Shorelines in Maryland: General License and Wetland License. Maryland Department of the Environment is regulatory authority.
- Three arenas that have to work together to be successful:
  - Political: grant funding, community association.
  - Regulatory: permitting and authorizations
  - Technical: is the project technically feasible?
- Research effort to understand how age influences performance, impacts of and co-benefits for the living shorelines. Initial findings include accretion of soil after installation and that there is no significant differences overall for SAV habitat, but it does significantly vary by individual site.
- Intersecting concerns of community resilience, habitat needs, dredging and marsh loss & shoreline erosion all influence impacts of the systems. Blue carbon intersects with all of these areas.
- Significant species impacts due to loss of habitat. Habitat loss due to erosion, sea level rise, loss of salt marshes, etc.
- Marsh loss in the Coastal Bays is significant and concerning. Interim results from an analysis showing 15-20% loss of interior marsh within the Coastal Bays.
- Blue carbon habitats have high carbon burial rates, but they vary significantly by site and occupy much smaller area than terrestrial habitats.
- Research effort to understand the carbon emissions from installation of generic living shorelines. Trucking in materials to the site is a significant source of carbon emissions.
- Annual sequestration is variable with a big driver being methane emissions (and the impact on wetland salinity).

Living Shorelines in Practice - Enhancing Coastal Resilience

February 10, 2022 | 1:00 – 4:30pm

Speaker Bios

Wes Gould 	Wes currently works with the Chesapeake and Coastal Service at the Maryland Department of Natural Resources. There he works with the Shoreline Conservation Service team to provide waterfront property owners with technical and financial assistance on shoreline erosion control projects. He helps to manage the Shoreline Erosion Control Revolving Loan Fund which provides communities and private property owners an opportunity to apply for an interest-free loan to install nature-based living shoreline practices.
Nicole Carlozo 	Nicole Carlozo is the Acting Section Chief of Waterfront & Resource Planning at the Maryland Department of Natural Resources, Chesapeake & Coastal Service, where she focuses on bridging planning and implementation. She manages the Department's Resiliency through Restoration Initiative to enhance community resilience to the impacts of climate change. She has a BA in Biology and English from St. Mary's College of Maryland, and a Masters of Environmental Management in Coastal Environmental Management from Duke University.
Tammy Roberson 	Tammy Roberson is the Maryland Department of the Environment's (MDE) Tidal Wetlands Division Chief where she oversees the development and implementation of Maryland's Tidal Wetlands Law and serves as the national and statewide liaison for MDE and the State of Maryland in the management and administrative practices relating to tidal wetlands. In addition, she worked in MDE's Compliance Program ensuring regulatory compliance with State and Federal environmental laws and regulations. She also developed and implemented on the ground wetland restoration projects while working in the Conservation Program at the National Aquarium. She holds a bachelor's degree in Marine Biology from the College of Charleston and a master's degree from Johns Hopkins University in Environmental Science & Policy.

Albert McCullough 	Albert McCullough currently serves as a Principal Ecological Engineer with Sustainable Science. Since 1996, Mr. McCullough has designed, permitted and overseen construction of living shoreline projects. He is both a licensed engineer and professional wetland scientist.
Dr. Cindy Palinkas 	Cindy Palinkas is an Associate Professor with the Horn Point Laboratory at the University of Maryland Center for Environmental Science. She received her PhD in Geological Oceanography from the University of Washington. She specializes in the formation and preservation of sedimentary strata in the geologic record, sediment deposition and accumulation in intertidal, fluvial, estuarine and continental-shelf environments, radioisotope geochronology, and sediment-vegetation interactions.
Kevin Smith 	As Executive Director of the Maryland Coastal Bays Program (MCBP), Kevin handles the primary responsibilities of organizational management. Kevin implements the CCMP through a close relationship with the Management Conference (including Board, IC, CAC, and partners). The Executive Director supervises staff and plans and implements budgets and carries out the daily supervision of managing all operations of the organization. Kevin joined the MCBP after spending 34 years at the Maryland Department of Natural Resources. He spent most of his career in the field of aquatic and habitat restoration – much of it on Maryland's Eastern Shore. Kevin graduated from the University of Maryland with degrees in Resource Conservation and Fish and Wildlife Management. His previous work includes working for the North American Wildfowl Trust on waterfowl habitat enhancement.
Carolyn Currin 	Dr. Carolyn Currin has conducted research investigating coastal ecosystem structure, function, and response to environmental change. Recent work has addressed the response of coastal wetlands to sea level rise, evaluated the carbon sequestration potential of salt marsh habitats, and assessed adaptive management approaches to increase coastal resilience to sea level rise. Dr. Currin earned a Doctor of Philosophy (Ph.D.) degree in Marine Science from the University of North Carolina at Chapel Hill and a Bachelor of Science in Zoology from North Carolina State University. She was a scientist with the NOAA Beaufort Lab in N.C. for 34 years, and recently joined EA Engineering, Science and Technology as a senior scientist in the Coastal Resilience group.

Dr. Peter May 	Peter May is an Assistant Research Professor in the Department of Environmental Science and Technology at the University of Maryland College Park. He has over 30 years of experience in ecological restoration. He was previously with the Washington, D.C. government in the Watershed Protection Division and worked for the Smithsonian Marine Systems Laboratory.
Elliott Campbell 	Dr. Campbell directs the Office of Science and Stewardship within the Chesapeake and Coastal Service at the Maryland Department of Natural Resources. His expertise is ecological economics, a field focusing on the interactions between people and the natural environment. His work focuses on developing natural land climate mitigation strategies for Maryland and quantifying economic benefits from ecosystems. Prior to his current position he was a research faculty member at the University of Maryland.
Rachel Lamb 	Dr. Rachel Lamb is a Maryland Sea Grant State Science Policy Fellow in the Maryland Department of Environment's Climate Change Program. Rachel supports carbon assessments and accounting for Maryland's natural and working lands. She also works to advance supportive policy for strategic carbon sequestration activities relative to the state's Greenhouse Gas Reduction Act and broader participation in the Regional Greenhouse Gas Initiative (RGGI). Rachel earned her PhD in Geographical Sciences at the University of Maryland College Park (UMD) where her research centered on the applications of NASA Carbon Monitoring System science to advance strategic reforestation with co-benefits for biodiversity and human livelihoods.

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Implementation of Living Shorelines in Maryland

Living Shorelines in Practice: Enhancing Coastal Resilience
February 10, 2022

Wesley Gould
Acting Chief, Shoreline Conservation Service
Maryland Department of Natural Resources

Legislation Supporting LS

-Shore Erosion Control Program-established in 1968.

-Program provides technical and financial assistance to waterfront property owners who experience erosion.

-Living Shoreline projects- **preferred**, but structural projects are used in areas with high rates of erosion.

-Technical assistance- site evaluations, problem assessments and recommended solutions.

Shore Erosion Control Law: 1968

WHAT IS A LIVING SHORELINE?

"Living shorelines are the result of applying erosion control measures that include a suite of techniques which can be used to **minimize coastal erosion and maintain coastal process**. Techniques may include the use of fiber coir logs, sills, groins, breakwaters or other natural components used in combination with sand, other natural materials and/or marsh plantings. These techniques are used to **protect, restore, enhance or create natural shoreline habitat**."

2008 Living Shorelines Protection Act

Shorelines in Maryland: Current Status

- MD's shoreline- approx. 6,659 miles.
- 84-85% of MD's shorelines are privately owned
- More than 50% of Bay tributary shorelines are hardened.
- Shorelines are continually eroded by the movement of water, waves, and wind.
- Human activities like high-speed boating and hardened shorelines on adjacent properties can increase rates of erosion.
- Erosion affects all 16 coastal counties and Baltimore City

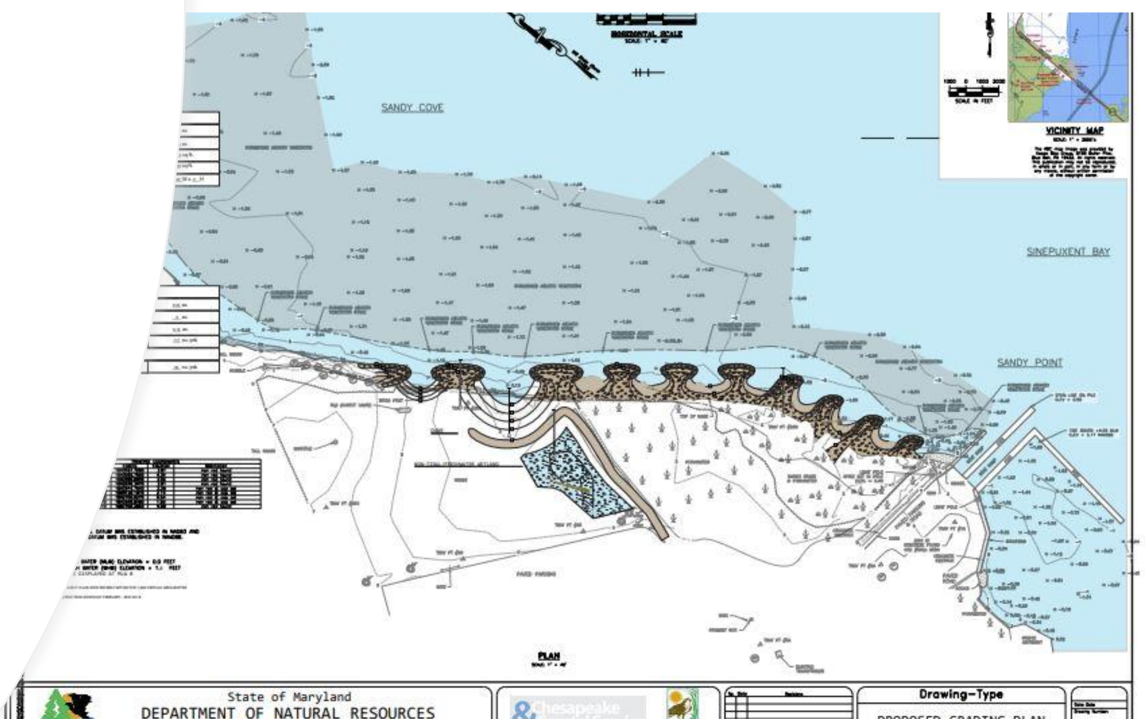
Erosion is not always a bad thing!

A natural process- maintains beach, marsh and offshore habitats.

The **ecological health** of the estuary depends on it!

Design Considerations

- Fetch
- Orientation
- Wave Energies
- Salinity
- Existing Substrate
- Sediment Transport
- Water Depth
- Slope
- Shading
- Existing Lang Use
- Upland Drainage
- Other Resource Impacts
- Project Goals
- Cost
- Property Ownership



EVOLUTION

Shoreline Erosion Control Techniques

Traditional Approach

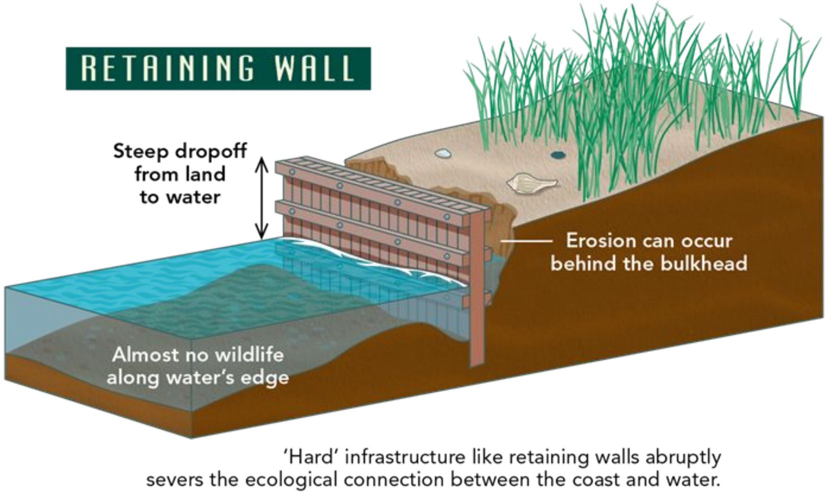
Revetment

Wooden Bulkhead

Problems Associated with a Structural Approach

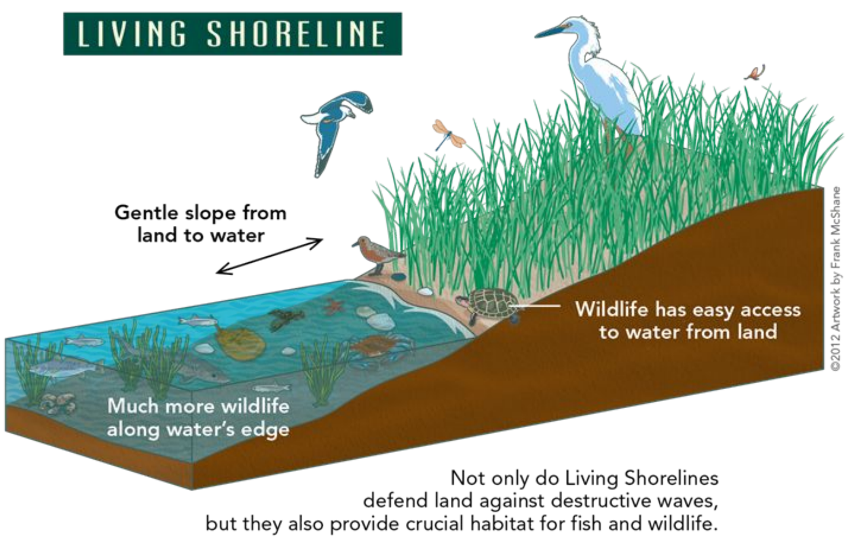
These approaches ***fight*** nature instead of working with it.

Grey vs Green Infrastructure



Structural Solution

- Strongest day in the ground is the day after construction



Nature-based Solution

- Weakest day in the ground is the first day construction - becomes **stronger over time**

Sills

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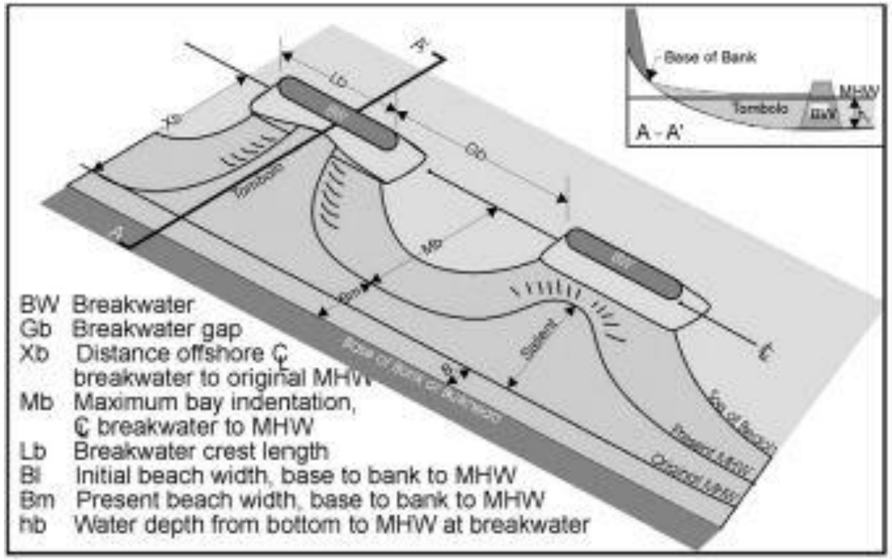
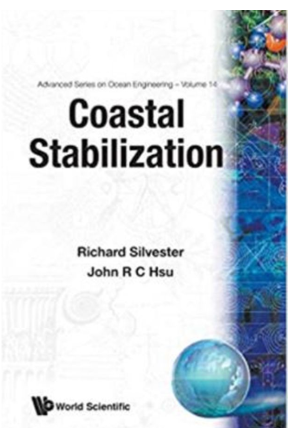
Segmented Stone Sill

High-profile Stone Sill

Headland Breakwaters





Shingle Beach

Technical Assistance & Financing Opportunities:

Program	Organization	Contact
Shoreline Conservation Service Resiliency Through Restoration	Maryland Department of Natural Resources	Wesley Gould 410-260-8812 Nicole Carlozo 410-260-8726

Resiliency through Restoration Initiative

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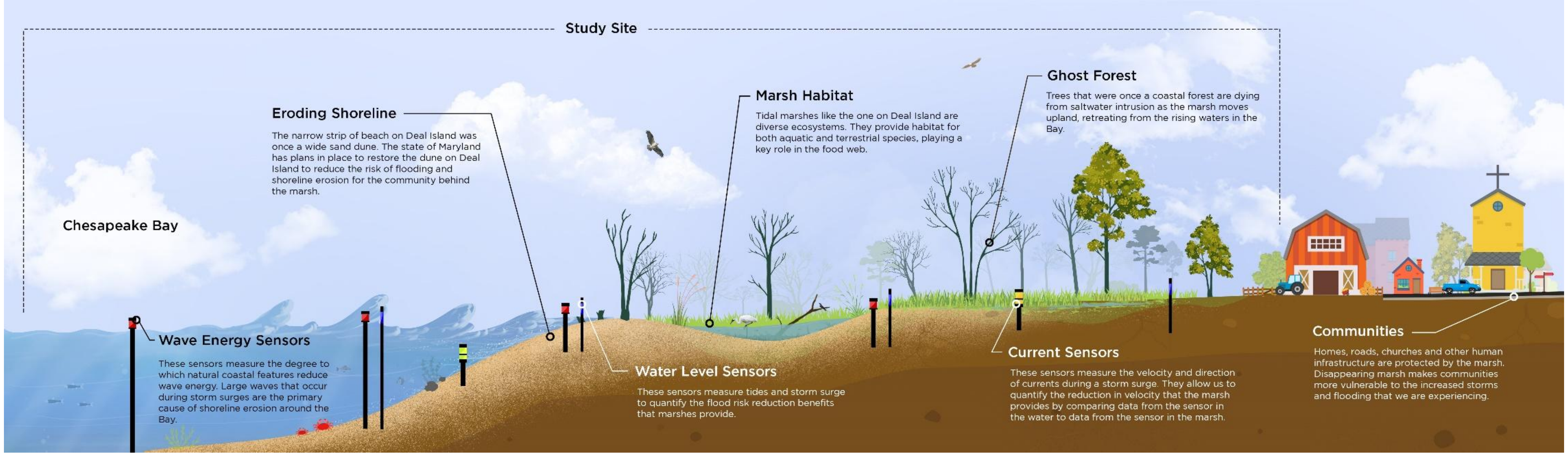
Resiliency through Restoration Initiative: Long-term Goals

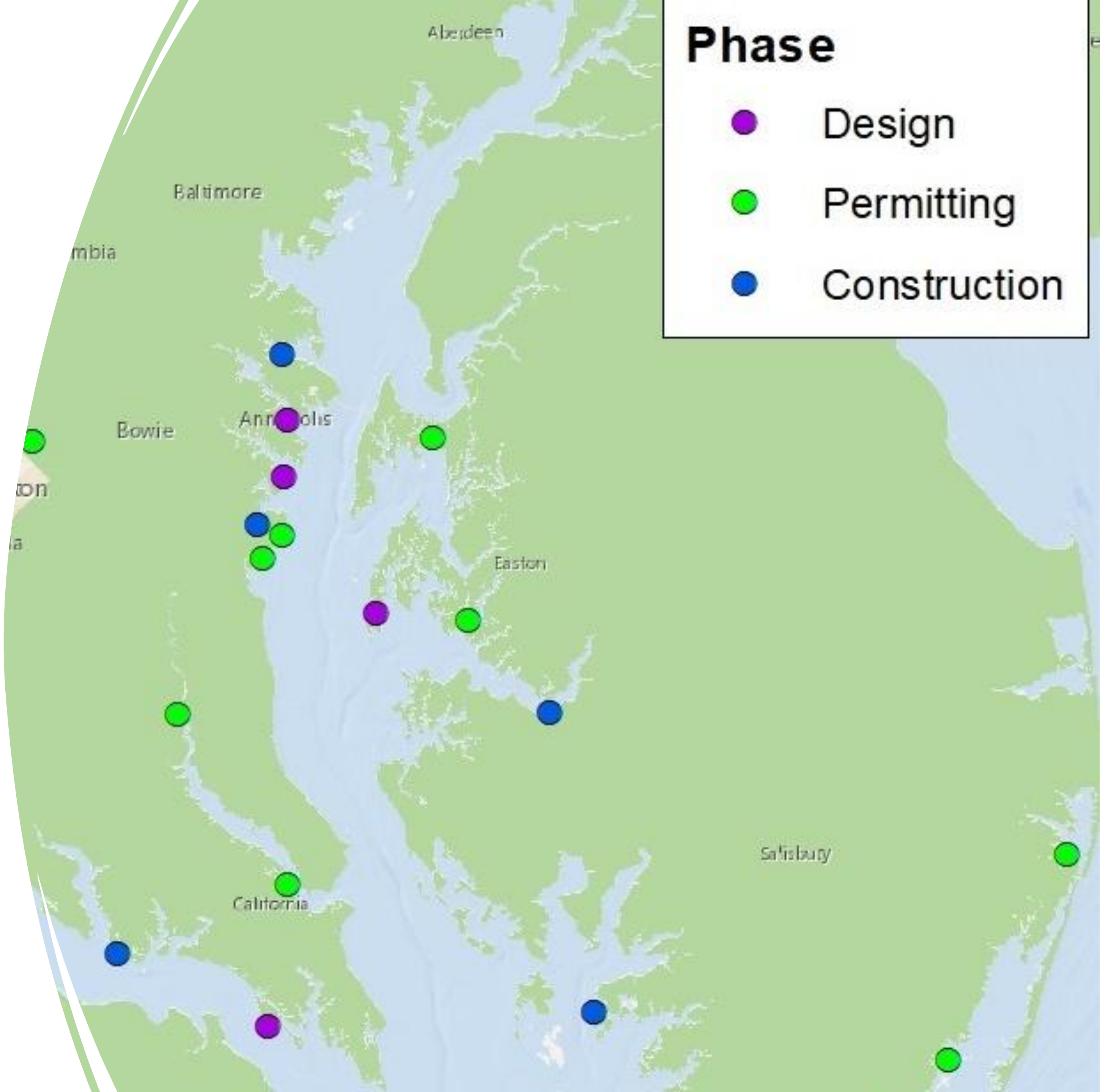
- Reduce Maryland’s vulnerabilities to climate change impacts and enhance resiliency of local economies
- Improve understanding of the community benefits of natural solutions through state and community-led monitoring and ecosystem service evaluation
- Elevate the use of and understanding of where nature-based practices are feasible and practical
- Demonstrate and encourage public-private partnerships to support future private funding investments



[Ecological Effects of Sea Level Rise: https://www.nature.org/MDEESLRstudy](https://www.nature.org/MDEESLRstudy)

Short-term Goal

Demonstrate how natural and nature-based features (like living shorelines!) can help enhance community resilience to the impacts of climate change.

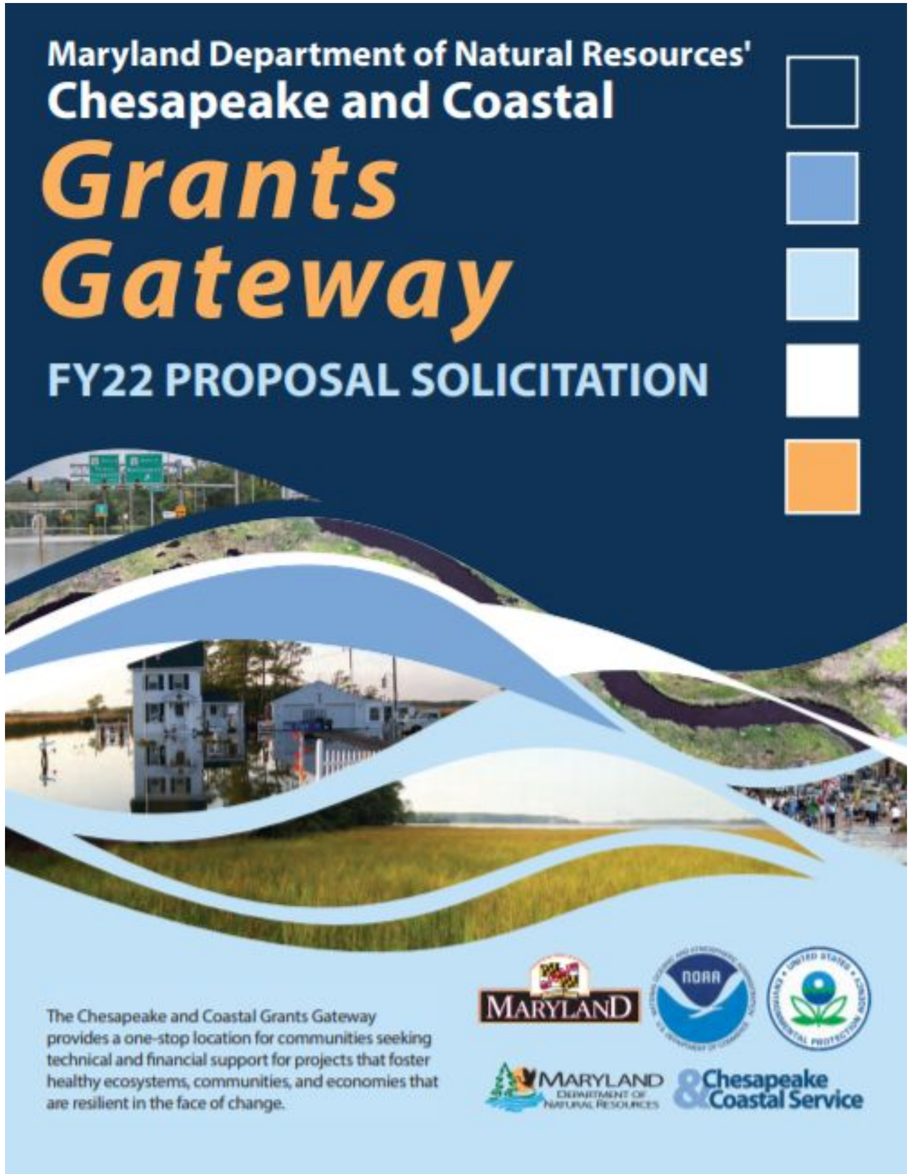


Project Solicitation

Outcome 3

Utilize natural and nature-based infrastructure to enhance resilience to climate change.

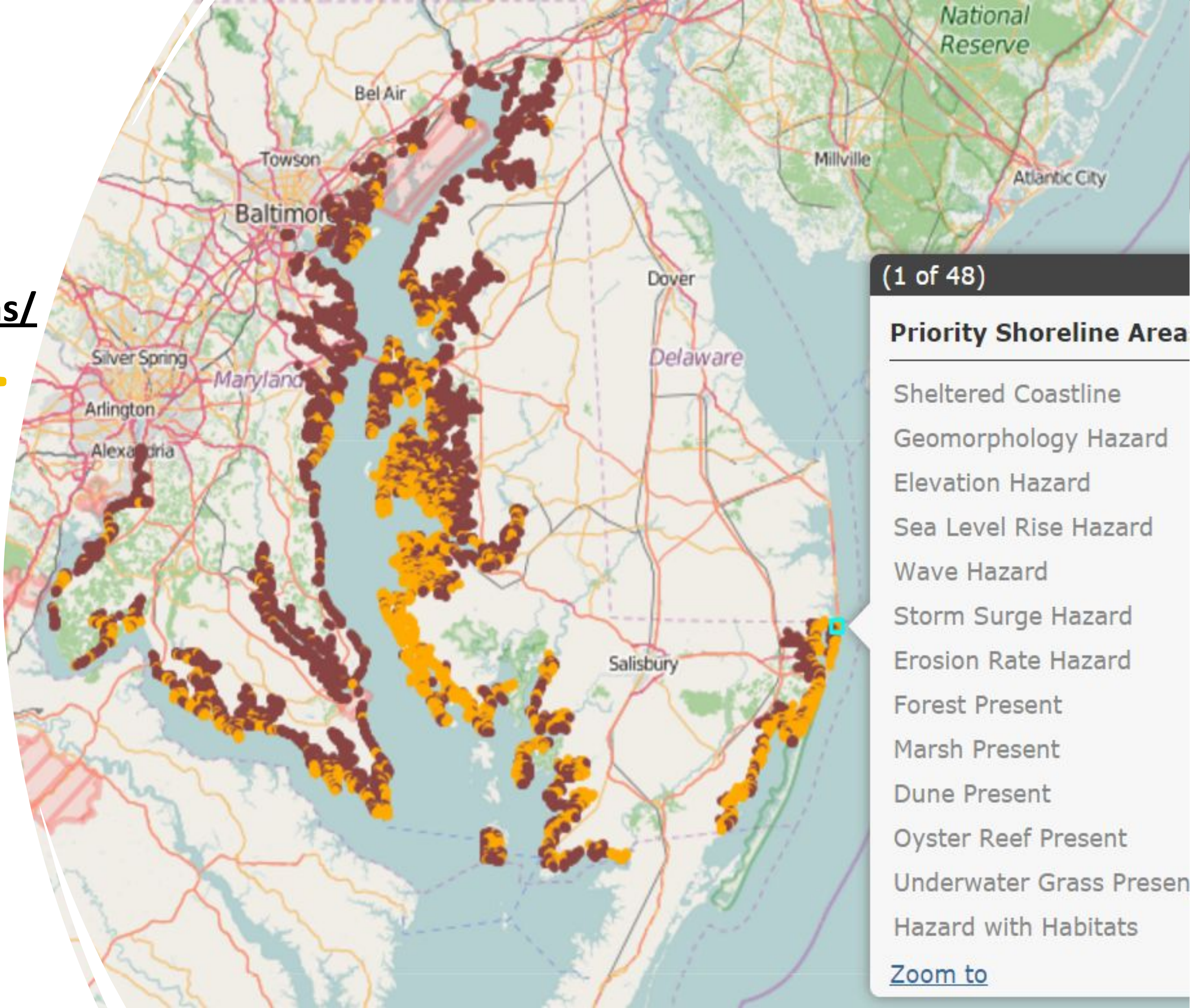
- **Who:** Local governments or non-profits (registered, in compliance, and in good standing with the Maryland Secretary of State)
- **What:** Nature-based restoration projects
- **Where:** Maryland communities impacted by coastal or stormwater flooding
- **When:** July – December 15th
- **Why:** Enhance resilience to climate change impacts (***water quantity***)
- **How:** Design (up to $100K), Construction, or Design-Build



Coastal Resiliency Assessment

dnr.maryland.gov/ccs/coastalatlas/

- **Tier 1 Shorelines (Orange)**
  - High Habitat Role
  - Conserve/Maintain
- **Tier 2 Shorelines (Brown)**
  - Moderate Habitat Role
  - Evaluate/Restore

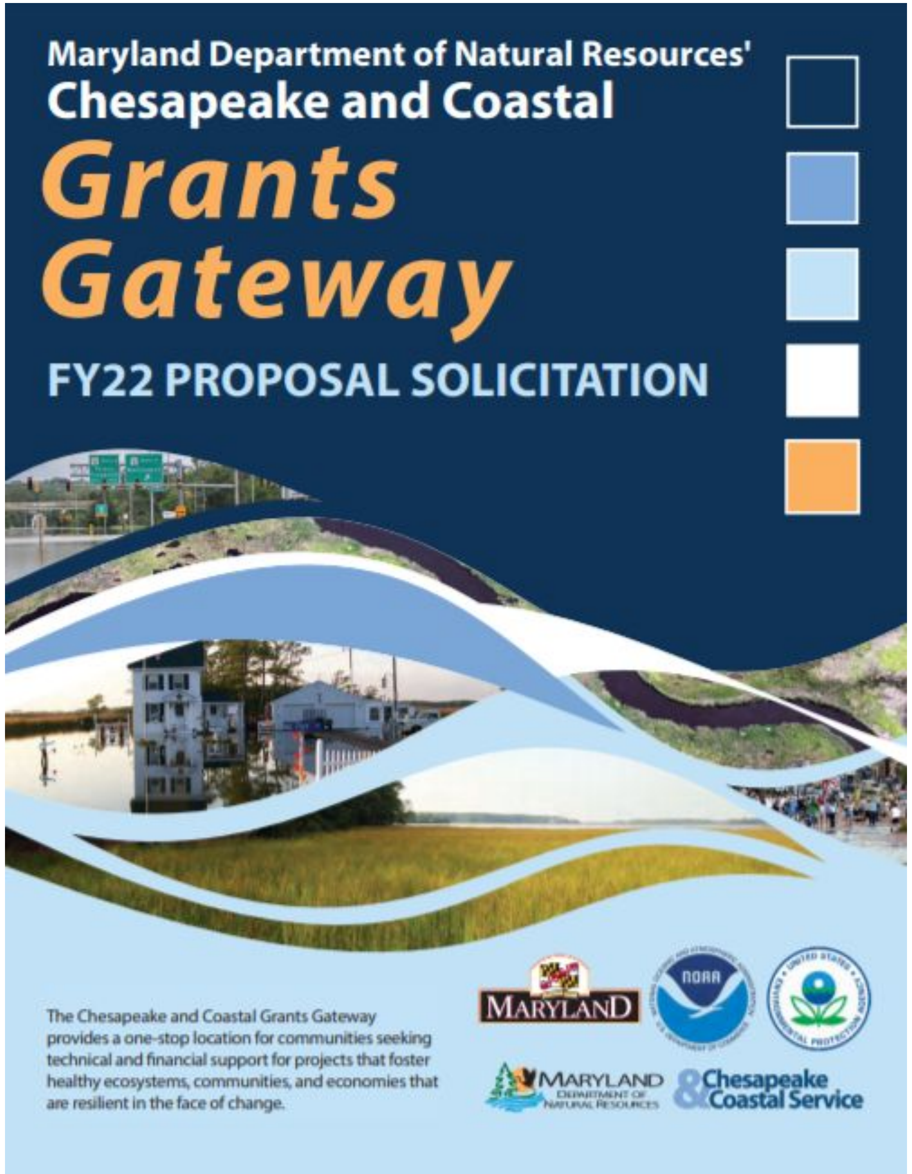


Outcome 3

Utilize natural and nature-based infrastructure to enhance resilience to climate change.

