Marsh Migration Models & GIS Tools: visualizations for informed decisions

Wetlands Workshop
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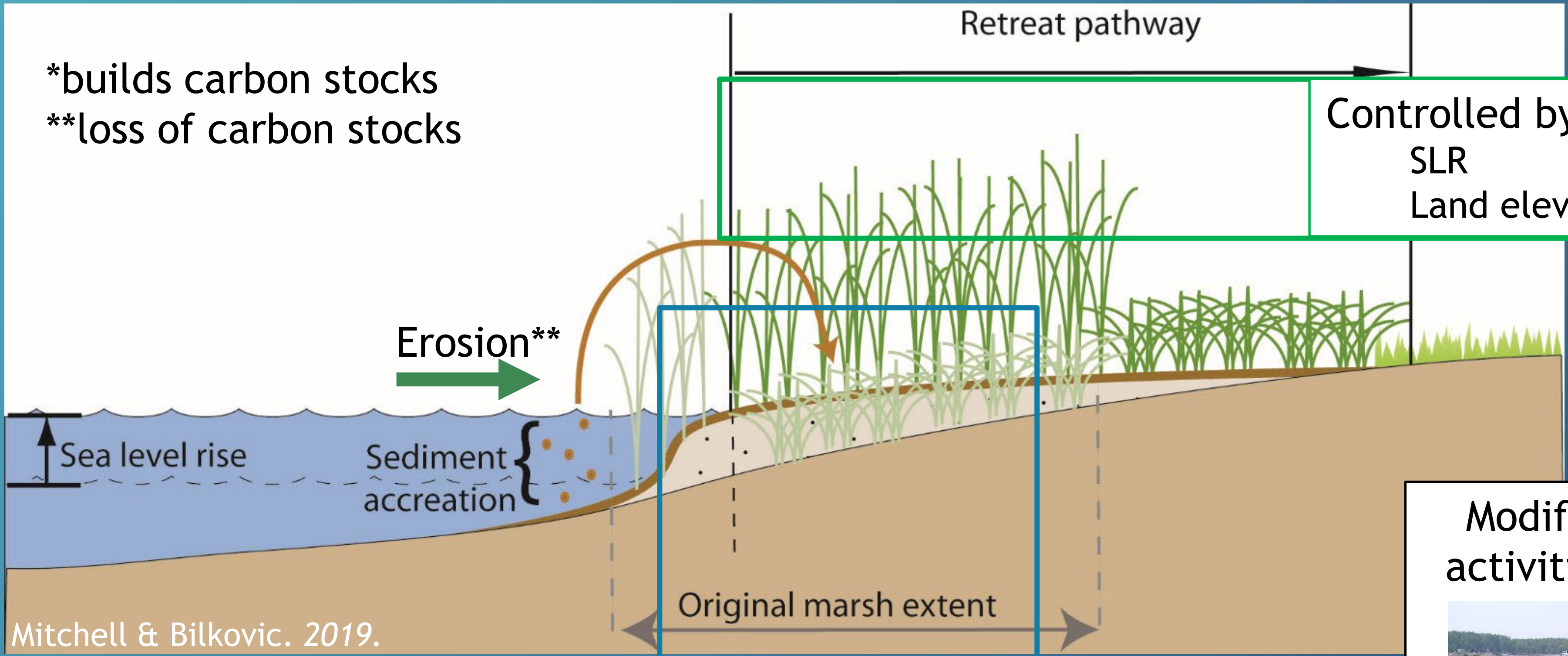
What role is wetland migration expected to play in the future of marshes and climate resilience in the Chesapeake region?

Expected to be of critical importance!

