Framework for wetland vulnerability assessments: Delaware Bay case study

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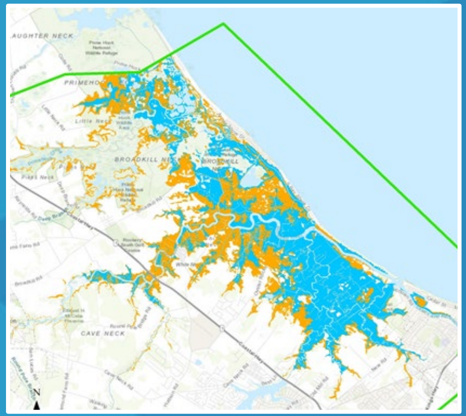

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Office of Research and Development
Center for Public Health and Environmental Assessment

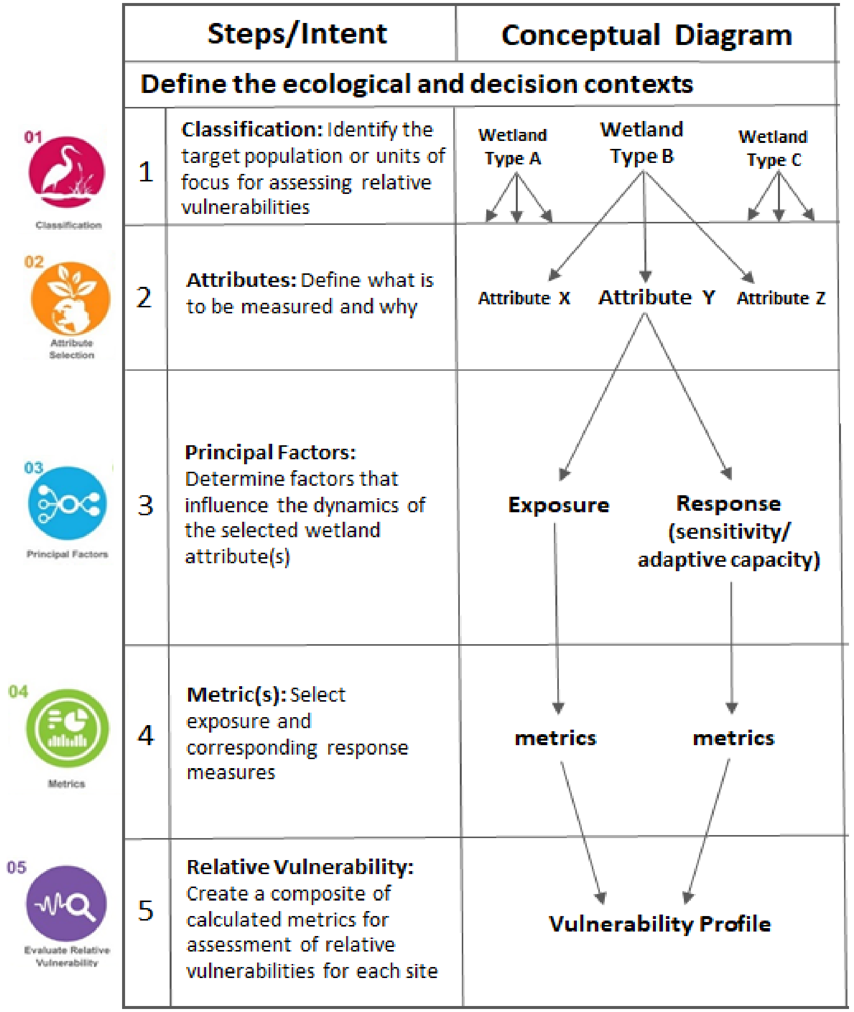
Overview

Goal: Support practitioners in integrating information from climate change vulnerability assessments into their decision making

Approach

- Carry out a climate change vulnerability assessment in the lower Delaware Bay, in collaboration with the Partnership for the Delaware Estuary (PDE)
- Characterize vulnerabilities of different marsh zones to sea level rise and storm surge, with consideration of how resilience response may be mediated by marsh condition
- Demonstrate a framework for using data that are widely available for coastal wetlands in the U.S. and straightforward to interpret

