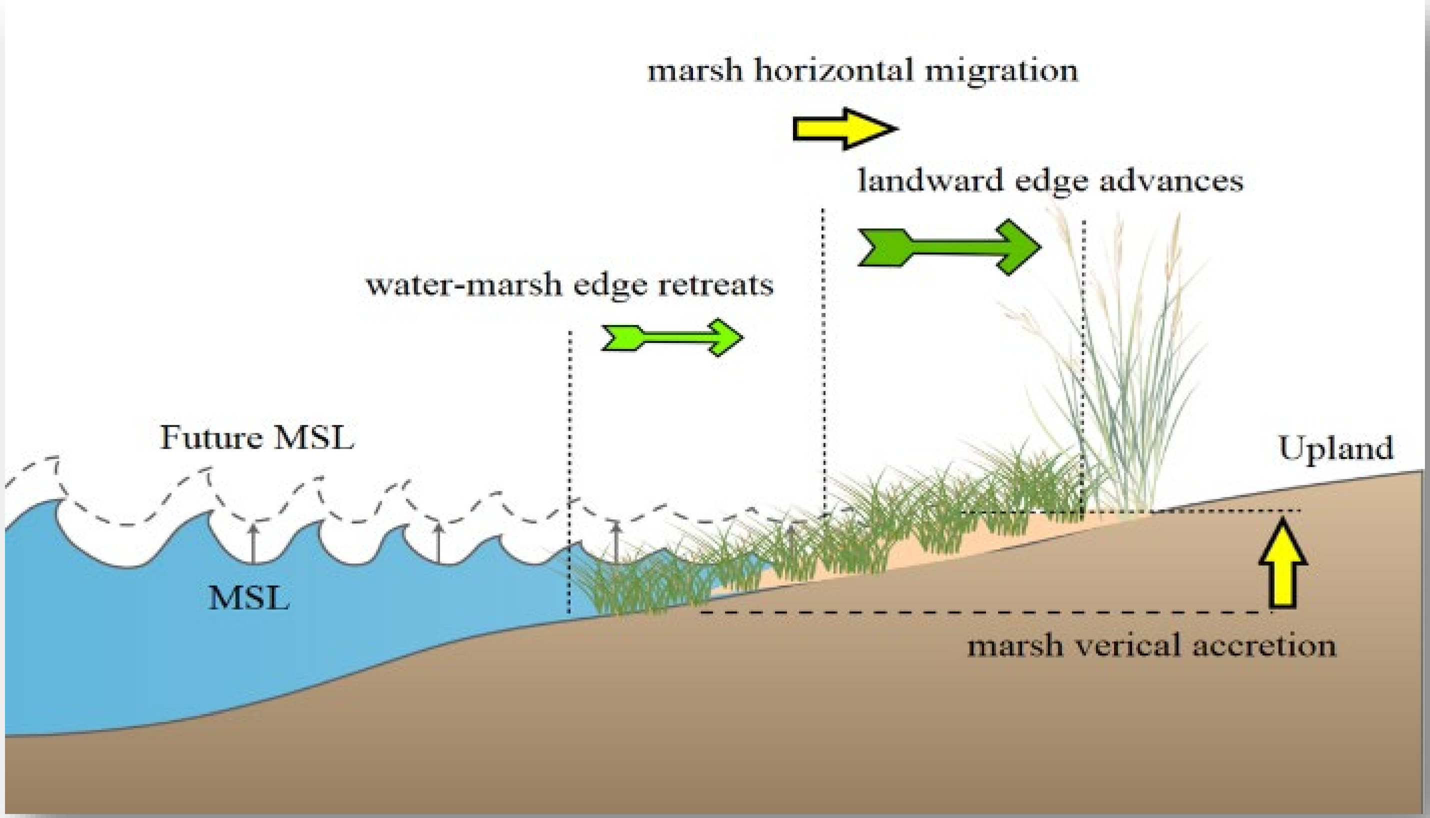
Wetlands Emerging Science

Chesapeake Bay Commission
November 14, 2025

- Marsh Migration
- Living Shoreline Economic Benefits
- Stormwater BMPs

Tidal Marshes & Sea Level Rise (SLR)



(Nunez et al., 2020)

To keep pace with SLR:

- **Marshes accrete vertically** (organic accumulation & inorganic sediment deposition)
- **Marshes migrate horizontally**

A critical factor controlling marsh sustainability is the rate of vertical development compared to the rate of relative sea-level rise

What Drives Marsh Migration

Rising Sea Levels

Existing marshes face inundation as water levels increase.

Topography and Elevation Gradient of Adjacent Uplands

Gentle, low-lying uplands allow marshes to shift inland, while steep or high terrain limits movement.

Presence or Absence of Barriers (Natural or Human-Made)

Natural features and human development can block marsh migration, causing habitat loss through coastal squeeze.

