Relative Wetland Vulnerability Framework Delaware Bay Pilot in support of Adaptation Planning for Salt Marsh Management

CBP Climate Resiliency WG Meeting

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Progress for a Stronger Future

*The views expressed in this presentation are those of the authors and do not represent official policy of the US EPA.

United States Environmental Protection Agency

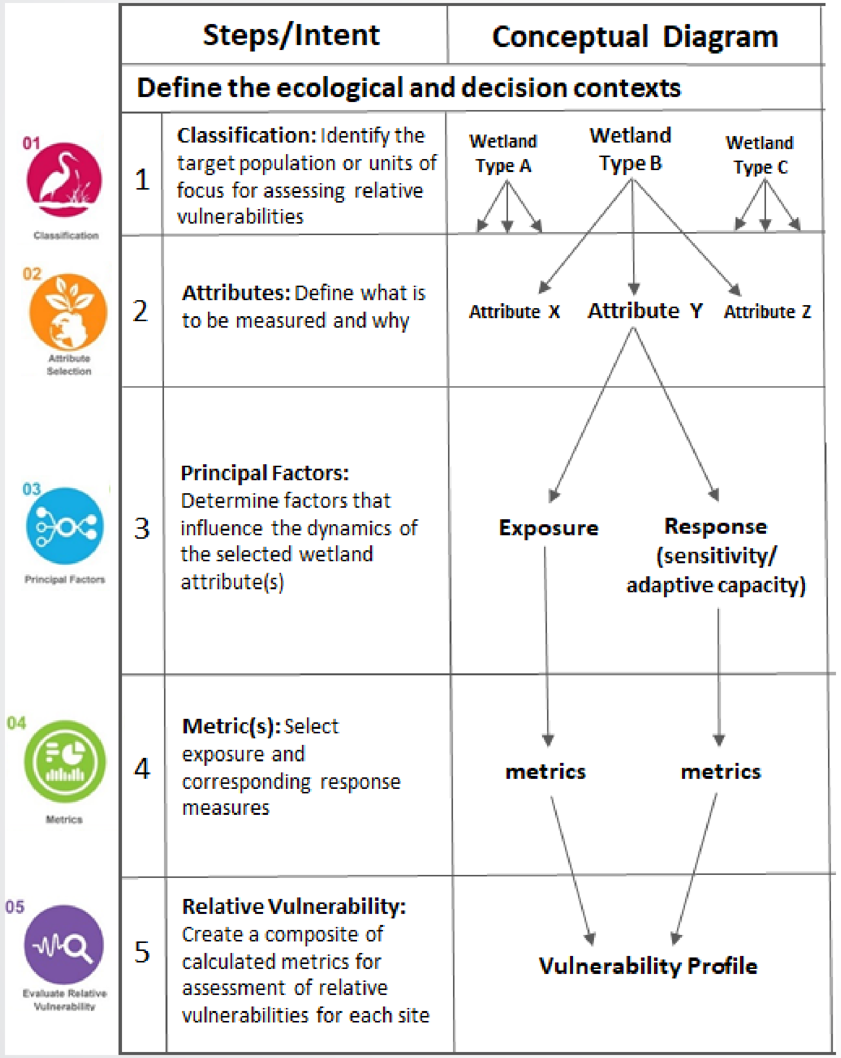
Vulnerability Assessment Results and Application

Anna Hamilton, Tetra Tech

Background

- Collaboration with the Partnership for the Delaware Estuary (PDE)
- Goal: Develop/test Relative Wetland Vulnerability Framework (RWVF) in coastal wetlands, to support climate change adaptation and resilience management in wetlands.
- Key approach components
  - Relative Wetland Vulnerability Framework (RWVF)
  - Sea Level Affecting Marshes Model (SLAMM)
- Characterization of vulnerabilities
- How results can inform management adaptation decisions

Relative Wetland Vulnerability Framework



https://doi.org/10.1002/ecs2.2561

A framework and methodology that:

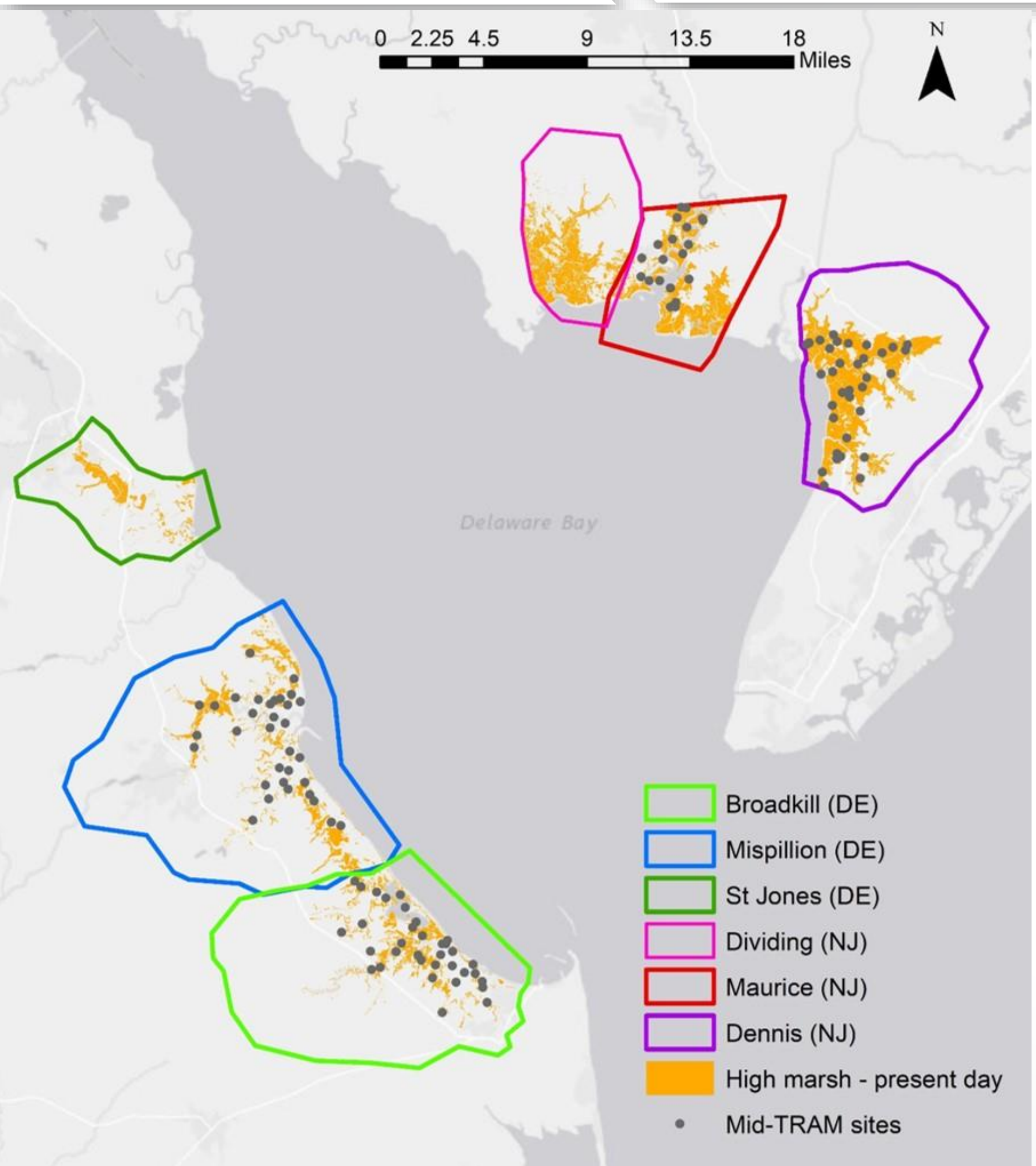
- Leads practitioners through the construction, implementation, and interpretation of a **climate change vulnerability assessment**
- Focuses assessment steps by **defining ecological and decision contexts**
- Separately examines **exposure and response** components of vulnerability
- Generates vulnerability profiles that can be linked to evaluation of **management tactics** to support adaptation