Relative Wetland Vulnerability Framework

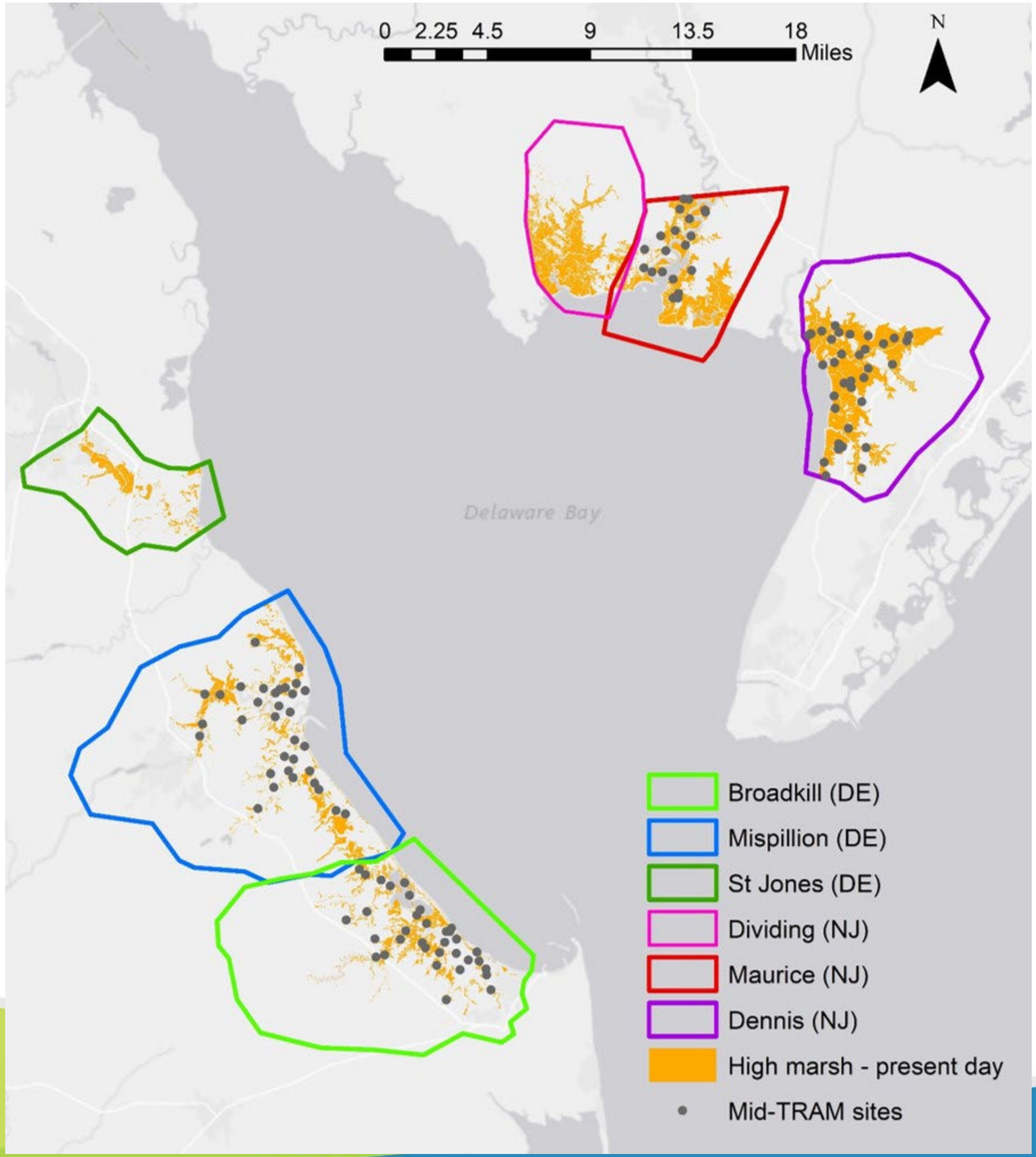


First used in freshwater wetlands in Pennsylvania (Wardrop et al. 2019)

Five steps (classification, attributes, principal factors, metrics, relative vulnerability)