Response of marshes to sea level rise

To keep pace with sea level: a) Marshes migrate b) Marshes accrete



Controlled by:
SLR
Land elevation

Δ Water Levels

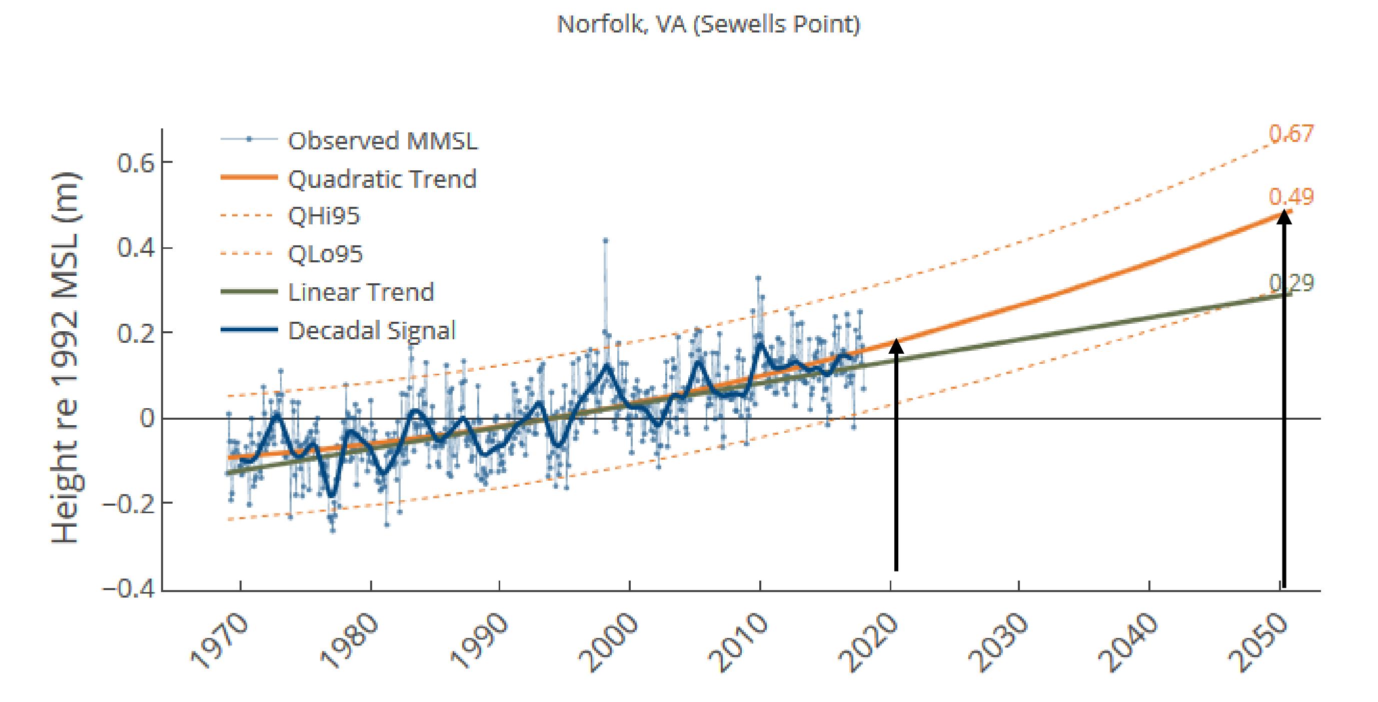
Δ CO_2
Δ Water Levels
Δ Temperature

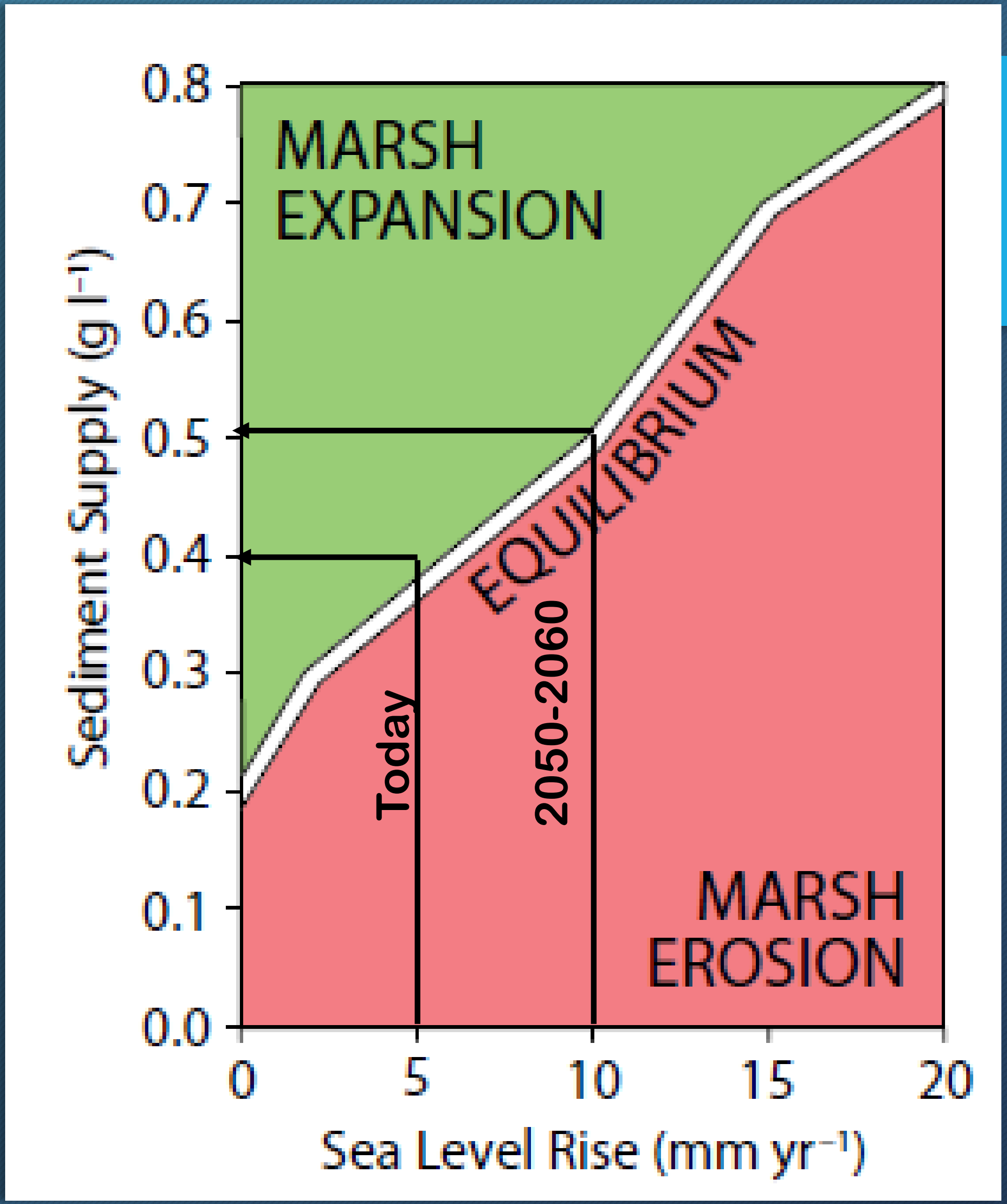
Controlled by:
Plant production*
Sediment availability*
Sediment respiration**

Modified by human activities & decisions

Marsh accretion affected by:

- Sediment supply coming from
  - Watershed
  - Adjacent lands (via runoff or tidal waters)
  - Marsh front edge erosion
- <u>Current CP management goals are to restrict sediment in waters</u>