Review Criteria

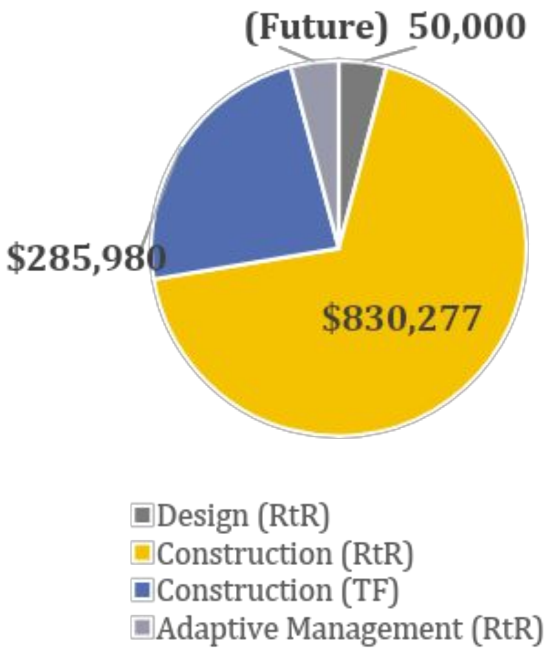
- **Coastal Exposure Reduction**
- **Ecological Enhancement**
- **Cost Efficiency**
- **Adaptation Potential**
- **Local Capacity for Implementation**
- **Demonstration Value**
- **Social Benefits and Equity**
- **Proposal Completeness**
- *Community-wide benefits**
- *Readiness and Ability to Proceed **
- *Landowner Agreement / Access Agreement / HOA Community Project Authorization **
- *Climate Change Data**



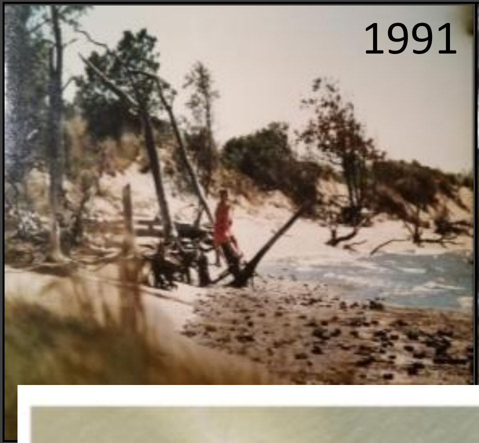
** Required*

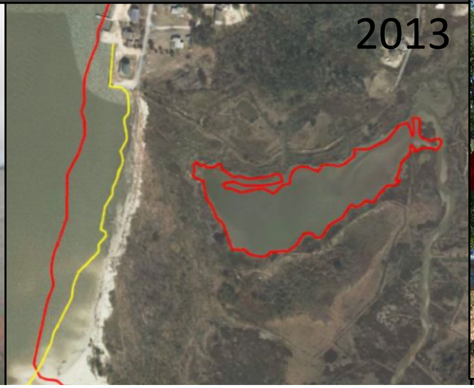
Project Spotlight:
West River Methodist Center

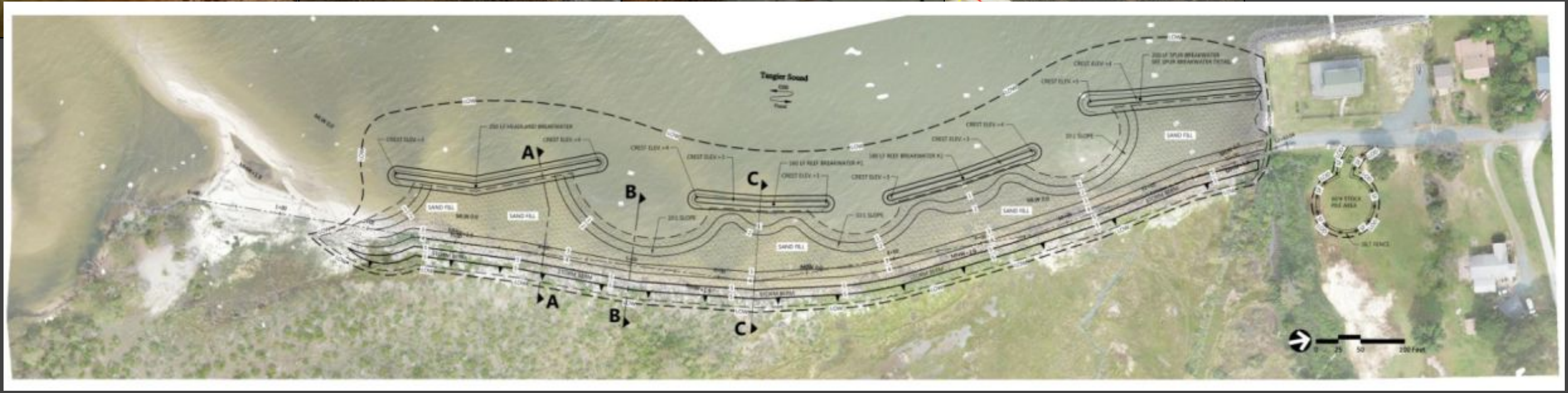
- 885 linear-foot (vegetated breakwater + cobble beach) living shoreline
- 430 linear-foot Regenerative Stormwater Conveyance (RSC) Wetland
- Bulkhead replacement



First Constructed Project!







Project Spotlight: **Deal Island Peninsula**

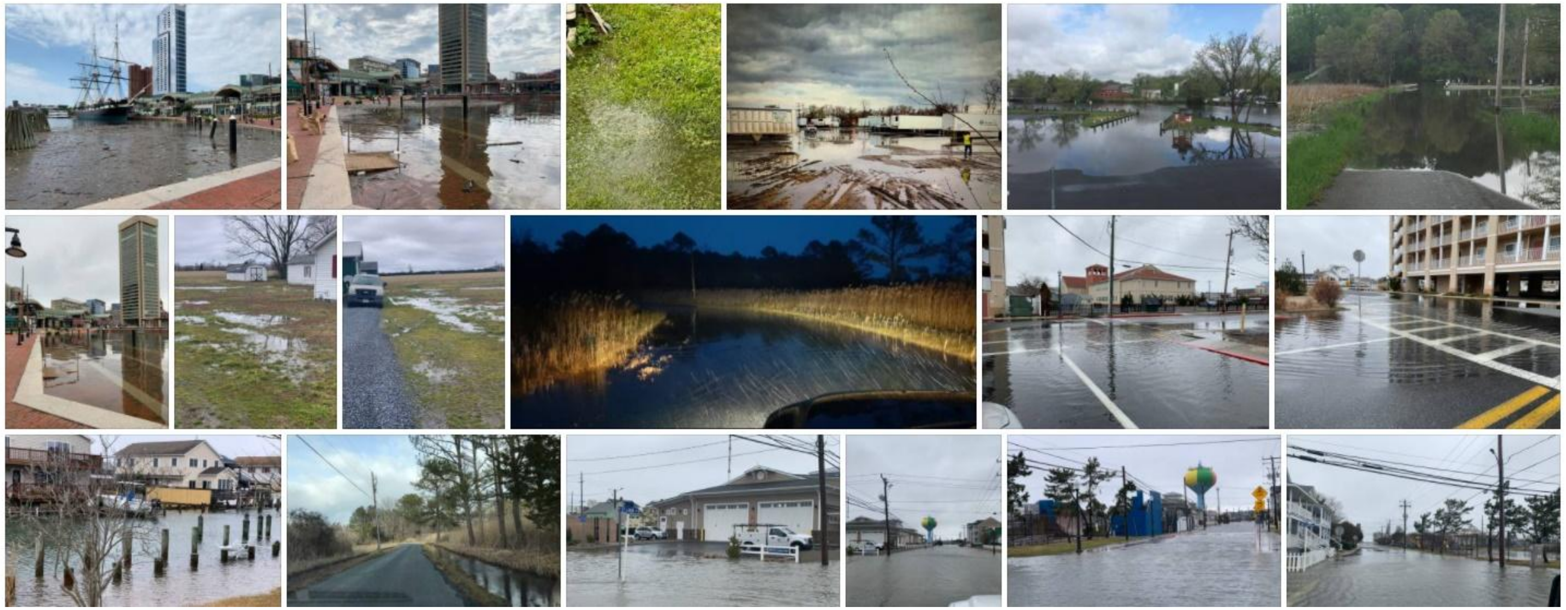
- 1,100 linear-foot (headland breakwater) living shoreline
- Dunes with high marsh and dune grass plantings
- Reef breakwaters with pocket beaches

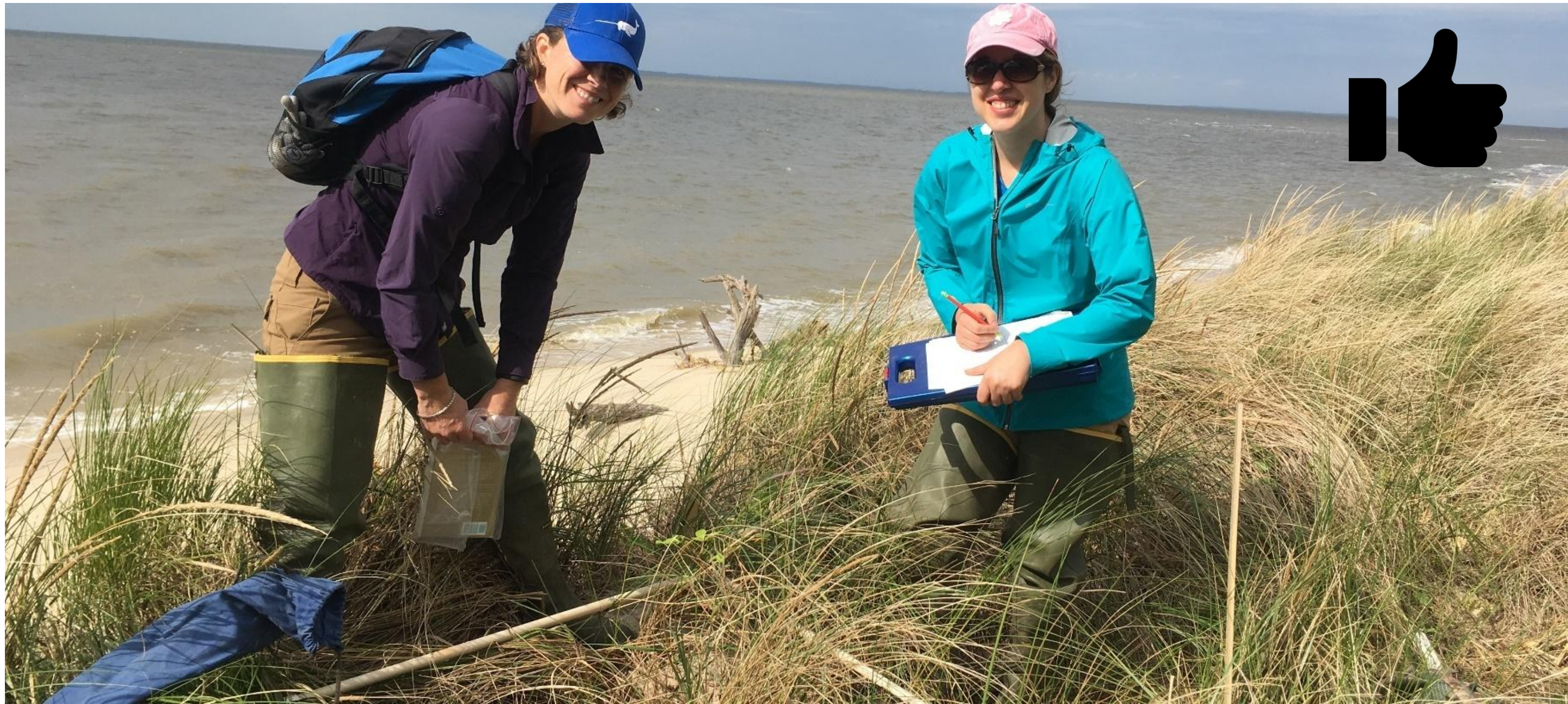
Adaptive Management

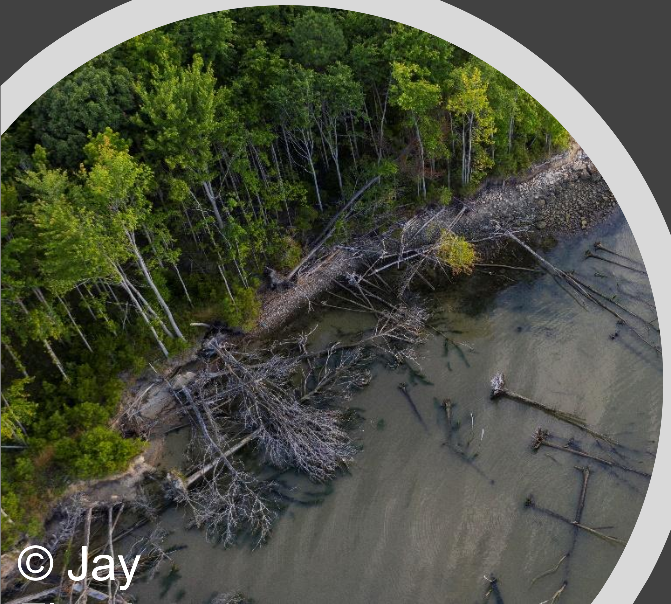
The act of monitoring and adjusting a restoration practice in the face of changing and dynamic conditions

- Project Monitoring
- Community Science
- Maintenance

MyCoast Reports







CONTACT

Nicole Carlozo
nicole.carlozo@maryland.gov
410-260-8726

Grants Gateway:
https://dnr.maryland.gov/ccs/Pages/funding/grantsgateway.aspx

Resiliency through Restoration:
https://dnr.maryland.gov/ccs/Pages/Resiliency-through-Restoration.aspx

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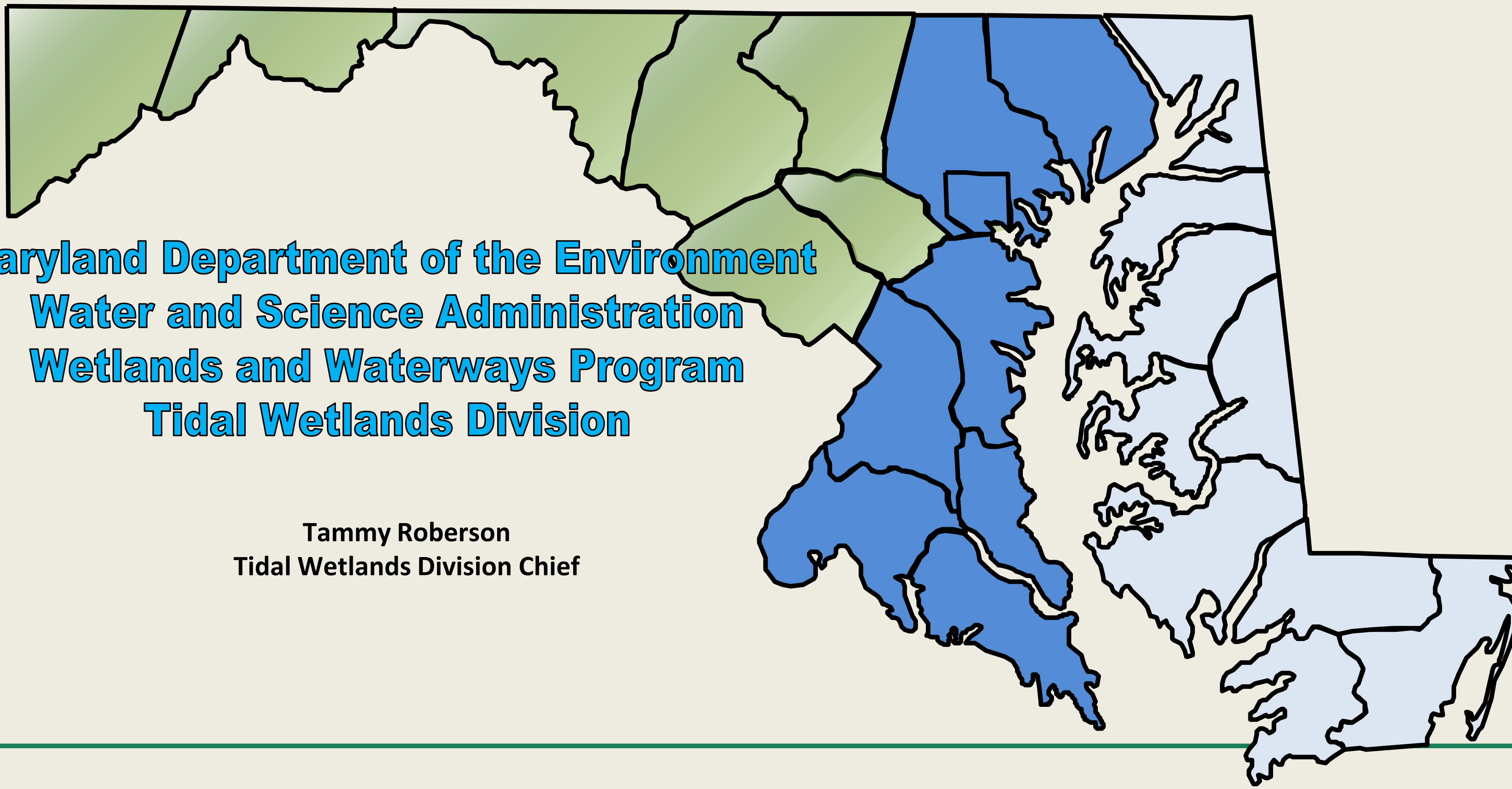
Living Shorelines in Practice - Enhancing Coastal Resilience



Maryland Department of the Environment
Water and Science Administration
Wetlands and Waterways Program
Tidal Wetlands Division

Tammy Roberson
Tidal Wetlands Division Chief

Living Shorelines Protection Act

- Dominated by tidal wetlands vegetation and designed to preserve the natural shoreline, minimize erosion and establish aquatic habitat
- May obtain a waiver to the requirement:
  - Shoreline is mapped as an area appropriate for structural shoreline stabilization measures
  - Living Shoreline Waiver Request
  - DNR's Chesapeake & Coastal Services / Coastal Engineer

Pre-Application Meeting

- Expedites Application Processing
- Identify informational requirements and potential hurdles
- Highlight review procedures specific to the project

State Authorizations For Living Shoreline Projects

General License (GL)
Activities in State Tidal Wetlands
90-Day State Review
Authorization Issued by the Department
Cannot include mitigation
Exempt from Public Notice under COMAR 26.24.01.04A(1)
3 Year Term – May grant a one-time extension of a general license for a period up to 3 years
Living Shorelines - no greater than 35' channelward of MHWL/up to 500' of shoreline

State Authorizations For Living Shoreline Projects

Wetland License (WL)
Activities in State Tidal Wetlands
240-Day State Review
Report and Recommendation issued by the Department Authorization issued by the Board of Public Works
GL activity limits exceeded - greater than 35’ channelward
Requires Public Notice
3 Year Term – 3 year time extension allowed
Can include mitigation

MDSPGP-6 Categorization

Activity	Category A	Category B	Alternative
Living Shorelines	Less than 500 lf., less than 35' channelward, total impacts is limited to 17,500 sq. ft., no impacts to SAV	Less than 50' channelward, less than ½ acre of un-vegetated wetlands	Requires WQC

GP-6 Changes

Activity	MDSPGP-5 Permit	MDSPGP-6 Permit
Living Shorelines	CAT A: No SAV or marsh impact CAT A & B: No beneficial reuse (discharge of dredge material)	CAT B: No specific limit on SAV impact, but must reduce impact to SAV as much as possible CAT B: Allows for beneficial re-use of dredge material with some caveats.

Where does my application go?

- Application Process

  Regulatory Services Division (RSD)

  - **7 copies of application, plans, supplemental sheets, pictures, documents, etc.**
    - Sent to: MDE/WATER AND SCIENCE ADMINISTRATION
      REGULATORY SERVICES COORDINATION OFFICE
      MONTGOMERY PARK BUSINESS CENTER – ST 430
      1800 WASHINGTON BOULEVARD
      BALTIMORE, MD 21230-1708
      (410) 537-3762 OR 1-800-876-0200
  - **Front Page of application**
    - Sent to: MDE
      P.O. BOX 2057
      BALTIMORE, MD 21203-2057
      PCA: 13910 OBJ: 4142
    - <u>P.O. Box is a bank.</u>

  - Application is screened for resource hits – MHT, DNR, CORPS, Etc.

  - Application screening information is entered into ETS (Environmental Tracking System).

Help?

INSTRUCTION BOOKLET
for the
Abbreviated Joint Federal/State Application
for the Alteration of any Tidal Wetland
and/or Tidal Waters in Maryland

Photo: Team SWAMP, University of Maryland

Maryland Department of the Environment
Wetlands and Waterways Program

Prepared by:

US Army Corps
of Engineers®

Maryland
Department of
the Environment

Edition: 2017.10

MDE / USACE

SAMPLE ACTIVITY GUIDELINES
AND
DRAWINGS

Maryland Department of the Environment
Wetlands and Waterways Program
Tidal Wetlands Division

August 2013

Prepared by:

Maryland
Department of
the Environment

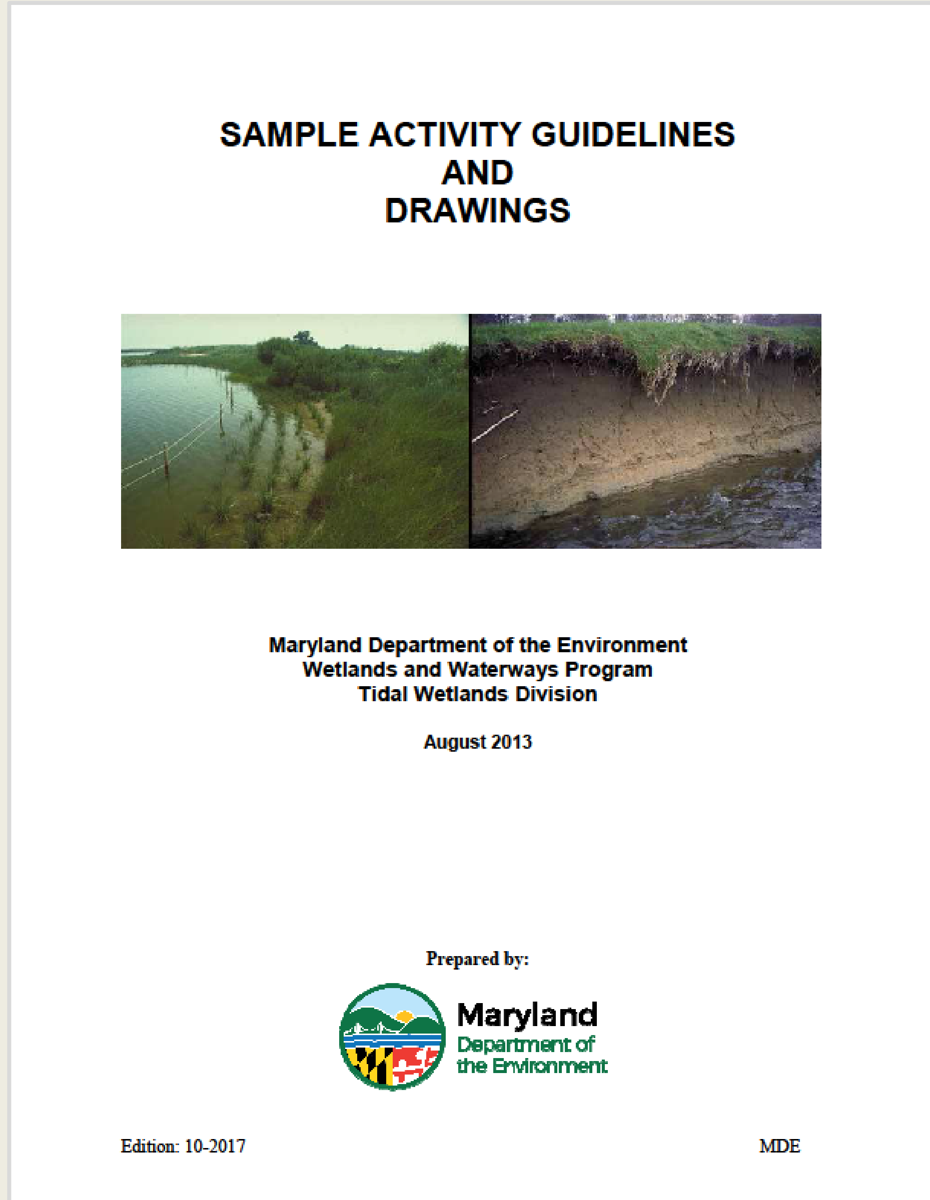
Edition: 10-2017

MDE

Plans

Arranged by Project-type:

- Checklists
- Sample Plans



SAMPLE ACTIVITY GUIDELINES
AND
DRAWINGS

Maryland Department of the Environment
Wetlands and Waterways Program
Tidal Wetlands Division

August 2013

Prepared by:

Maryland
Department of
the Environment

Edition: 10-2017 MDE

Where do I find this information?

Maryland Department of the Environment
http://mde.maryland.gov/Pages/index.aspx

Application and Links
http://mde.maryland.gov/programs/Water/WetlandsandWaterways/PermitsandApplications/Pages/tidal_permits.aspx

Waiver Form
http://mde.maryland.gov/programs/Water/WetlandsandWaterways/Pages/LivingShorelines.aspx

Program Contact Information
http://mde.maryland.gov/programs/Water/WetlandsandWaterways/Pages/contacts.aspx

HOLISTIC ECOSYSTEMS TACTICS & APPROACHES

Living Shorelines in Practice

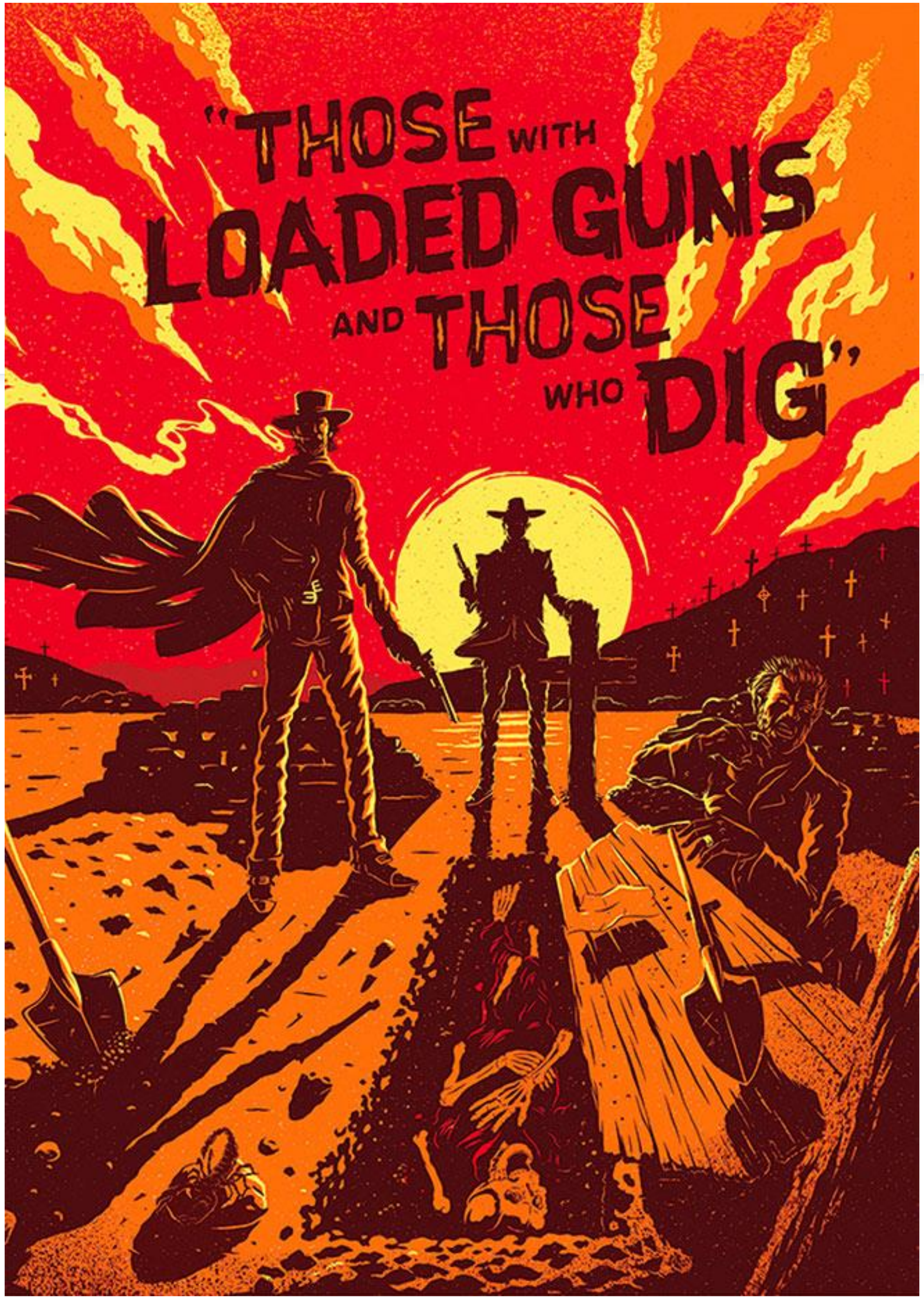
Enhancing Coastal Resilience

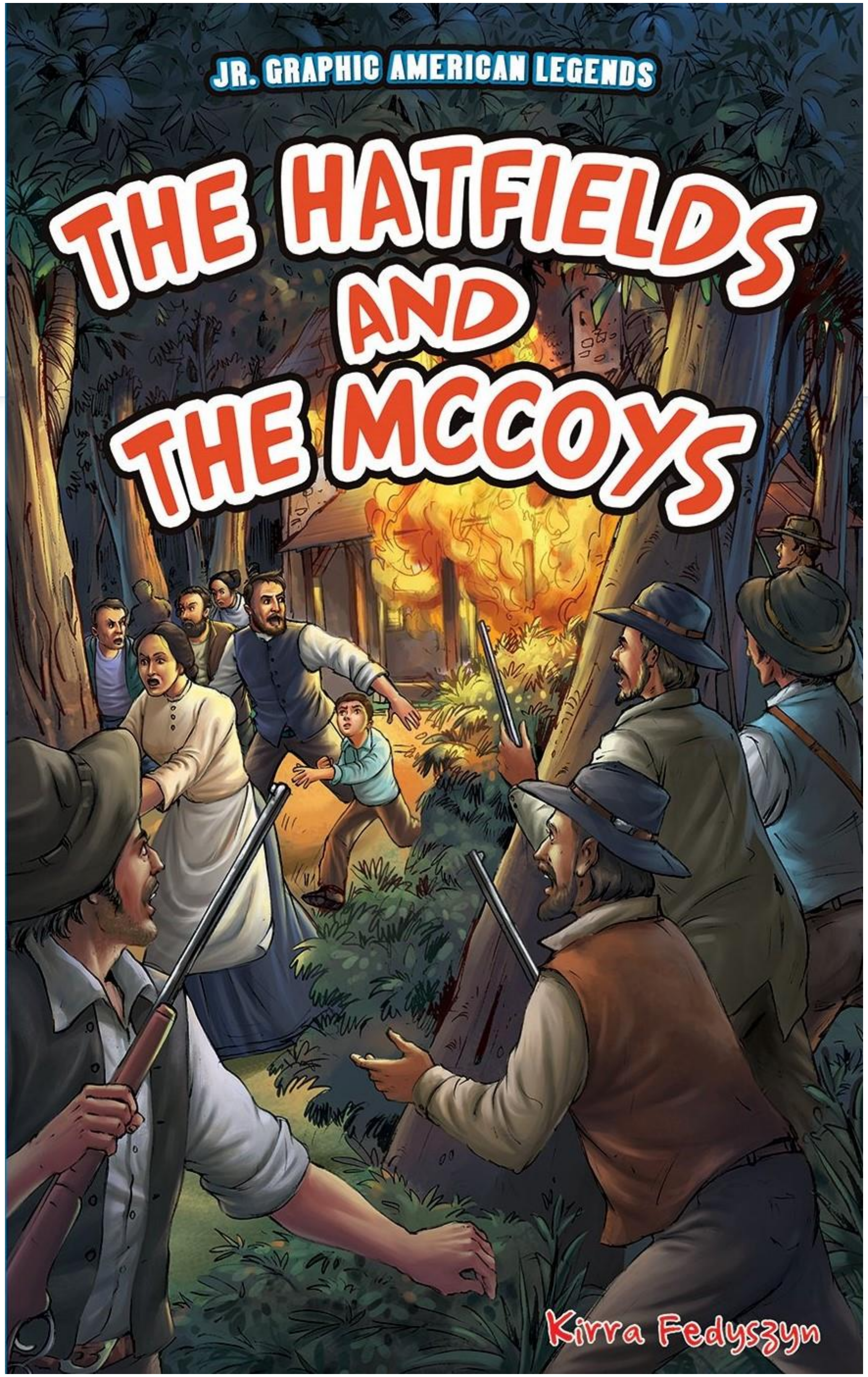
Albert McCullough

February 10th, 2022

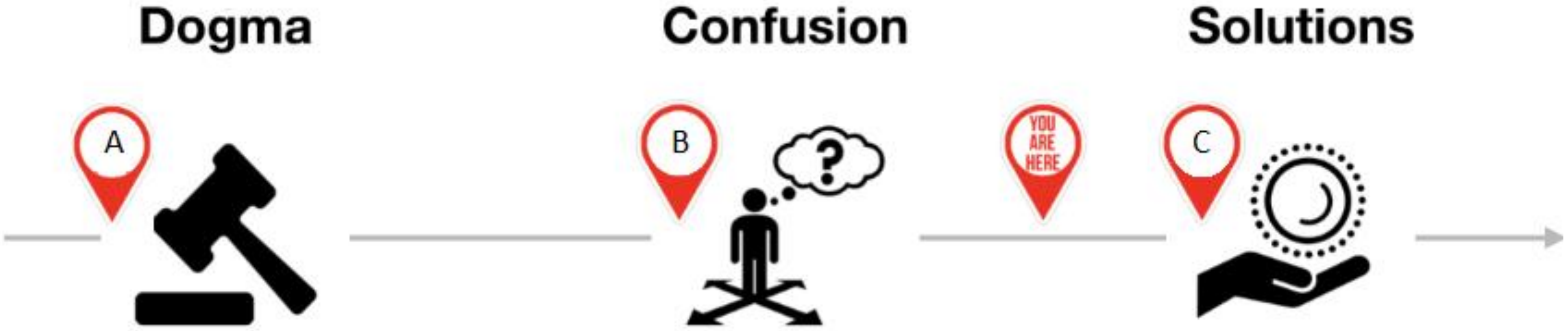
1970's

1980's


"THOSE WITH
LOADED GUNS
AND THOSE
WHO DIG"