RWVF for Delaware Bay case study

	Steps/Intent	Conceptual Diagram	Application for Delaware Bay Coastal Case Study		
	Define the ecological and decision contexts				
01 Classification 1	**Classification:** Identify the target population or units of focus for assessing relative vulnerabilities	Wetland Type A / Wetland Type B / Wetland Type C	Six lower Delaware Bay **salt marsh** areas, identified as valued management units by PDE, classified based on salinity (14 to 26 ppt) and by flooding regime into **high, low, & total marsh** • **High marsh**: Covered by water only sporadically; defined as Irregularly Flooded Marsh (SLAMM code 20) + Transitional Marsh (SLAMM code 7) • **Low marsh**: Inundated by tidal water at least once per day; defined as Regularly Flooded Marsh (SLAMM code 8). • **Total marsh**: Sum of high & low marsh.		
02 Attribute Selection 2	**Attributes:** Define what is to be measured and why	Attribute X / Attribute Y / Attribute Z	Management objective: preservation of specified (bird or fish/crab) habitat or flood protection service. Associated **attribute**: Salt marsh acreage (assumption is that the greater the acreage extent, the greater the habitat provisioning or flood protection service) • **High marsh**: acreage (habitat for bird species of concern such as the salt marsh sparrow) • **Low** marsh: acreage (habitat for nursery and foraging of fish and crabs) • **Total marsh**: acreage (extent of salt marsh providing flood & storm surge protection)		
			SLR	**Storm Surge**	**Marsh Condition**
03 Principal Factors 3	**Principal Factors:** Determine factors that influence the dynamics of the selected wetland attribute(s)	Exposure / Response (sensitivity + adaptive capacity)	**Exposure**: Relative SLR based on historic global trends, future global mean SLR projections and vertical land movement (VLM). **Response**: Change in high, low, & total marsh acreage.	**Exposure**: Storm frequency and intensity; magnitude and extent of surge	**Response modifier**: Marsh condition as modifier of change in high marsh acreage
04 Metrics 4	**Metric(s):** Select exposure and corresponding response measures	metrics / metrics	**Exposure**: Historic SLR trend + VLM + Future global mean sea level (1-m rise by 2100, base year 2000) (Sweet et al. 2017)[1] **Response**: Percent[2] and actual high and low marsh acreage change by 2050 under the 'intermediate' SLR scenario[2] and the 'protect dry developed land' SLAMM scenario[3]	**Exposure**: - Number of hurricane strikes from 1900-2018 - Weighted average inundation depth from Category 3 storms	**Response modifier**: Overall condition score based on the mean of six Mid-TRAM condition metrics associated with: - hydrology - buffer/landscape - habitat
05 Evaluate Relative Vulnerability 5	**Relative Vulnerability:** Create a composite of calculated metrics for assessment of relative vulnerabilities for each site	Vulnerability Profile	• Site ratings based on the magnitude and direction of projected changes in marsh acreage; greater losses = greater vulnerability; greater gains = lesser vulnerability • Sites with higher numbers of historic hurricane strikes and higher predicted inundation depths are considered to have higher exposure to storm surge effects = greater vulnerability • Sites with higher-rated condition metrics = lesser vulnerability; sites with lower-rated condition metrics = greater vulnerability. **Combined visualization:** Juxtaposition of SLR, storm surge and condition metrics to create a single combined expression of relative vulnerabilities		

1. This corresponds with the 'intermediate' SLR scenario in Sweet et al. (2017), which is 'very likely' (>90% probability) under future simulations of moderate rates of warming

SLAMM simulations



Target population:

Salt marshes in the Delaware Estuary

Six sites:

- Delaware - Broadkill, St. Jones (lower), Mispillion,
- New Jersey - Dennis, Dividing, Maurice

Sea level rise scenarios (Sweet et al. 2017):

- Low scenario (0.3m rise by 2100)
- Intermediate scenario (1.0 m rise by 2100)
- High scenario (2.0m rise by 2100)

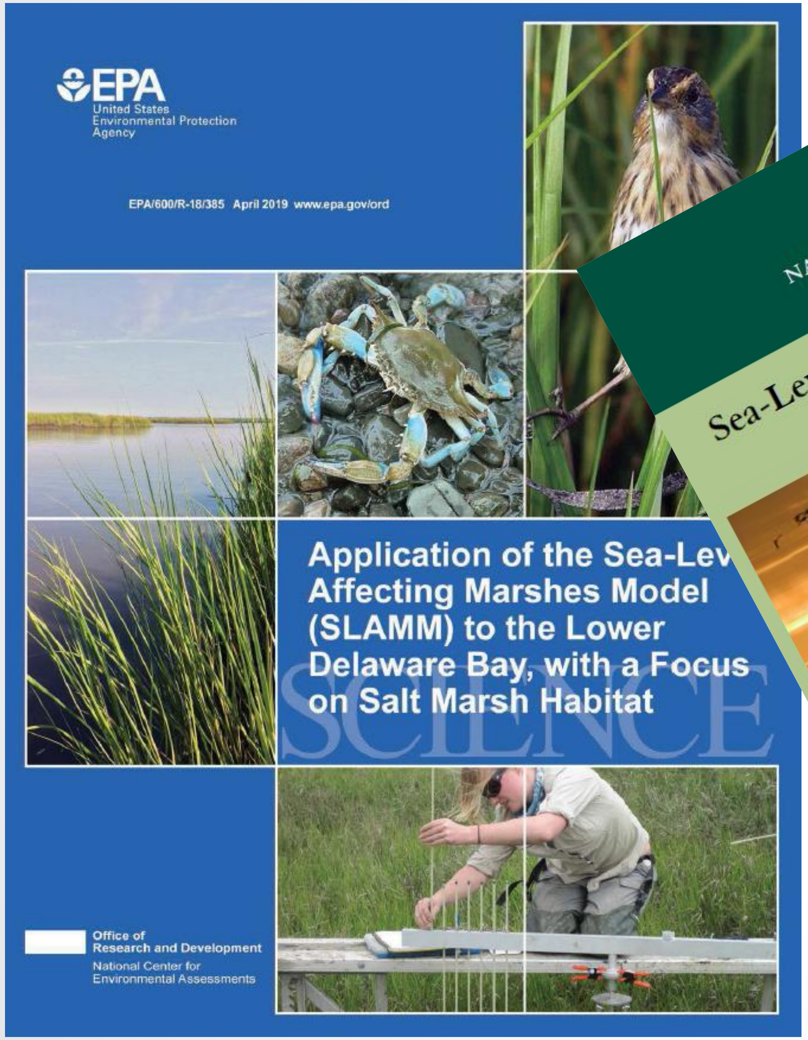
Time frame:

- Initial year (Time Zero): NWI photo date
- Future years: 2025, 2050, 2075, 2100

Land protection scenarios:

- Protect developed dry land, protect all dry land, and no protection

EPA technical report



https://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=344746

https://www.nwf.org/~/media/PDFs/Global-Warming/Reports/SeaLevelRiseandCoastalHabitats_ChesapeakeRegion.ashx

d in the report?

evel rise (SLR) induced salt marsh change in
es in the Lower Delaware Bay

hange in all categories

ess key input variables' relative effects

LAMM reports, we have …

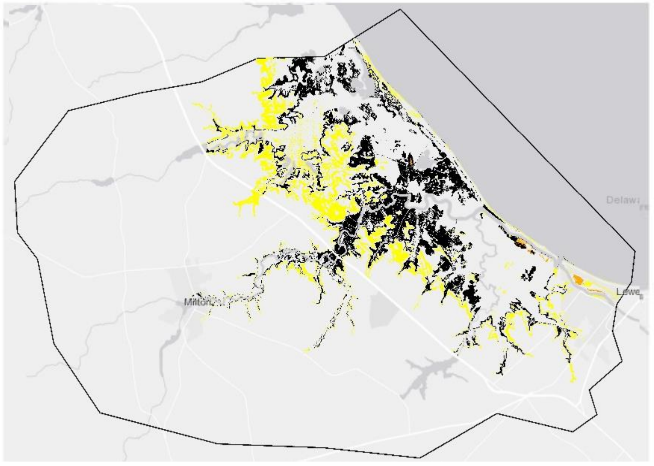
types and gain/loss (i.e. high
)

inform a larger project on assessing
vulnerabilities in order to inform management