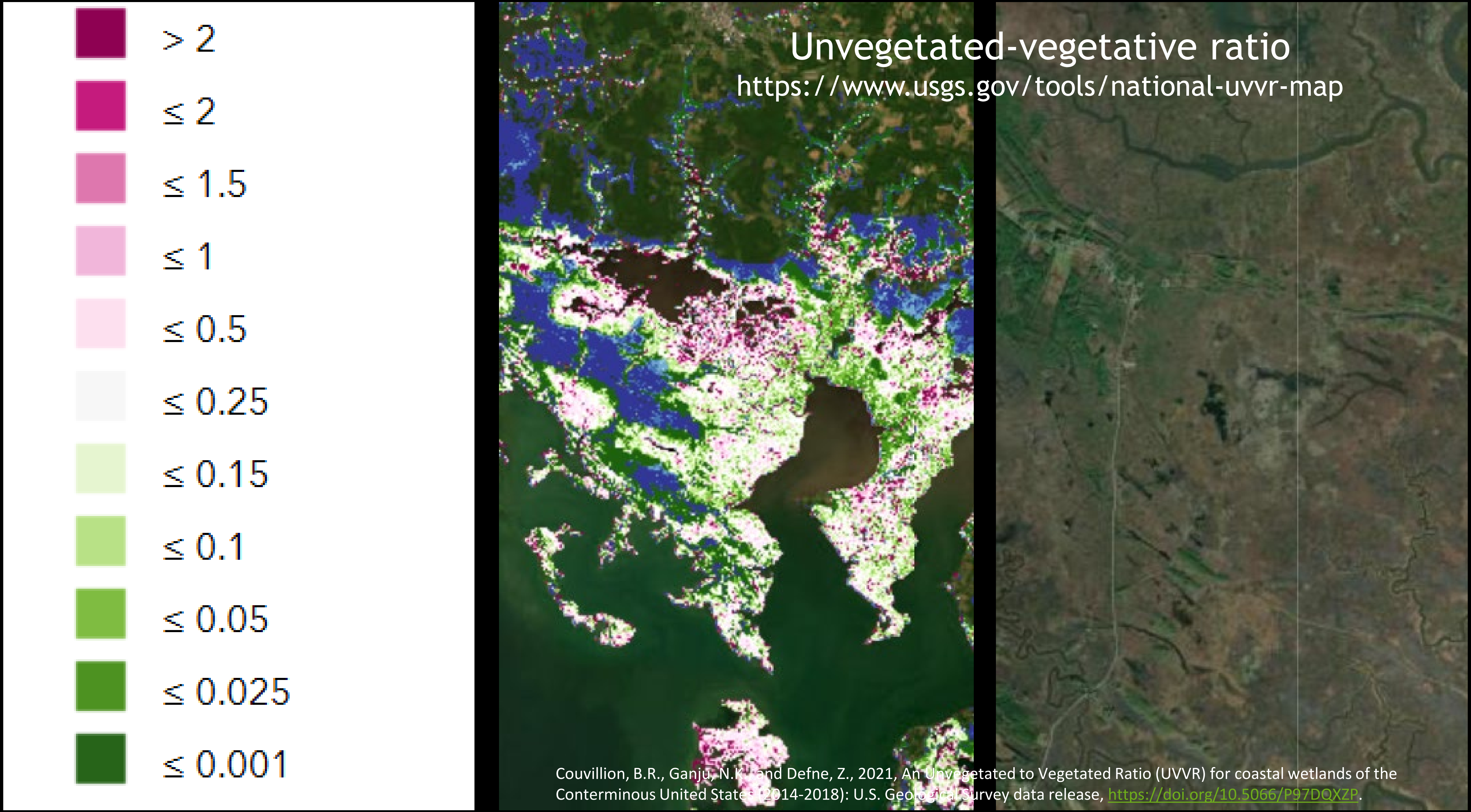




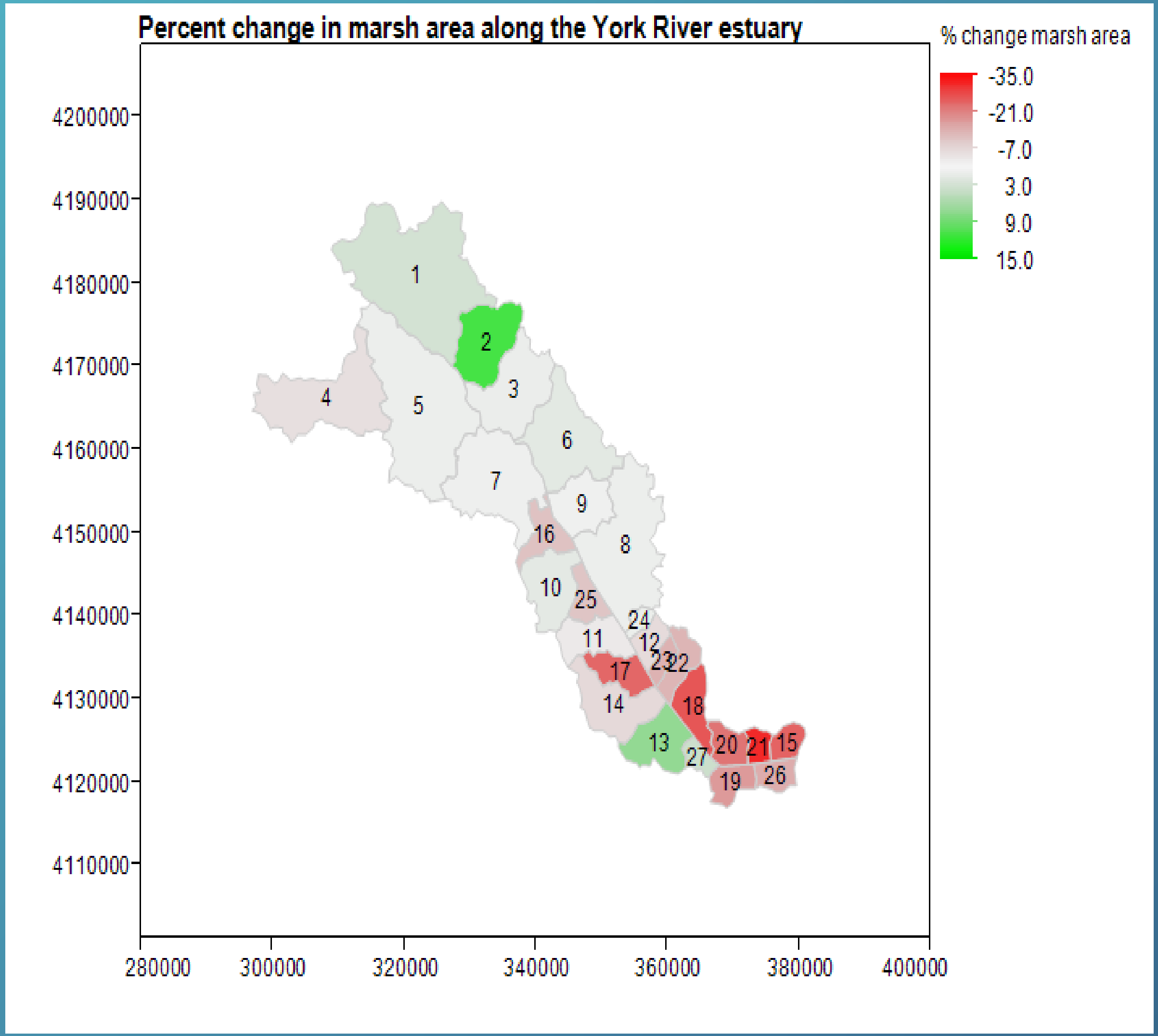
Fagherazzi et al. 2013. *Oceanography*, *26*(3): 70-77.