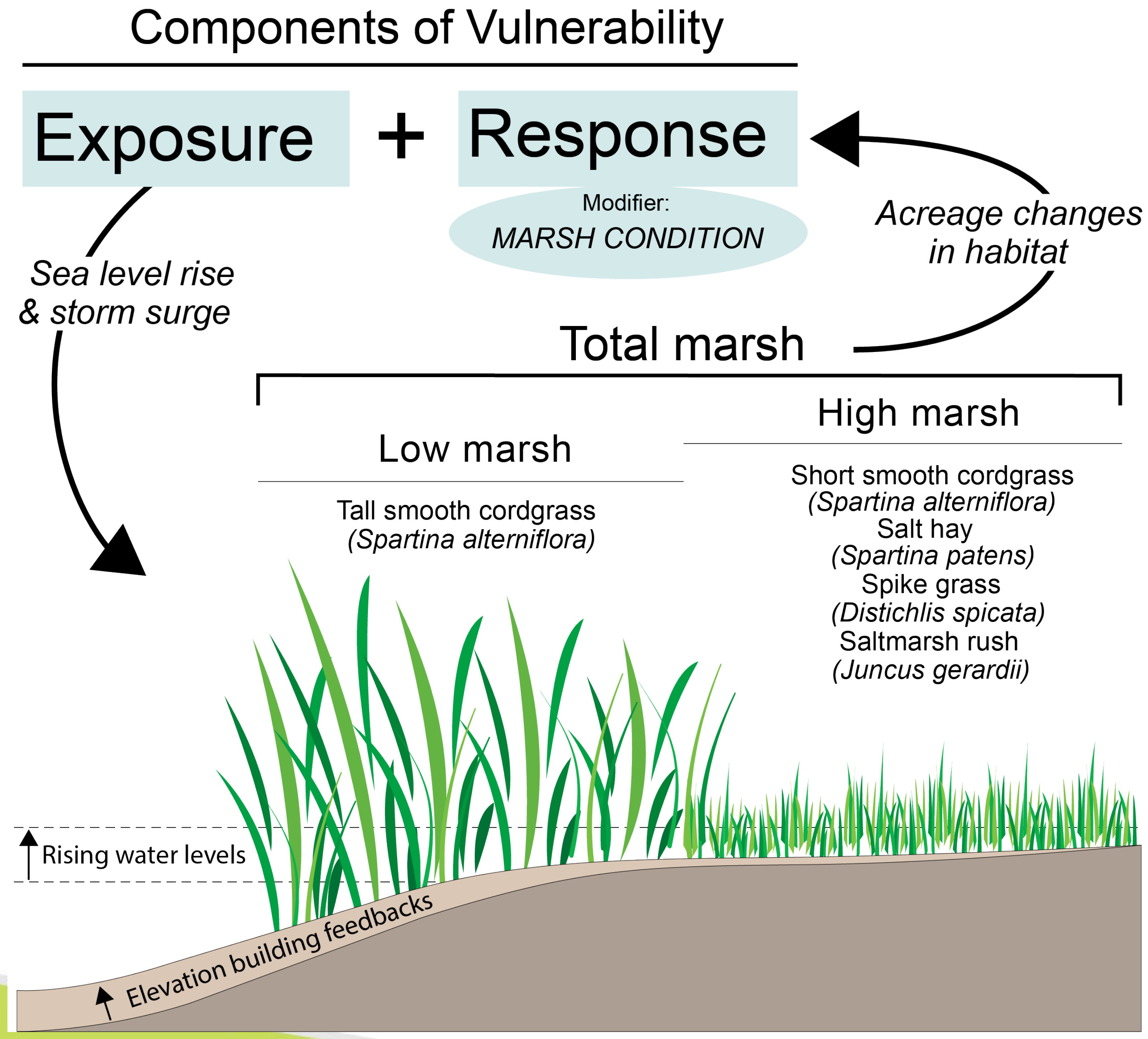
Why use the RWVF?