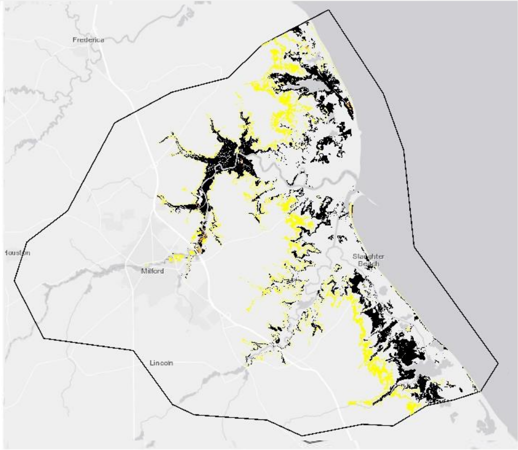
Simulation results—High marsh changes

2100

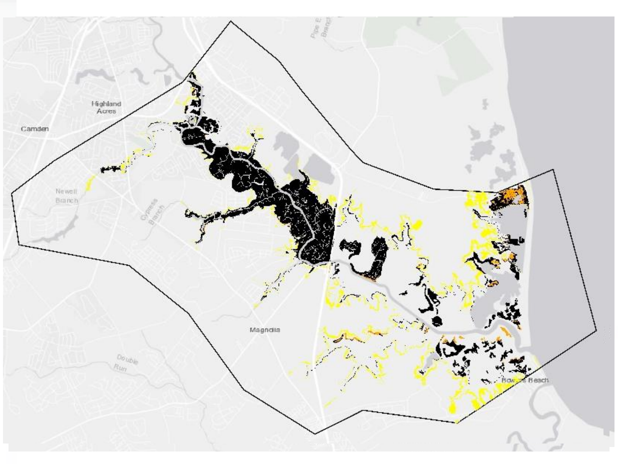
Delaware Subsites



Broadkill Subsite



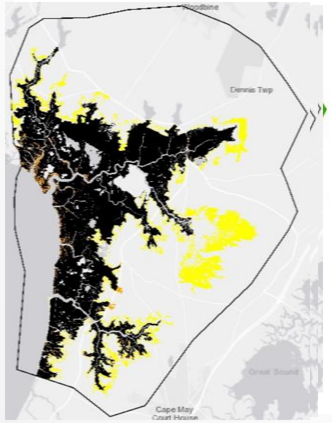
Mispillion Subsite



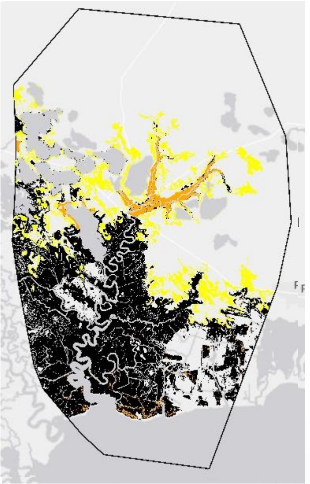
Lower St. Jones Subsite

- HM at Time Zero
- Loss of HM
- Gain of HM

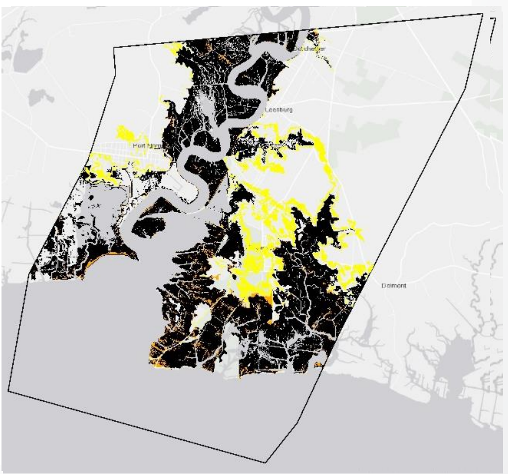
New Jersey subsites



Dennis Subsite



Dividing Subsite



Lower Maurice Subsite

Simulation results—Low marsh changes

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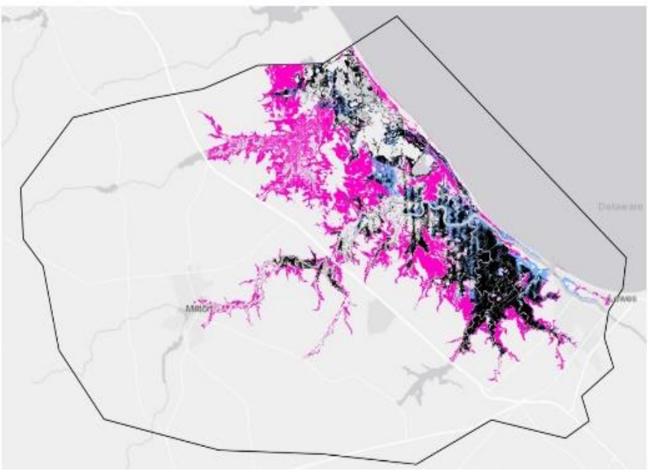
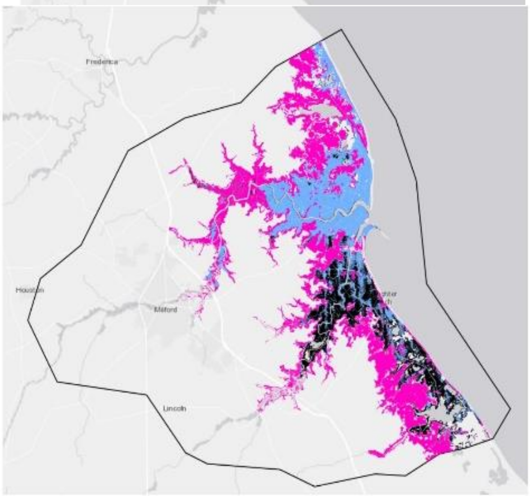
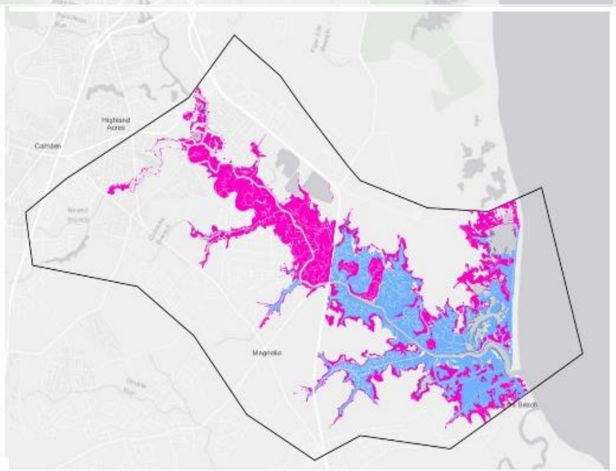
Delaware Subsites