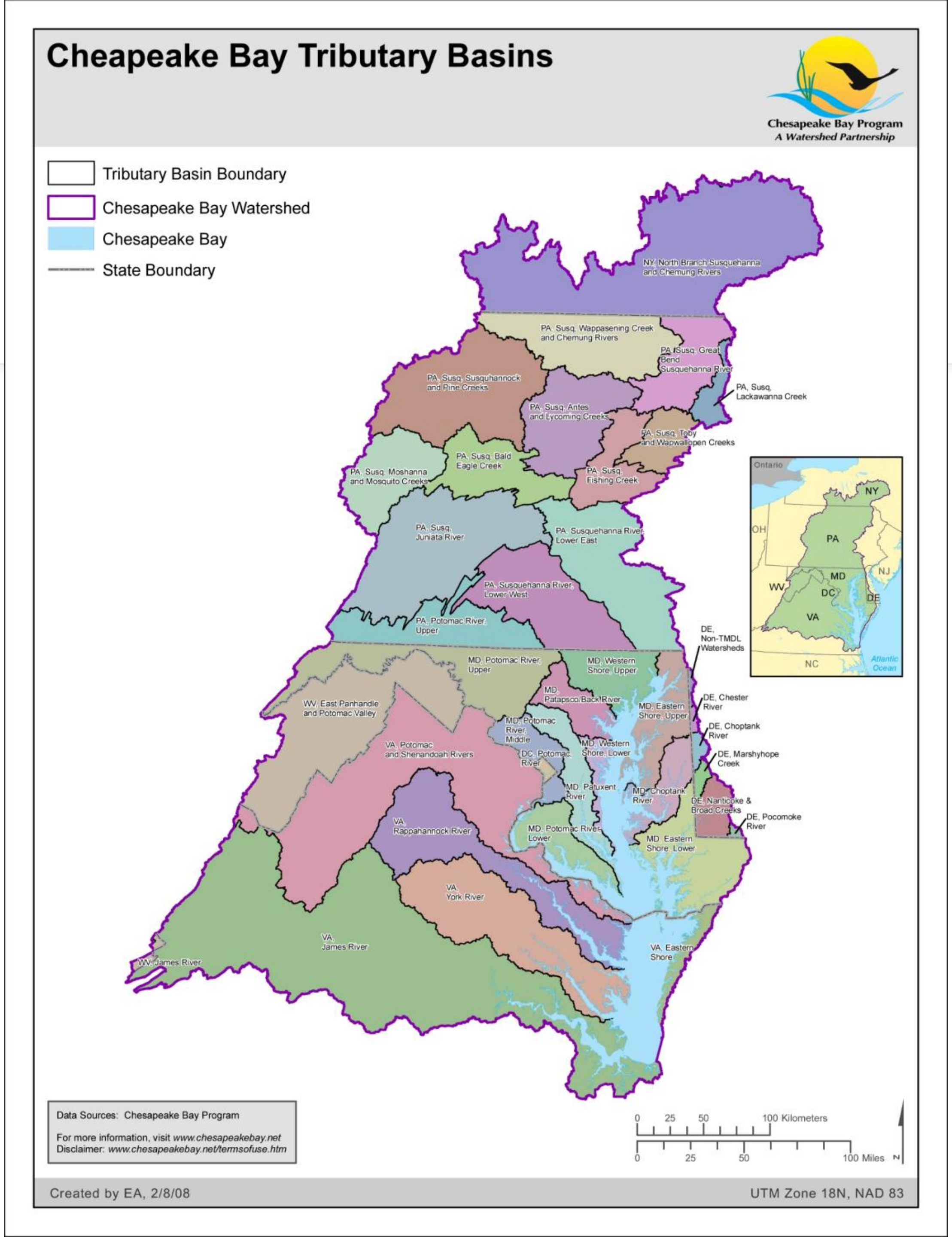

JR. GRAPHIC AMERICAN LEGENDS
THE HATFIELDS
AND
THE MCCOYS
Kirra Fedyszyn

1990's



2000's

2010's



Cheapeake Bay Tributary Basins
Chesapeake Bay Program
A Watershed Partnership
Tributary Basin Boundary
Chesapeake Bay Watershed
Chesapeake Bay
State Boundary
NY North Branch Susquehanna and Chemung Rivers
PA Susq. Wappasening Creek and Chemung Rivers
PA Susq. Great Bend Susquehanna River
PA Susq. Lackawanna Creek
PA Susq. Susquehannock and Pine Creeks
PA Susq. Antes and Lycoming Creeks
PA Susq. Toby and Wapwallopen Creeks
PA Susq. Bald Eagle Creek
PA Susq. Moshanna and Mosquito Creeks
PA Susq. Fishing Creek
PA Susq. Juniata River
PA Susquehanna River Lower East
PA Susquehanna River Lower West
PA Potomac River Upper
DE, Non-TMDL Watersheds
MD Potomac River Upper
MD Western Shore Upper
WV East Panhandle and Potomac Valley
MD Patapsco/Back River
MD Eastern Shore Upper
DE, Chester River
MD Potomac River Middle
DE, Choptank River
VA Potomac and Shenandoah Rivers
DC Potomac River
MD Western Shore Lower
DE, Marshyhope Creek
MD Patuxent River
MD Choptank River
DE Nanticoke & Broad Creeks
DE, Pocomoke River
VA Rappahannock River
MD Potomac River Lower
MD Eastern Shore Lower
VA York River
VA James River
WV James River
VA Eastern Shore
Ontario
NY
OH
PA
NJ
MD
WV
DC
DE
VA
NC
Atlantic Ocean
Data Sources: Chesapeake Bay Program
For more information, visit www.chesapeakebay.net
Disclaimer: www.chesapeakebay.net/termsofuse.htm
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0 25 50 100 Miles
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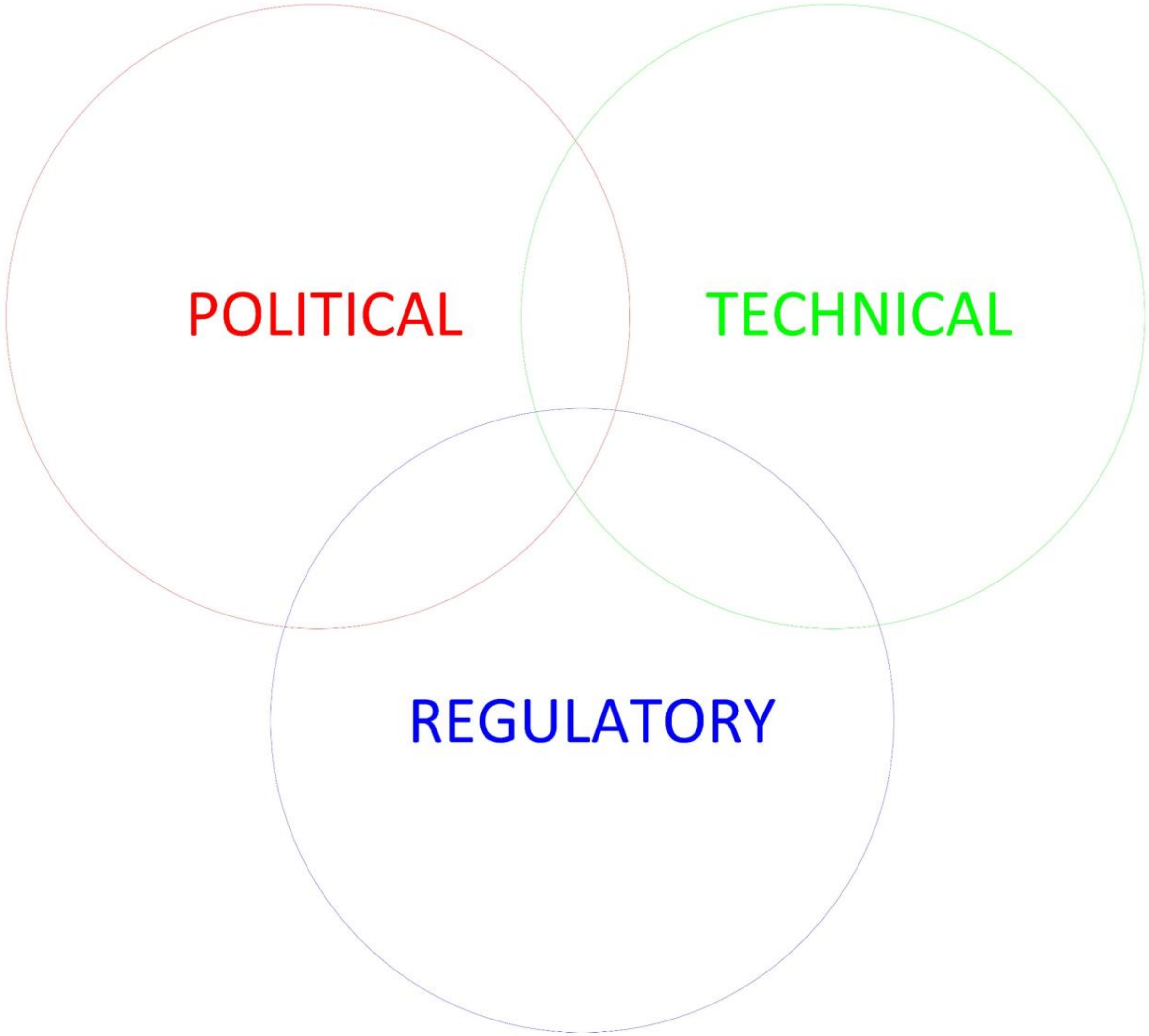
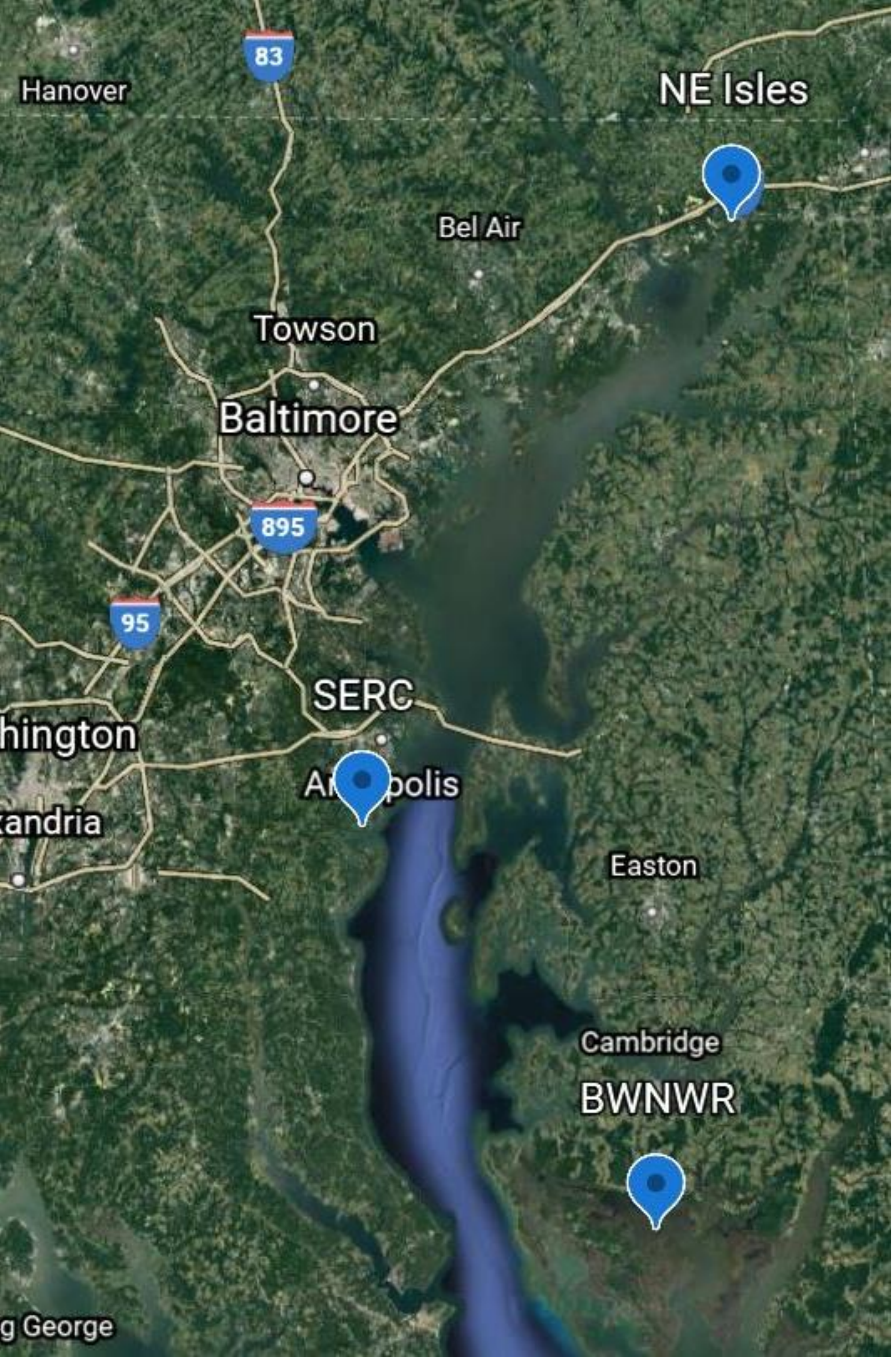
Created by EA, 2/8/08
UTM Zone 18N, NAD 83

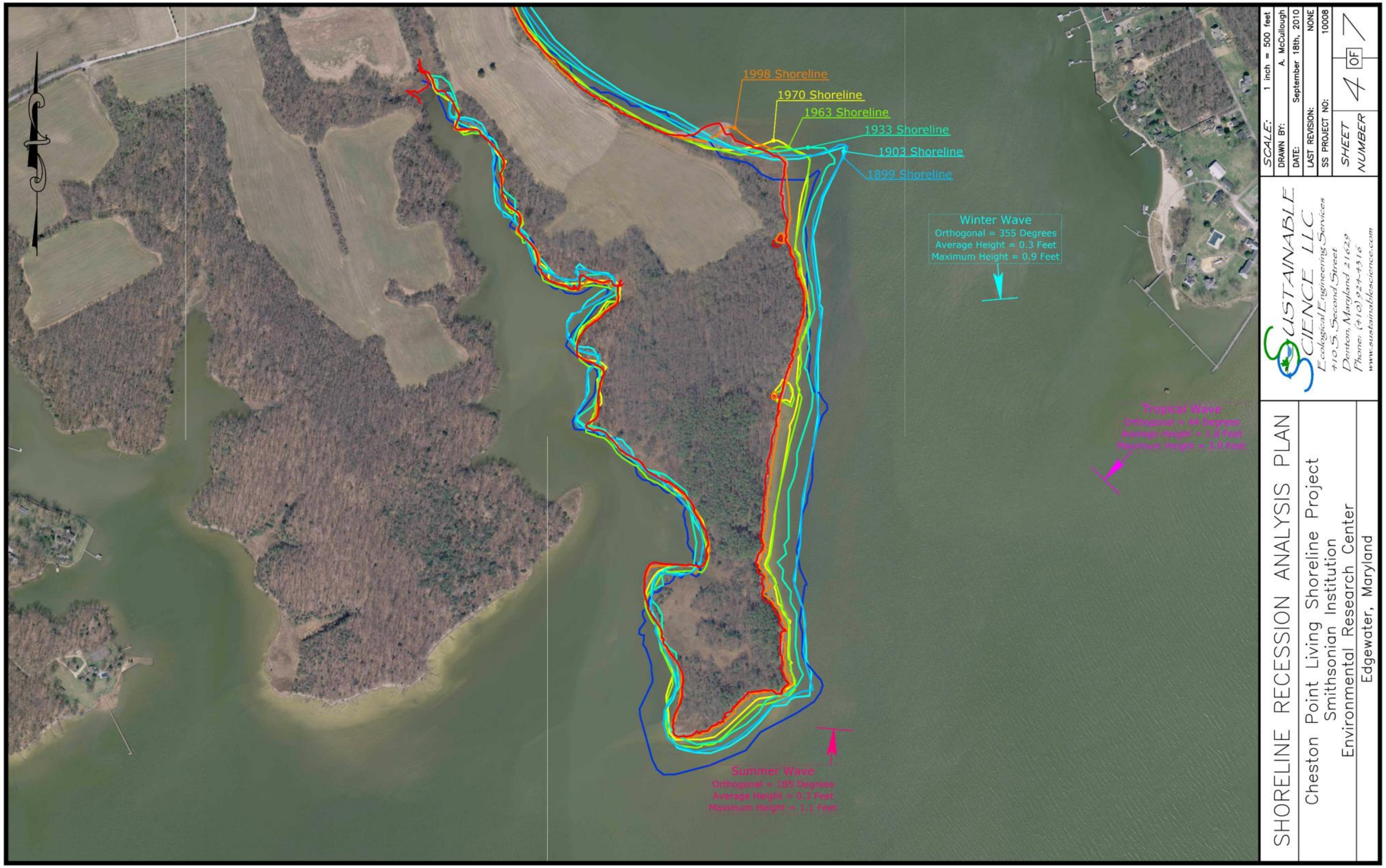

POLITICAL
TECHNICAL
REGULATORY



Projects

- Smithsonian Environmental Research Center (SERC):
  - 4,100 foot living shoreline on West & Rhode Rivers in Anne Arundel County
  - First phase constructed in 2012 with second phase currently in design & permitting phase
- North East Isles (NE Isles):
  - 3,800 foot living shoreline on North East River in Cecil County
  - Constructed in 2015
- Blackwater National Wildlife Refuge (BWNWR):
  - 41 acre marsh restoration thin layering project
  - Constructed in 2018

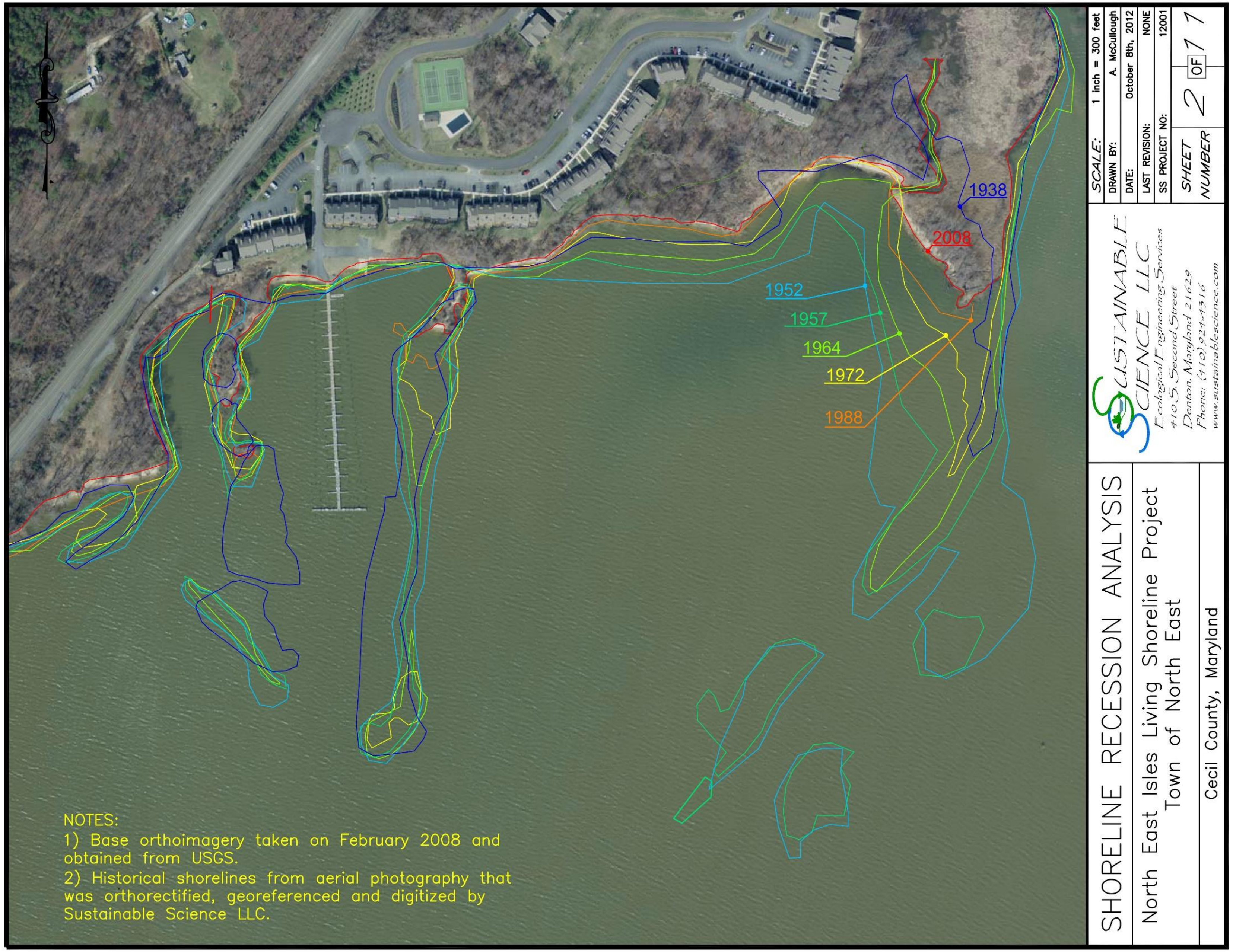
SERC


1998 Shoreline
1970 Shoreline
1963 Shoreline
1933 Shoreline
1903 Shoreline
1899 Shoreline
Winter Wave
Orthogonal = 355 Degrees
Average Height = 0.3 Feet
Maximum Height = 0.9 Feet
Tropical Wave
Summer Wave
SCALE: 1 inch = 500 feet
DRAWN BY: A. McCullough
DATE: September 18th, 2010
LAST REVISION: NONE
SS PROJECT NO: 10008
SHEET NUMBER 4 OF 7
SUSTAINABLE SCIENCE LLC
SHORELINE RECESSION ANALYSIS PLAN
Cheston Point Living Shoreline Project
Smithsonian Institution
Environmental Research Center
Edgewater, Maryland

SERC


U.S.TREASURY DEPARTMENT
COAST AND GEODETIC SURVEY
Henry S.Pritchett, Superintendent
Plane Table Survey
From Tolly Point to Curtis Point West Shore of
CHESAPEAKE BAY, MD.
Including South River and Rhode River
July 17th to Nov. 17th 1899
SHEET No.1
Register No.2394
SOUTH RIVER
Rhode River
West River
Curtis Point
Turkey Point
Selby Bay
Taylorsville
Edgewater

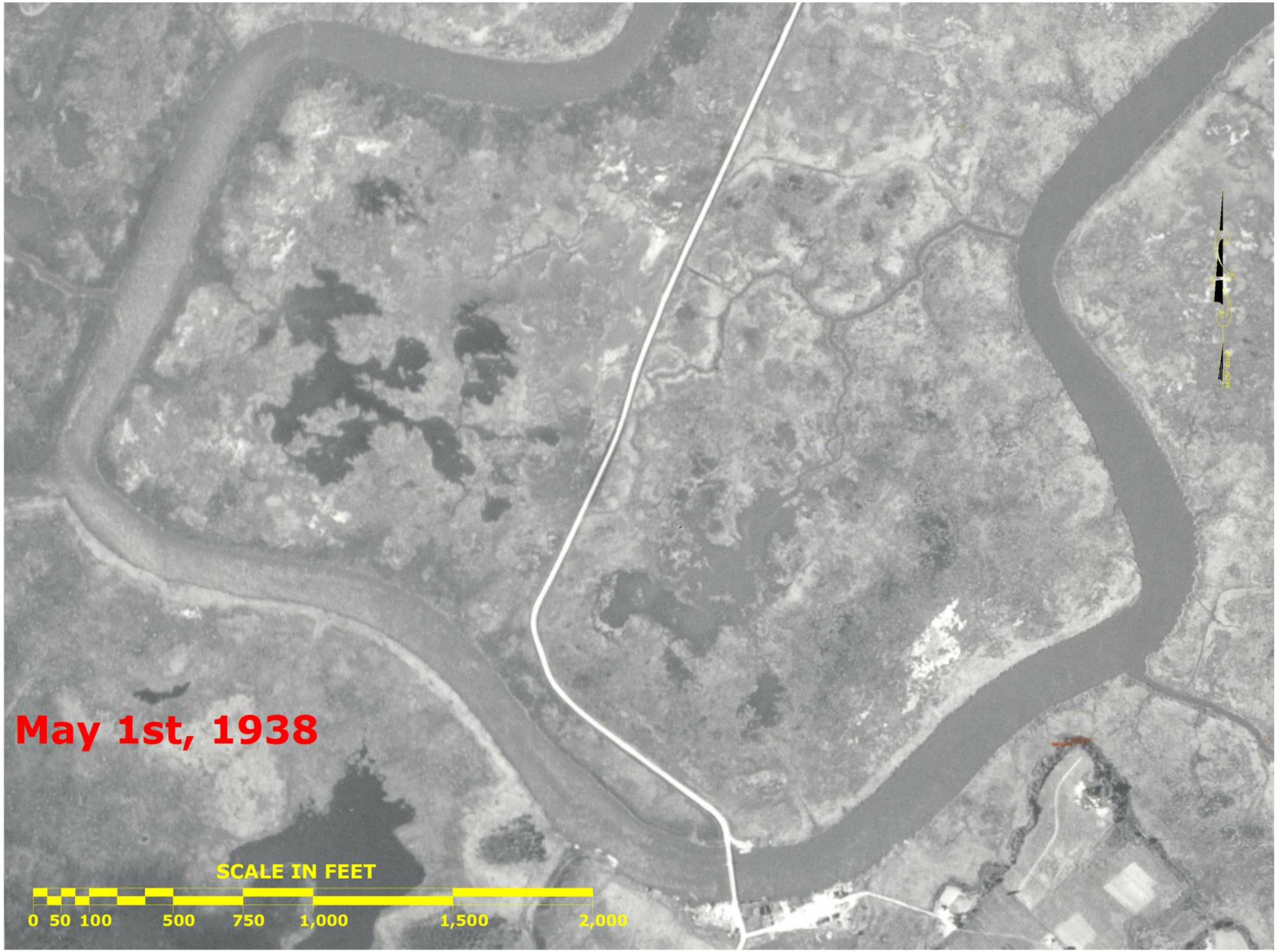
NE Isles



1938
2008
1952
1957
1964
1972
1988
NOTES:
1) Base orthoimagery taken on February 2008 and obtained from USGS.
2) Historical shorelines from aerial photography that was orthorectified, georeferenced and digitized by Sustainable Science LLC.
SHORELINE RECESSION ANALYSIS
North East Isles Living Shoreline Project
Town of North East
Cecil County, Maryland
SUSTAINABLE SCIENCE LLC
Ecological Engineering Services
410 S. Second Street
Denton, Maryland 21629
Phone: (410) 924-4316
www.sustainablescience.com
SCALE: 1 inch = 300 feet
DRAWN BY: A. McCullough
DATE: October 8th, 2012
LAST REVISION: NONE
SS PROJECT NO: 12001
SHEET NUMBER 2 OF 11

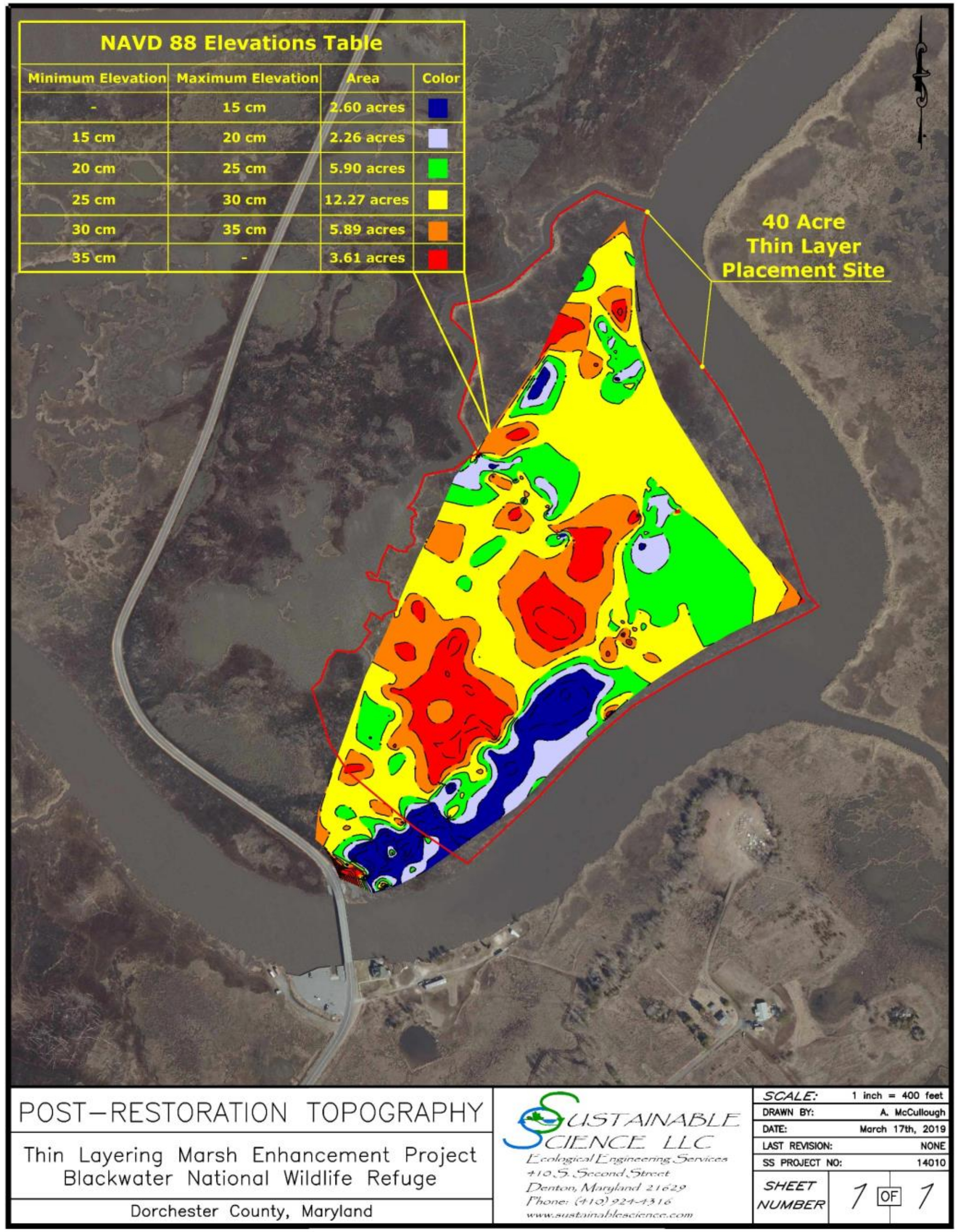
NE Isles

BWNWR



BNWR

BWNWR


NAVD 88 Elevations Table
Minimum Elevation | Maximum Elevation | Area | Color
- | 15 cm | 2.60 acres
15 cm | 20 cm | 2.26 acres
20 cm | 25 cm | 5.90 acres
25 cm | 30 cm | 12.27 acres
30 cm | 35 cm | 5.89 acres
35 cm | - | 3.61 acres
40 Acre Thin Layer Placement Site
POST–RESTORATION TOPOGRAPHY
Thin Layering Marsh Enhancement Project
Blackwater National Wildlife Refuge
Dorchester County, Maryland
SUSTAINABLE SCIENCE LLC
Ecological Engineering Services
410 S. Second Street
Denton, Maryland 21629
Phone: (410) 924-4316
www.sustainablescience.com
SCALE: 1 inch = 400 feet
DRAWN BY: A. McCullough
DATE: March 17th, 2019
LAST REVISION: NONE
SS PROJECT NO: 14010
SHEET NUMBER 1 OF 1


LOONEY TUNES
"That's all Folks!"

Living shoreline performance and impacts to adjacent nearshore benthic habitats: does age matter?

Cindy Palinkas, Lorie Staver

Horn Point Laboratory
University of Maryland Center for Environmental Science

CHESAPEAKE BAY TRUST

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Grayce B. Kerr Fund, Inc.

Research Questions

Main research questions – do living shorelines:

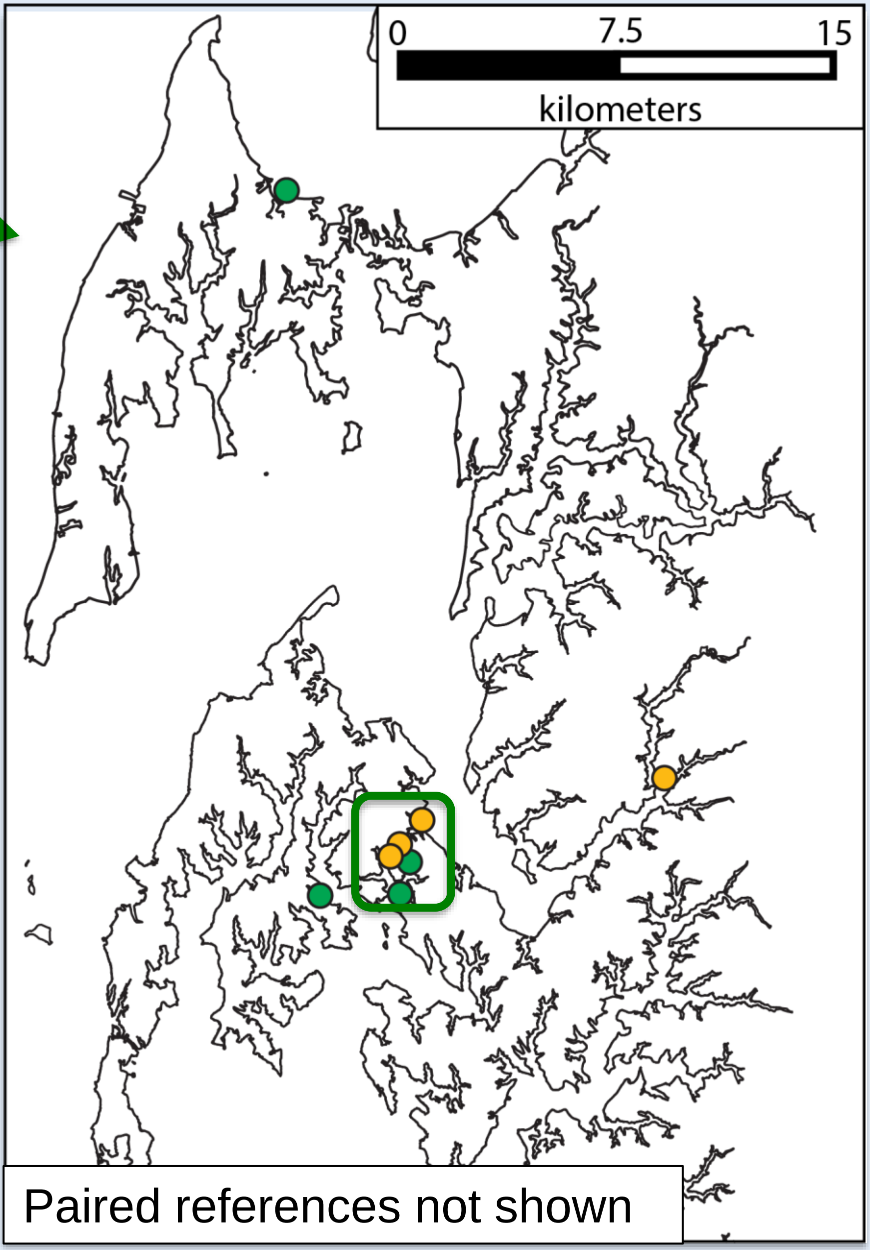
- Reduce shoreline erosion (**performance**)?
- Impact submersed aquatic vegetation (SAV) benthic habitat and/or distributions in adjacent shallow waters (subtidal) (**impacts**)?
- Increase net sediment/nutrient burial in the coastal zone (subtidal to intertidal) (**co-benefits**)?