- A **systematic process** that ensures:
  - ✓ Identification of objectives based on the **decision context** up front
  - ✓ Separate evaluation of **exposure** and **response** components
  - ✓ Selection of **metrics** for what you are measuring and why, that allow clear links to **management objectives**
  - ✓ **Flexibility** with regard to input data, spatial and temporal scales



Study area

- Six sites (3 in DE, 3 in NJ) with pre-existing boundary delineations based on ongoing studies and management activities of PDE and other partners
- Landscape scale → bay-wide comparisons (across sites)
    - site selection
- Also within-site comparisons



Considered multiple components of vulnerability in combination

Exposures
- Sea level rise (SLR)
- Storm surge

Response
- Marsh acreage

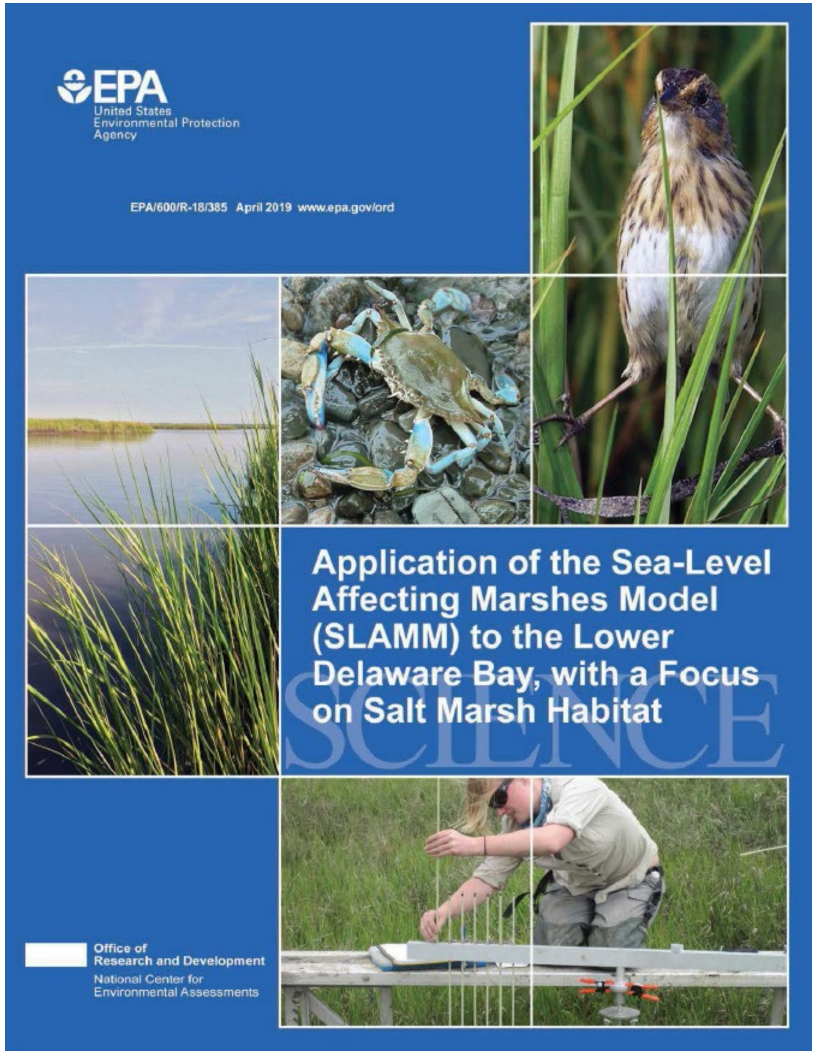
Response modifier
- Marsh condition

RWVF populated for our case study

Step	Steps/Intent	Conceptual Diagram	Case study
	Define the ecological and decision contexts		**Objective**: conservation of valued marsh habitats
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, divided into *zones* classified by inundation regime into **high**, **low**, & **total marsh**
02 Attribute Selection 2	**Attributes:** Define what is to be measured and why	Attribute X; Attribute Y; Attribute Z	**Acreage** of high marsh, low marsh, total marsh
03 Principal Factors 3	**Principal Factors:** Determine factors that influence the dynamics of the selected wetland attribute(s)	Exposure; Response (sensitivity/ adaptive capacity)	<u>Exposure:</u> **Relative SLR** based on historic global trends, future global mean SLR projections and vertical land movement (VLM) <u>Response:</u> **Acreage change** <u>Exposure</u>: **Storm surge** magnitude and extent <u>Response modifier</u>: Marsh **condition** as modifier of change in marsh acreage
04 Metrics 4	**Metric(s):** Select exposure and corresponding response measures	metrics; metrics	<u>Exposure:</u> **Historic SLR trend + VLM + Future global mean sea level** <u>Response:</u> **Percent and areal acreage change** by 2050 <u>Exposure</u>: Weighted average **inundation depth** from Category 3 storms <u>Response modifier</u>: Overall **condition score** based on Mid-TRAM condition metrics
05 Evaluate Relative Vulnerability 5	**Relative Vulnerability:** Create a composite of calculated metrics for assessment of relative vulnerabilities for each site	Vulnerability Profile	**Site rankings** where greater acreage losses to SLR = greater vulnerability Sites with higher predicted **inundation depths** are considered to have greater vulnerability Sites with higher-rated **condition metrics** are considered to have less vulnerability **Combined visualization**: Juxtaposition of SLR, storm surge and condition metrics to create a single combined expression of relative vulnerabilities

Sea Level Affecting Marshes Model (SLAMM)

- Used to derive SLR (exposure) and marsh acreage change (response)
- Widely applied in many coastal areas (by USEPA, NWF, USGS, and USFWS, among others)
- Metrics derived for:
  - ✓ SLR projections for intermediate scenario (1.0 m rise by 2100) (Sweet et al. 2017) by 2050
  - ✓ "Protect developed dry land" scenario
  - ✓ Marsh acreage change
- New twists
  - ✓ Maps that feature high, low and total marsh (rather than all land cover categories shown together)
  - ✓ Results customized for the six marsh areas
  - ✓ Used site-specific accretion data