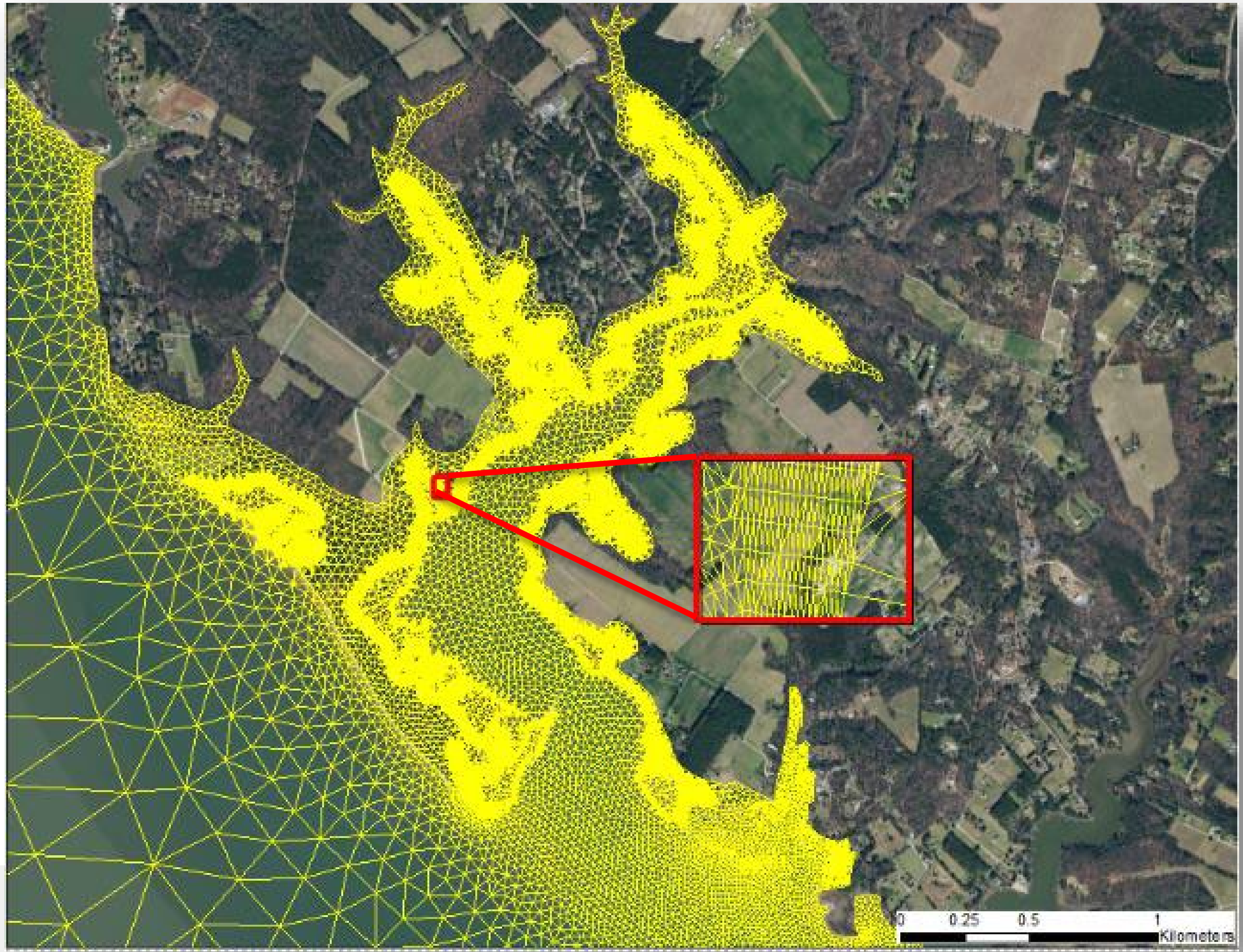
Why Marsh Migration Matters

- Marshes buffer coasts, store carbon, and support biodiversity
- Sea-level rise outpacing marsh vertical growth
- Marshes must migrate upland — or drown
- Migration pathways critical for wetland survival
- Management relies on data + models
- Strategic mapping and modeling enable effective adaptation

VIMS -Tidal Marsh Model

TIDAL MARSH MODEL (TMM)

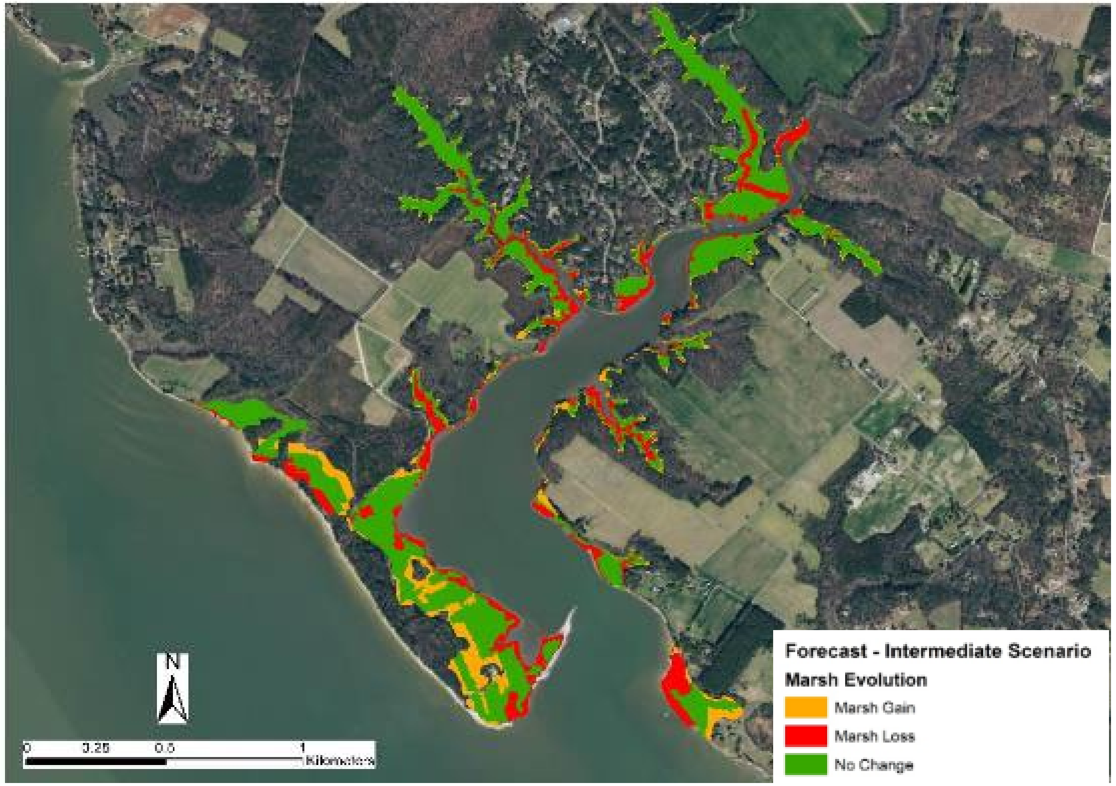
cross-scale model	dynamic rates	barriers to marsh migration
Process at one temporal (e.g. day, year) or spatial (e.g. creek, ocean) scale can interact with processes at another scale.	varying rates in space and time	Shoreline erosion control structures (e.g. bulkhead)



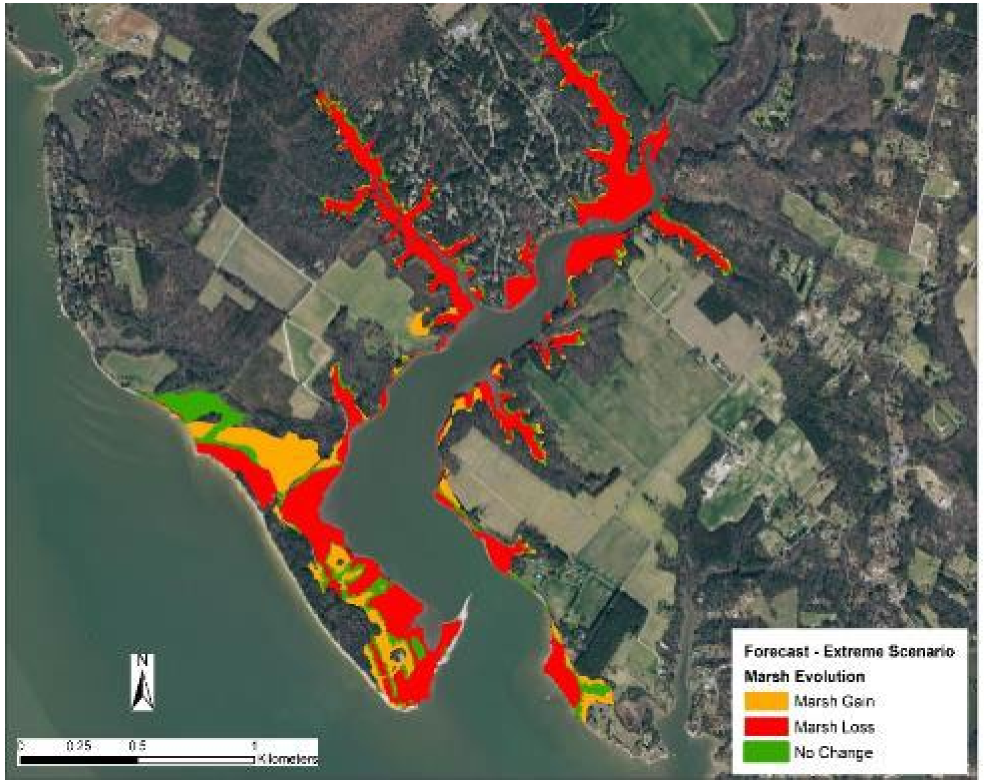
https://www.vims.edu/ccrm/research/modeling/schism/tidal_marsh/

(Nunez et al., 2021)