Do the answers to these questions depend on age?

~10 years old: Chesapeake Bay Trust; MD Sea Grant (soon!)
3-5 years old (time series!): Grayce B. Kerr Fund
0-? years old (pre-construction only so far): MD-DNR



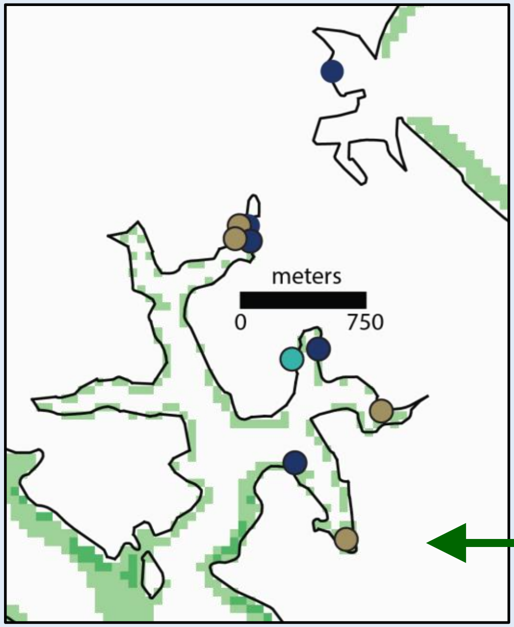

Study sites in Chesapeake Bay

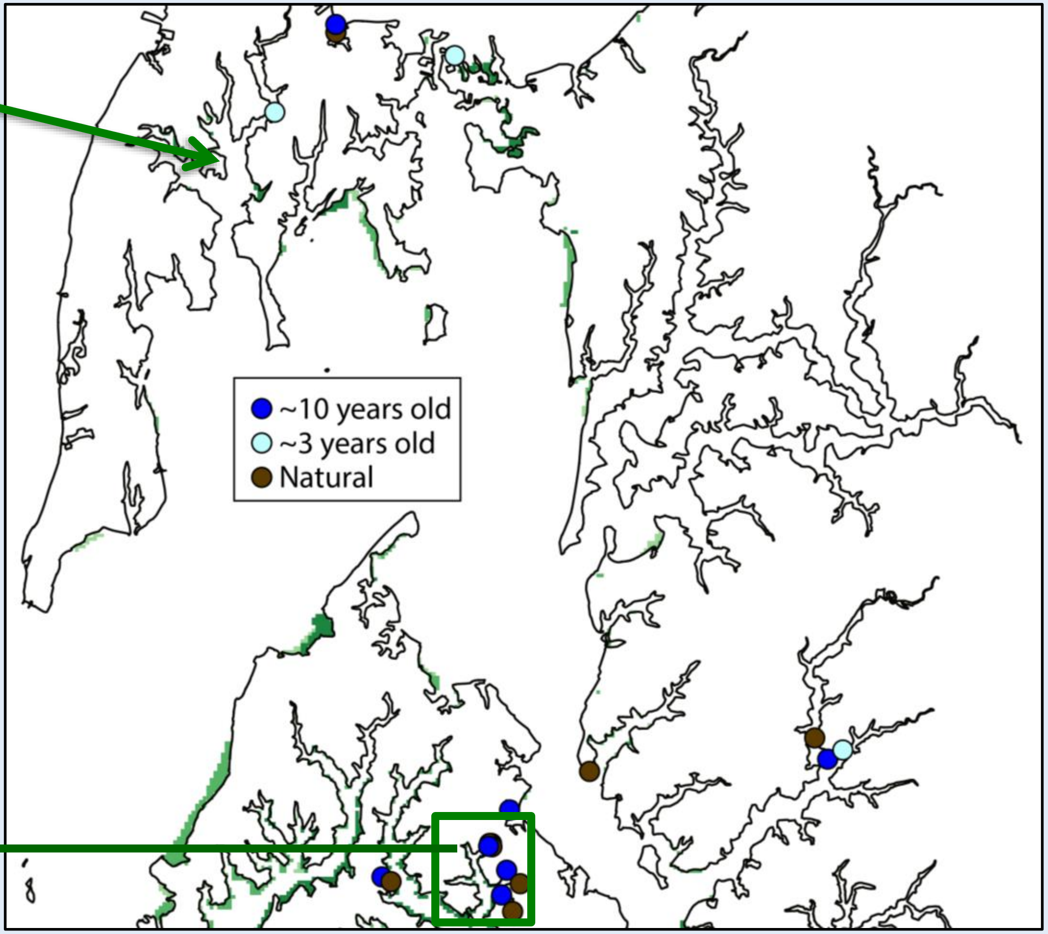


8 sites with paired reference sites (natural shorelines, typically within ~0.5 km, similar physical setting) in the mesohaline portion of Chesapeake:

- Installed 2004-2008
- Weighted-bed density of SAV from 1978-2005 (GIS analysis of VIMS aerial data)
- 4 sites with persistent, dense SAV before installation (green)
- 4 sites without SAV before installation (yellow)

Study sites in Chesapeake Bay





Green shading = weighted SAV density 1978-2005 (data from VIMS)

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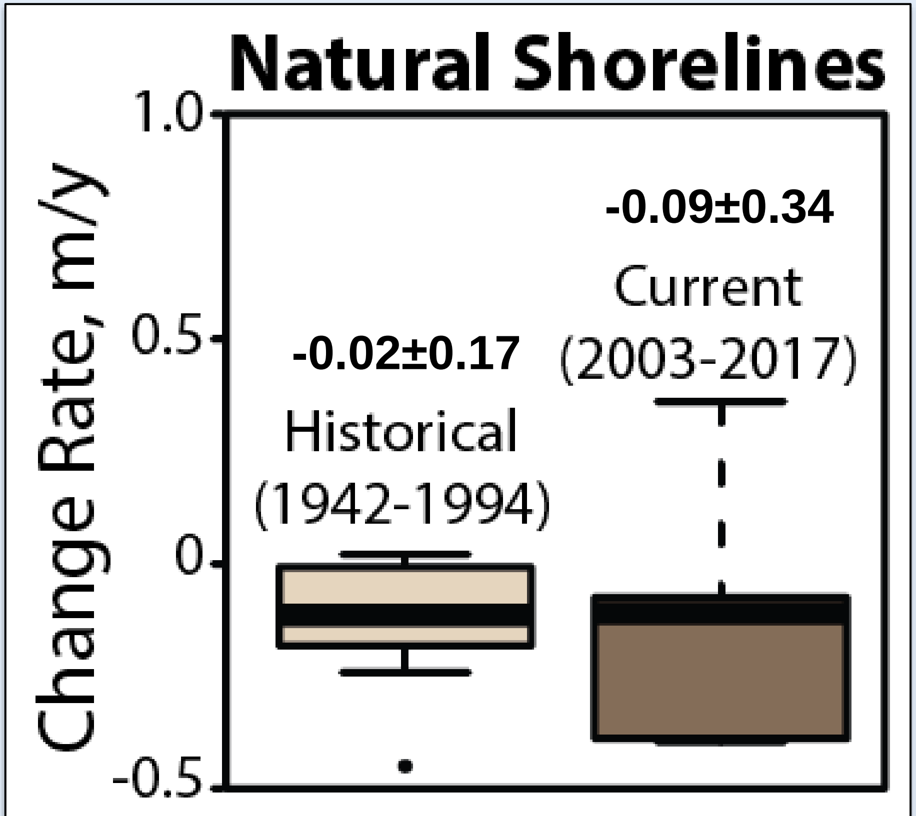
Performance: erosion rates before and after installation



Feb 2007 Google Earth

LS
natural

Negative: erosion (shoreline moves landward)
Positive: accretion (shoreline moves landward)

Erosion continues at or above historical rates at natural sites

cp

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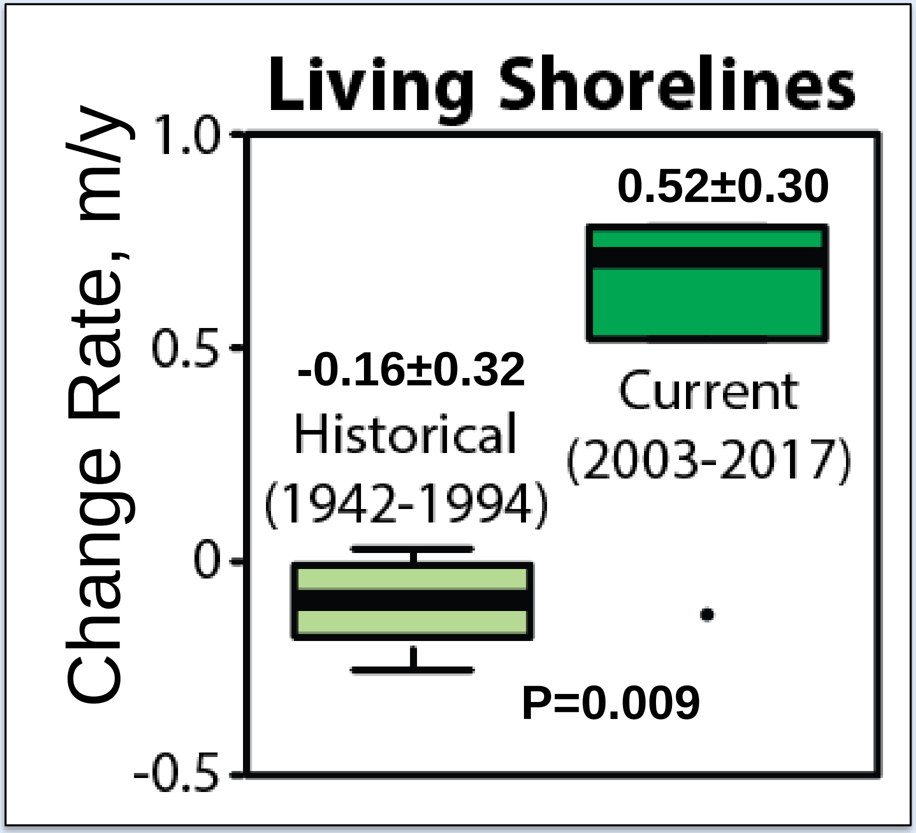
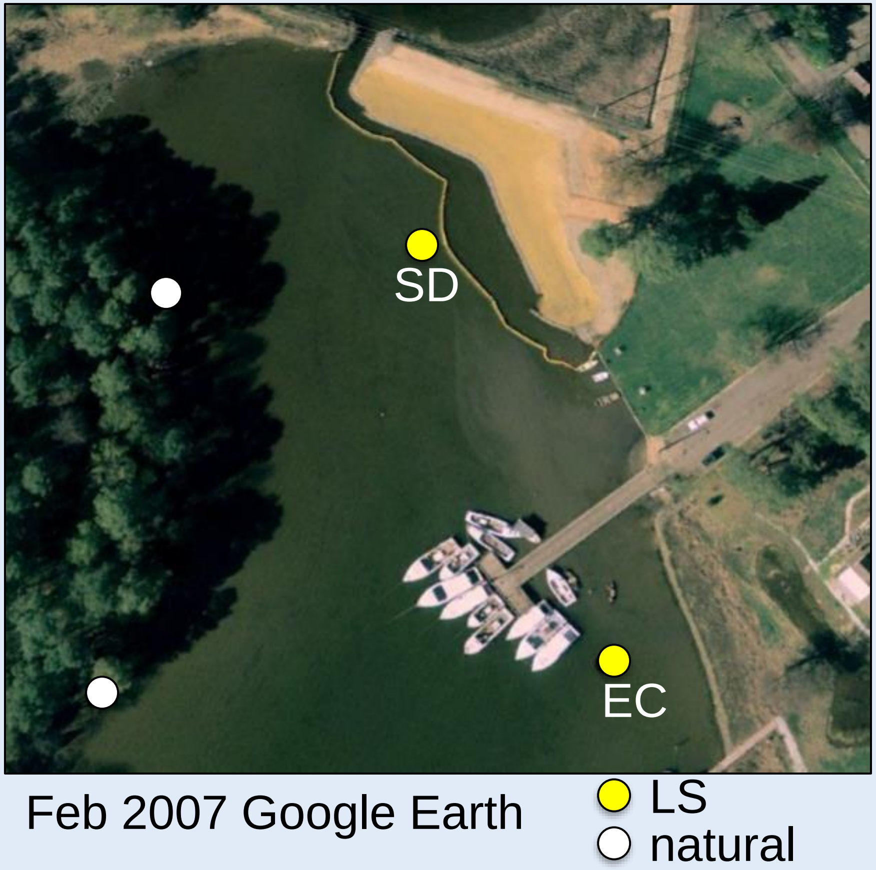
Performance: erosion rates before and after installation





Feb 2007 Google Earth

Net accretion occurs at living shorelines due to installation (~instantaneous change rather than rate)

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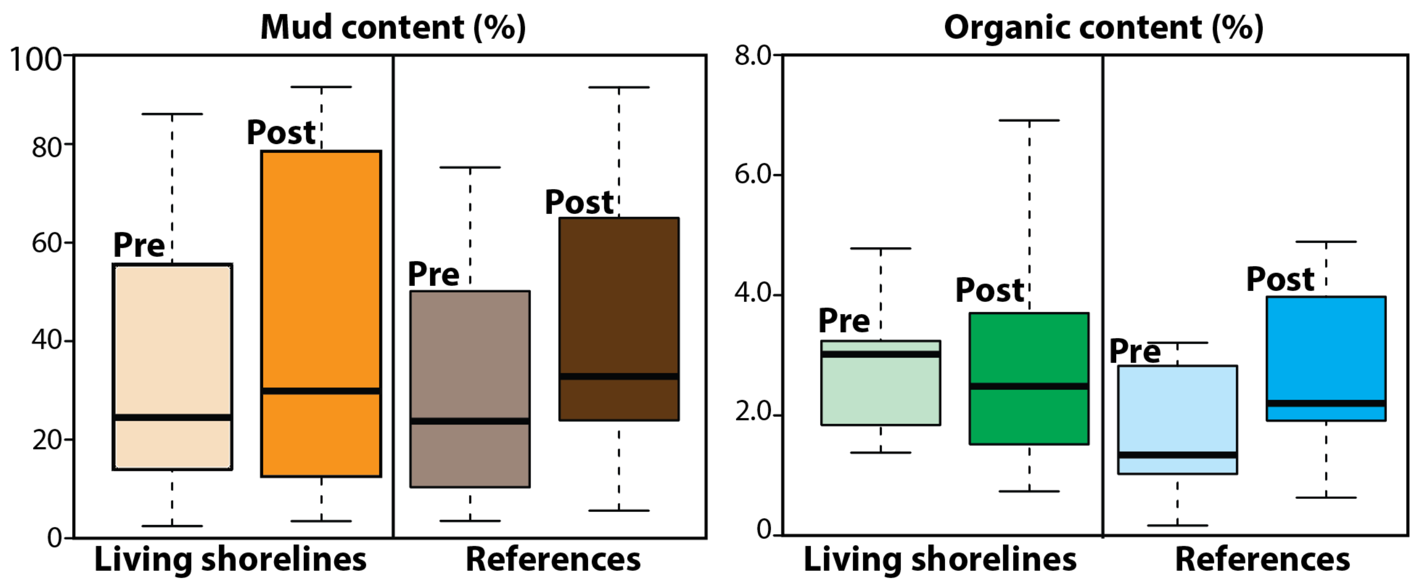
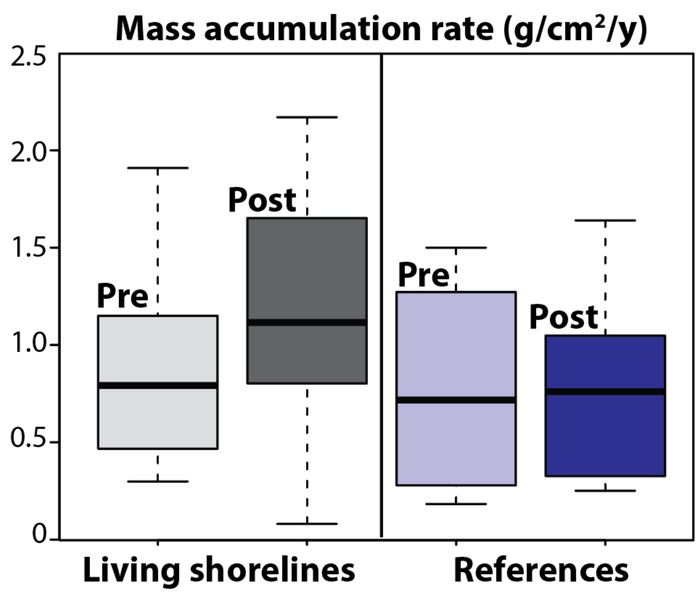
Impacts: Do living shorelines alter SAV habitat?





No significant differences

- Pre- versus post-installation
- Living versus reference shorelines

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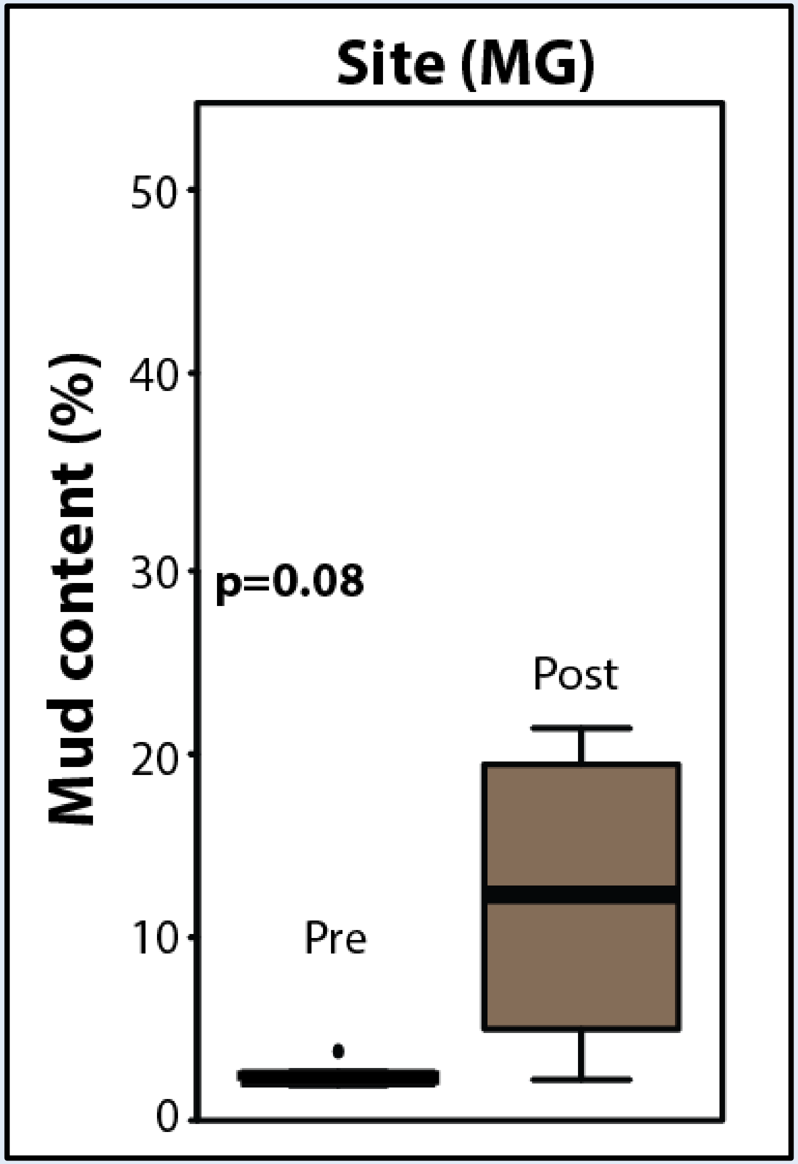
Changes can be significant at individual sites



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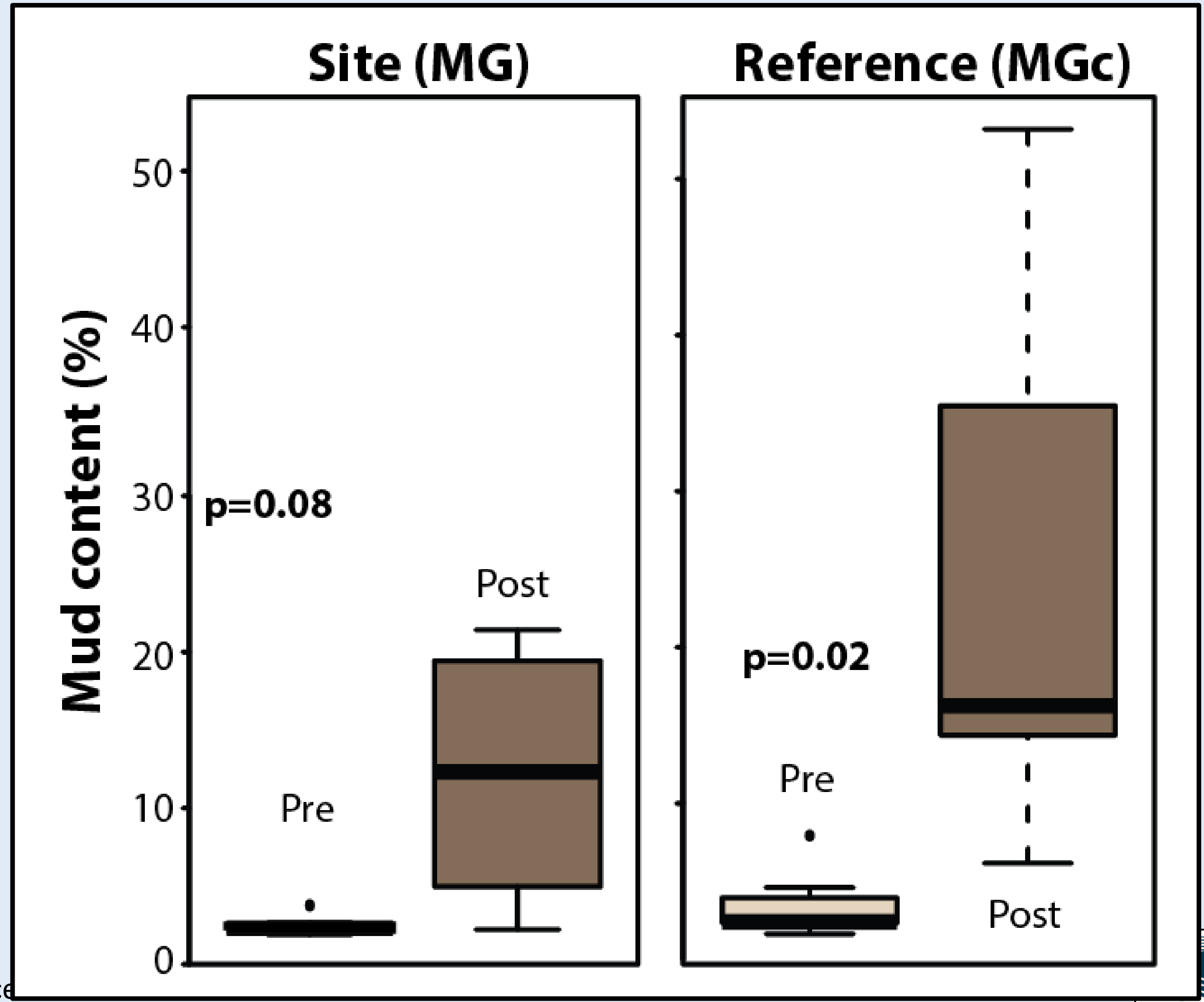
Changes can be the same at living shorelines and references



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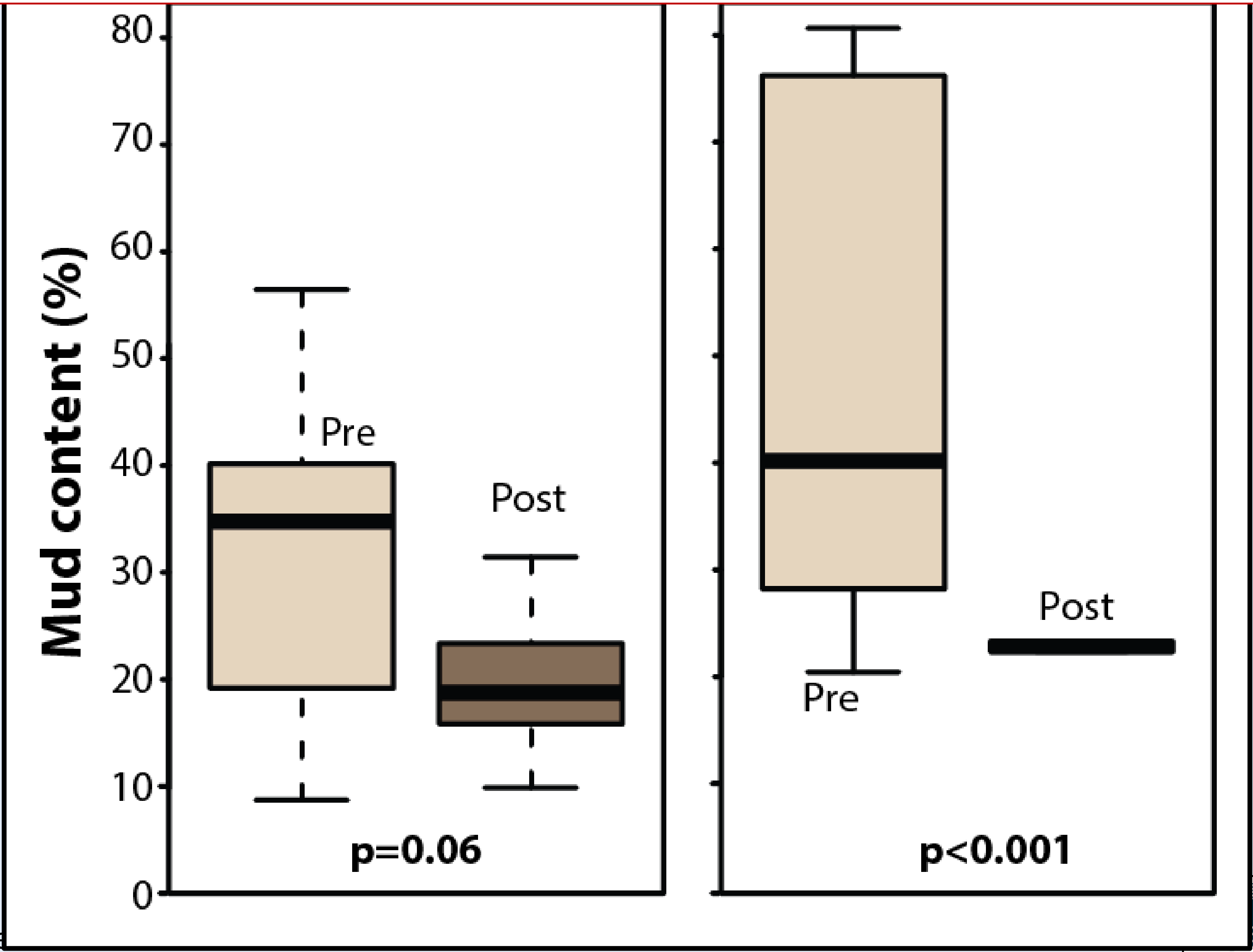
Changes can be the same at living shorelines and natural shorelines – or not

Sediment impacts are site-specific. What about SAV?



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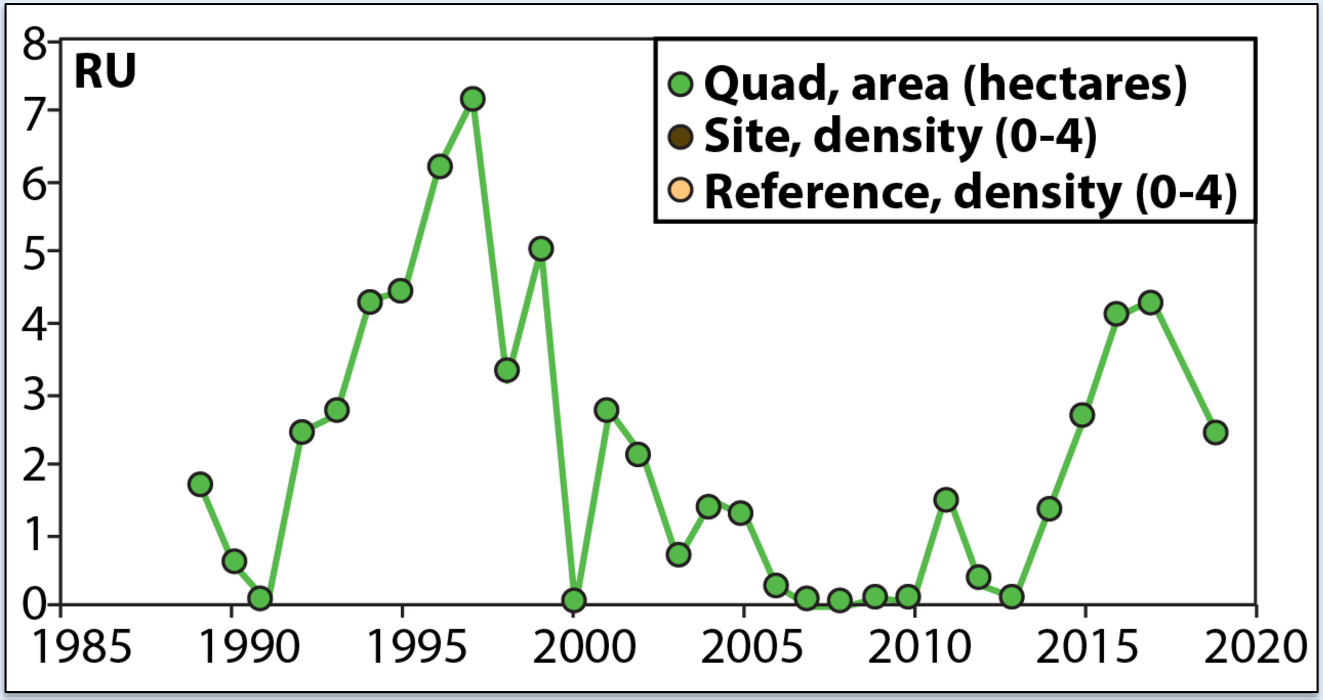
SAV area within the quad – lots of variability!