Unvegetated-vegetative ratio

https://www.usgs.gov/tools/national-uvvr-map



Couvillion, B.R., Ganju, N.K., and Defne, Z., 2021, An Unvegetated to Vegetated Ratio (UVVR) for coastal wetlands of the Conterminous United States (2014-2018): U.S. Geological Survey data release, https://doi.org/10.5066/P97DQXZP.



Marsh area change

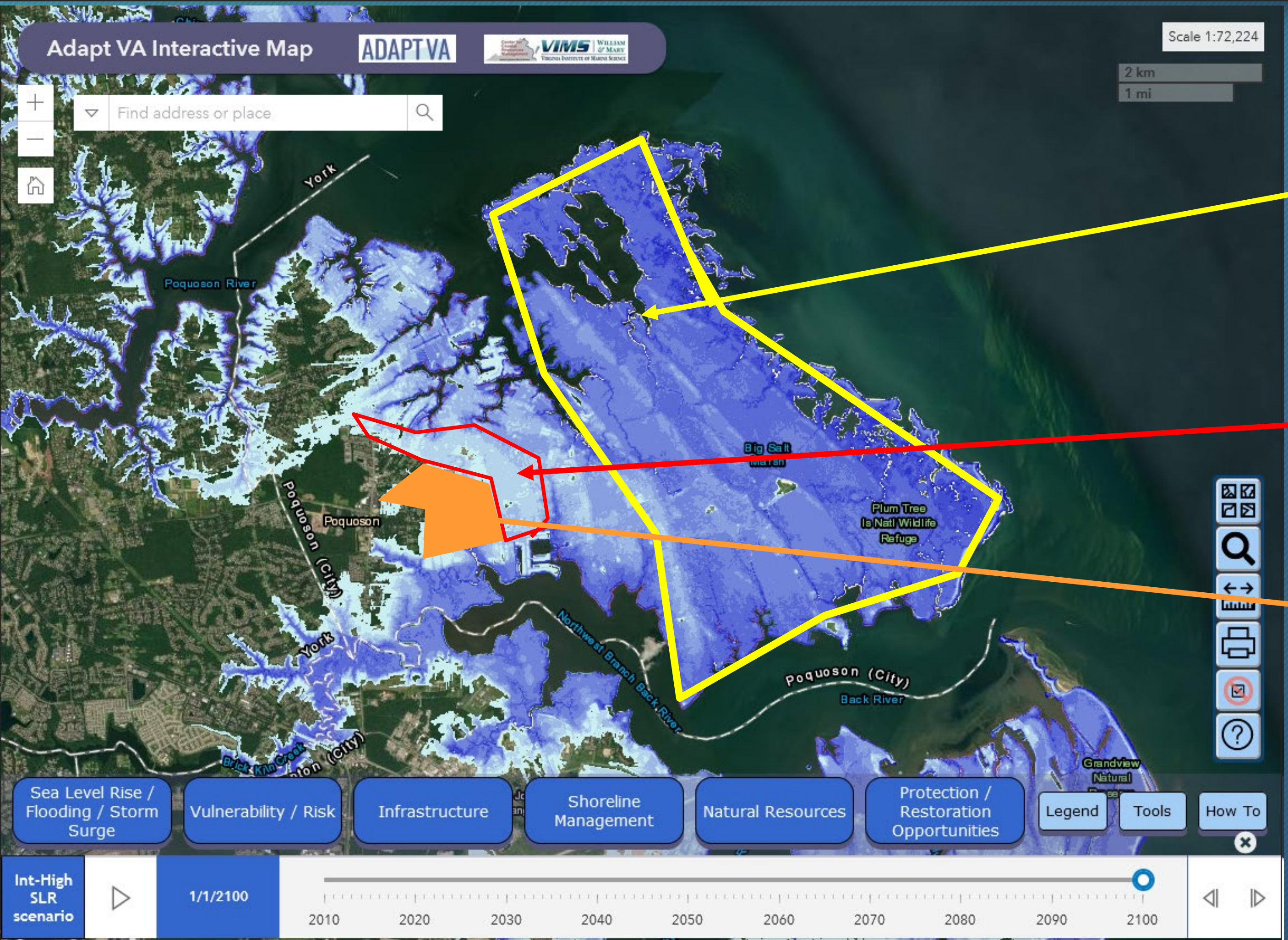
over ~30 years with ~ 15-20 cm of sea level rise