VIMS -Tidal Marsh Model

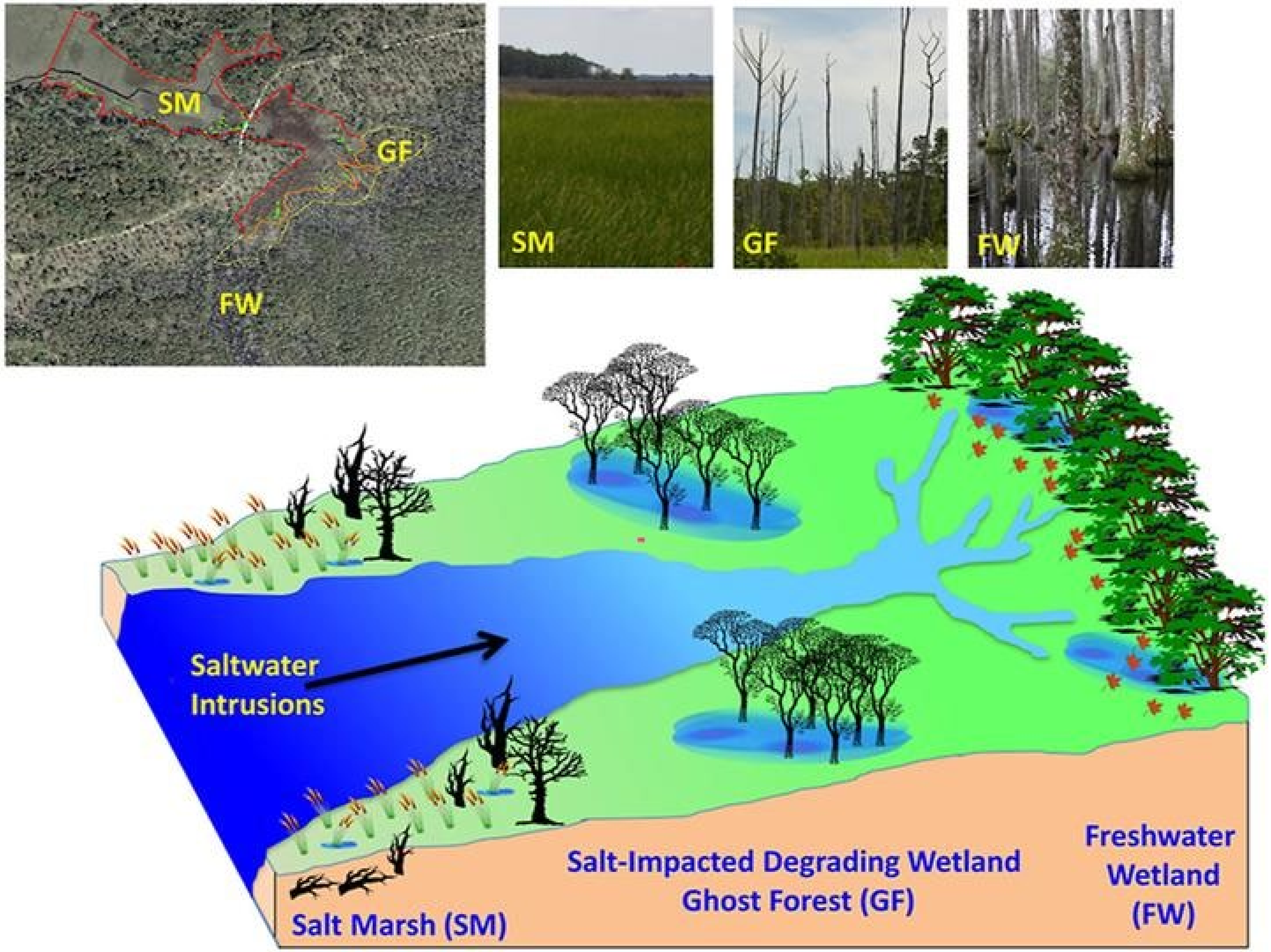


Forecast Period:
50 years (2020-2070)



Increase in sea level by the end of the simulation:
- Intermediate Scenario: **622 mm** (2.04 ft**)**
- Extreme Scenario: **1,243 mm** (4.08 ft)

(Nunez et al., 2021)



Chen et al. 2023. Unique biogeochemical characteristics in coastal ghost forests – The transition from freshwater forested wetland to salt marsh under the influences of sea level rise. Soil & Environmental Health.

Summary

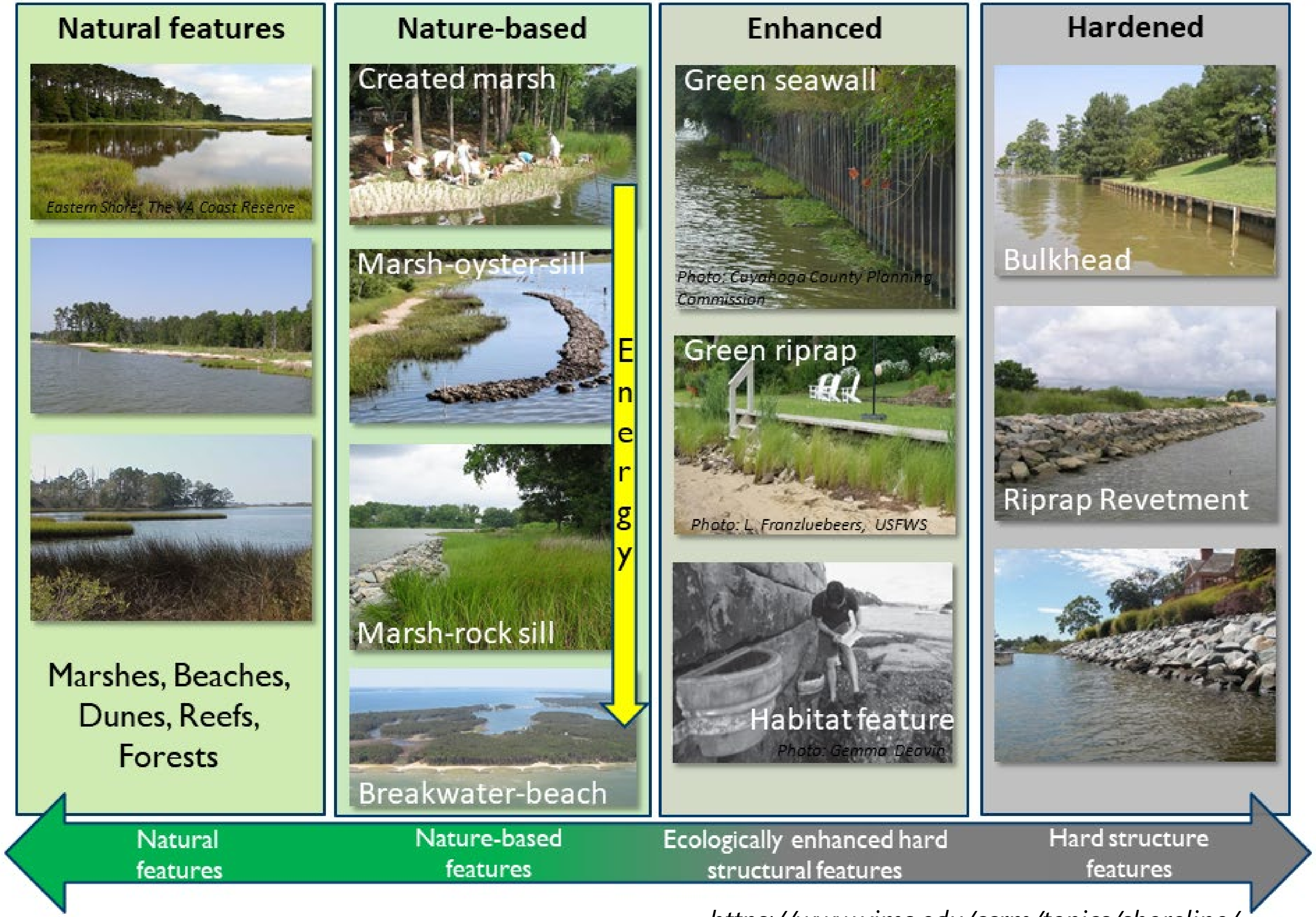
What we know	What we are unsure about
Marshes are migrating in response to SLR	The persistence of the current marsh and how that contributes to total future marsh
Marshes will expand in some areas and contract in others	Which marshes will expand; dependent on land use and decision making
Accelerating SLR means that future changes will occur more rapidly than past changes	The timeline on which these changes will occur

Marsh migration – largest potential for marsh gain – how to facilitate in a manner that 1) allows for the **continued benefits provided by marshes**, 2) recognizes **landowner needs**, and 3) addresses **local government priorities** (i.e. tax base)?