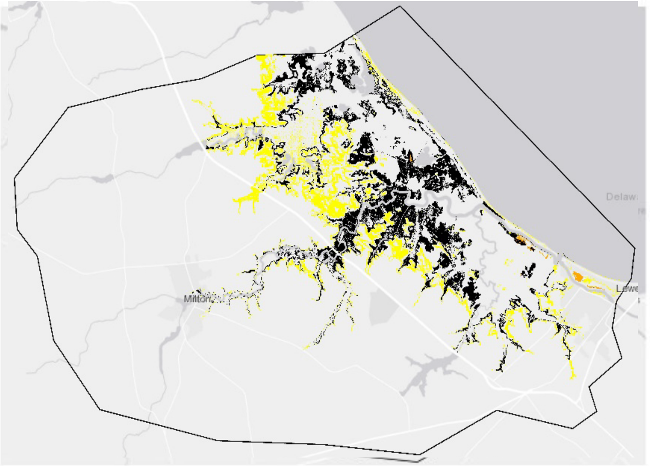


https://cfpub.epa.gov/ncea/global/recordisplay.cfm?deid=344746

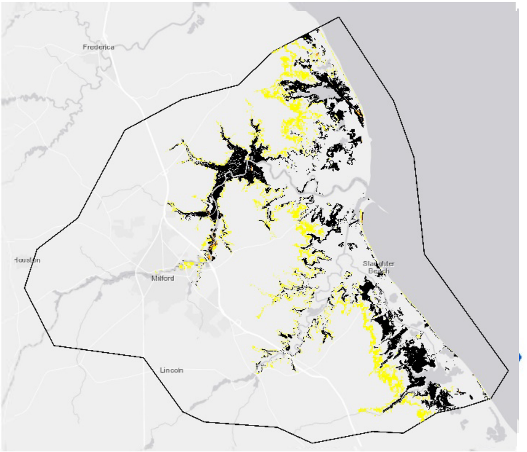
Simulation Results - High Marsh Changes

2100

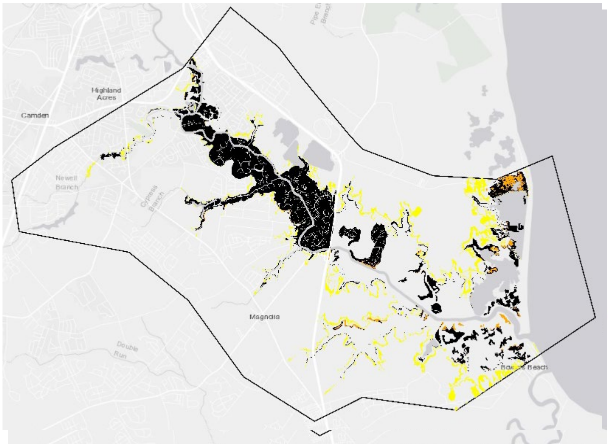
Delaware Subsites



Broadkill Subsite



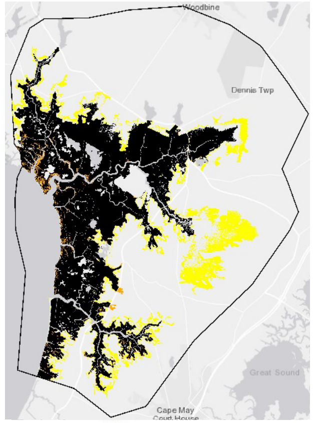
Mispillion Subsite



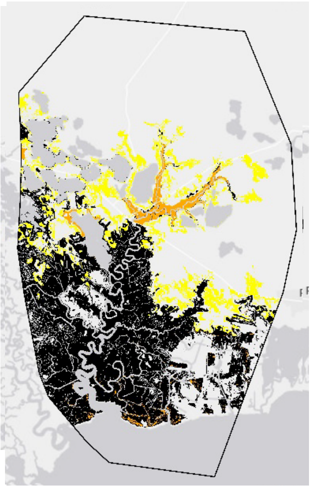
Lower St. Jones Subsite

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

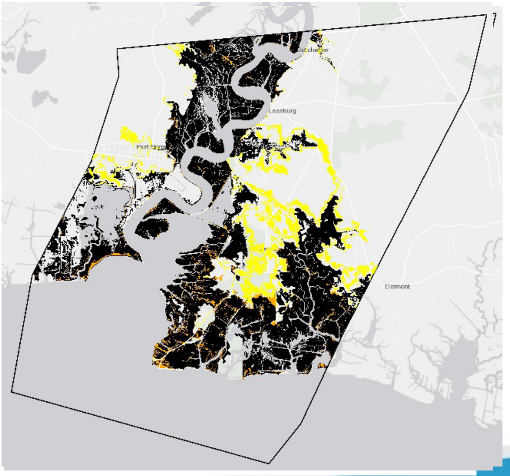
New Jersey subsites



Dennis Subsite



Dividing Subsite



Lower Maurice Subsite

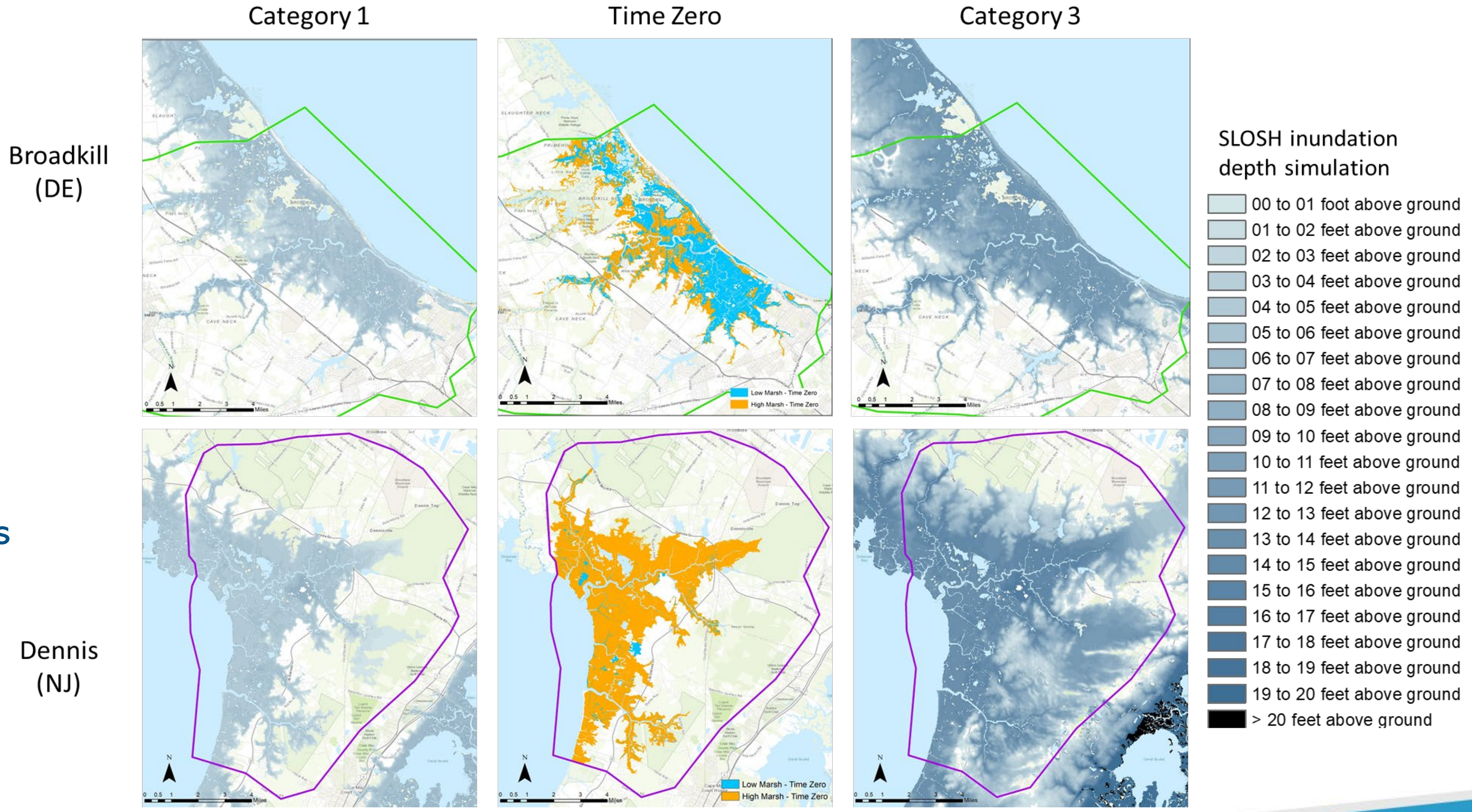
Results quite different - High vs. Low vs. Total Marsh

Site	State	Historic SLR trend + VLM (mm/yr)	Future GMSL by 2050 (m)	High marsh			Low marsh			Total marsh		
				Time zero (acres)	2050 (acres)	% Change	Time zero (acres)	2050 (acres)	% Change	Time zero (acres)	2050 (acres)	% Change