- overall change = loss of 2,187,000 m^2, or ~2.7% of marsh area
- Highest loss areas = high development, high erosion

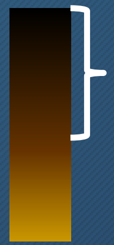
Next 30 years will have ~3x the sea level rise

Mitchell et al 2018

Impact of accelerating SLR on carbon sequestration



Current marsh
(100+ years of sequestration)



2100 marsh
(40 years of sequestration)

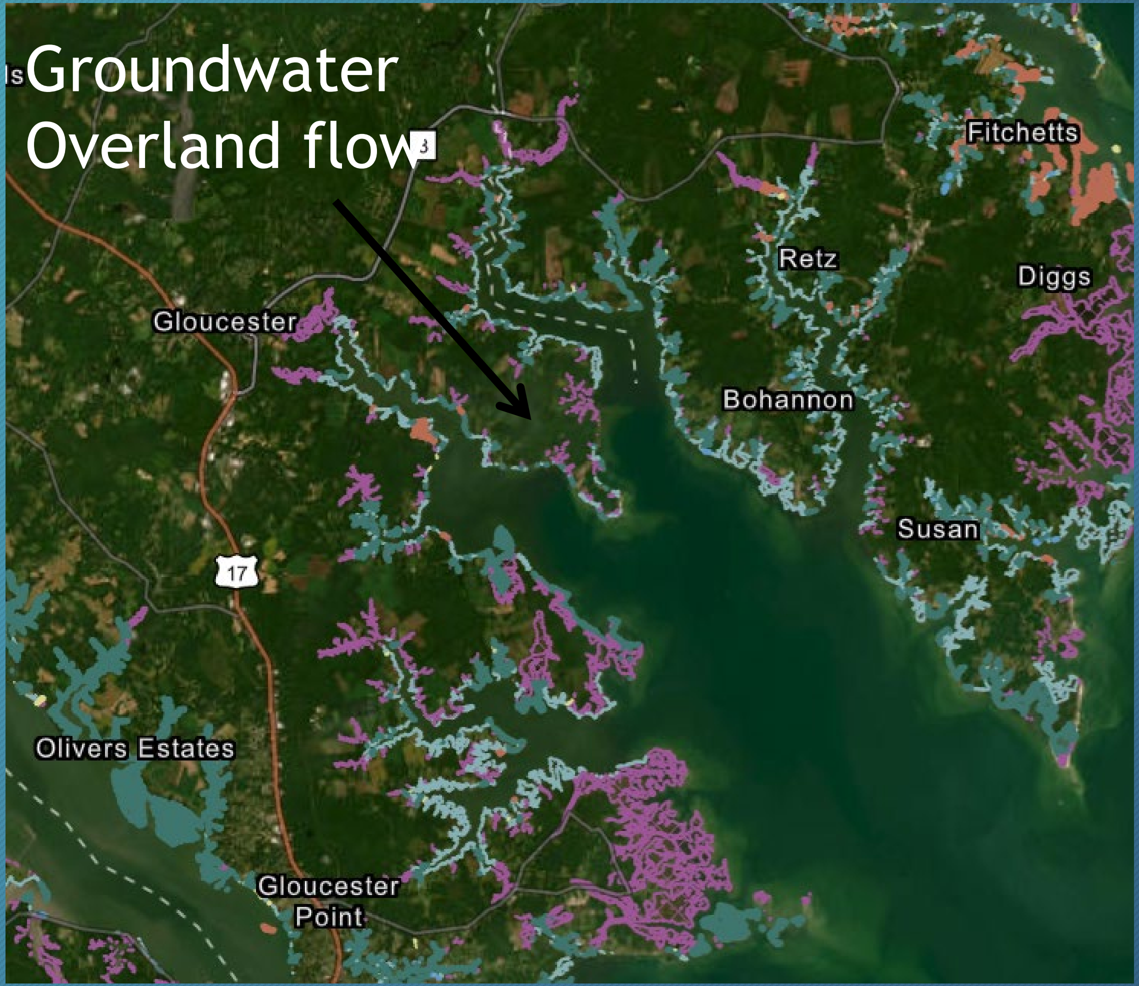
2100 marsh
(20 years of sequestration)

The impact of marsh change on habitat provision (preliminary results)

- Key survey during the early 1990's established a baseline for bird communities (including marsh obligates & facultative species); repeated in 2022-2023
- The "newness" of a marsh was a significant predictor of bird usage.
- Newly migrated marsh was associated with **lower** abundance of saltmarsh and marsh obligate species, but **higher** abundance of facultative marsh breeding species