Photo: VA Institute of Marine Science

Living Shorelines

CONTINUUM OF SHORELINE PROTECTION APPROACHES



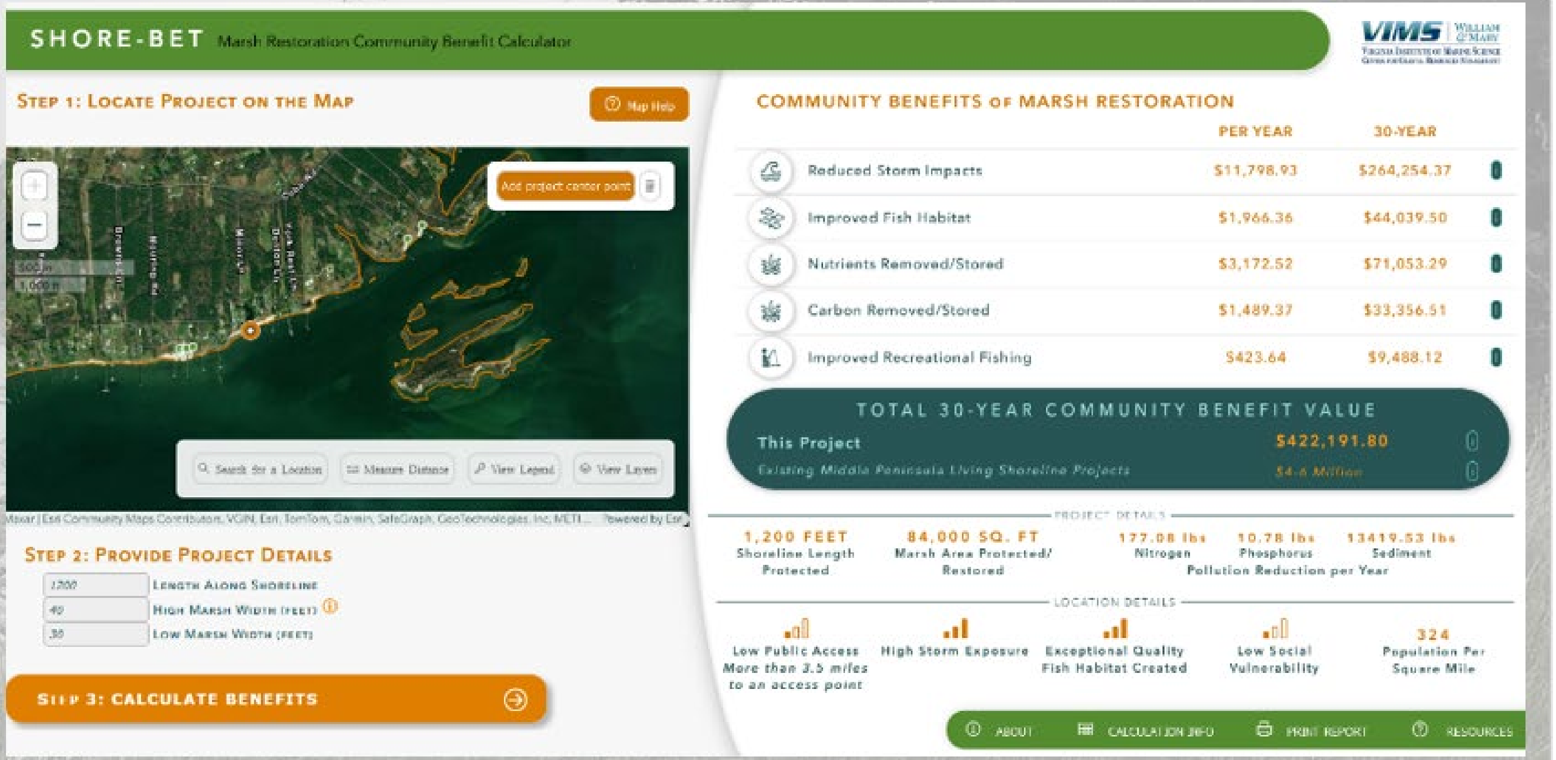
https://www.vims.edu/ccrm/topics/shoreline/

Valuing the Community Benefits of Living Shorelines – Shore-Bet

Total Benefits

~$20,000 USD/ha/yr

Marshes and living shorelines generate **~$90M** per year in benefits for the Middle Peninsula, VA



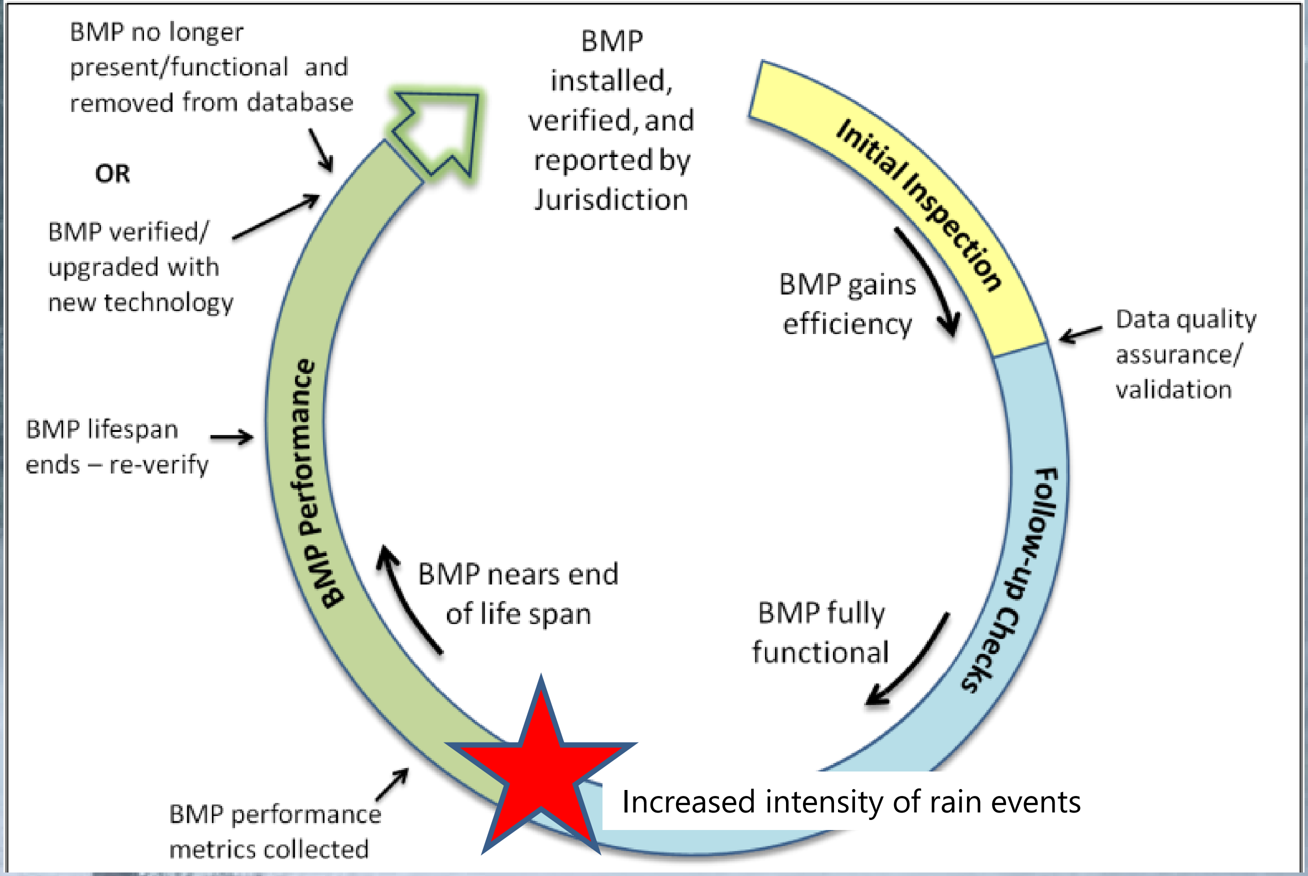
Living shorelines generate **more than 3X** the value for anglers than armored shores