Broadkill Subsite



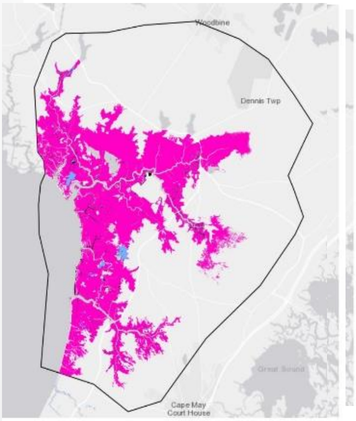
Mispillion Subsite



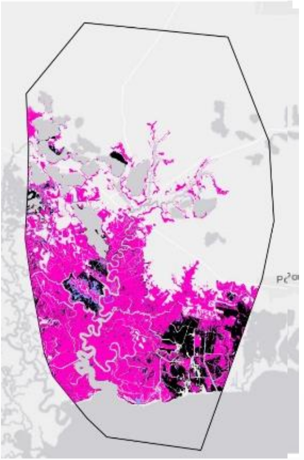
Lower St. Jones Subsite

- LM at Time Zero
- Loss of LM
- Gain of LM

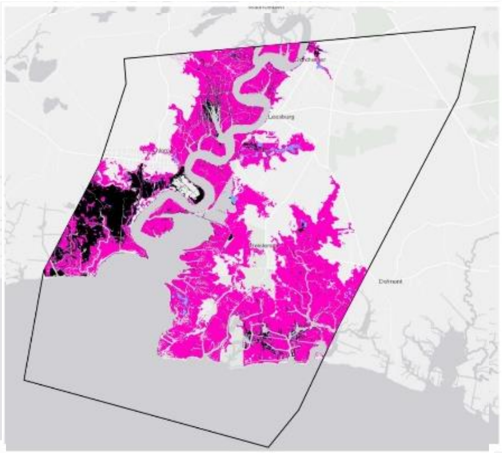
New Jersey subsites



Dennis Subsite



Dividing Subsite

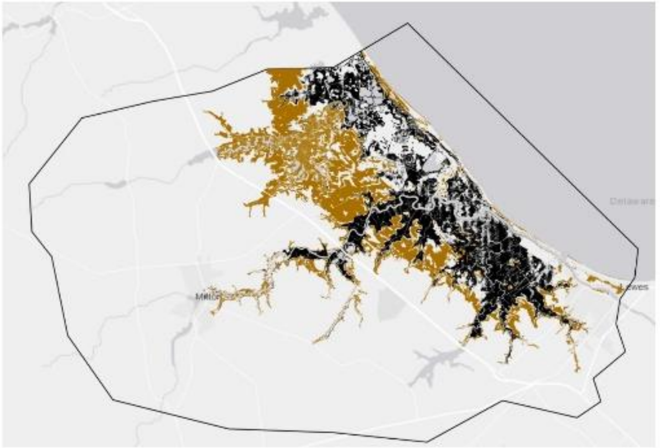


Lower Maurice Subsite

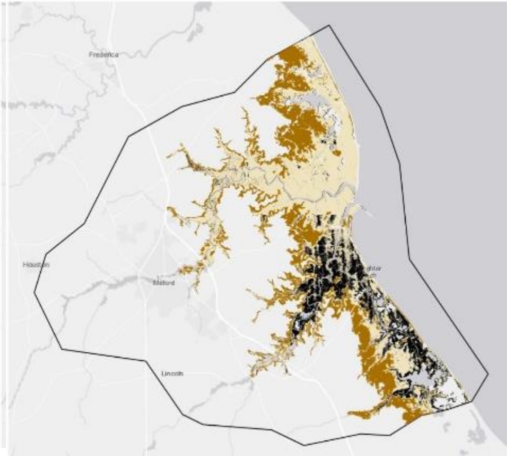
Simulation results—Total marsh changes

2100

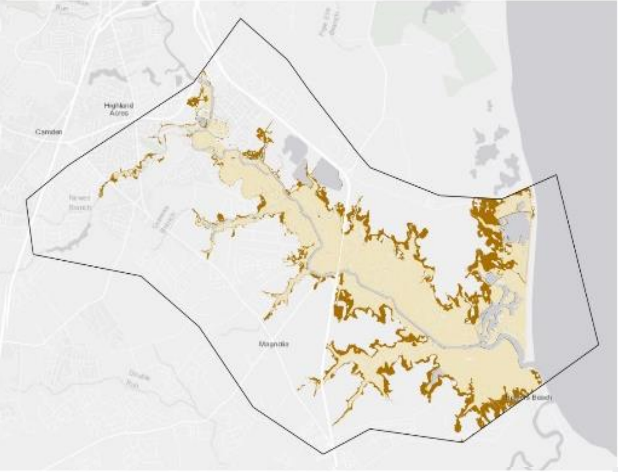
Delaware Subsites



Broadkill Subsite



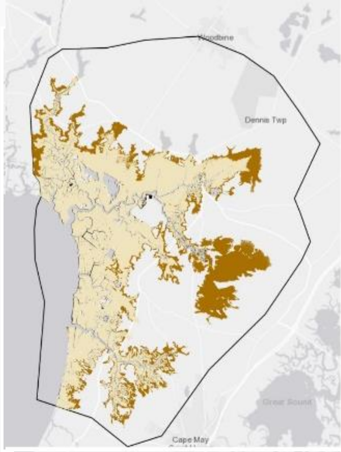
Mispillion Subsite



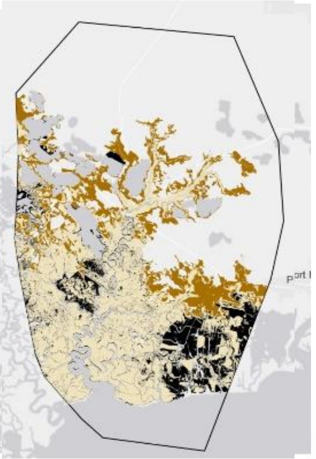
Lower St. Jones Subsite

- TM at Time Zero
- Loss of TM
- Gain of TM

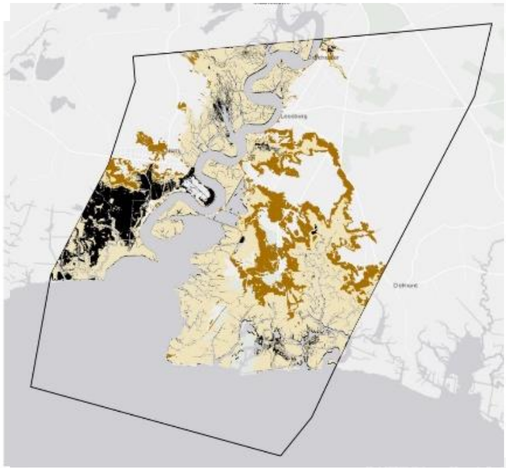
New Jersey subsites



Dennis Subsite



Dividing Subsite



Lower Maurice Subsite

Results are quite different—High vs. total marsh

Different management targets

High Marsh:

Sparrow nesting habitat protection

Total Marsh:

Overall flood protection

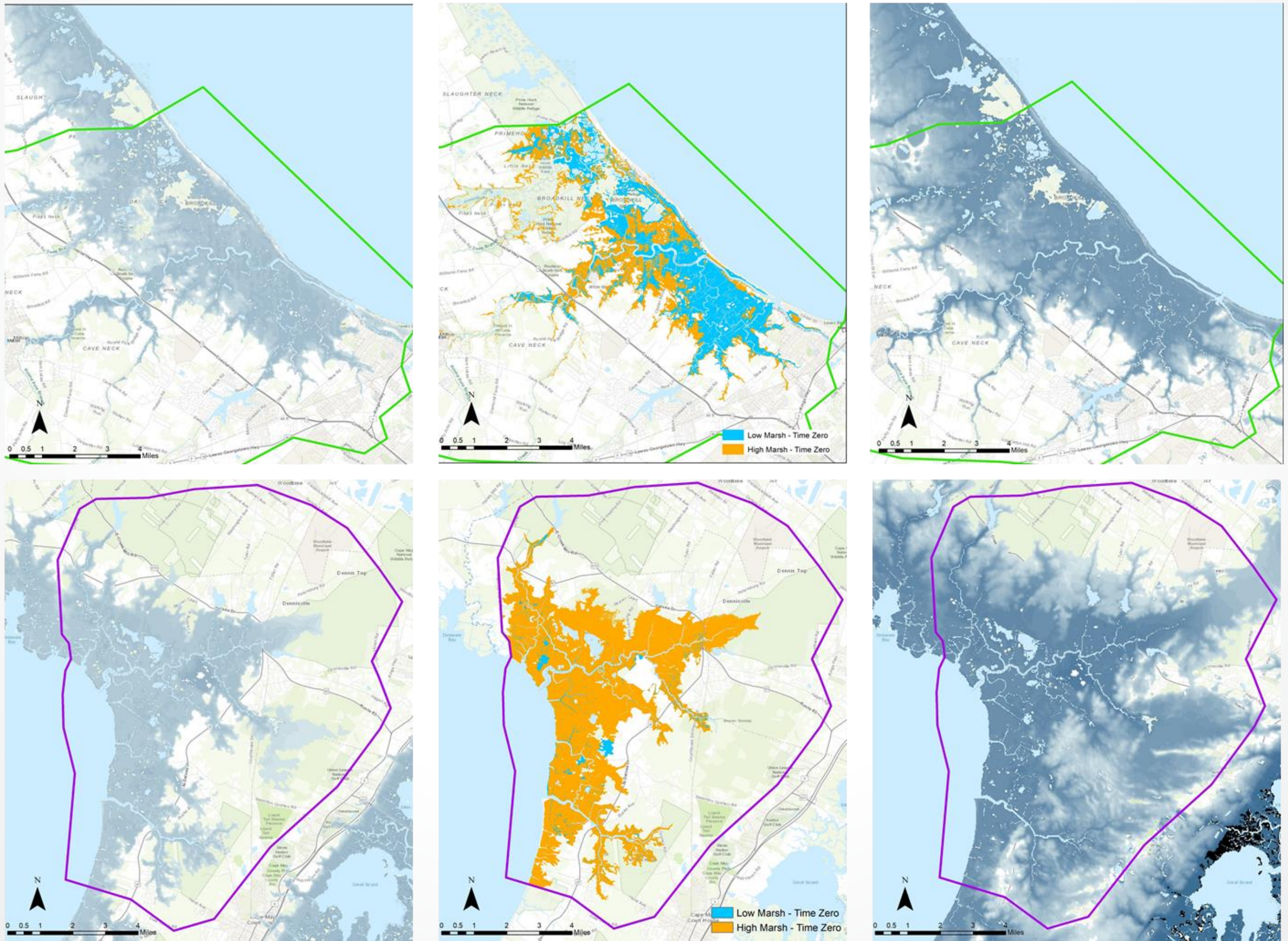
Site	Exposure		High marsh Response			Total marsh Response		
	Historic SLR trend + VLM (mm/yr)	Future GMSL by 2050 (m)	Time zero (acres)	2050 (acres)	% Change	Time zero (acres)	2050 (acres)	% Change
Broadkill DE	3.4	0.34	3240	2522	**-22 %**	7196	8429	**17 %**
Mispillion DE	3.4		4262	4153	**-3 %**	11428	13341	**17 %**
Lower St. Jones DE	3.4		1519	1563	**3 %**	3384	3665	**8 %**
Dennis NJ	3.8		9153	9206	**1 %**	9574	10146	**6 %**
Dividing NJ	3.8		5027	3821	**-24 %**	6734	6942	**3 %**
Lower Maurice NJ	3.8		5225	4927	**-6 %**	6525	6827	**5 %**

Cat 1 & 3 storm surge inundation areas & depths

Category 1 | Time Zero | Category 3

Broadkill (DE)

Dennis (NJ)



SLOSH inundation depth simulation

- 00 to 01 foot above ground
- 01 to 02 feet above ground
- 02 to 03 feet above ground
- 03 to 04 feet above ground
- 04 to 05 feet above ground
- 05 to 06 feet above ground
- 06 to 07 feet above ground
- 07 to 08 feet above ground
- 08 to 09 feet above ground
- 09 to 10 feet above ground
- 10 to 11 feet above ground
- 11 to 12 feet above ground
- 12 to 13 feet above ground
- 13 to 14 feet above ground
- 14 to 15 feet above ground
- 15 to 16 feet above ground
- 16 to 17 feet above ground
- 17 to 18 feet above ground
- 18 to 19 feet above ground
- 19 to 20 feet above ground
- > 20 feet above ground

Marsh condition scores

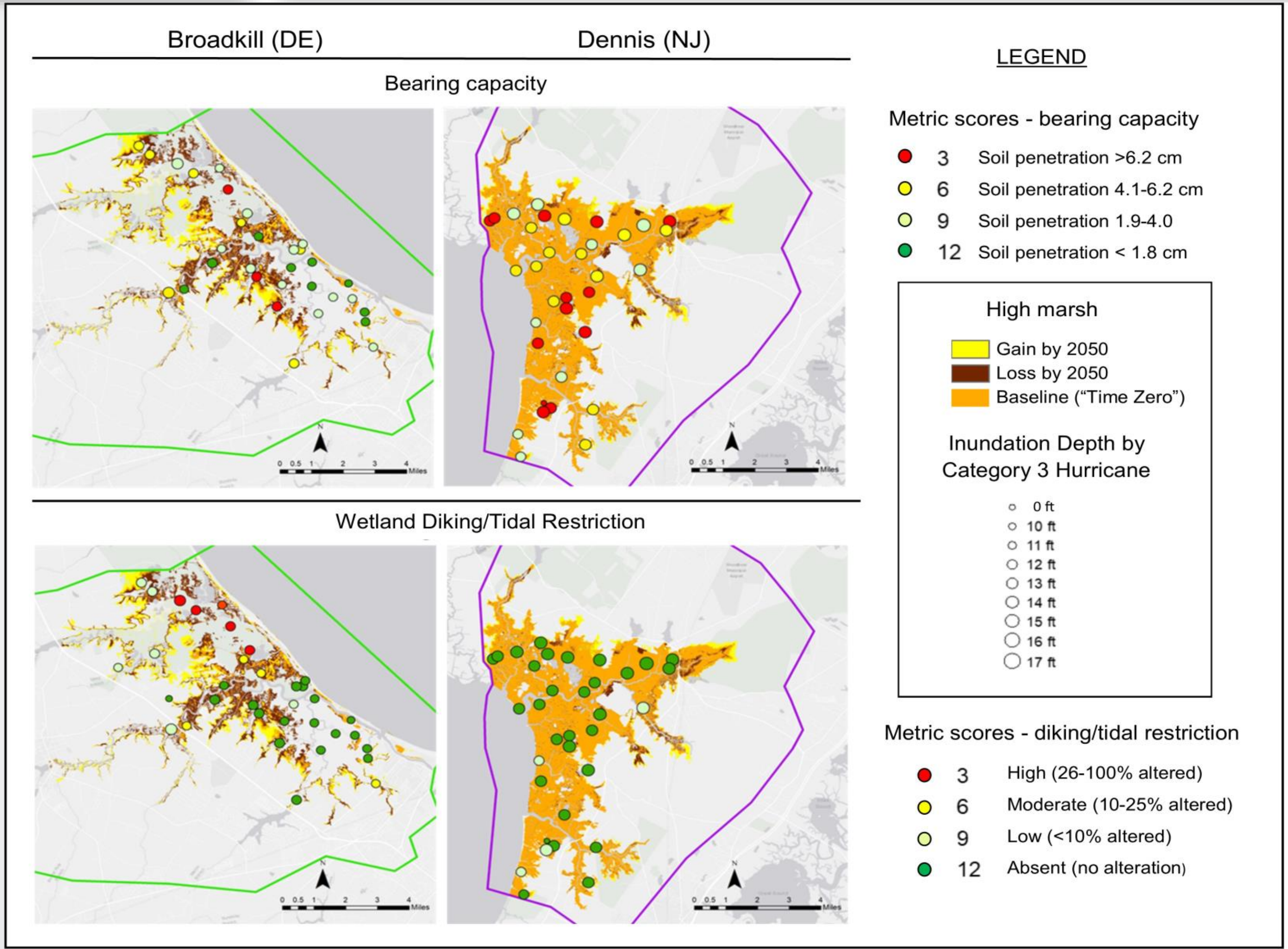
Site	# Survey locations	Buffer	Hydrology		Soils	Vegetation		Overall Mean
		250m Landscape Condition (B4)	Ditching & Draining (H1)	Wetland Diking/ Tidal Restriction (H3)	Soil Bearing Capacity (HAB1)	Horizontal Vegetative Obstruction (HAB2)	Number of Plant Layers (HAB3)	
Broadkill (DE)	35	7.2 (3-9)	8.2 (3-12)	9.5 (3-12)	8.5 (3-12)	7.2 (3-12)	9 (6-12)	8.3
Mispillion (DE)	34	7.0 (3-12)	8.4 (3-12)	9 (9-9)	7.7 (3-12)	6.2 (3-12)	8 (3-9)	7.7
Dennis (NJ)	35	8.7 (6-12)	10.5 (3-12)	11.7 (9-12)	5.6 (3-9)	7.3 (3-12)	9.1 (9-12)	8.8
Maurice (NJ)	20	7.4 (3-12)	11.9 (3-12)	9.3 (3-12)	7.7 (3-12)	11 (9-12)	8.9 (6-12)	9.3