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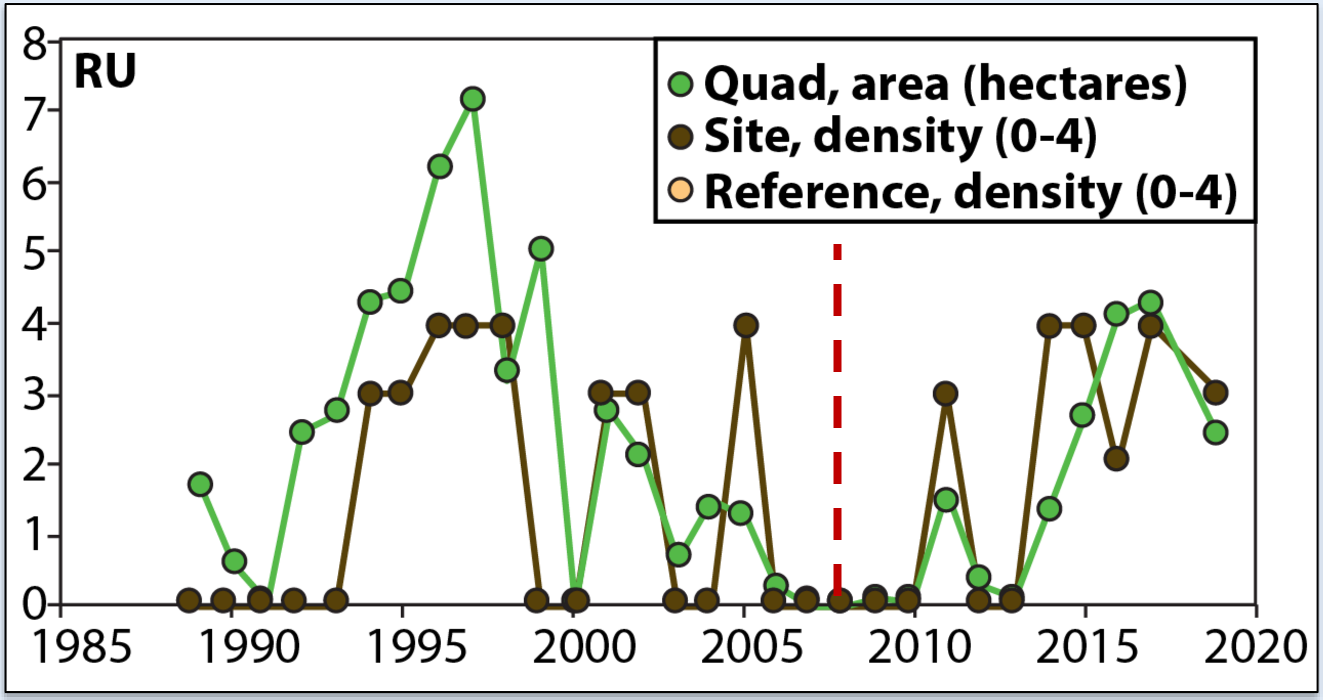
SAV area at the site follows the quad



Install 2008 (red line)

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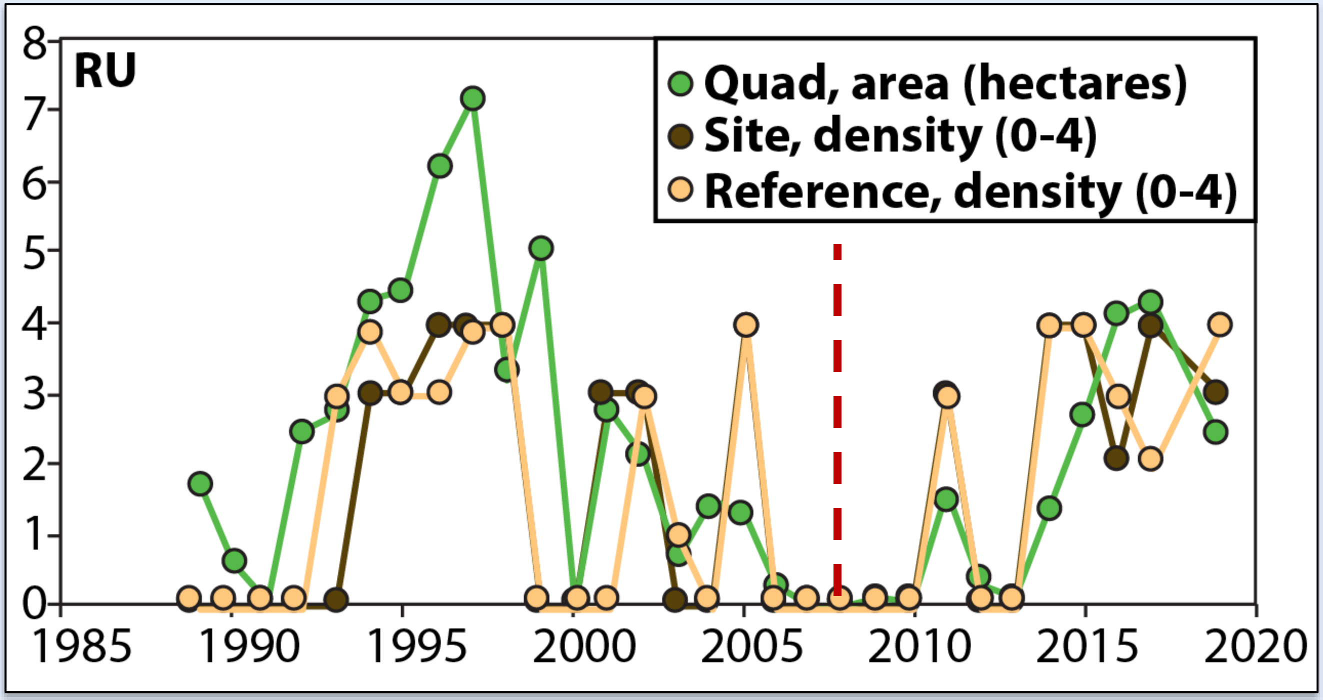
SAV area at the reference site follows general trend



Install 2008 (red line)

No difference between SAV at site and reference site; both follow quad

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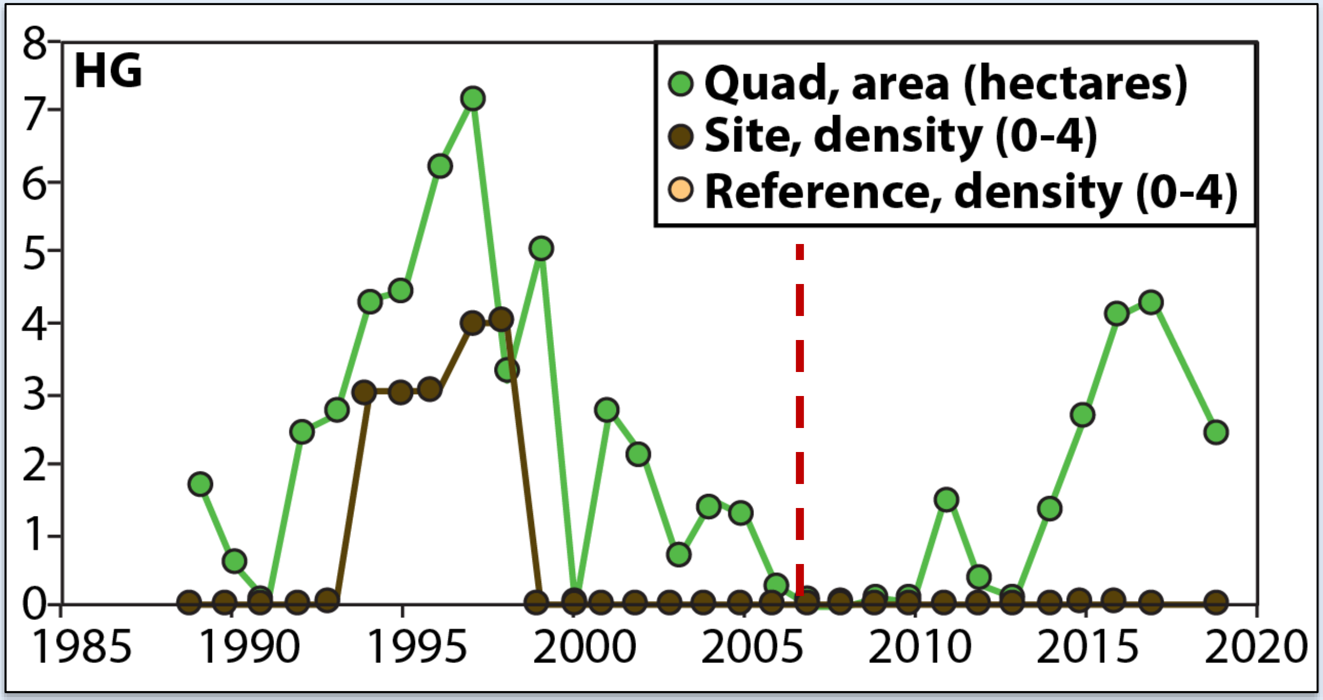
At a nearby site (same quad), SAV disappears many years before installation



Install 2007 (red line)

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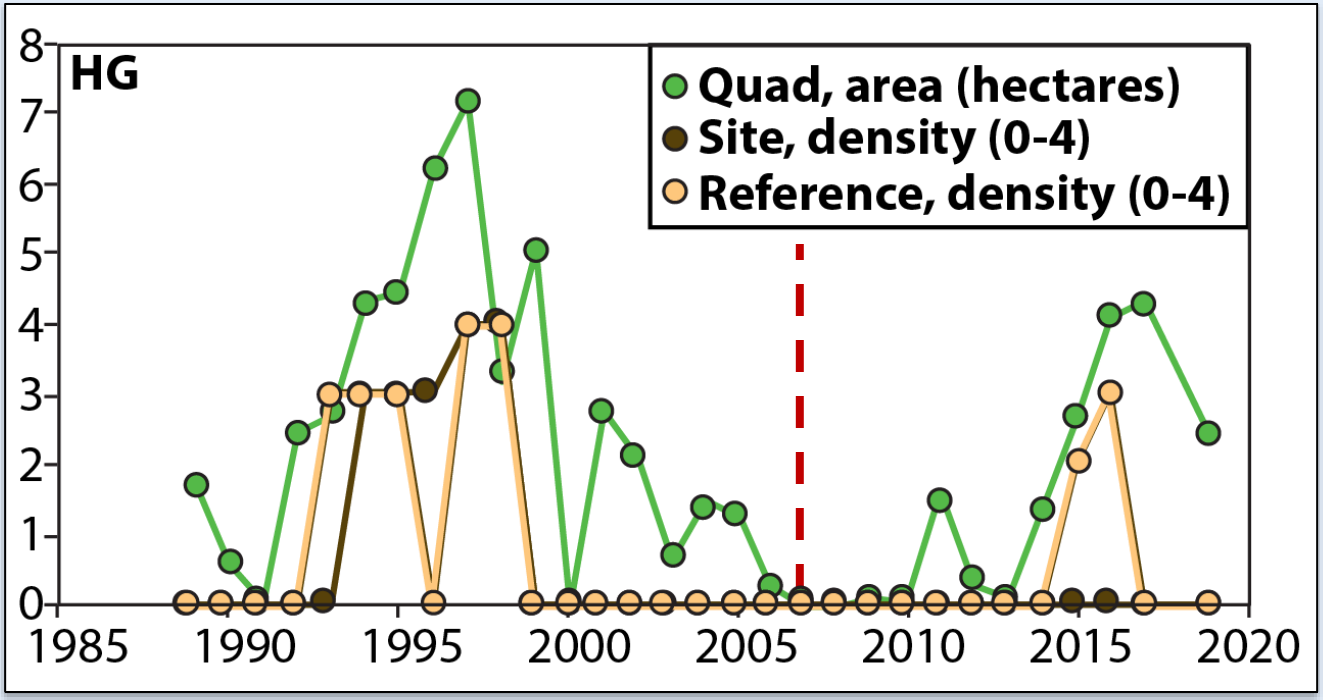
SAV also disappears at reference site



Install 2007 (red line)

SAV generally **follows regional (quad) trends** except for some sites where more **local processes** affect both living and reference shorelines Living shoreline installation **does not appear to influence** SAV distributions!

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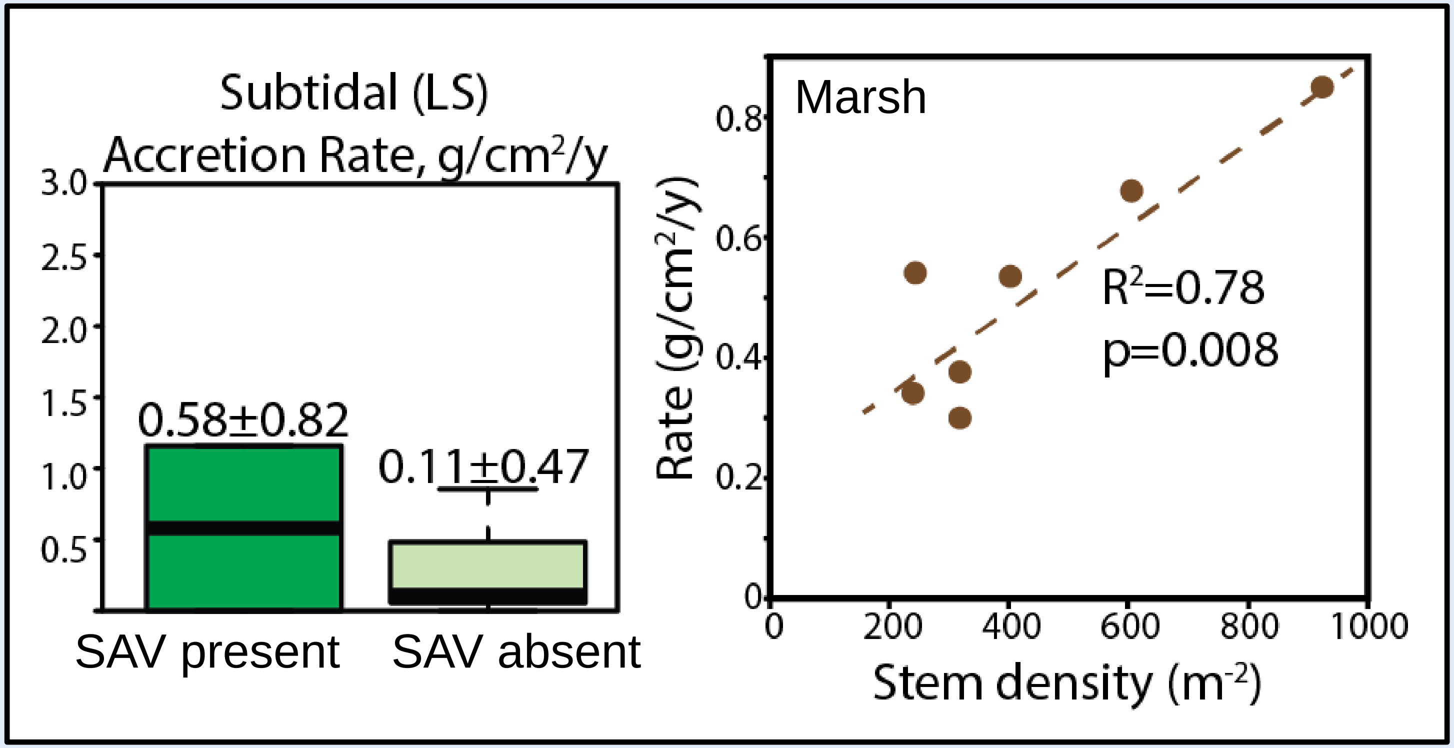
Co-benefits: what controls burial rates in marsh and subtidal? Plants!



Subtidal (LS) = shallow water adjacent to living shorelines; rates tend to be higher at sites with SAV

Marsh accretion rates increase with stem density

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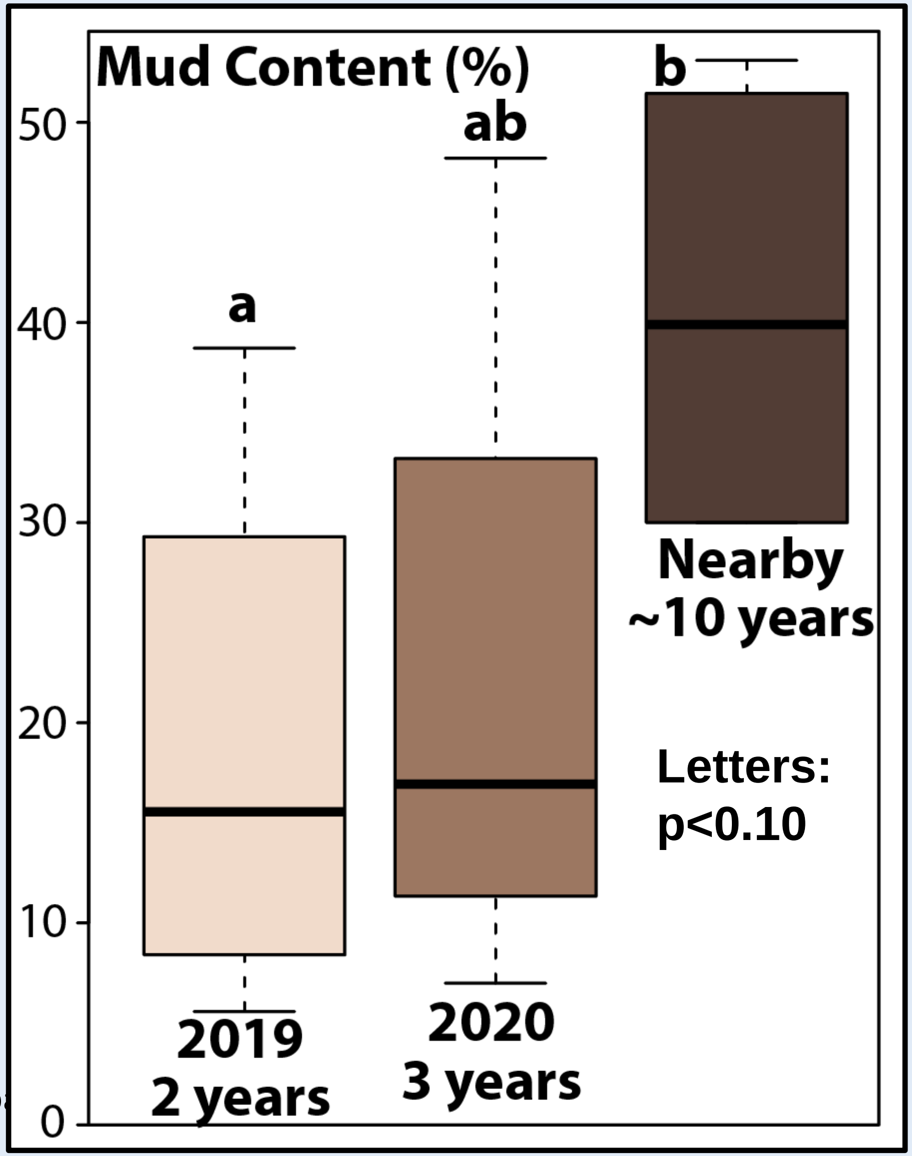
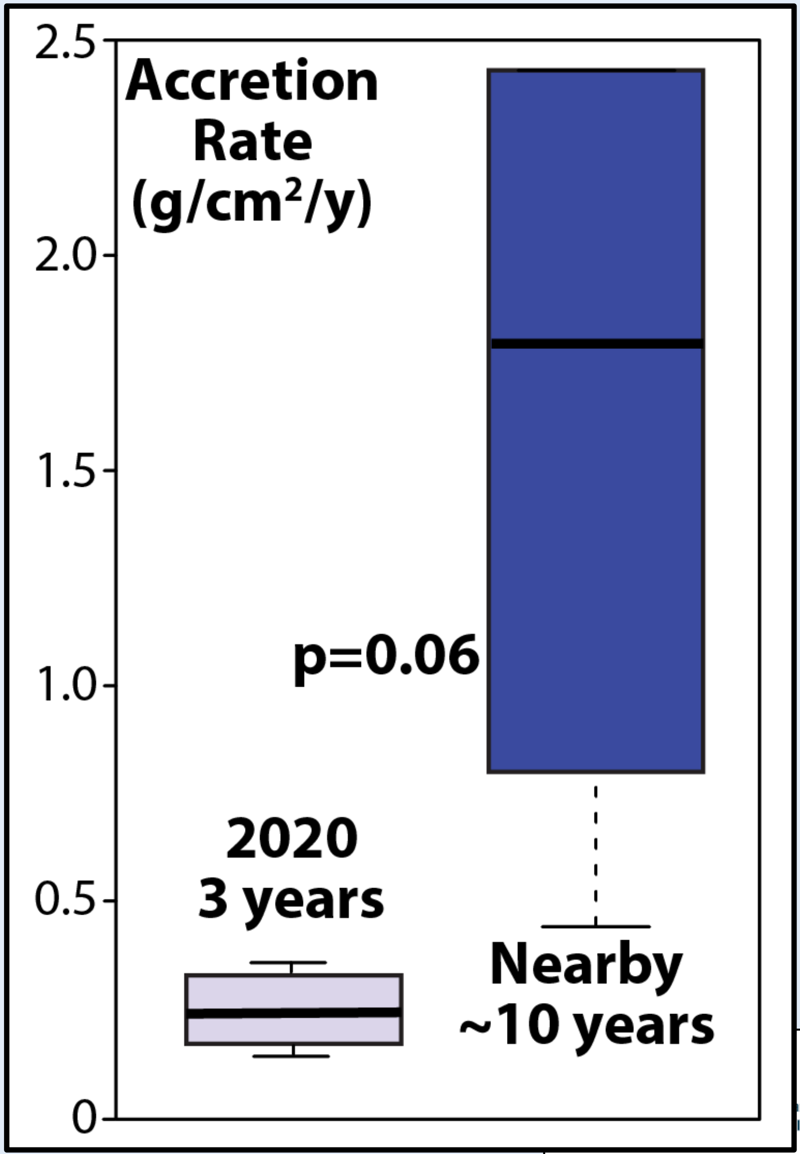
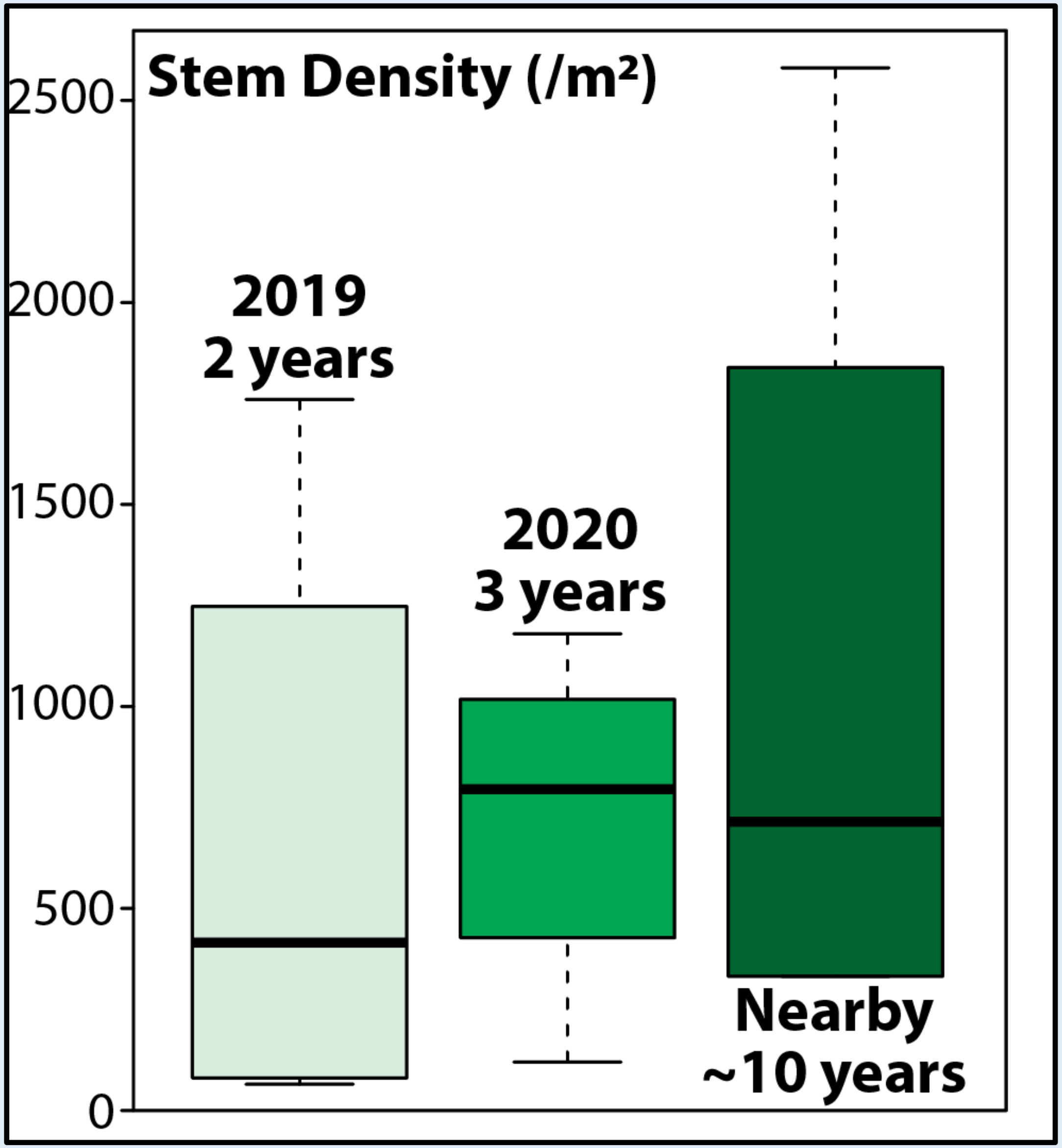
Mud content and accretion rates are higher at older living shorelines





cp

Stem density is similar in young and old living shorelines, on average, with high variability



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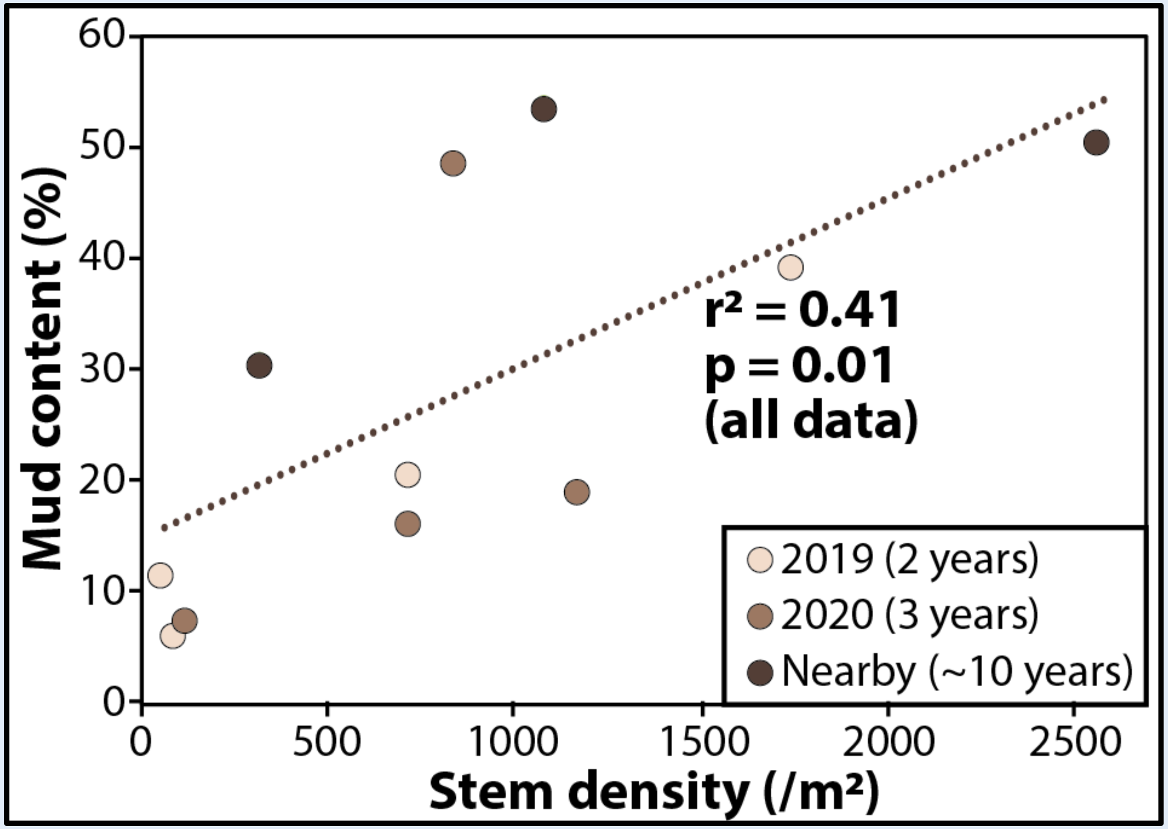
Mud varies with stem density



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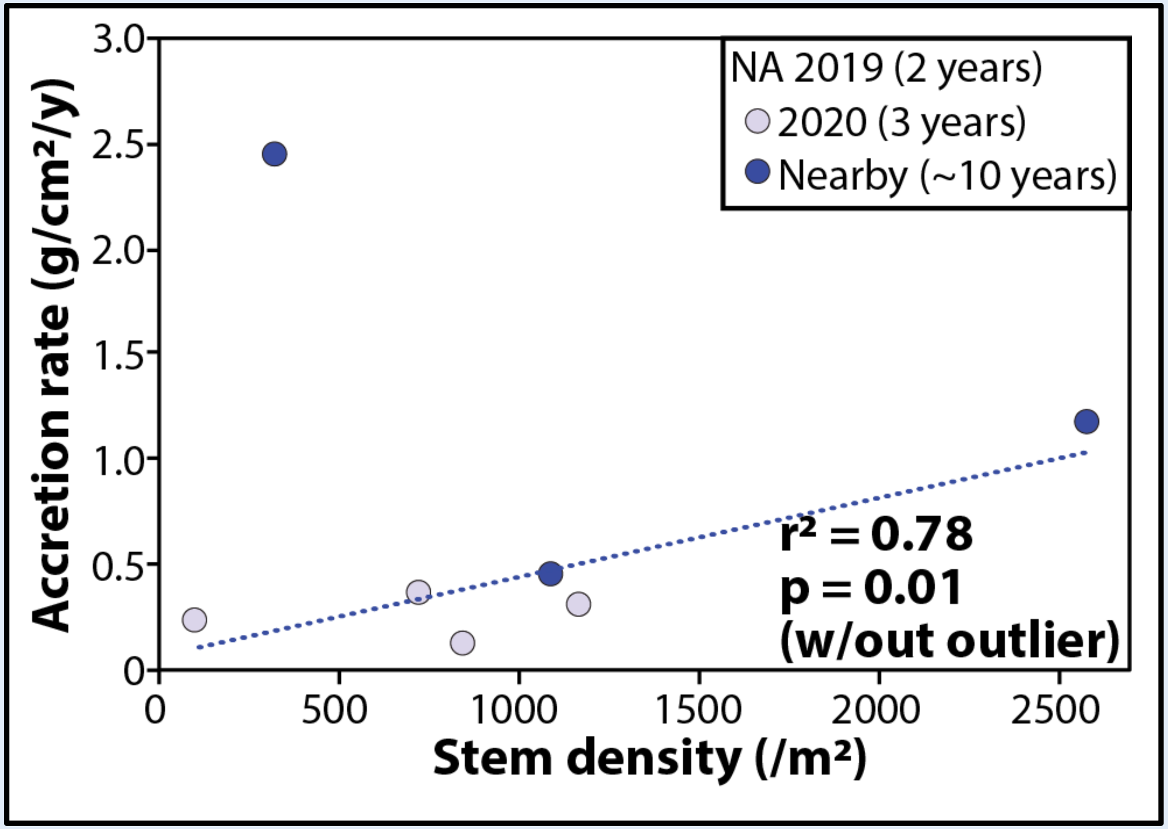
Accretion rates might(?) vary with stem density



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Summary

Performance: shoreline erosion rates

- Net accretion at living shorelines due to construction
- Continuing erosion at or above historical rates at natural shorelines

Impacts of living shorelines to adjacent benthic habitat

- Site-specific impacts to sediment
- No obvious (qualitative) impact to SAV distributions, appear to follow trends at larger spatial scales (local, regional (quad))

Co-benefits: sediment/nutrient burial rates

- SAV and marsh plants effectively trap sediments and associated nutrients
- Accretion rates in subtidal and marsh increase with more vegetation for older living shorelines

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Does age matter?

For sediment trapping, sure seems like it!

- Mud and accretion rates are higher at older living shorelines

For vegetation, not really?

- Similar stem density for young and old living shorelines (but broad range for both)

Role of plants in younger living shorelines – mud content (and maybe accretion rates) appear to be correlated with stem density, but statistics limited by number of sites

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Working with Communities to Balance Habitat and Infrastructure Needs

A Presentation for the Webinar Series

"Collaborative Activities on Blue Carbon In Maryland"

February 10, 2022

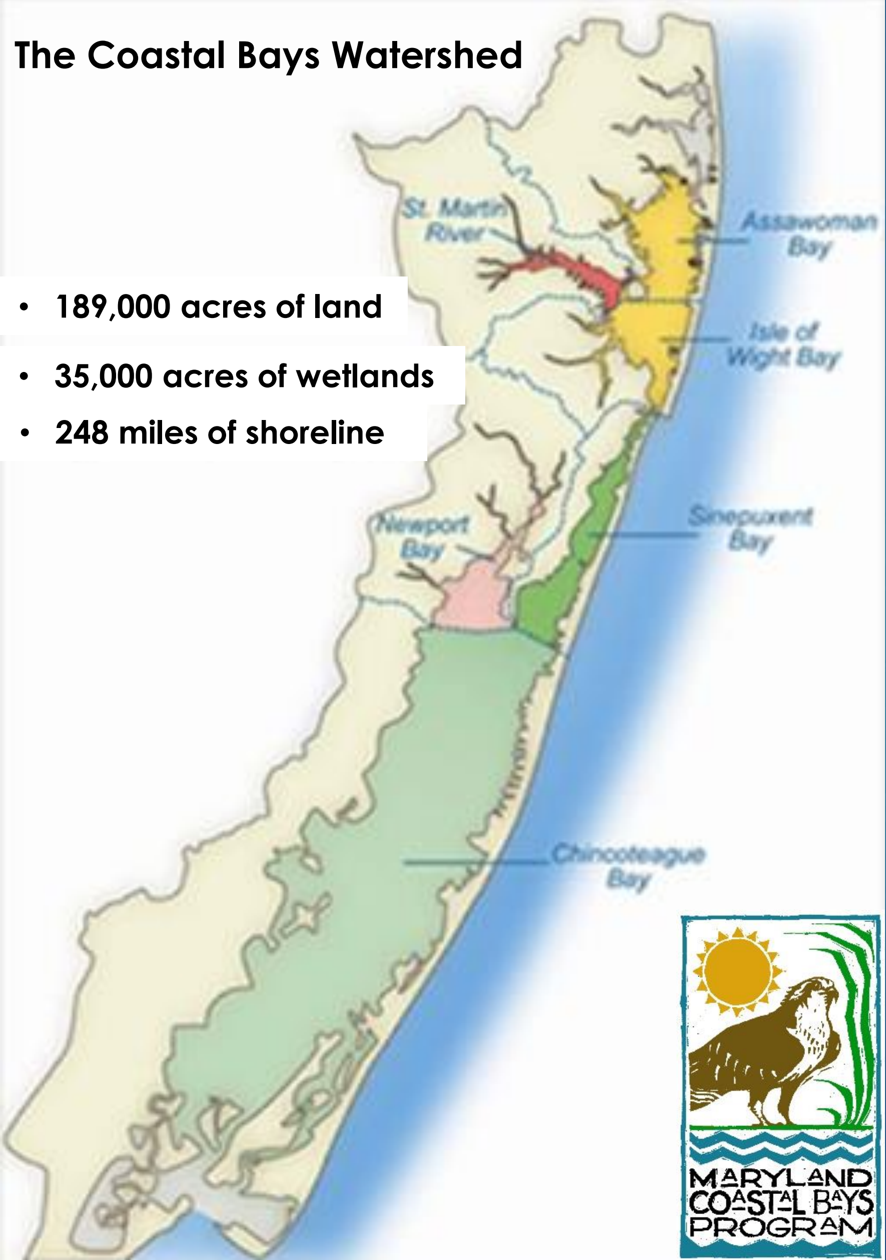
By: Kevin M. Smith – Maryland Coastal Bays Program

ksmith@mdcoastalbays.org

Maryland Coastal Bays Program

The Coastal Bays Watershed

- 189,000 acres of land
- 35,000 acres of wetlands
- 248 miles of shoreline



- Established in 1996
- Part of the National Estuary Program (NEP) funded by EPA
- One of 28 NEPs in the United States
- NEP boundary lies entirely within Worcester County Maryland
- Mission is to protect and restore the waters, wildlife and lands that make up this coastal ecosystem.

Our Mission: One of 28 National Estuary Programs nationwide, our goal is to protect and enhance the watershed, which includes Ocean City, Ocean Pines, Berlin, and Assateague Island National Seashore.