Scheld et al. 2024. *Valuing shoreline habitats for recreational fishing. Ocean & Coastal Management*

Bilkovic et al. 2025. *Valuing present and future benefits provided by coastal wetlands and living shorelines. Nature-Based Solutions.*

Living Shoreline economic benefit, water quality bmp– how to facilitate for local communities? (landowner incentives?)

Stormwater BMP lifecycle / design life
Issue of increased frequency of intense rain events (legacy BMPs)



Chesapeake Bay Program. 2014. Strengthening Verification of Best Management Practices Implemented in the Chesapeake Bay Watershed: A Basinwide Framework.

Historic rainfall events

CISA Carolinas Integrated Sciences and Assessments A NOAA RISA TEAM | MARISA a NOAA Mid-Atlantic RISA team | GLISA A NOAA RISA TEAM

Climate and Hazard Mitigation Planning (CHaMP) Tool

Selection Panel

Themes: Extreme Rainfall/Flooding

Hazards: Days w/ Pcpn >1in

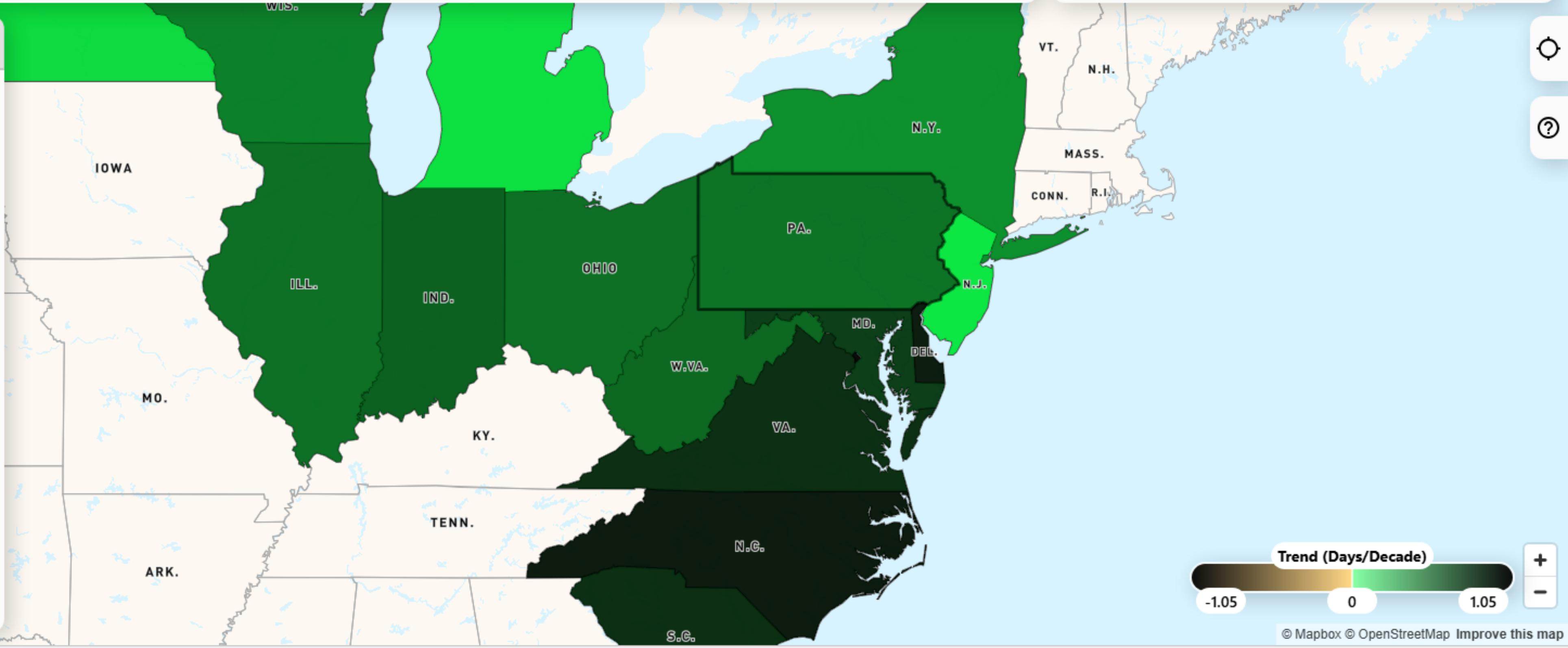
Time Range: 1981 – 2024

REGIONAL OVERVIEW | STATE DETAILS

Overview

The Mid-Atlantic region has experienced increases in extreme rainfall events[1] since at least 2006, exacerbating stormwater challenges throughout the region. The Mid-Atlantic sits within the larger Northeast region, which has experienced the largest increases in the intensity and frequency of extreme precipitation[2] of anywhere in the United States. Research examining downscaled global climate model (GCM) output has also shown that these trends are anticipated to continue[3] through the middle to late 21st century. As a result, urban and coastal flooding could be magnified and more frequent in the future[4] in the absence of adaptation.

SHOW HISTORICAL DATA | SHOW PROJECTED DATA



This tool was co-produced by the Urban Sustainability Directors Network and the Carolina, Great Lakes and Mid-Atlantic Regional Integrated Sciences and Assessments (CISA, GLISA, and MARISA) Programs. Team members from MARISA are also affiliated with the National Oceanic and Atmospheric Administration (NOAA) Northeast Regional Climate Center (NRCC).

This effort was funded by the NOAA Climate Program Office (CPO).