Relative vulnerability – combined visualization

Site	High marsh acreage (time zero)	SLR	Storm Surge		Marsh Condition
		% Change in high marsh acreage by 2050	Hurricane strikes (1900-2018)	Category 3 inundation depth (ft)[a]	Mid-TRAM mean score
Broadkill (DE)	3239.7	-22.2 %	9	11.7	8.3
Mispillion (DE)	4261.6	-2.6 %	9	12.3	7.7
St. Jones (DE)	1518.8	2.9 %	6	12.8	NA
Dennis (NJ)	9152.5	0.6 %	8	14.3	8.8
Dividing (NJ)	5026.6	-24.0 %	6	15.0	NA
Maurice (NJ)	5225.4	-5.7 %	8	14.4	9.3

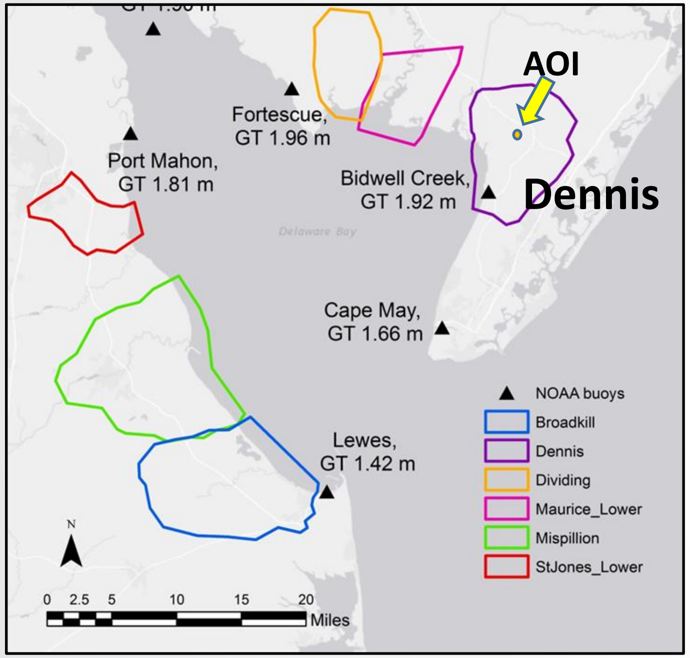
[a]weighted averages of SLOSH model data

Relative vulnerability – map visualization



Case study: Dennis high marsh

RWVF case study areas



Management goal: conserve Saltmarsh Sparrow (SALS) high marsh nesting habitat. A primary threat to SALS is **sea level rise**. Using the RWVF, can determine which sites have **lower vulnerabilities** to SLR than other areas.

Site	High marsh acreage (time zero)	SLR
		% Change in high marsh acreage by 2050
Broadkill (DE)	3239.7	-22.2 %
Mispillion (DE)	4261.6	-2.6 %
St. Jones (DE)	1518.8	2.9 %
Dennis (NJ)	9152.5	0.6 %
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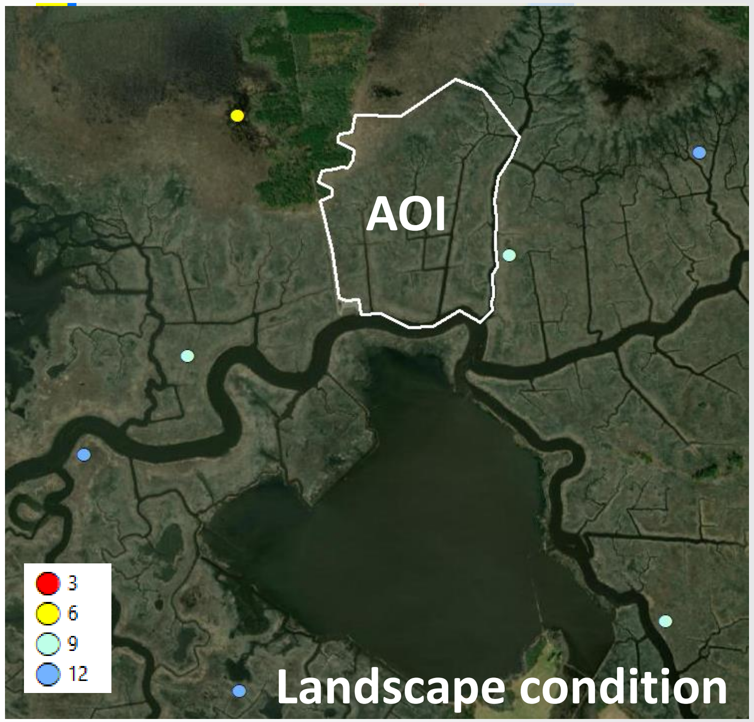
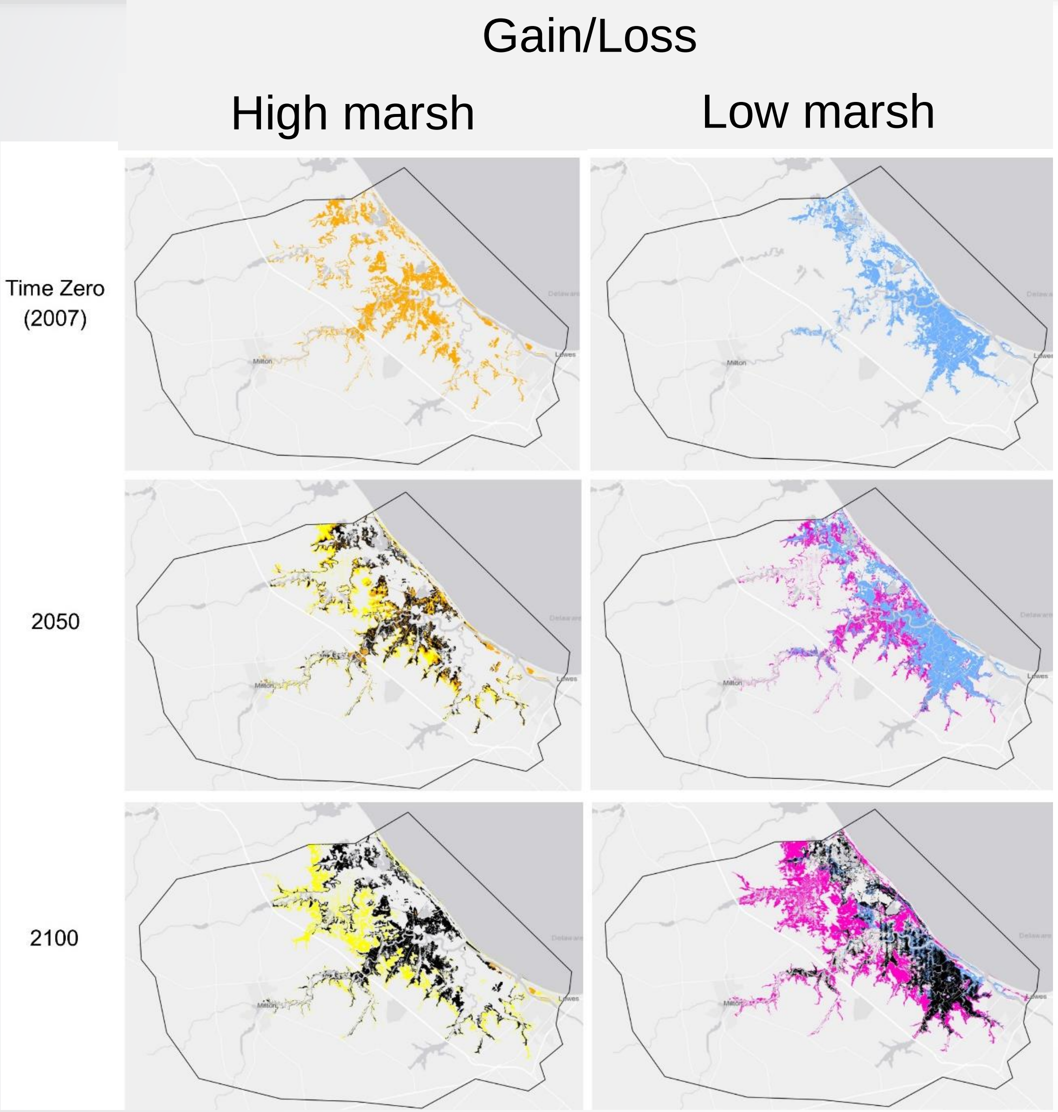
Maurice (NJ)	5225.4	-5.7 %