Broadkill	DE	3.4	0.34	3240	2522	**-22%**	3956	5907	**49%**	7196	8429	**17%**
Mispillion				4262	4153	**-3%**	7166	9189	**28%**	11428	13341	**17%**
Lower St. Jones				1519	1563	**3%**	1865	2102	**13%**	3384	3665	**8%**
Dennis	NJ	3.8		9153	9207	**1%**	422	939	**123%**	9574	10146	**6%**
Dividing				5027	3821	**-24%**	1708	3122	**83%**	6734	6942	**3%**
Lower Maurice				5225	4927	**-6%**	1300	1900	**46%**	6525	6827	**5%**

Storm surge

Exposure metrics derived from:

- SLOSH (Cat 3 storm surge inundation depth)
- Historic hurricane strikes



Hurricane Strikes

Site	Number of hurricane strikes (2000-2018)				
	Category 1	Category 2	Category 3	Category 4	All
Broadkill (DE)	6	2	1	0	9
Mispillion (DE)	6	2	1	0	9
St Jones (DE)	3	3	0	0	6
Dennis (NJ)	4	3	1	0	8
Dividing (NJ)	3	3	0	0	6
Maurice (NJ)	4	3	1	0	8

Marsh Condition ('response modifier')

Derived using selected Mid-Atlantic Tidal Rapid Assessment Method metrics

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

Putting it all together…

Results differed across marsh sites

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

Conclusions

- Results are quite different for high, low, and total marsh
- Different marsh areas support different ecosystem services, e.g., provision of habitat for valued species or provision of flood protection
- Thus, the concept of vulnerability depends on the management target of interest → and having management objectives in mind from the start
- Management objectives for different or multiple targets/services could lead to conflicts/trade-offs among management interventions
- How can such relative vulnerability assessment results be applied to help inform management decisions?