Version 1.0 of the CHaMP tool is currently active. Version 2.0 will be released as the project team continues to improve and enhance the tool's functionality. Any comments or

Northeast Regional Climate Center

USDN urban sustainability directors network

Climate Adaptation Partnerships

VIMS | William & Mary

Virginia Institute of Marine Science

Historic rainfall events

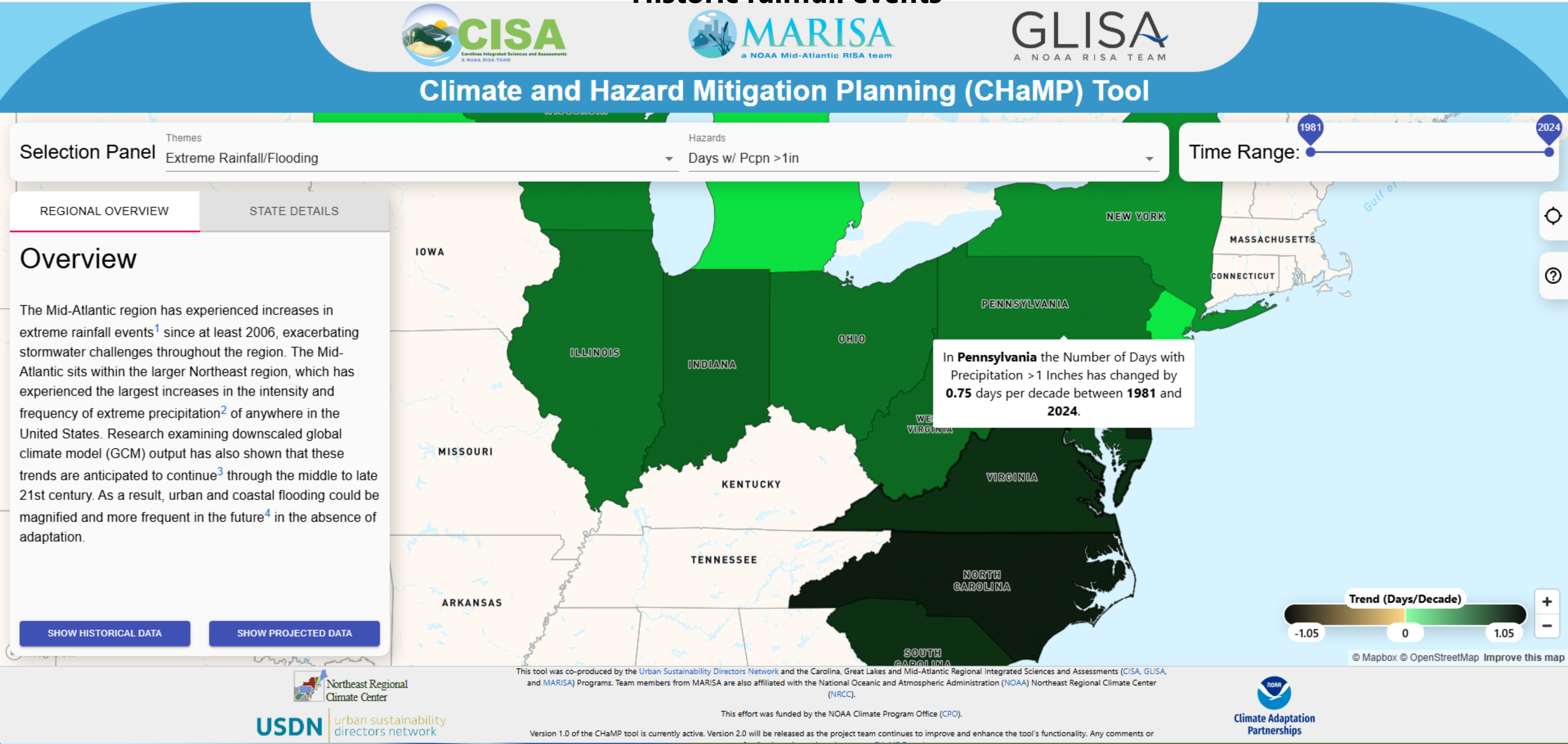


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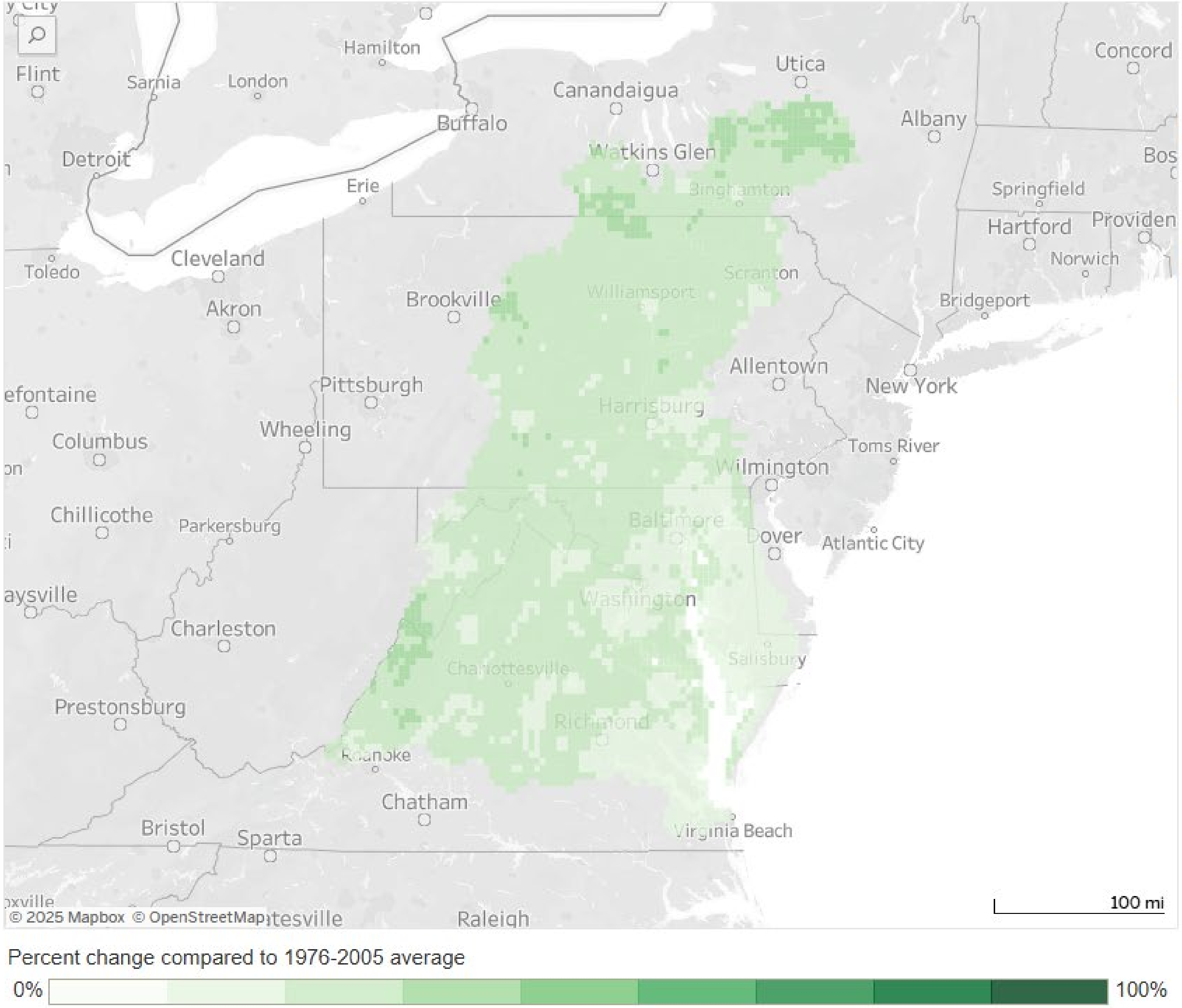
Figure 3b. Projected change in the average annual number of days with precipitation above 1" (2036-2065: Moderate Emissions (RCP 4.5))