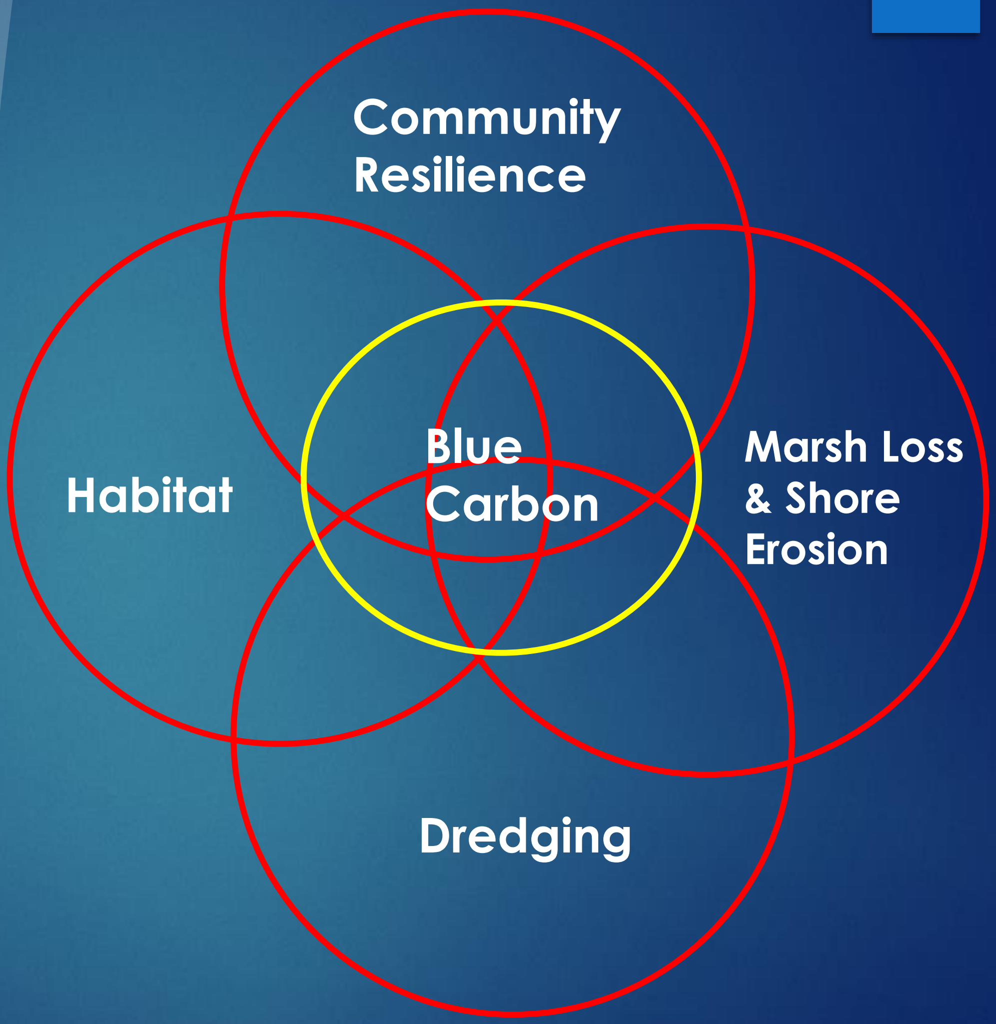
MARYLAND COASTAL BAYS PROGRAM

Our Program is Guided by our Comprehensive Conservation & Management Plan (CCMP)

- 2015: CCMP Revision included Coastal Resilience Focus
- 10 Separate Focus Areas which include:
  - Water Quality
  - Fish and Wildlife
  - Recreation and Navigation
  - Community & Economic Development
  - Coastal Resiliency
  - Public Involvement
  - Financial Management
  - Monitoring
  - Science Agenda
  - Habitat Plan

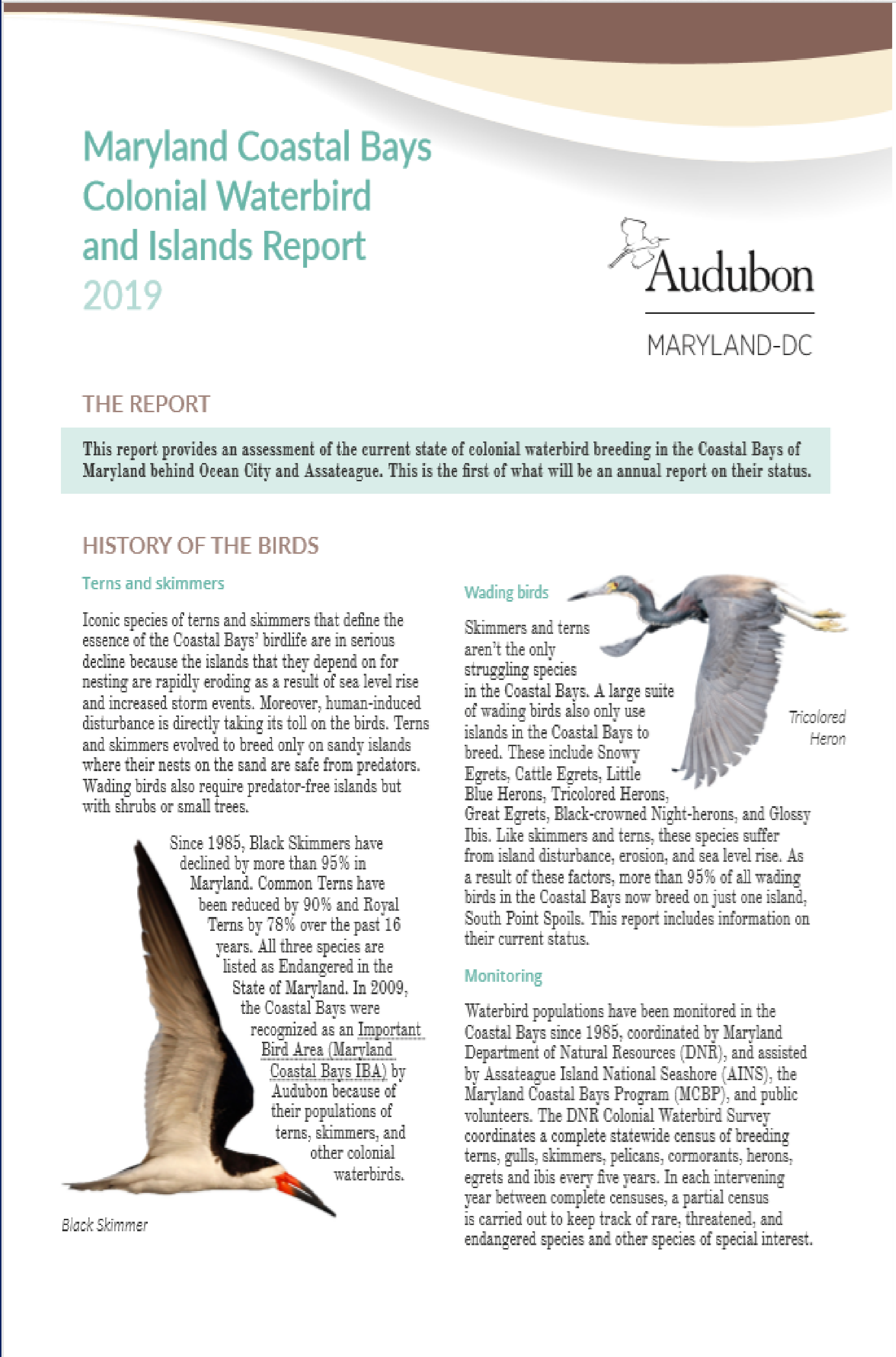
- 2015: CCMP Revision included Coastal Resilience Focus
- 2016: Initiated EPA Climate Ready Estuaries Planning Process2018: Completed Climate Change Vulnerability Assessment
- 2021 Developed Climate Change Action Plan

Intersecting Concerns



Habitat Loss

- Populations of some of our iconic colonial nesting species (black skimmers, royal terns, least terns) are down 90%.
- Loss of nesting habitat is associated with loss of island habitat



Maryland Coastal Bays Colonial Waterbird and Islands Report 2019

Audubon

MARYLAND-DC

THE REPORT

This report provides an assessment of the current state of colonial waterbird breeding in the Coastal Bays of Maryland behind Ocean City and Assateague. This is the first of what will be an annual report on their status.

HISTORY OF THE BIRDS

Terns and skimmers

Iconic species of terns and skimmers that define the essence of the Coastal Bays' birdlife are in serious decline because the islands that they depend on for nesting are rapidly eroding as a result of sea level rise and increased storm events. Moreover, human-induced disturbance is directly taking its toll on the birds. Terns and skimmers evolved to breed only on sandy islands where their nests on the sand are safe from predators. Wading birds also require predator-free islands but with shrubs or small trees.

Since 1985, Black Skimmers have declined by more than 95% in Maryland. Common Terns have been reduced by 90% and Royal Terns by 78% over the past 16 years. All three species are listed as Endangered in the State of Maryland. In 2009, the Coastal Bays were recognized as an Important Bird Area (Maryland Coastal Bays IBA) by Audubon because of their populations of terns, skimmers, and other colonial waterbirds.

Black Skimmer

Wading birds

Skimmers and terns aren't the only struggling species in the Coastal Bays. A large suite of wading birds also only use islands in the Coastal Bays to breed. These include Snowy Egrets, Cattle Egrets, Little Blue Herons, Tricolored Herons, Great Egrets, Black-crowned Night-herons, and Glossy Ibis. Like skimmers and terns, these species suffer from island disturbance, erosion, and sea level rise. As a result of these factors, more than 95% of all wading birds in the Coastal Bays now breed on just one island, South Point Spoils. This report includes information on their current status.

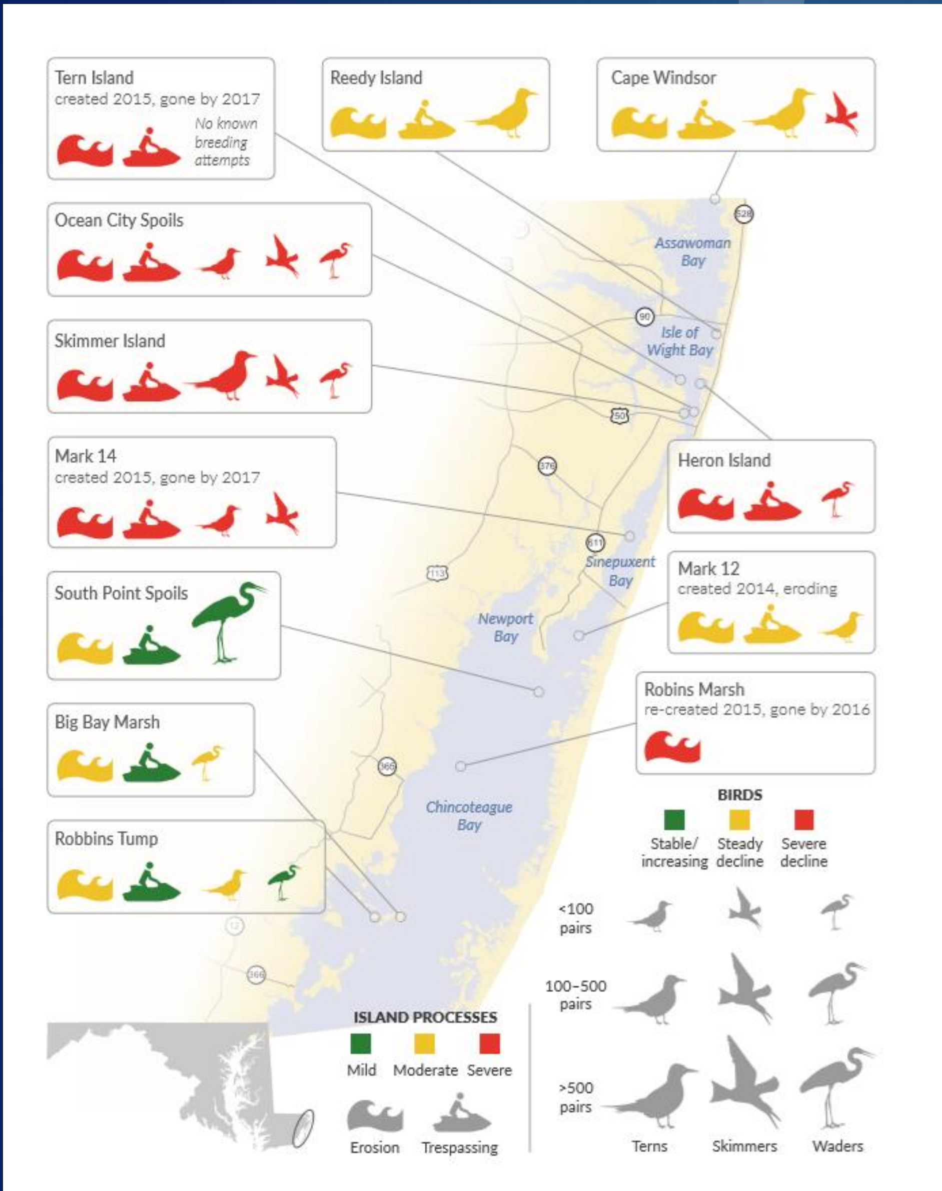
Tricolored Heron

Monitoring

Waterbird populations have been monitored in the Coastal Bays since 1985, coordinated by Maryland Department of Natural Resources (DNR), and assisted by Assateague Island National Seashore (AINS), the Maryland Coastal Bays Program (MCBP), and public volunteers. The DNR Colonial Waterbird Survey coordinates a complete statewide census of breeding terns, gulls, skimmers, pelicans, cormorants, herons, egrets and ibis every five years. In each intervening year between complete censuses, a partial census is carried out to keep track of rare, threatened, and endangered species and other species of special interest.

Skimmer Island

A natural tidal shoal island supported 1,400 pairs of terns, skimmers, herons, egrets and ibises in 2003. Today, no birds successfully nest on the island.

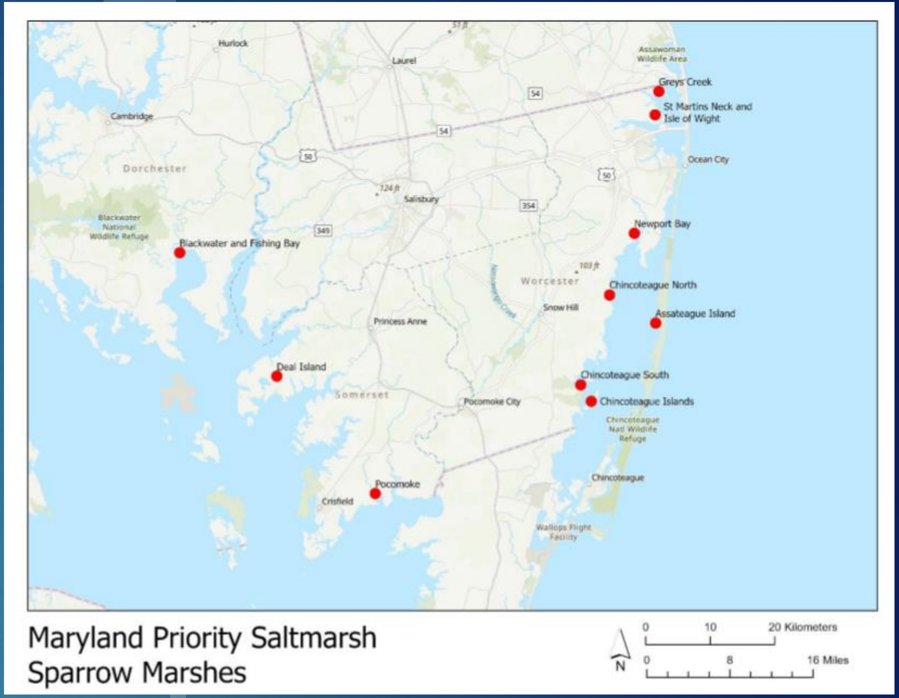


Skimmer Island

Reduced from 8 acres in 2000 to just barely over one acre today.

Saltmarsh Sparrow

A species in precipitous decline in the Northeast and Mid-Atlantic. Nests in salt-marsh hay (Spartina patens) high marshes in the Coastal Bays and Chesapeake Bay.

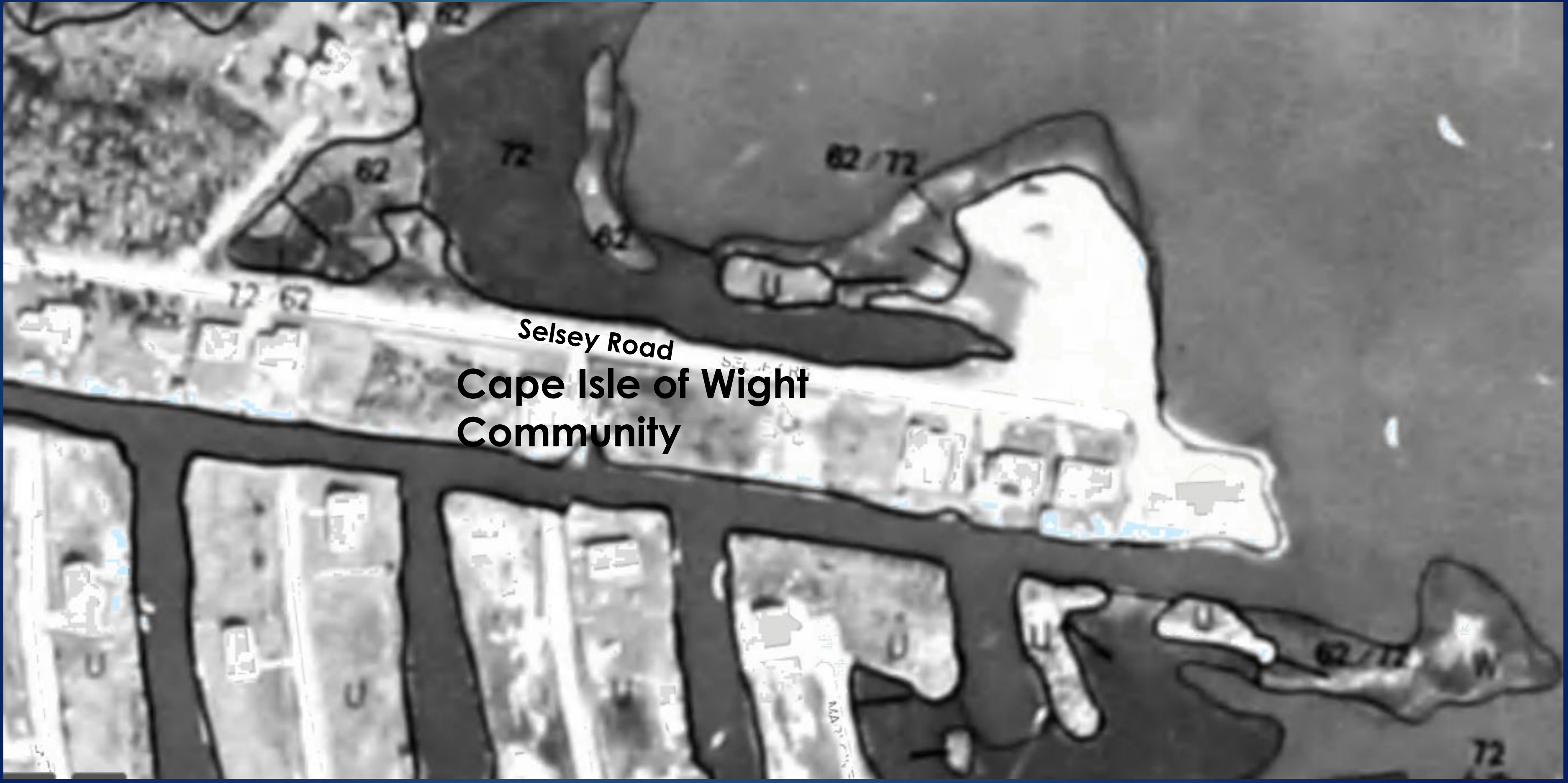


Maryland Priority Saltmarsh Sparrow Marshes

Community Needs

Community Needs

Community Needs



Step 3 – Risk Identification

Generating a broad list of reasonably foreseeable ways that climate stressors could keep your organization from achieving its goals

Step 4 – Risk Analysis

Evaluating the probability and severity of loss linked to threats or hazards and vulnerabilities

- One initial rating of low, medium, high for:
  - Consequence
  - Likelihood
  - Spatial scale
  - Time horizon
  - Habitat type

Step 5 – Risk Evaluation: Comparing Risk

FIGURE 5-1. An example consequence/probability matrix.

Likelihood (probability) of occurrence	Low (Consequence of impact)	Medium (Consequence of impact)	High (Consequence of impact)
High	1. Warmer water may stress immobile biota 2. Warmer water may lead to changes in drinking water treatment processes n. ____________	1. Warmer water may hold less dissolved oxygen 2. Sea level rise may cause bulkheads, sea walls and revetments to become more widely adopted n. ____________	1. Shoreline erosion from sea level rise may lead to loss of beaches, wetlands and salt marshes 2. Combined sewer overflows may increase from more intense precipitation n. ____________
Medium	1. Increased wildfires from warmer summers may lead to soil erosion 2. Warmer winters may lead species that once migrated through to stop and stay n. ____________	1. Parasites and bacteria may have greater abundance, survival or transmission due to warmer water 2. Warmer summers may drive greater water demand n. ____________	1. More frequent drought may diminish freshwater flow in streams 2. More intense precipitation may cause more flooding n. ____________
Low	1. Warmer water may lead open seasons and fish to be misaligned 2. Warmer winters may lead to more freeze/thaw cycles that impact water infrastructure n. ____________	1. Warmer water may lead jellyfish to be more common 2. Ocean acidification may cause the recreational shellfish harvest to be lost n. ____________	1. Contaminated sites may flood from sea level rise 2. Warmer water may promote invasive species n. ____________

- Develop a Consequences vs Probability Matrix
- Review it with Stakeholders
- Reach agreement on the overall assessment

Climate Change Vulnerability Summary

Goals	Number of Risks		
	Red	Yellow	Green
WQ 1: Decrease nutrient loading throughout the watershed	17	7	2
WQ 2: Decrease inputs of toxic contaminants	2	3	15
WQ 3: Implement a strategy to meet TMDL reductions	4	0	2
FW 1: Characterize, monitor and manage fishery resources and habitats	21	9	6
FW 2: Characterize, monitor and manage estuarine resources and habitats	10	3	1
FW 3: Characterize, monitor and manage terrestrial resources and habitats	14	1	1
FW 4: Expand upon the coordinated effort to collect and report on Coastal Bays geomorphic and biometric info	1	0	0
RN 1: Improve recreational opportunities and access to the Coastal Bays and tributaries	0	2	2
RN 2: Balance resource protection with recreational use	5	0	2
RN 3: Continue to implement the Ocean City Water Resources Study recommendations	3	2	1
RN 4: Manage sediment alterations in a manner beneficial to the local economy and natural resources	2	0	1
CE 1: Manage the watershed to maximize economic benefits while minimizing negative resources impacts	5	7	3
CE 2: Enhance the level of sustainability in land use decision making	2	3	8
CE 3: Educate and inform the population so it can make knowledgeable decisions for the community and its future	0	1	0
Total 168 Risks	86	38	44

Action Plan Steps

- **Step 6—Establishing the Context for the Action Plan**
- **Step 7—Risk Evaluation: Deciding on a Course**
- **Step 8a—Finding Adaptation Actions**
- **Step 8b—Selecting Adaptation Actions**
- **Step 9—Preparing and Implementing an Action Plan**
- **Step 10—Monitoring and Review**

Step 6: Establishing Context

- Affirm partnerships and possible leads
  - CCMP has leads for each goal already
  - Each partner should review CCMP goals for which they are the lead
    - Goal still necessary and/or relevant?
    - Is the partner still willing to be the lead?
- Organizational context
  - Anything MCBP should be aware of that will limit action?

Step 7: Risk Evaluation – Deciding on a course of Action

Risk management approach	Description	How your organization would use this approach
Mitigate	Take action to lower the consequence or likelihood of the risk (or both).	Address the risk, or lead the effort to address the risk. Good for risks in Green happening now, and Yellow risks happening in 10-30 yrs.
Transfer	Another party has responsibility for mitigating the risk.	Allow or ask others to take the lead; assist as you can.
Accept	Run the risk. Accept that the consequences may occur.	Business as usual in spite of the risk. Monitor, and reassess options in the future. Good for risks in Green more than 10 yrs. away, and for Yellow risks with a long time horizon. Not recommended for Red risks.
Avoid	Take organizational or administrative action so that you will not be exposed to the risk.	Stop putting resources toward the goal that would be affected. Or delete/revise your goal and thus be out of the risk altogether.

Step 8A & 8B: Evaluation & Selection of Adaptation Actions

Evaluation of Adaptation Actions

Ada[tation Actions	Risk reduction potential	Feasibility and effectiveness	Cost and cost-effectiveness	Ancillary costs and benefits	Equity and fairness	Robustness	Appropriate to proceed with this action? (yes/no)
1.							
2.							
3.							
4.							
5.							

Selection of Adaptation Actions

Risk selected for mitigation	Potential adaptation action (one or more for each risk)	Could the action reduce likelihood (by itself or in combination with another action)? Yes/No	Could the action reduce consequence (by itself or in combination with another action)? Yes/No
1.			
2.			
3.			
n.			

Selecting Actions for Implementation

Limit of organizational resources

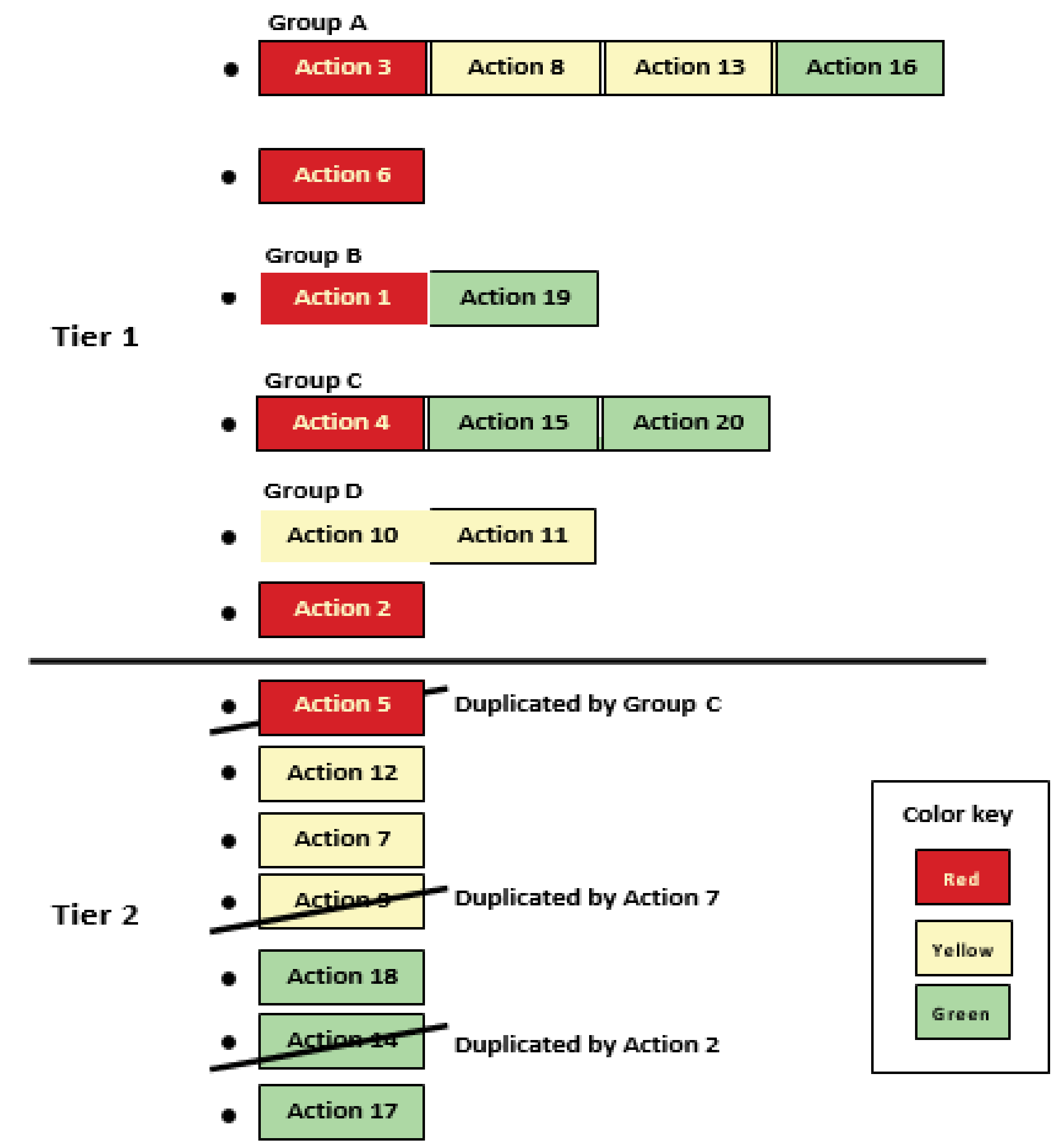


Figure 8b-2. Place a line as far down from the top of a list like Figure 8b-1 as your resources will allow. Tier 1 actions (above the line) will move forward for implementation, while Tier 2 actions (below the line) will not move forward right now. This is the plan that will get your organization the most risk reduction you can achieve using available resources.

Steps 9 and 10: Where we are now

- **Prepare/Implement Action Plan**
  - Designate lead/project manager for each Tier 1 adaptation action
  - Ensure organizational leaders have given concept approval of the work
  - Charge the responsible parties with developing and implementing project plans
  - Create 2 risk management tracking systems
  - Actions (Table 9-1)
  - Risks (Table 9-2)
- **Monitor and Review**
  - Set routine meetings
  - Monitor changes in science and context for the organization
  - Review and revise plan based on regulatory, political, financial context

Resiliency to Restoration Projects

- Reedy Island
- Tizzard Island
- Jenkins Pt.
- Big Mill Dam
- Assateague State Park
- Sinepuxent South Shoreline
- Selsey Road

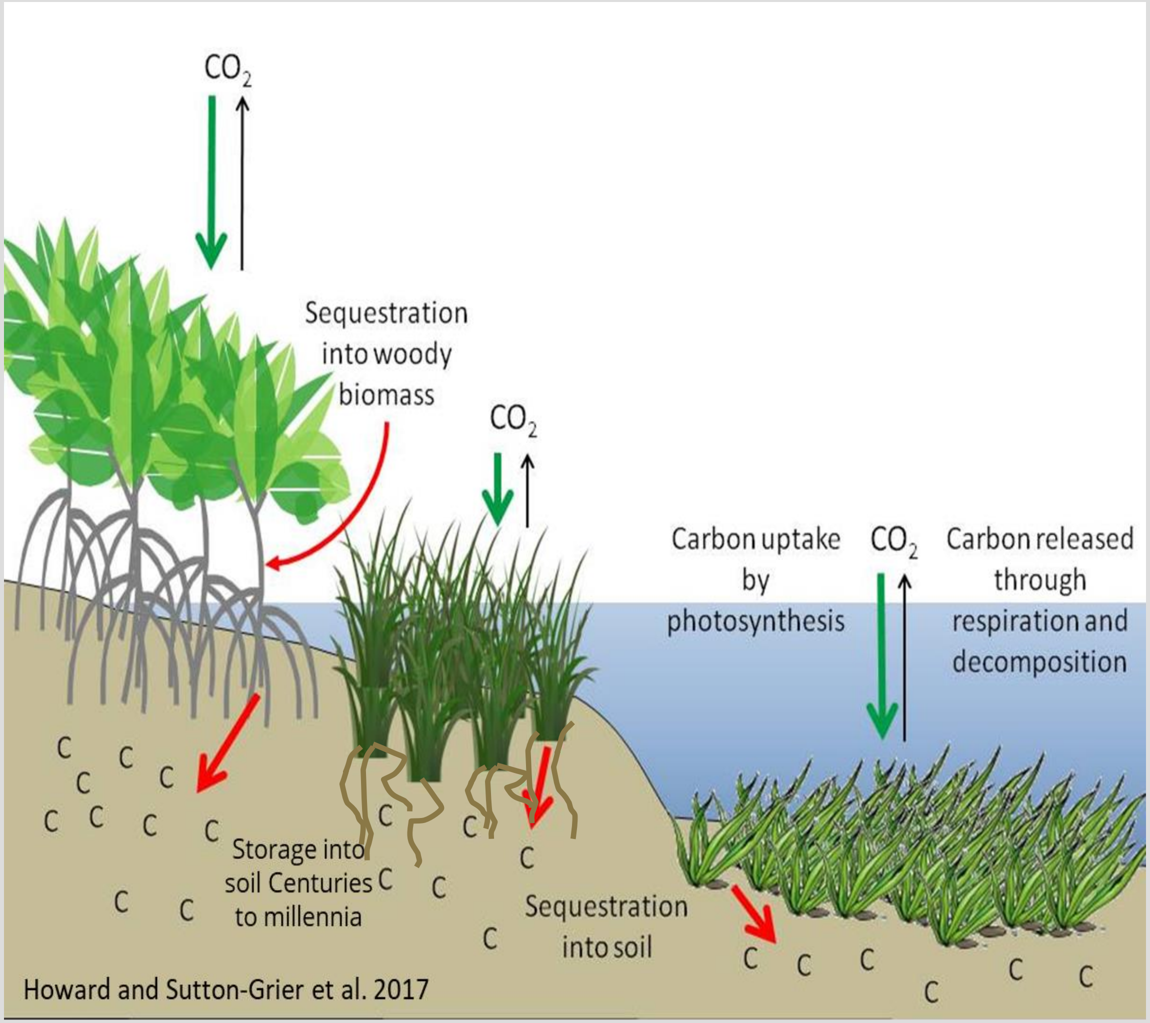
Building Robust and Resilient Natural Systems

NOAA Laboratory, Beaufort NC

Blue Carbon and Living Shorelines
Dr. Carolyn Currin, EA

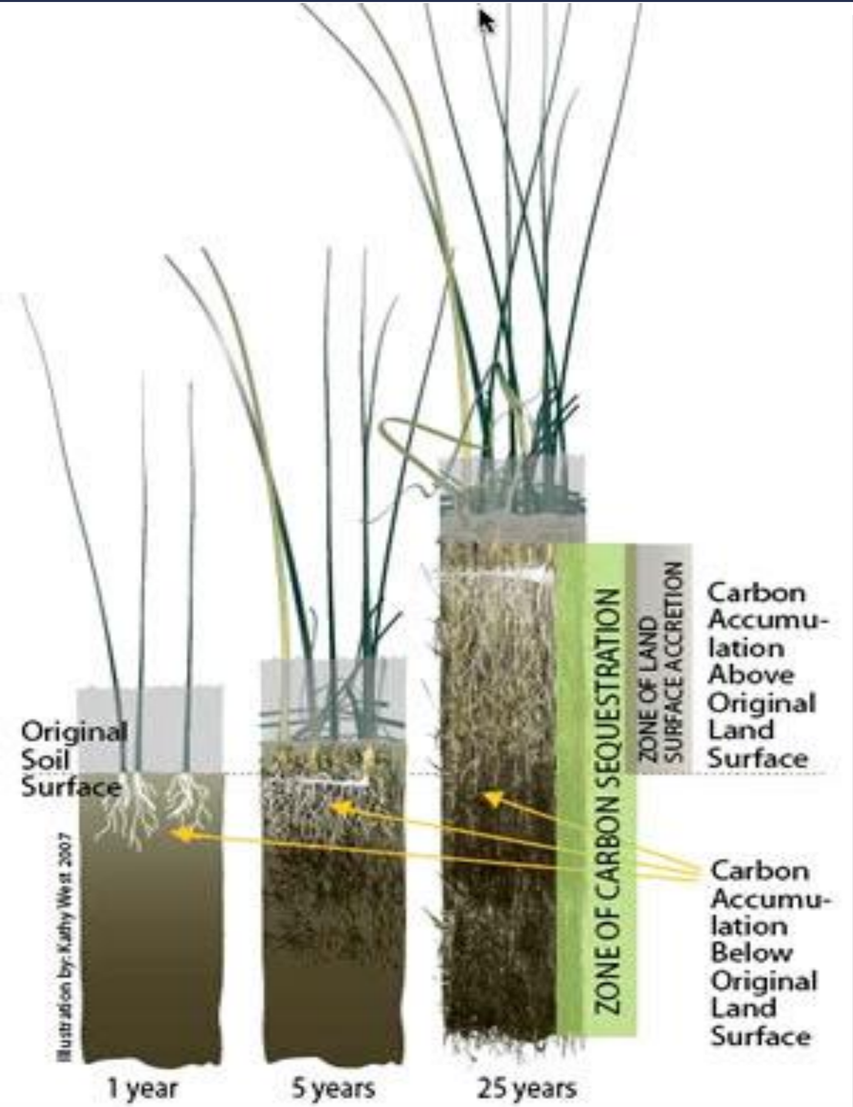
2/10/2022

Coastal Blue Carbon



- **Key Features**
  - High primary production
  - Anaerobic saline sediment
  - Sediment accretion increases soil volume
  - Small % of annual production preserved for 100 yr C market
  - Most C exits habitat as dissolved or particulate C

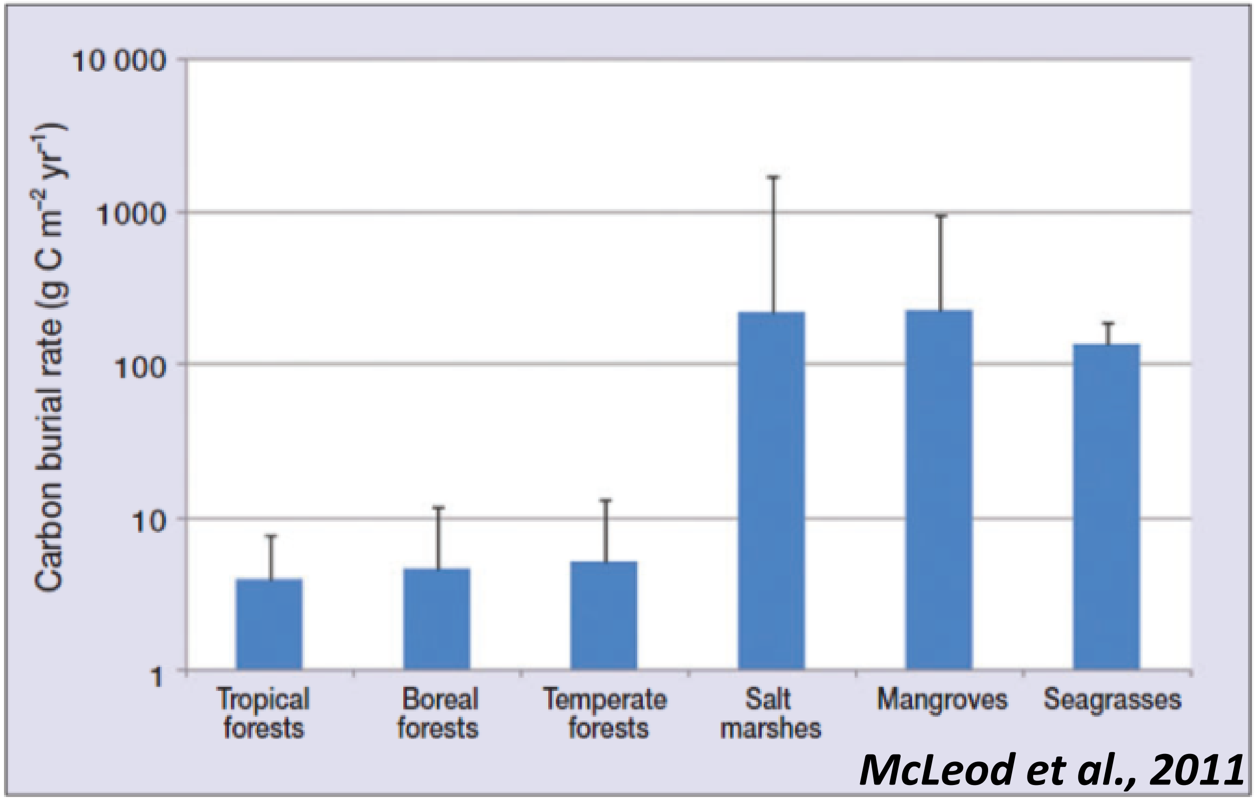
Marsh sediment volume and C increase



How carbon-capture farming works. Cutaway illustration of peat soils building after 1 year, 5 years and 25 years.