https://ccbbirds.org/2023/06/01/ccb-and-saltmarsh-bird-surveys/

How marsh ecosystem services scale



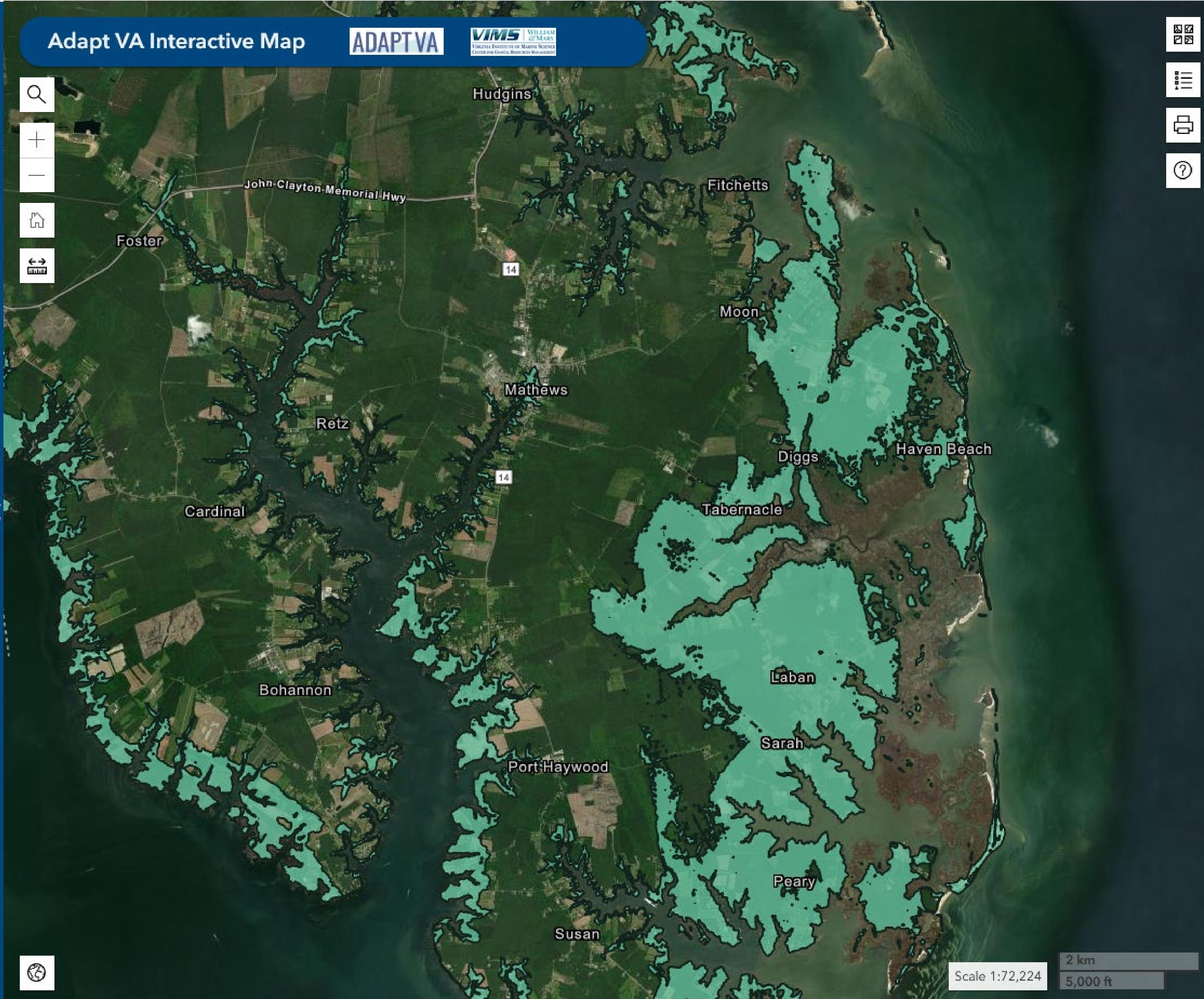
- Fish/crab usage
- mussel habitat
- erosion protection,
- flood protection