Condition (modifier of response): Could indicate where tactic success is more likely, or condition improvement is critical

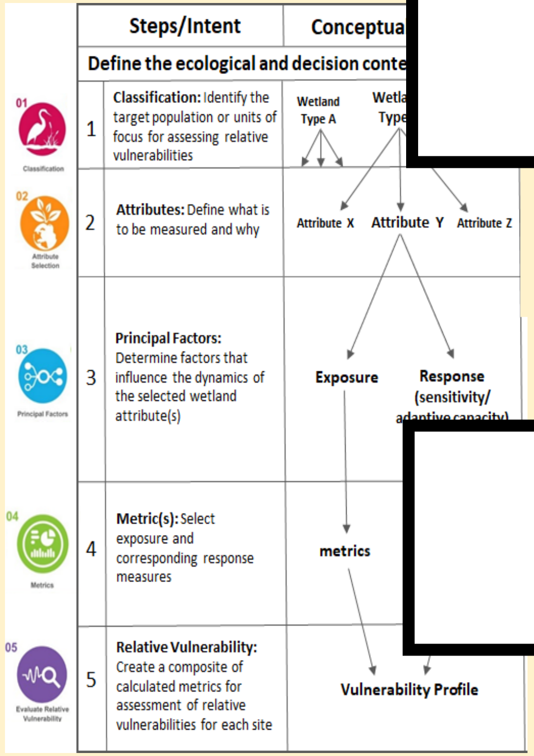
Informing decisions



Results can help managers:

- Prioritize marshes for focus (site selection)
- Understand timing of ‘tipping points’
- Inform monitoring approaches (tactic selection, design)
- Decide on strategies and tactics for high marsh vs. low marsh

Tools in concert



Relative Wetland Vulnerabilities Framework (EPA)

Level 1: Site Prioritization

Where should we foc… …urces (dependent on goals)?

L…

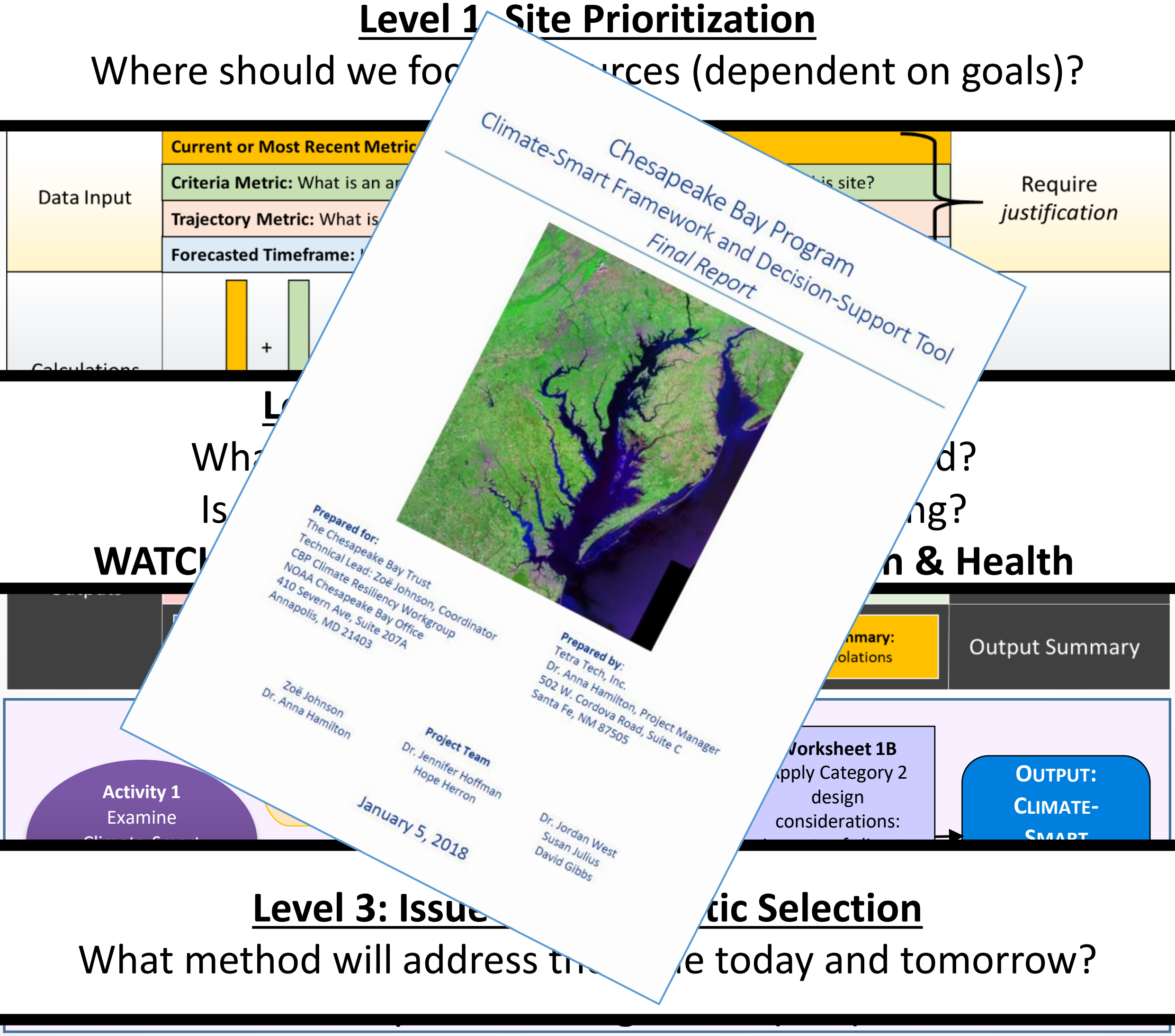
Wh… …d?

Is… …ng?

WATC… …n & Health

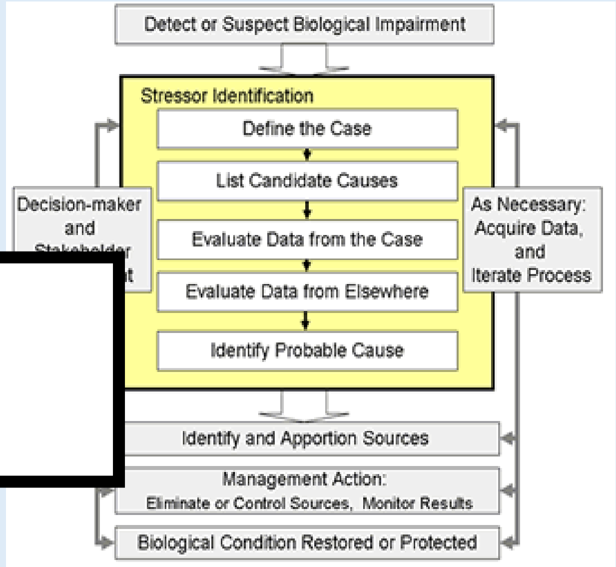
Level 3: Issue… …tic Selection

What method will address th… …e today and tomorrow?