Credit: San Francisco Bay Joint Venture

Blue C habitats have high C burial rates/area



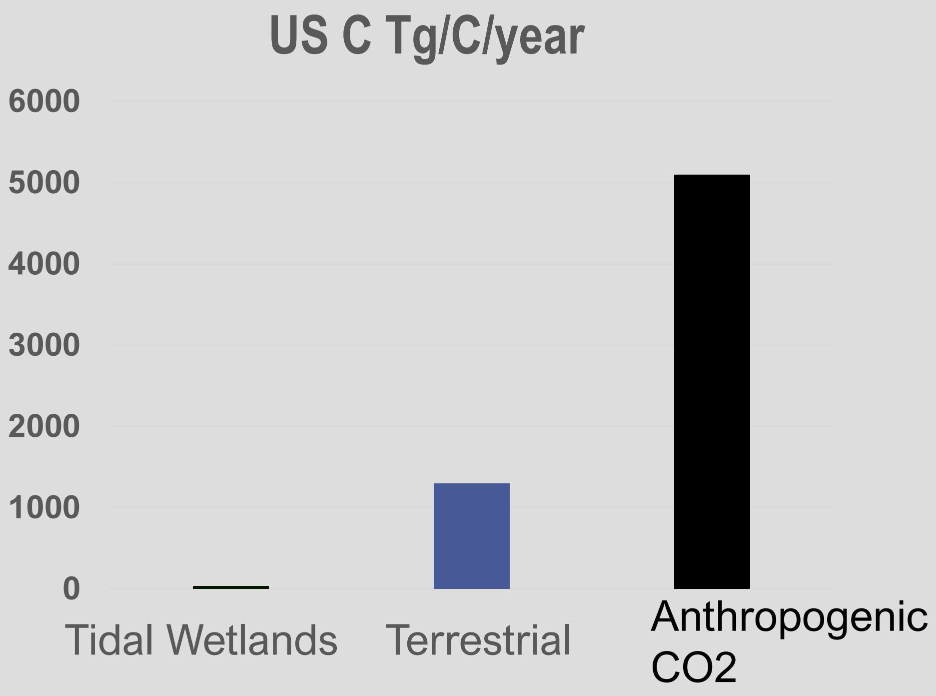
McLeod et al., 2011

-Per area burial rates vary by site and measurement technique

-Blue C habitats occupy a comparatively much smaller area than terrestrial habitats

Carbon sources and sinks

But limited areal extent reduces overall contribution of Blue C



EPA GHG inventory 2019

SLR, shoreline erosion, and marsh carbon

2400 yr BP

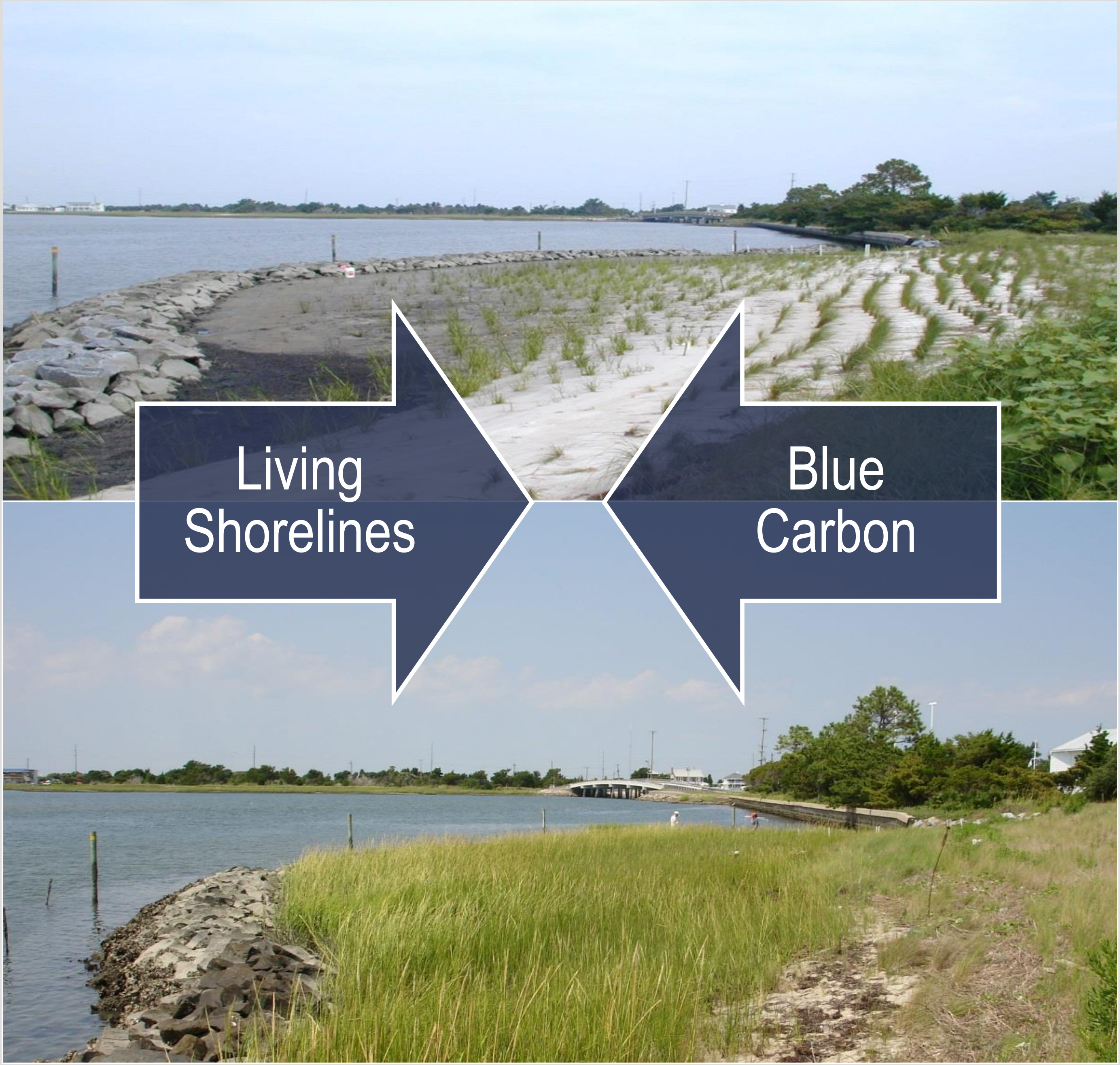
- Marsh sediment can contain C 100 to 1000’s years old
- Carbon accumulation increases with increased SLR to a point (~10-12 mm/yr)

McTigue et al. 2019 JGR SLR and C accumulation

-Coastal wetland loss leads to loss of stored marsh Blue C, 120 Tg/yr globally
-US erosion rates * temperature dependent decomposition = 63 Gg C/yr CONUS (0.6 Tg)

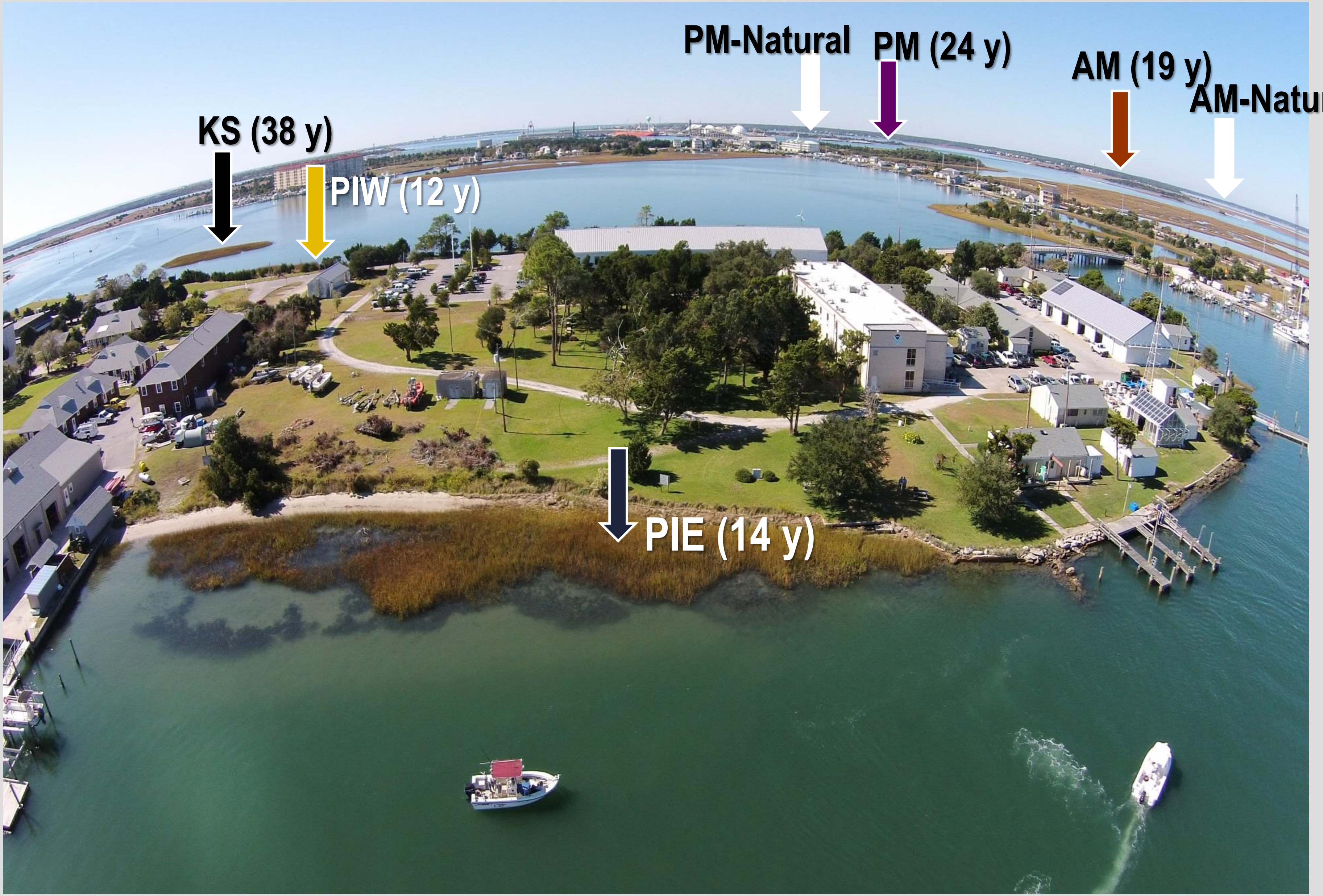
Pendleton et al. 2012 C loss from wetland loss
McTigue, Currin, Walker 2021 Frontiers Mar Sci

2002



2009

Restored and Natural marshes sampled near Beaufort NC to determine sediment Carbon stock and sequestration rate

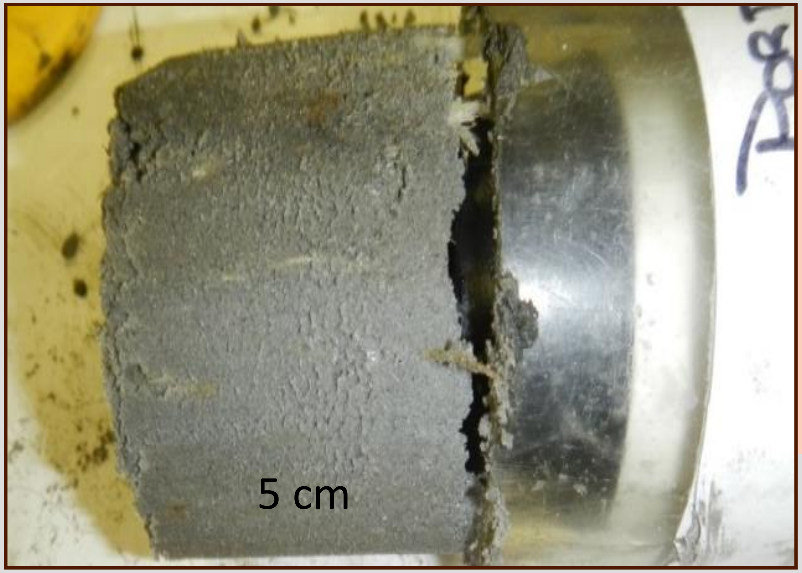


Davis, J., Currin, C et al. 2015 PLOs One

Sample Collection

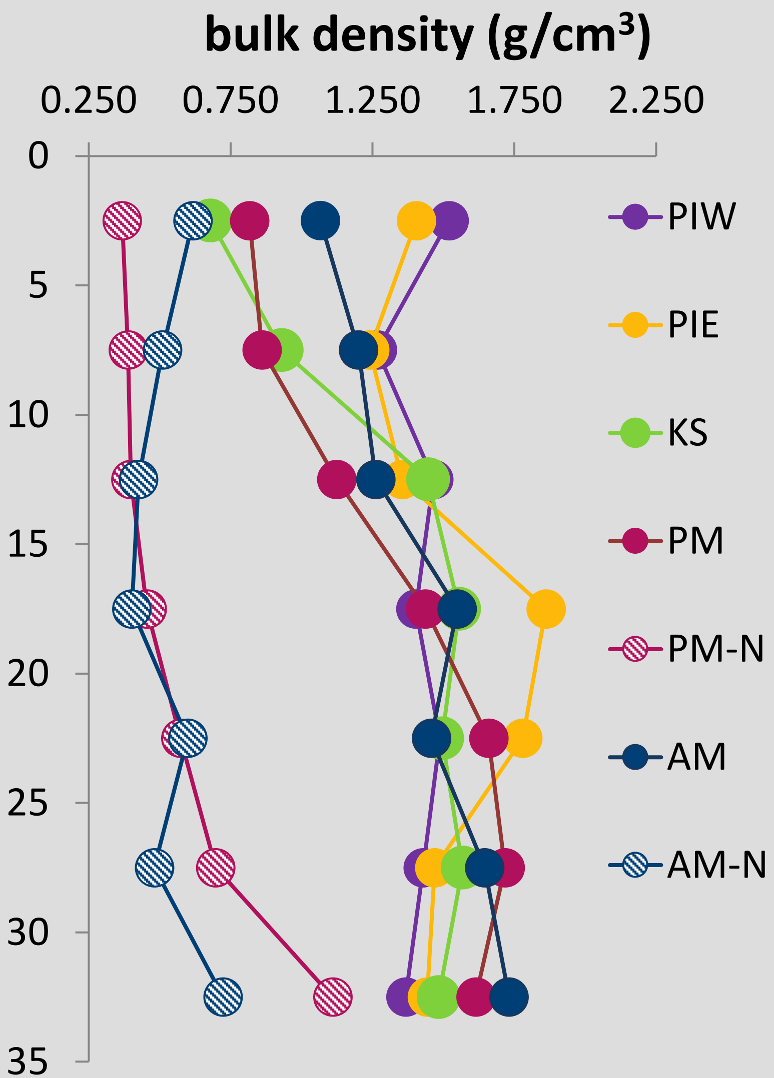
- 35 cm deep cores

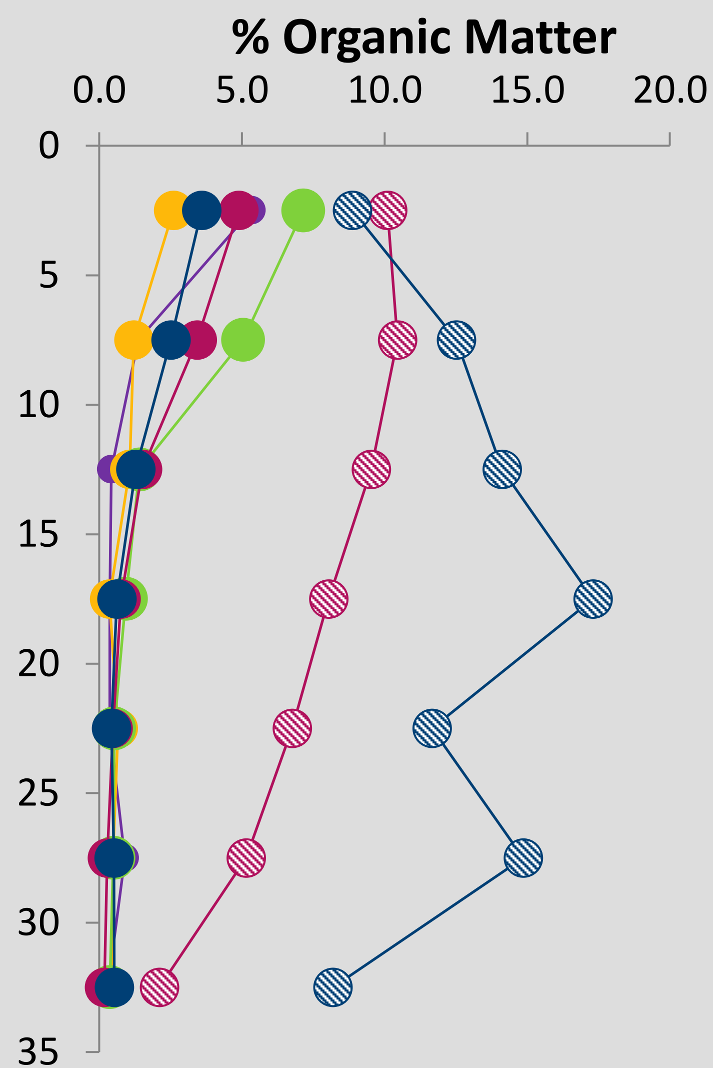
-Sectioned into 5 cm intervals

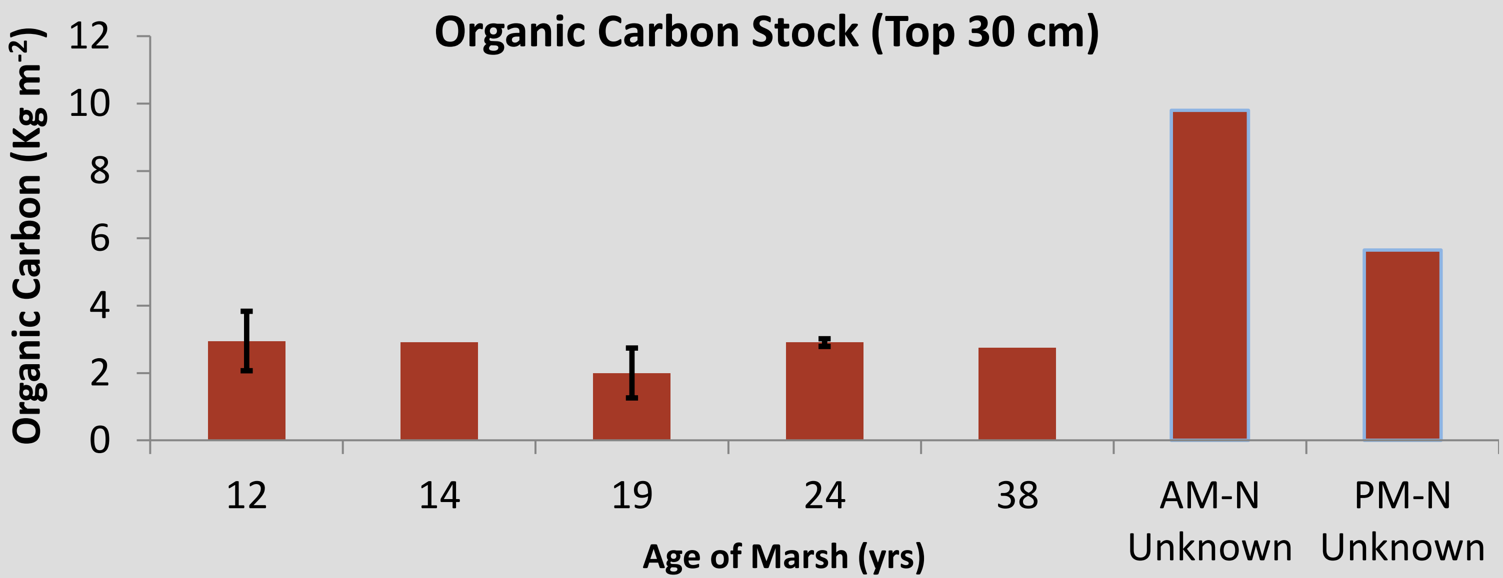


- % OM (loss on ignition)
- Bulk Density
- C,N (elemental analysis)

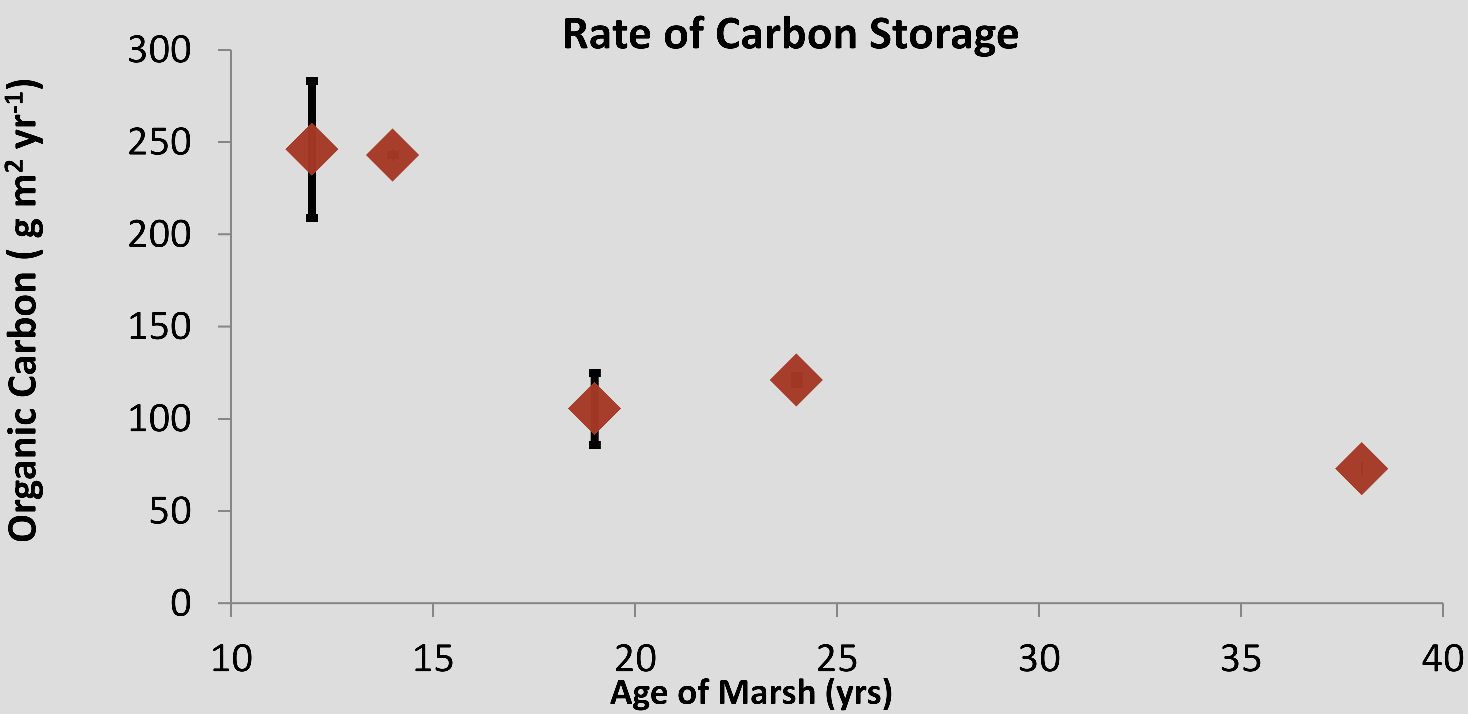
Soils of the oldest created sites are most similar to natural marshes



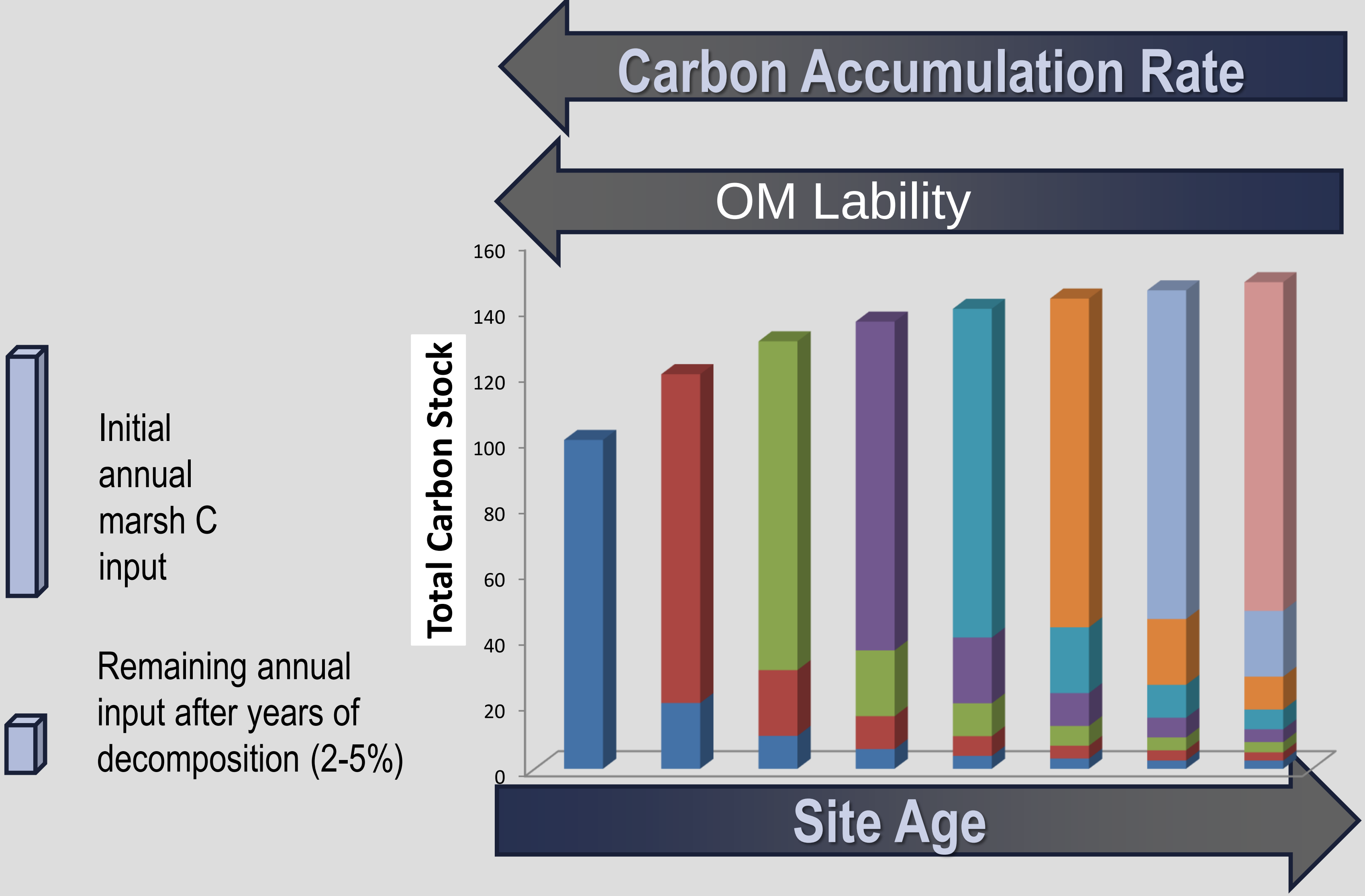




Organic Carbon Stock (Top 30 cm)
Organic Carbon (Kg m-2)
0
2
4
6
8
10
12
12
14
19
24
38
AM-N Unknown
PM-N Unknown
Age of Marsh (yrs)



Rate of Carbon Storage
Organic Carbon (g m2 yr-1)
0
50
100
150
200
250
300
10
15
20
25
30
35
40
Age of Marsh (yrs)



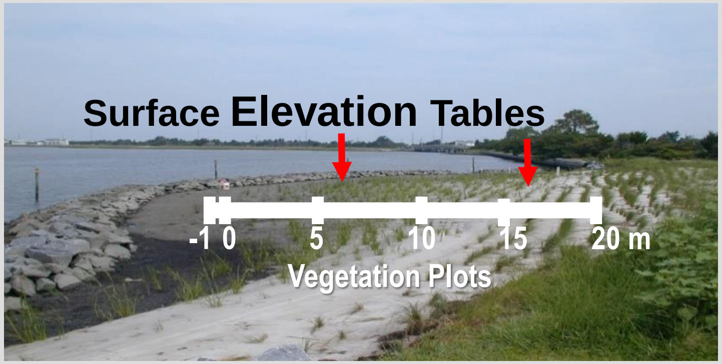
Living Shoreline salt marshes sequester and store C at rates similar to natural marshes (~100 g C/m^2/y)

However, sequestration rates determined from young (<25 yr old) marshes will overestimate long-term carbon accumulation rate

Natural and Sill - Marsh Living Shorelines
Response to SLR

Can Living Shoreline marshes keep up with SLR for the next century?