2030

2050

2070

2090

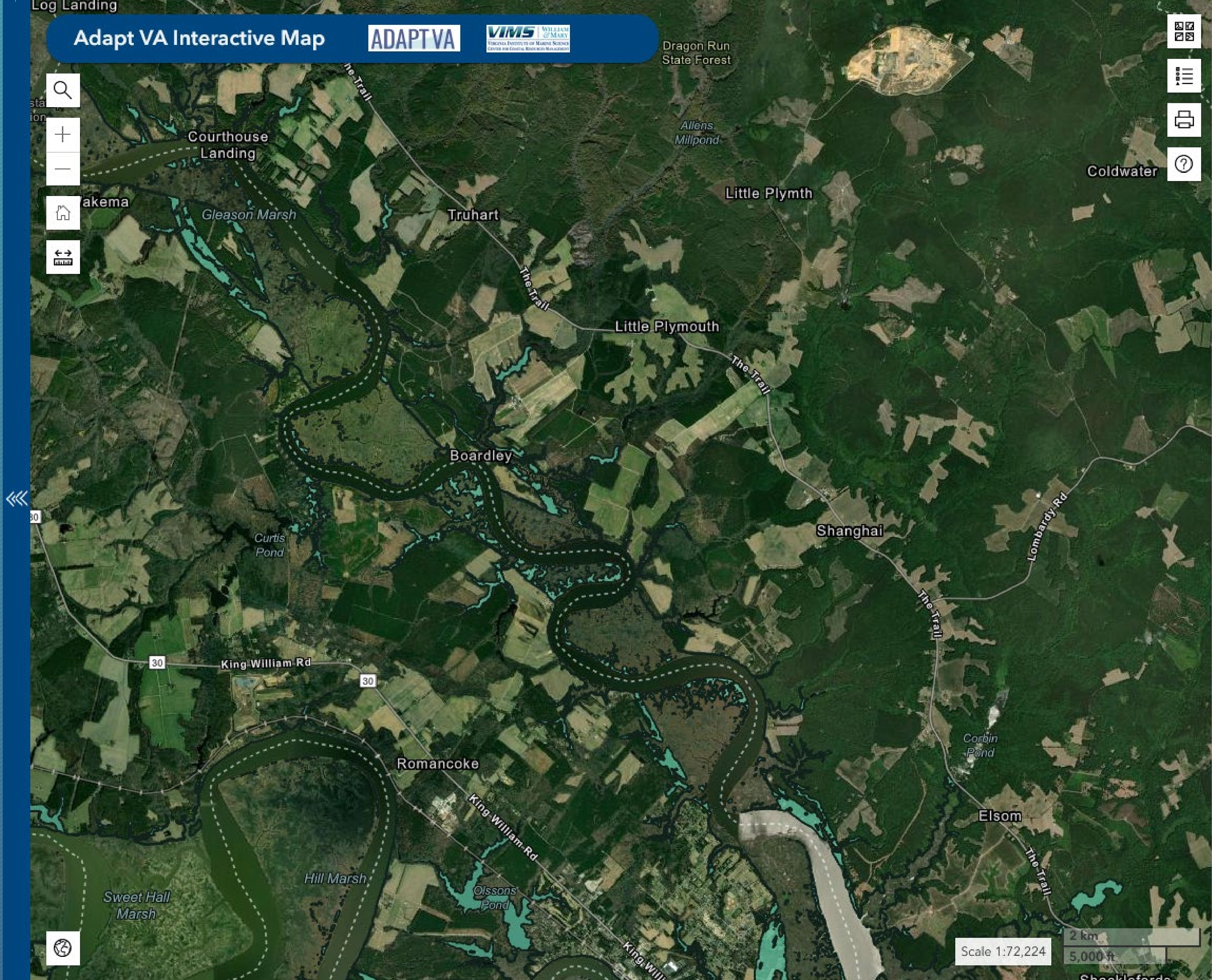


2030

2050

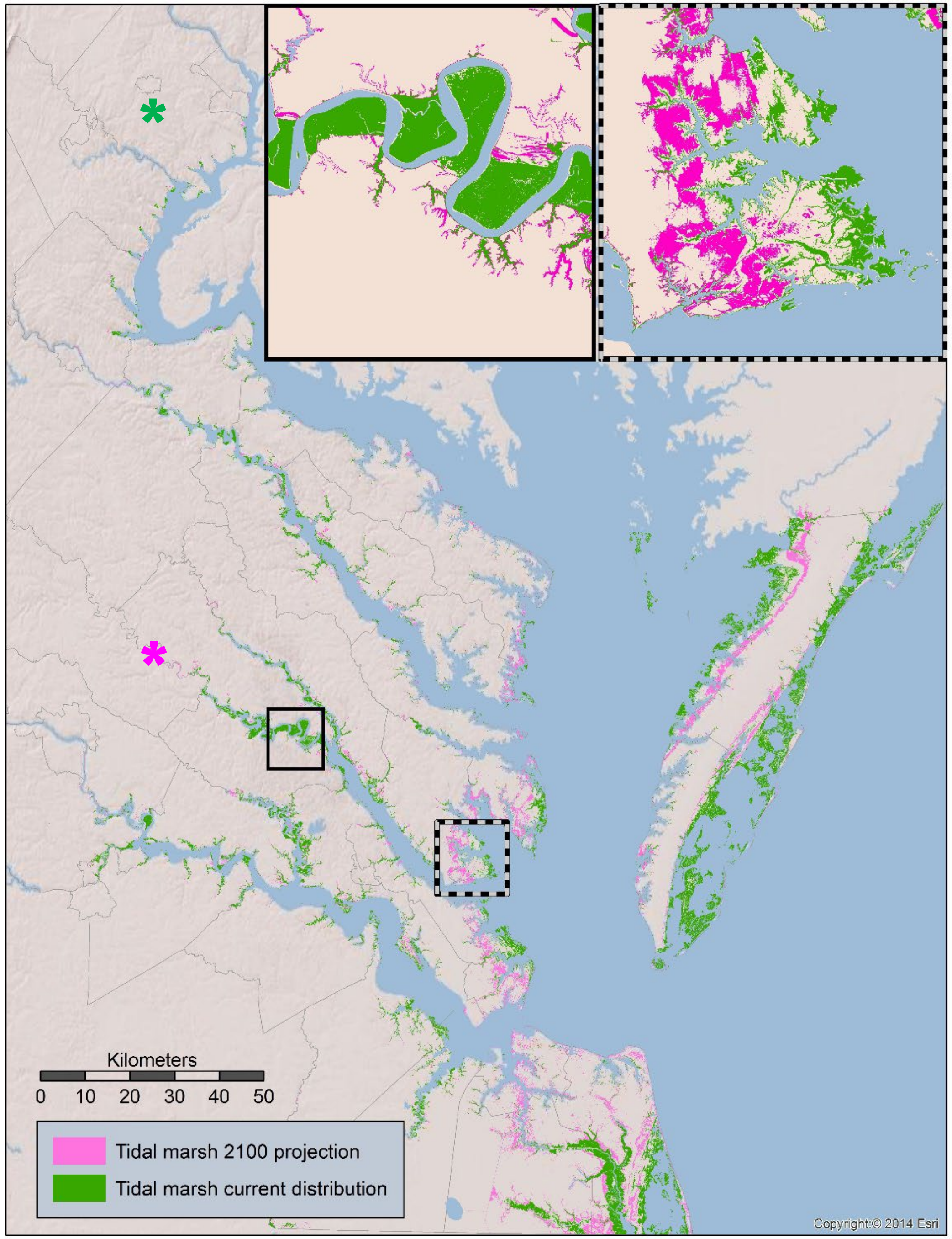
2070

2090



Scenario step number	Elevations (NAVD88)	Approximate year
1	0 m - 0.61m	2010
2	0.15 m – 0.46 m	2020
3	0.30 m – 0.91 m	2030
4	0.46 m – 1.07 m	2040
5	0.61 m – 1.22 m	2050
6	0.76 m – 1.37 m	2058
7	0.91 m – 1.52 m	2062
8	1.07 m – 1.68 m	2070
9	1.22 m – 1.83 m	2078
10	1.37 m – 1.98 m	2082
11	1.52 m – 2.13 m	2090
12	1.68 m – 2.29 m	2095
13	1.83 m – 2.44 m	2100
14	1.98 m – 2.59 m	2105
15	2.13 m – 2.74 m	2110
16	2.29 m – 2.90 m	2115
17	2.44 m – 3.05 m	2118
18	2.59 m – 3.20 m	2121
19	2.74 m – 3.35 m	2124
20	2.90 m – 3.51 m	2127
21	3.05 m – 3.66 m	2130