…al Analysis/Diagnosis

…ion Information System



Key collaborators

Thanks!

Contact: Jordan West (west.jordan@epa.gov)

Mid-Atlantic Inland Wetlands

- Denice Wardrop & Mike Nassry, Penn State University
- Regina Poeske, EPA Region 3
- Anna Hamilton & Jen Stamp, Tetra Tech

Adaptation Design Tool

- Britt Parker, NOAA
- Petra MacGowan, Cherie Wagner & Liz Shaver, TNC
- Zoë Johnson, CBP
- Hudson Slay, EPA Region 9 & David Cuevas, EPA Region 2
- David Gibbs, EPA ORISE Fellow
- Anna Hamilton, Kitty Courtney & Pat Bradley, Tetra Tech

Coastal Wetlands PDE Collaboration

- LeeAnn Haaf & Josh Moody, PDE
- Cathy Wigand & Marissa Liang, EPA ORD
- Regina Poeske, EPA Region 3
- Jonathan Clough & Marco Propato, Warren Pinnacle Consulting
- Anna Hamilton & Jen Stamp, Tetra Tech

Multi-Regional Workshop

Protecting Coastal Communities with Resilient Coastal Wetlands

(Online, Spring 2022)

Jordan West, EPA ORD

EPA's resilience-based research

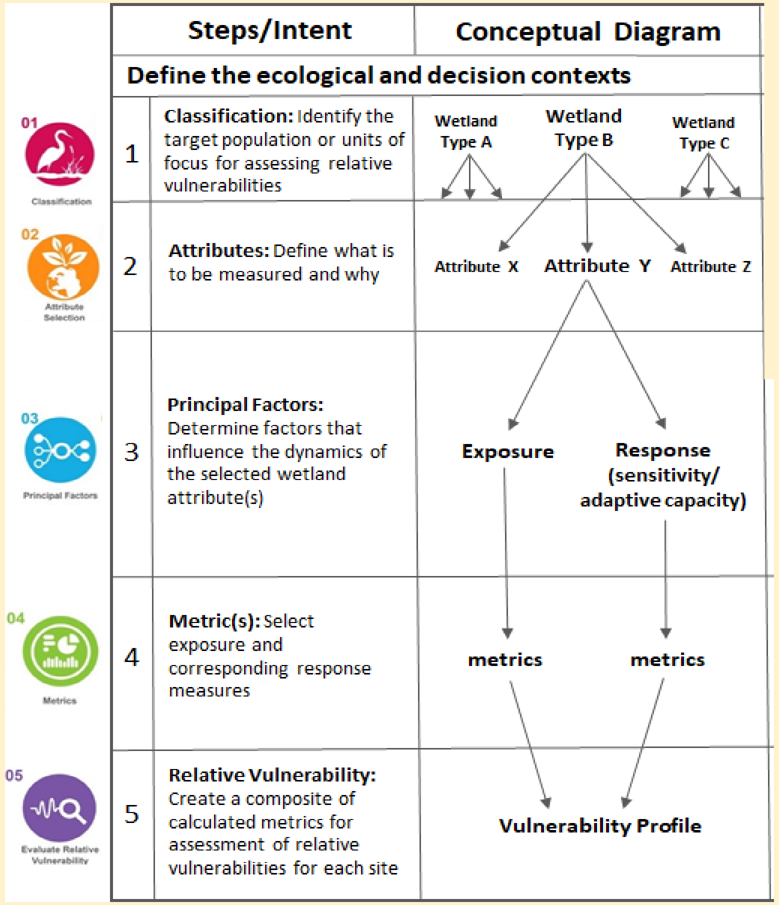
A suite of activities across two regions to provide methods and guidance for coastal resilience with a focus on salt marsh wetlands and coupled socio-ecological systems

What determines resilience? How do we manage for it?

Mid-Atlantic

- Demonstration of ORD wetland vulnerability assessment and adaptation frameworks applied in concert with existing diagnosis and planning tools in use in the Delaware Bay area *(EPA lead: Jordan West)*

- Collaborators: Partnership for the Delaware Estuary, EPA Region 3



Wetland Vulnerability Framework

https://doi.org/10.1002/ecs2.2561

Northeast

- Management strategy that analyzes existing wetland adaptation efforts and identifies areas of success, opportunities for improvements, and methods to maximize social and ecological co-benefits for restored wetlands *(EPA lead: Cathy Wigand)*

- Collaborators: Rhode Island National Estuarine Research Reserve, Environmental Council of the States (RI Dept. of Public Health)

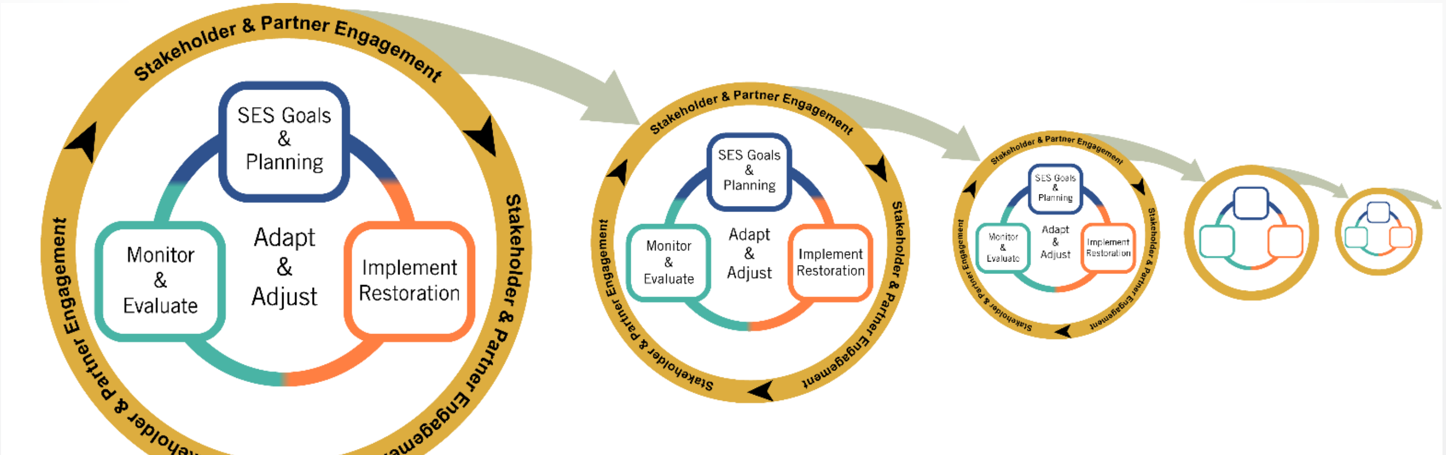


Figure from Mulvaney et al., in review
SES: Socio-ecological system

Workshop

Purpose: to integrate parallel but related approaches to resilience across multiple regions

(Online)

Day 1: EPA Research Presentations

- Results of two regional tracks of research and applications
- Interactive discussions: lessons learned, synthetic conclusions, next steps

Day 2: Partner Panels

- Speed talks: PDE, RI NERR, ECOS, CBP, others?
- Interactive discussions: challenges, joint interests, research priorities, potential collaborations

Workshop topics

- Coastal wetlands vulnerability and resilience
- Applications of resilience-based management
- Implications for coastal community resilience
- Translational science and human-centered design
- Transferability of methods across regions
- Lessons learned about
  - ✓ Translating vulnerability information to match the decision context
  - ✓ Dealing with issues of scale
  - ✓ Dealing with data limitations
  - ✓ Assessing questions of site selection for project prioritization
  - ✓ Examining trade-offs among tactics based on their adaptation/resilience potential
  - ✓ Barriers and opportunities for successful implementation of management actions
  - ✓ Accounting for uncertainty in the decision process

Questions?

Thanks!

Workshop Planning Team:

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