Time Period
2036-2065

Future Emissions Scenario
- (•) Moderate Emissions (RCP 4.5)
- ( ) High Emissions (RCP 8.5)

Daily precipitation threshold
- (•) 1"
- ( ) 2"
- ( ) 3"

Filter on Geography
Entire Watershed

Geography
Chesapeake Bay Watershed

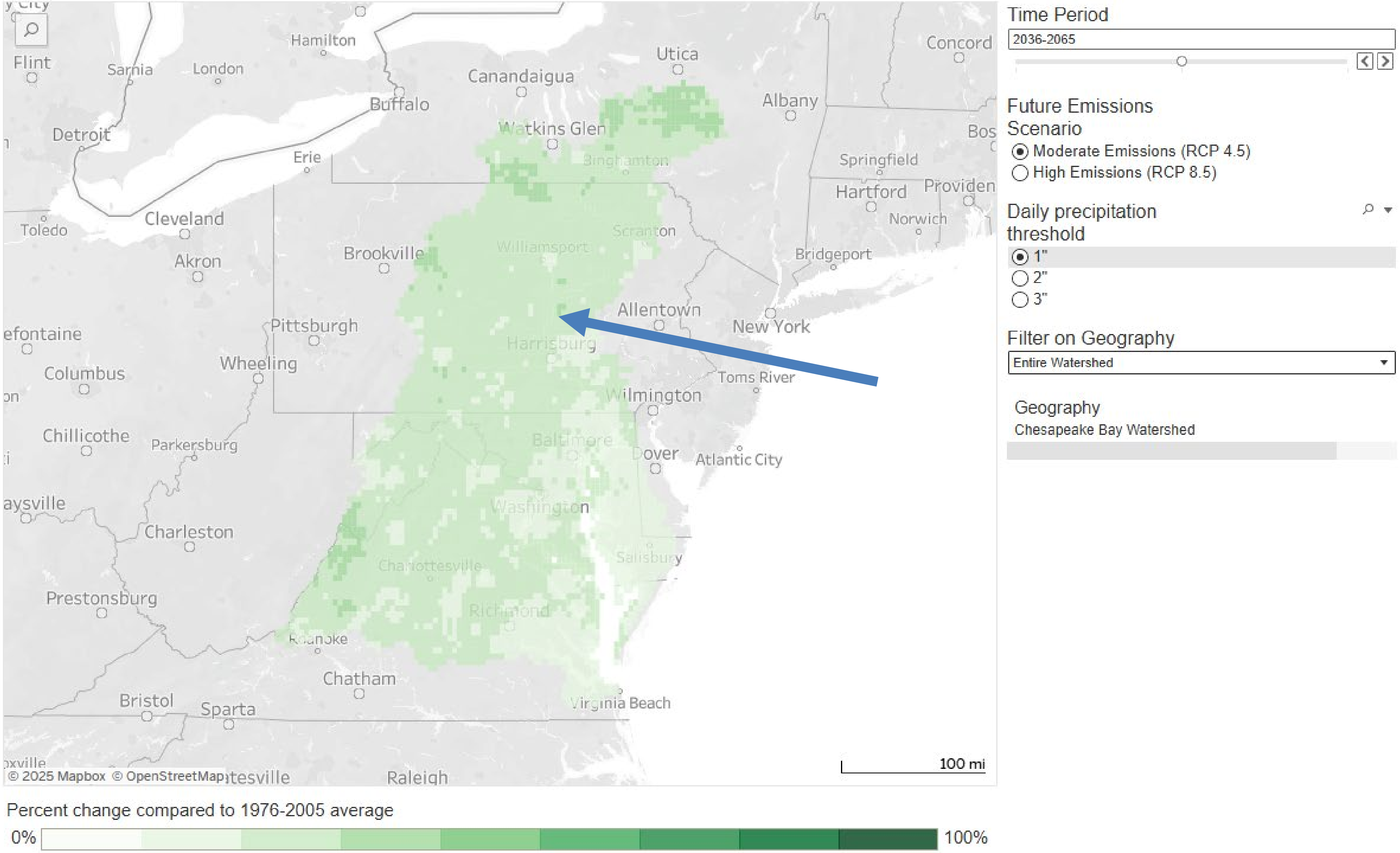
Projected rainfall events

1″ rain event

MARISA
a NOAA Mid-Atlantic CAP team

Changes in Future Extreme Precipitation

Figure 3b. Projected change in the average annual number of days with precipitation above 1" (2036-2065: Moderate Emissions (RCP 4.5))



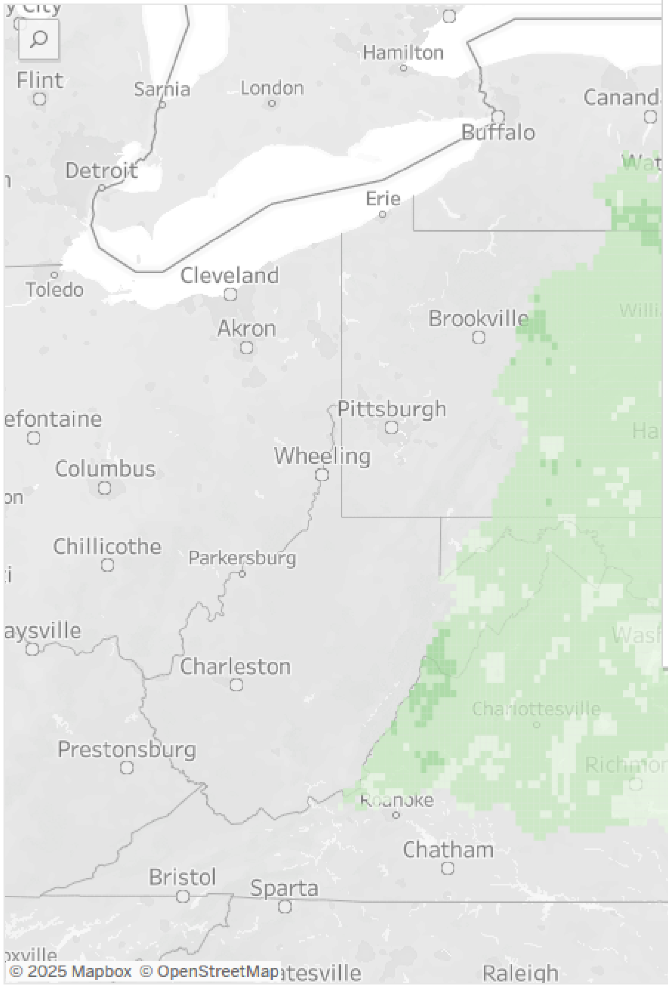
Projected rainfall events

1″ rain event

Projected rainfall events

1″ rain event

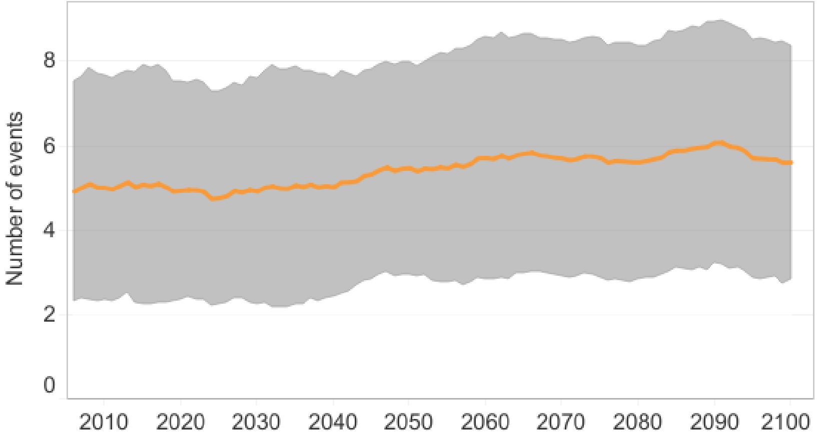
Figure 3b. Projected change in the average annual number of
Emissions (RCP 4.5))



Location: Unincorporated Northumberland, Pennsylvania

In 2036-2065, the projected average number of days per year with rainfall greater than 1" is **5.4, 34%** more than in 1976-2005.