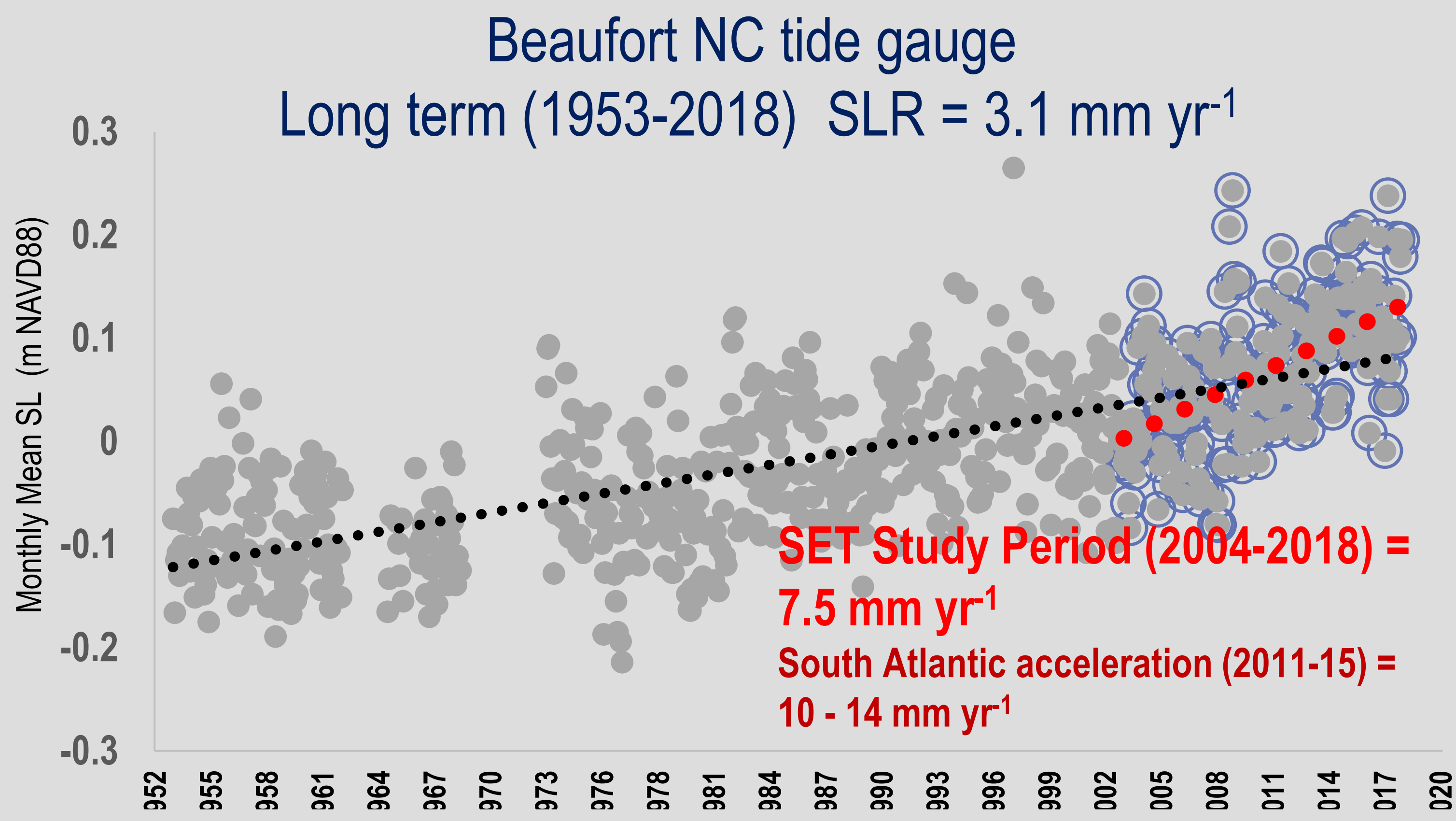
Pivers Island, Beaufort NC



- Monitoring to detect changes in surface elevation over 15 years at paired natural/sill sites
  Establish permanent plots at marsh shoreline and transects to upper edge
- Establish elevation benchmarks

Currin et al. 2017

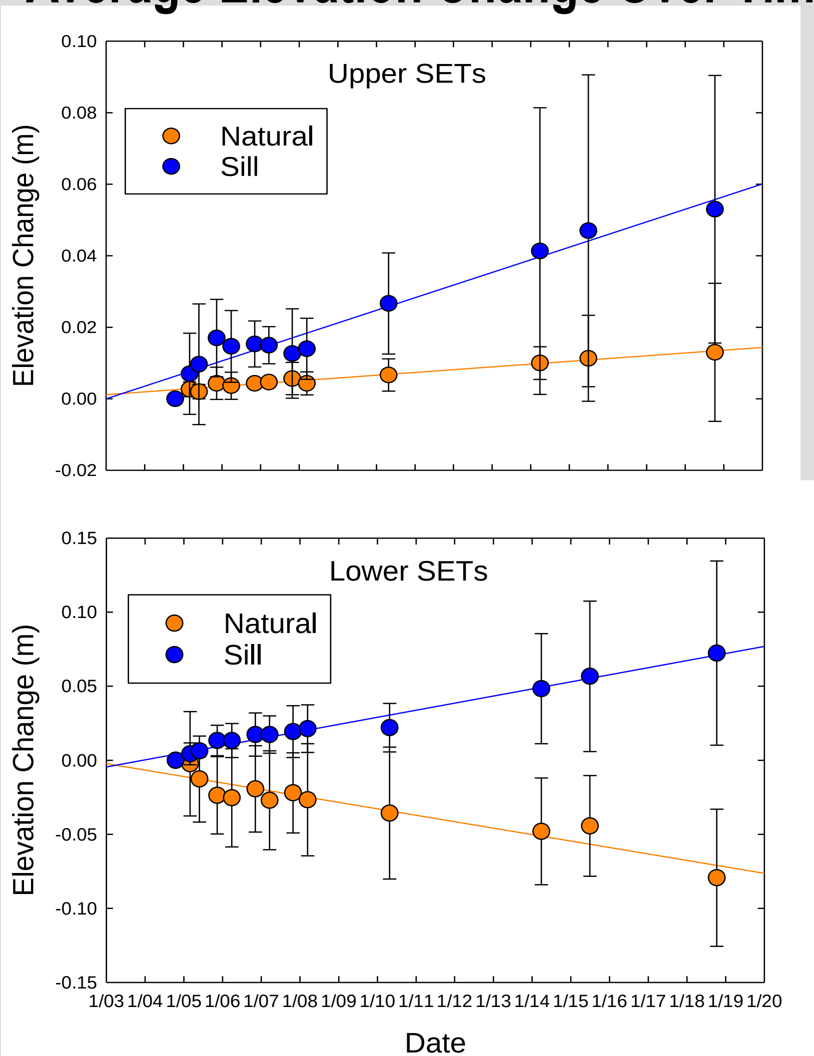
Relative Sea Level Rise Beaufort, NC



NOAA NWLON; Valle-Levinson et al. 2017 GRL

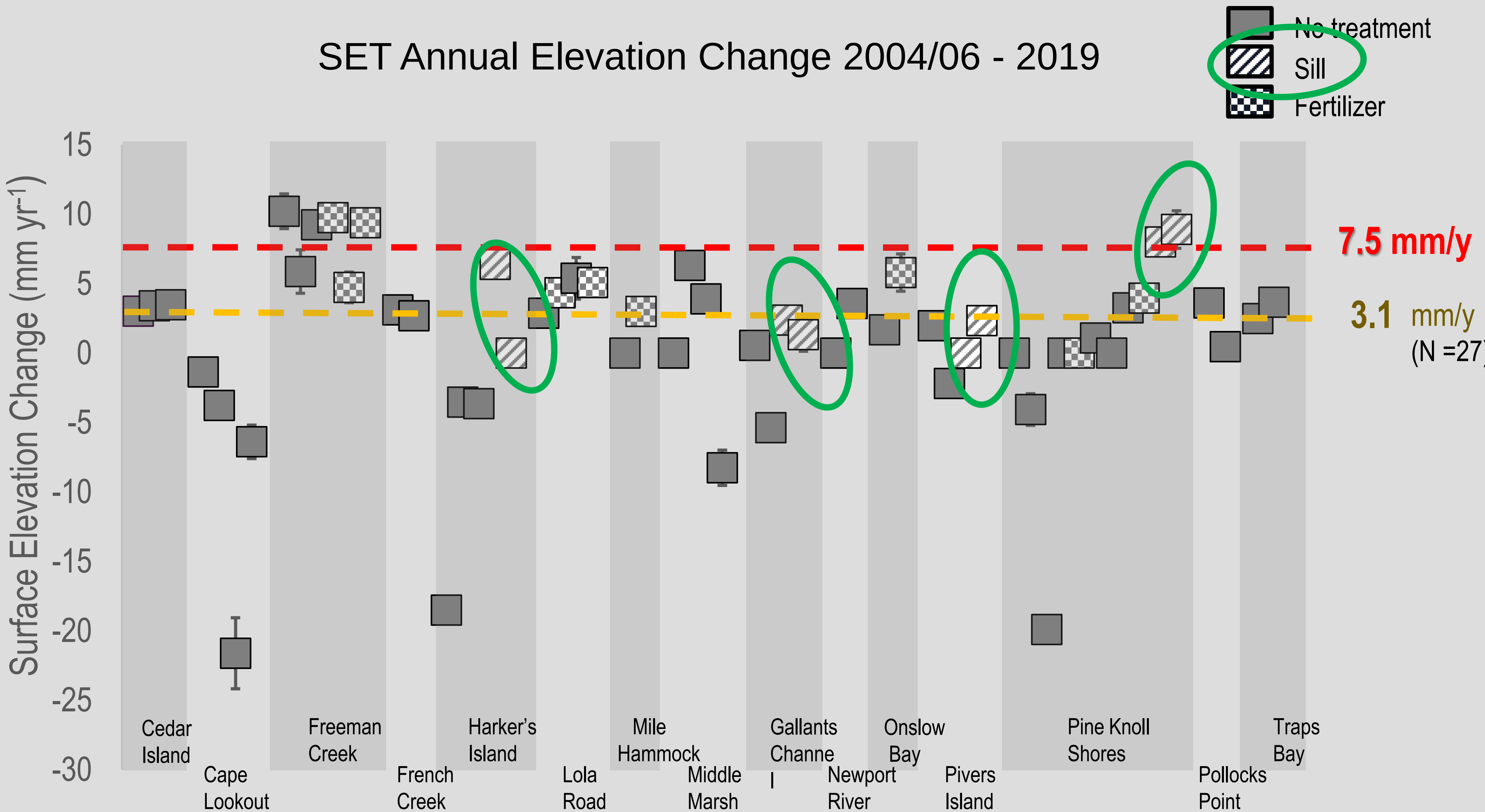
SET Results

Average Elevation Change Over Time



Sill marshes have greater sediment accretion rates than natural fringing marshes

Are NC **marshes** keeping up with SLR?

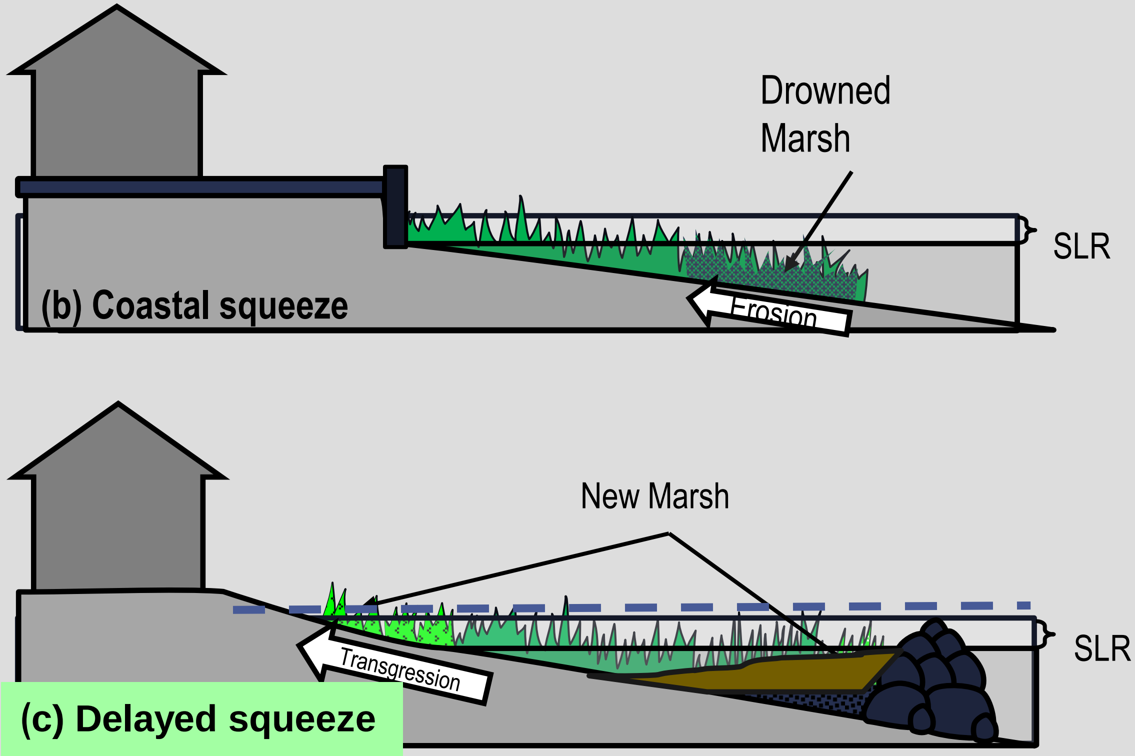


Marshes at 1 of 4 sill sites kept up with contemporary SLR

Currin et al. 2017; Davis et al. 2017; Currin et al In Prep

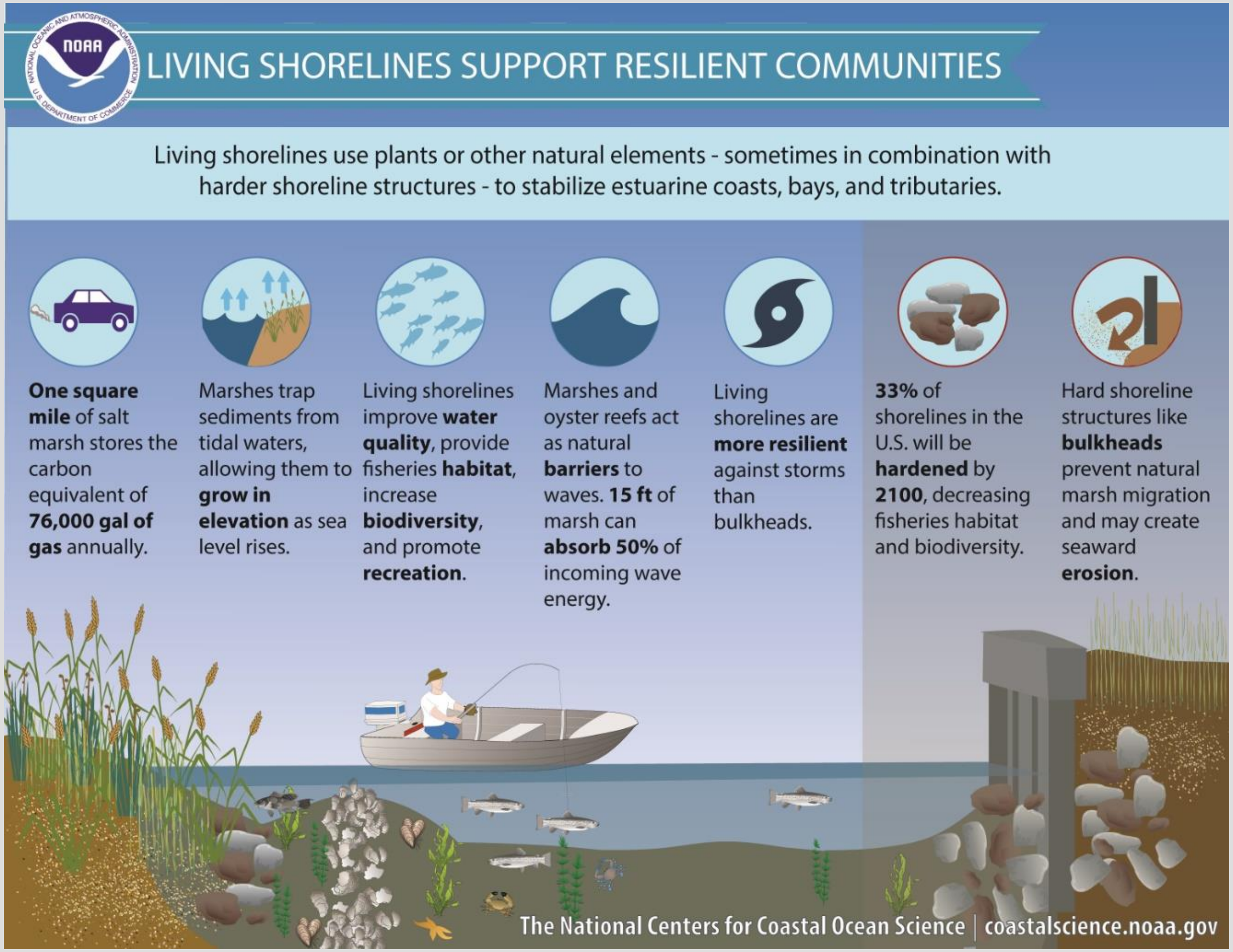
Using Living Shorelines to protect Property and Infrastructure

…And Blue Carbon



- **Sills reduce erosion and increase accretion**
- **Long-term C storage can only occur in marshes that ‘keep up’ with SLR**

Currin 2019. Living Shorelines for Coastal Resiliency in *Coastal Wetlands: An Integrated Assessment. Elsevier*



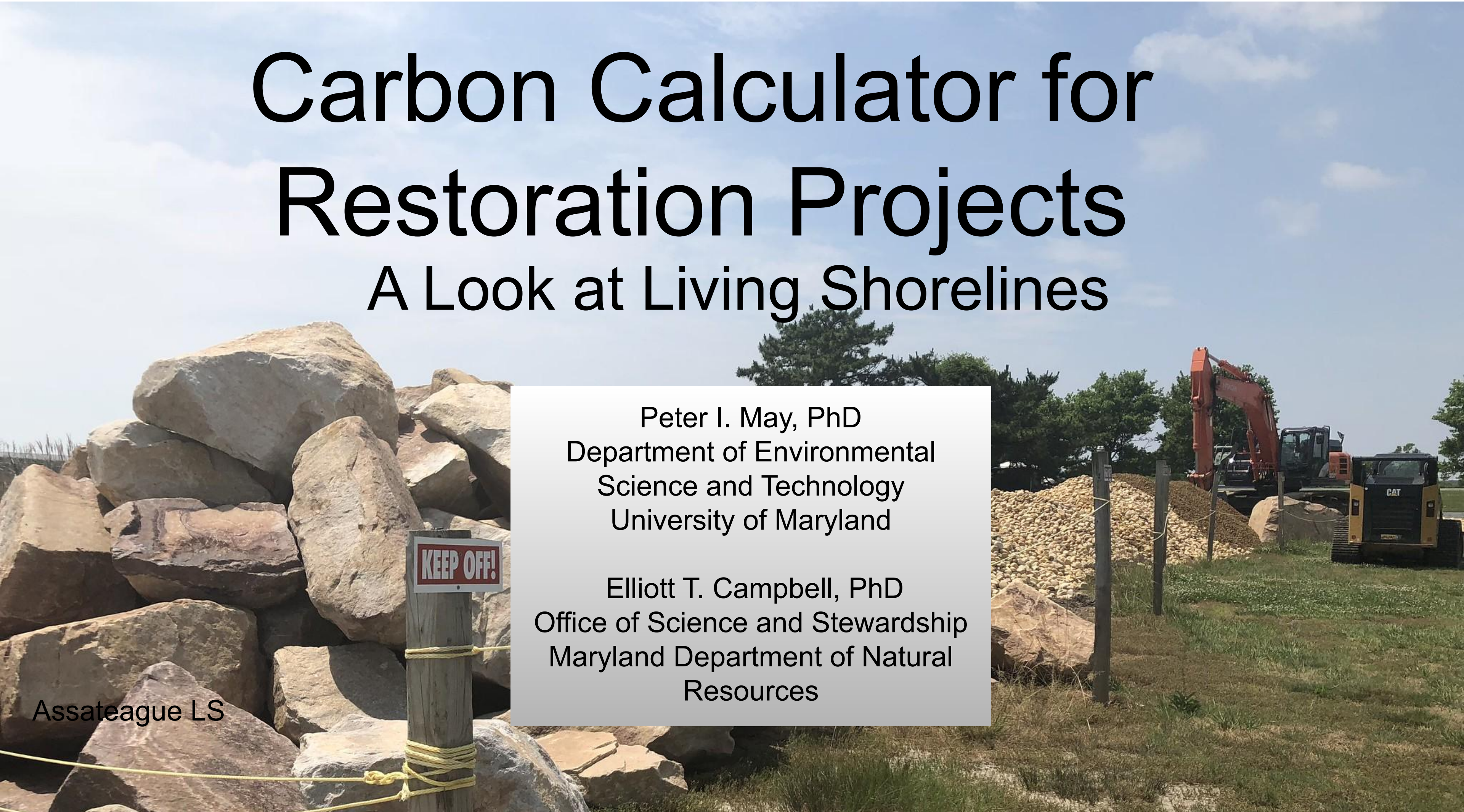
Davis JL, Currin CA, O'Brien C, Raffenburg C, Davis A (2015) Living Shorelines: Coastal Resilience with a Blue Carbon Benefit. PLoS ONE 10(11): e0142595. doi:10.1371/journal.pone.0142595

Carbon Calculator for Restoration Projects

A Look at Living Shorelines

Peter I. May, PhD
Department of Environmental Science and Technology
University of Maryland

Elliott T. Campbell, PhD
Office of Science and Stewardship
Maryland Department of Natural Resources



Assateague LS


Havre de Grace


Havre de Grace

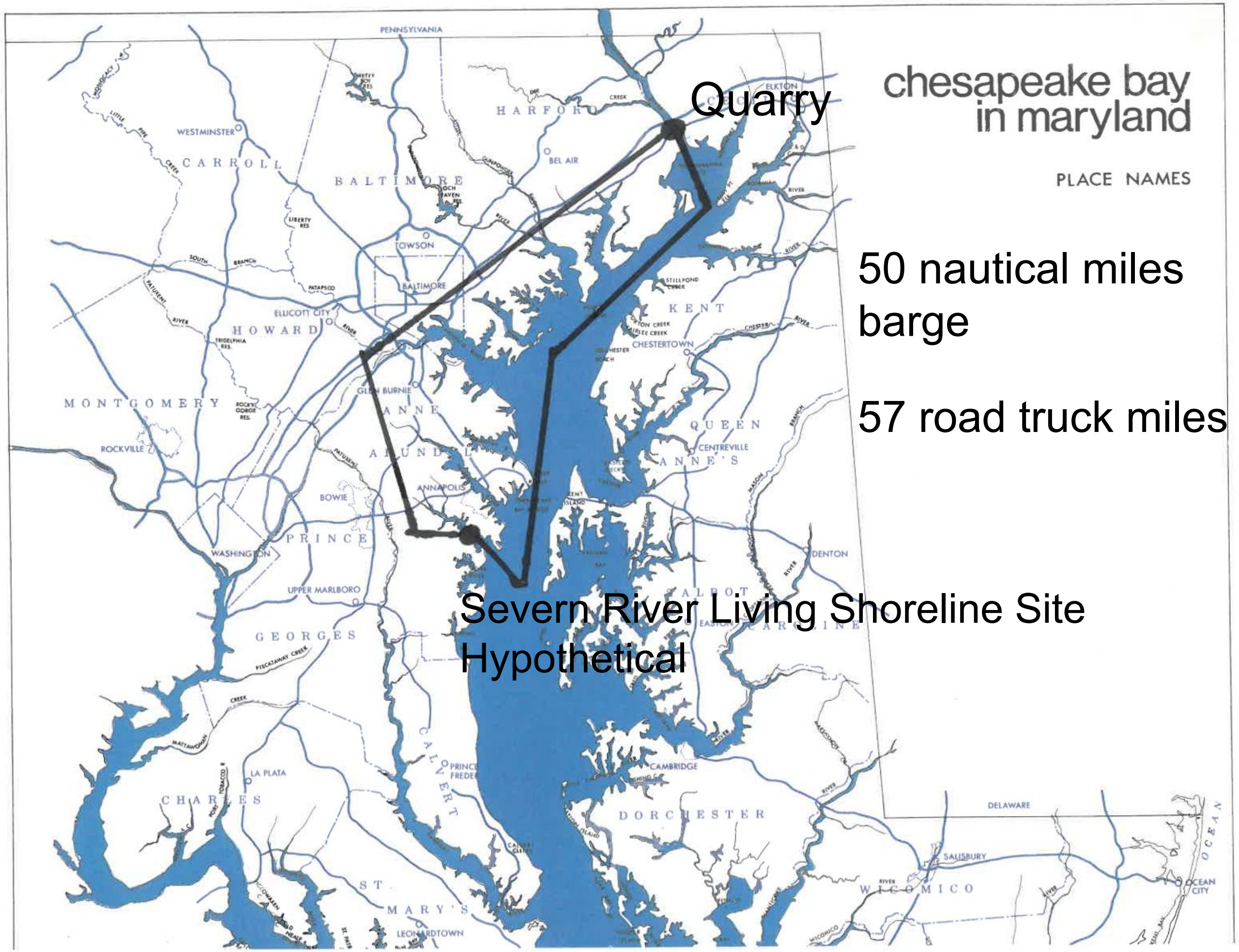
Ferry Point, Kent Island


Ferry Point

Annapolis Maritime Museum

Annapolis Maritime Museum

Annapolis Maritime Museum



Truck vs Barge

Materials Transport

Inputs to a Generic Living Shoreline Project, 1 Acre

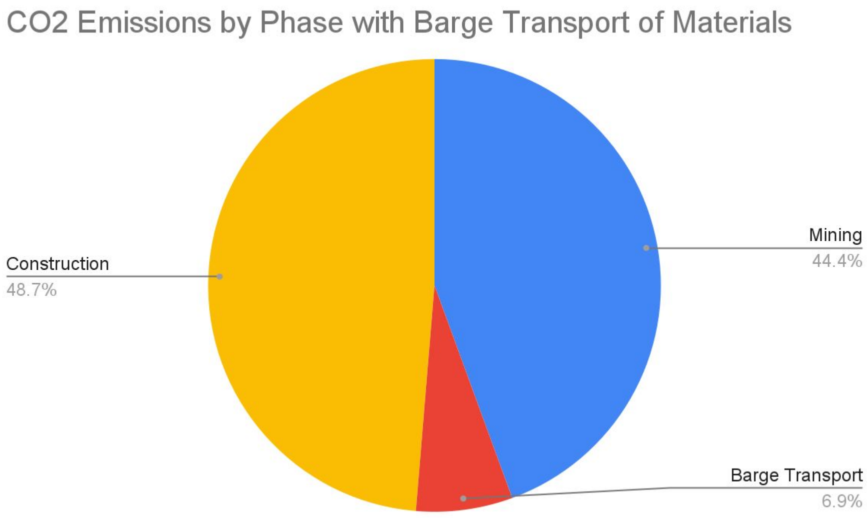
Input	**Quantity**	**# of Employed/Maintained**	**Hours of Labor**
Environmental Engineering Services	22 days	2	352
Quarry Rock	19,000 tons @ 0.2 ton/hr	8	3,800
Quarry Sand	16,333 tons @ 0.1 ton/hr	5	1,633
Barge transportation	8 hrs/trip @ 300 trips	4	2,400
Plant Materials	50,000 plants @ 0.08/hr	4	4,400
Construction	264 days @ 8hr/day	5	10,560
Project Mgmt.	600 hours ea.	2	1,200
TOTAL		**30**	**24,345**

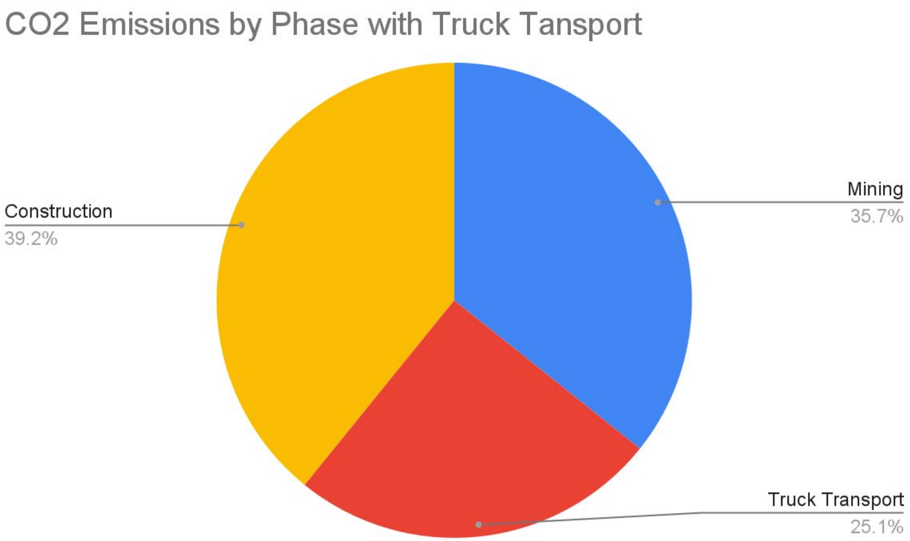
Carbon Emissions Associated with Generic Living Shoreline-
1 acre, 1000 lf, 50 miles to deliver materials

	CO_2 Emissions (t)	per lf
Mining	194.7	0.19
Barge Transport	30.2	0.03
Construction	213.5	0.21
total	438.4	0.44
Mining	194.7	0.19
Truck Transport	136.8	0.14
Construction	213.5	0.21
total	545.0	0.55

At a 50 mile distance Trucking in materials increases total project emissions by 24%

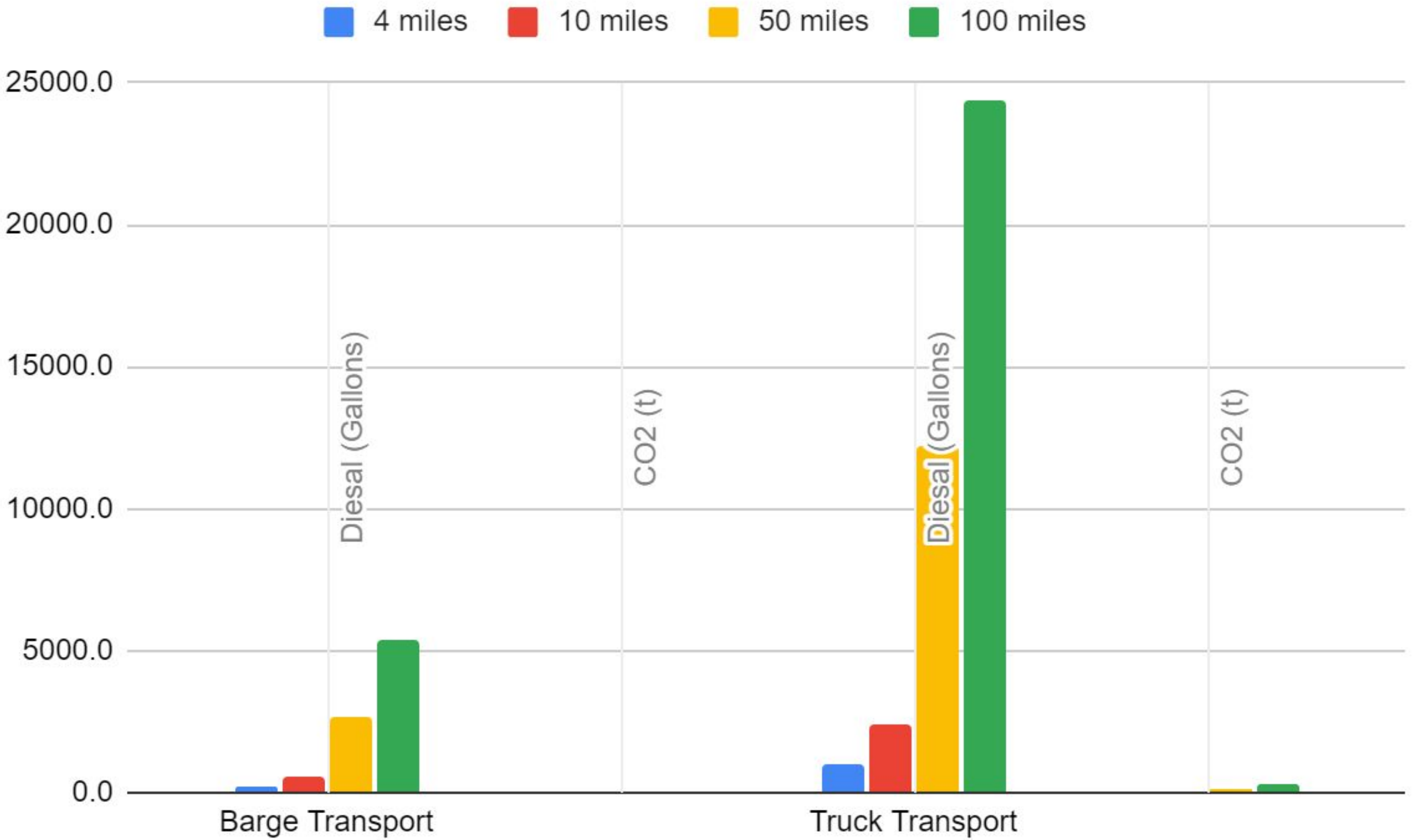
Carbon Emissions Associated with Generic Living Shoreline





Comparison of Travel Distances and Mode To Transport Material for 1 acre LS Restoration

		4 miles	10 miles	50 miles	100 miles
Barge Transport	Diesal (Gallons)	215.1	537.8	2689.0	5377.9
	CO2 (t)	2.4	6.0	30.2	60.4
Truck Transport	Diesal (Gallons)	974.7	2436.8	12183.8	24367.6
	CO2 (t)	10.9	27.4	136.8	273.6


4 miles
10 miles
50 miles
100 miles
25000.0
20000.0
15000.0
10000.0
5000.0
0.0
Diesal (Gallons)
CO2 (t)
Diesal (Gallons)
CO2 (t)
Barge Transport
Truck Transport

Carbon Sequestration and Storage in Coastal Marshes

Tremendous stores of carbon in coastal wetland soils-

Typically over 500 Mt CO_2e per acre!

Annual sequestration is variable with a big driver being methane emissions (lower salinity wetlands tend to have higher methane emissions)

Net C seq. Estaurine (IPCC AR4 & EPA 100 yr GWP = 25)	CO_2e/acre/yr
Tidal Freshwater (<0.5 ppt)	-1.91
Oligohaline (0.5 - 5.0 ppt)	0.016
Mesohaline (5.0 - 18.0 ppt)	2.72
Polyhaline (> 18 ppt)	4.55

Carbon Emissions of Different Building Materials

Table 12.5. Embodied carbon footprint of selected building materials abstracted from Hammond & Jones, ICE	
Material	**Embodied carbon (kgCO2/t)**
Sandstone	62
Granite	75
Slate	96
Limestone	98
Conc. block: 13 MP	100
Concrete (RC28/35)	139
Brick: General	230
Timber: Softwood	450
Timber: Hardwood	470
Brick: Facing	520
Cladding panel (fibre-cement, colour-coated)	1280
Glass (toughened)	1350
Steel: General	1460
Steel: Section	1530
Steel: Plate	1660
Aluminium (general)	8240

Phragmites australis- Friend or Foe?

Time and effort (and GHG emissions) often spent to

Remove Phragmites as part of restoration, but-

- Phragmites sequestration rates are 2-5x those of many native species
- Phragmites is effective at shoreline stabilization, wave attenuation, and nutrient removal
- Several studies have shown that bird or macroinvertebrate species richness and abundance is not statistically different from native plant communities (Kiviat 2013, Whyte et al. 2017) , but does not support certain rare species

Suggestions for Minimizing Carbon Emissions and Maximizing Carbon Sequestration Associated with Living Shoreline Construction

- Barge in materials when possible!
- Utilize beneficial use of dredge materials- DNR has the BUILD tool on the Coastal Atlas to help align dredge and LS projects- https://dnr.maryland.gov/ccs/coastalatlas/Pages/default.aspx
  - Beneficial dredge would decrease total emissions by up to 50%!
- Utilize designs that use less rock
- Spat Set Oyster reef balls create habitat, enhance C sequestration, replace bluestone for wave energy disruption immediately adjacent to shorelines
- Integrate marsh creation into your design
- Don’t fight the phrag, unless there are specific habitat creation goals

Thank You!

Contact information

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