Number of extreme precipitation events per year



Ten-year moving average of the annual number of one-day precipitation events equal to or greater than the percentile value estimated from the recent historical climate (1976-2005). Results show weighted ensemble mean of days above threshold from all LOCA-downscaled GCM runs. Gray shading indicates 1 standard deviation away from the mean based on the weighted ensemble.

Percent change compared to 1976-2005 average

0% 100%

Projected rainfall events

Figure 3b. Projected change in the average annual number of days with precipitation above 1" (2036-2065: Moderate Emissions (RCP 4.5))

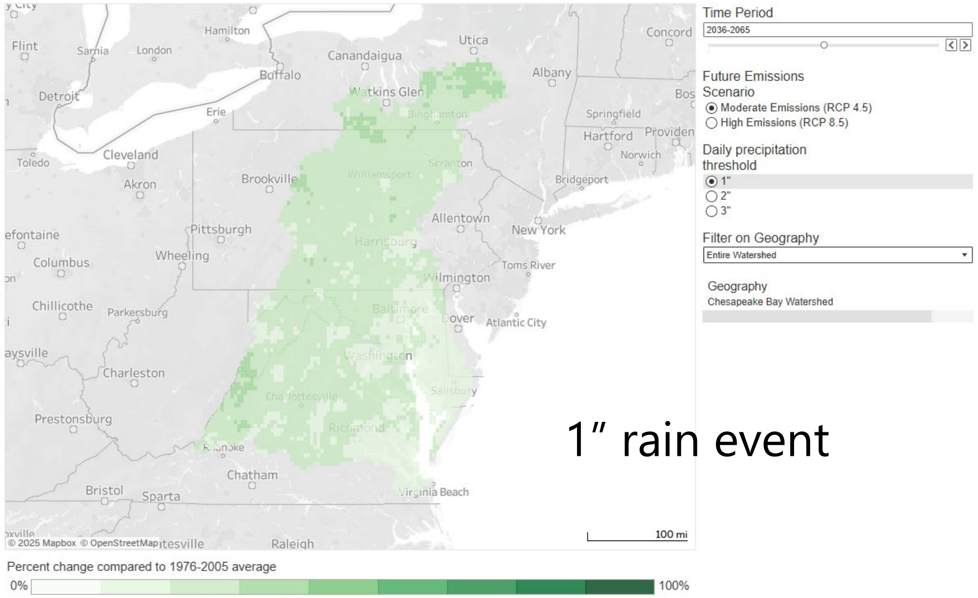


Figure 3b. Projected change in the average annual number of days with precipitation above 2" (2036-2065: Moderate Emissions (RCP 4.5))

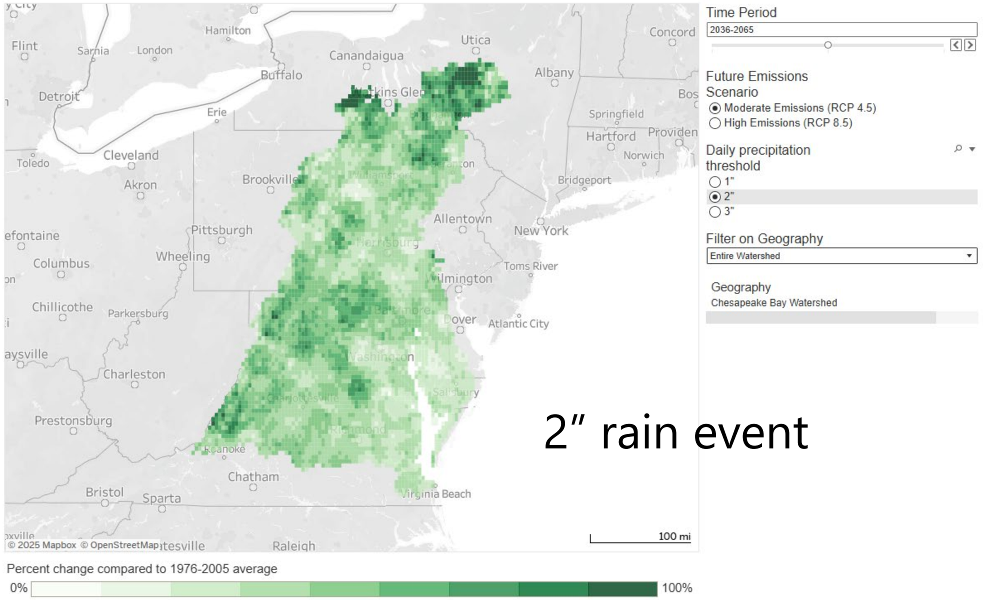
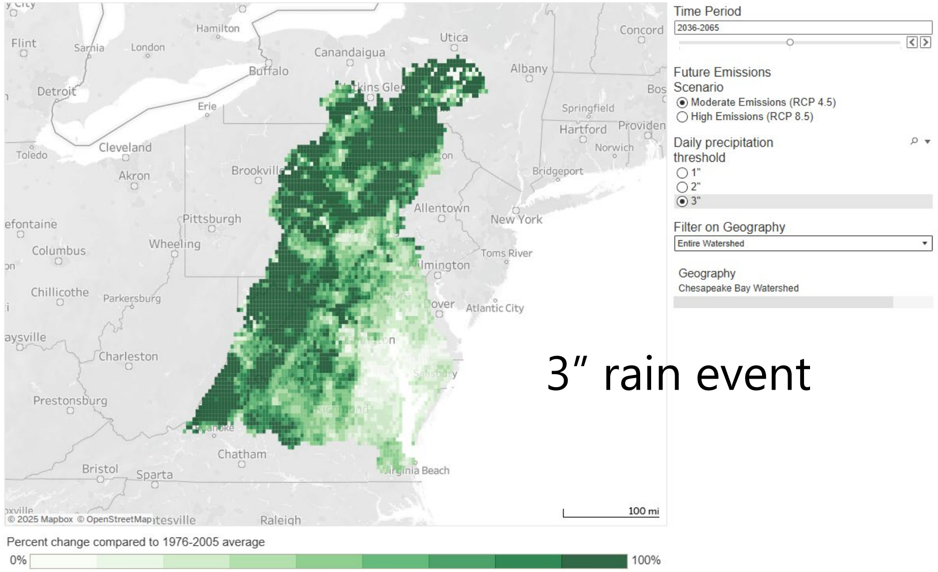


Figure 3b. Projected change in the average annual number of days with precipitation above 3" (2036-2065: Moderate Emissions (RCP 4.5))



More frequent and intense downpours can overwhelm design capacity. How to facilitate adjustments to stormwater infrastructure as precipitation events intensify?

CT Stormwater Quality Manual

Penn State Extension

Ruekert & Mielke, Inc

Questions?

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