Years based on Boon & Mitchell 2015



Mitchell, M., Herman, J. and Hershner, C., 2020. Evolution of tidal marsh distribution under accelerating sea level rise. *Wetlands*, *40*(6), pp.1789-1800.

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

What tools and timeframes are most appropriate to identify wetland migration corridors?

Marsh models are abundant and can be used for management in the next 30-50 years

Model comparison – Data differences

MODEL	Resolution (land use)	Resolution (elevation)	Elevation source	Vertical datum	Marsh Source
SLAMM	30m x 30m	10m x 10m	CUDEM	Mean Tide Level	NWI (1988 - 1992)
InVEST	30m x 30m	3m x 3m	CUDEM	MHHW	VIMS TMI (Berman et al. 2016)
TMM	30m x 30m (C-CAP)	1m x 1m	CBTBDEM	NAVD88	VIMS TMI (2016)
NOAA	30m x 30m (C-CAP)	*	CUDEM	tidal datums	C-CAP?
ETM	1m x 1m (VGIN)	1m x 1m (lidar)	CBTBDEM	NAVD88	NWI and TMI

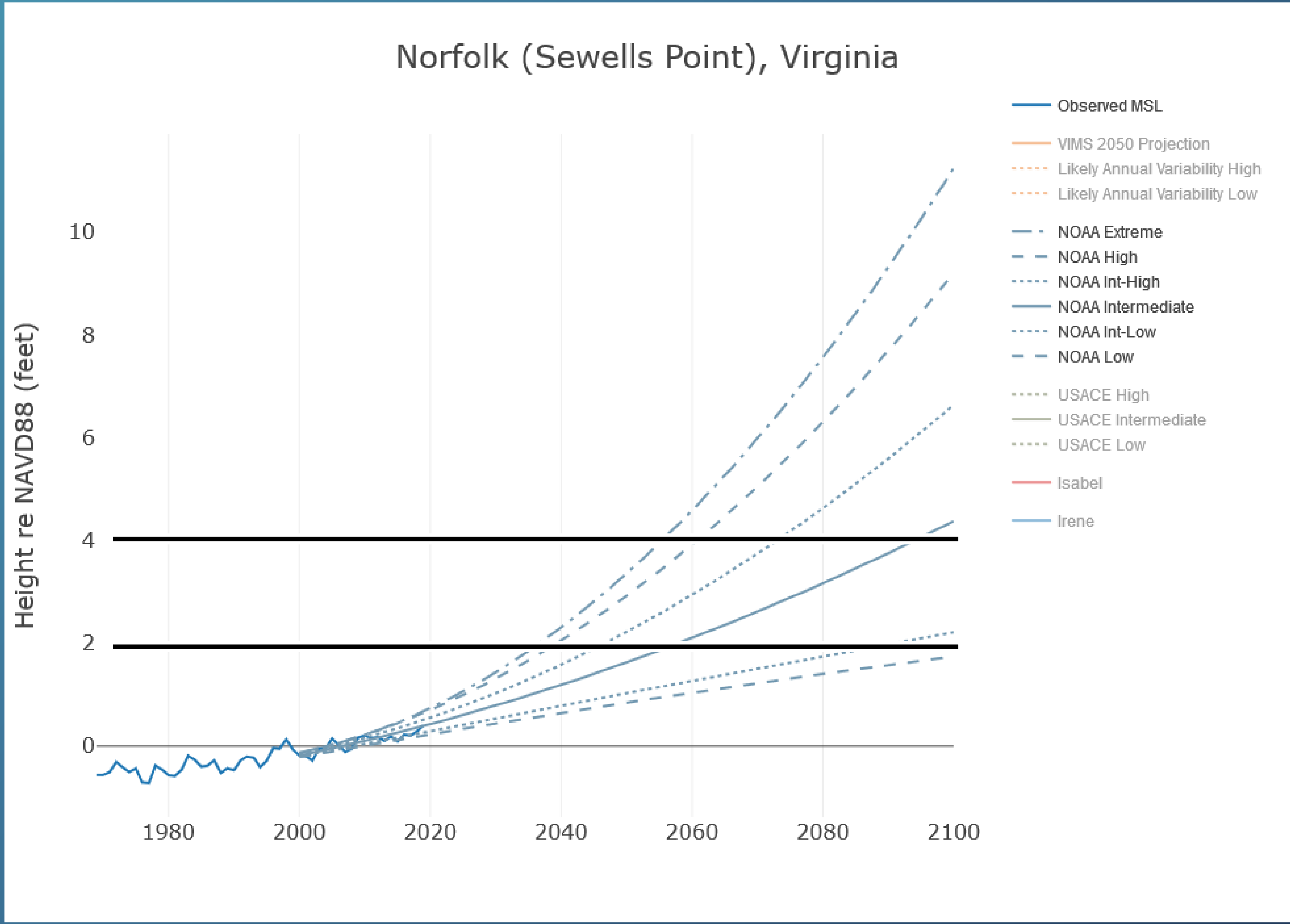
Sea-level rise (SLR) scenarios

2 water levels were selected to allow for consistent comparison across models

The selected water levels were:

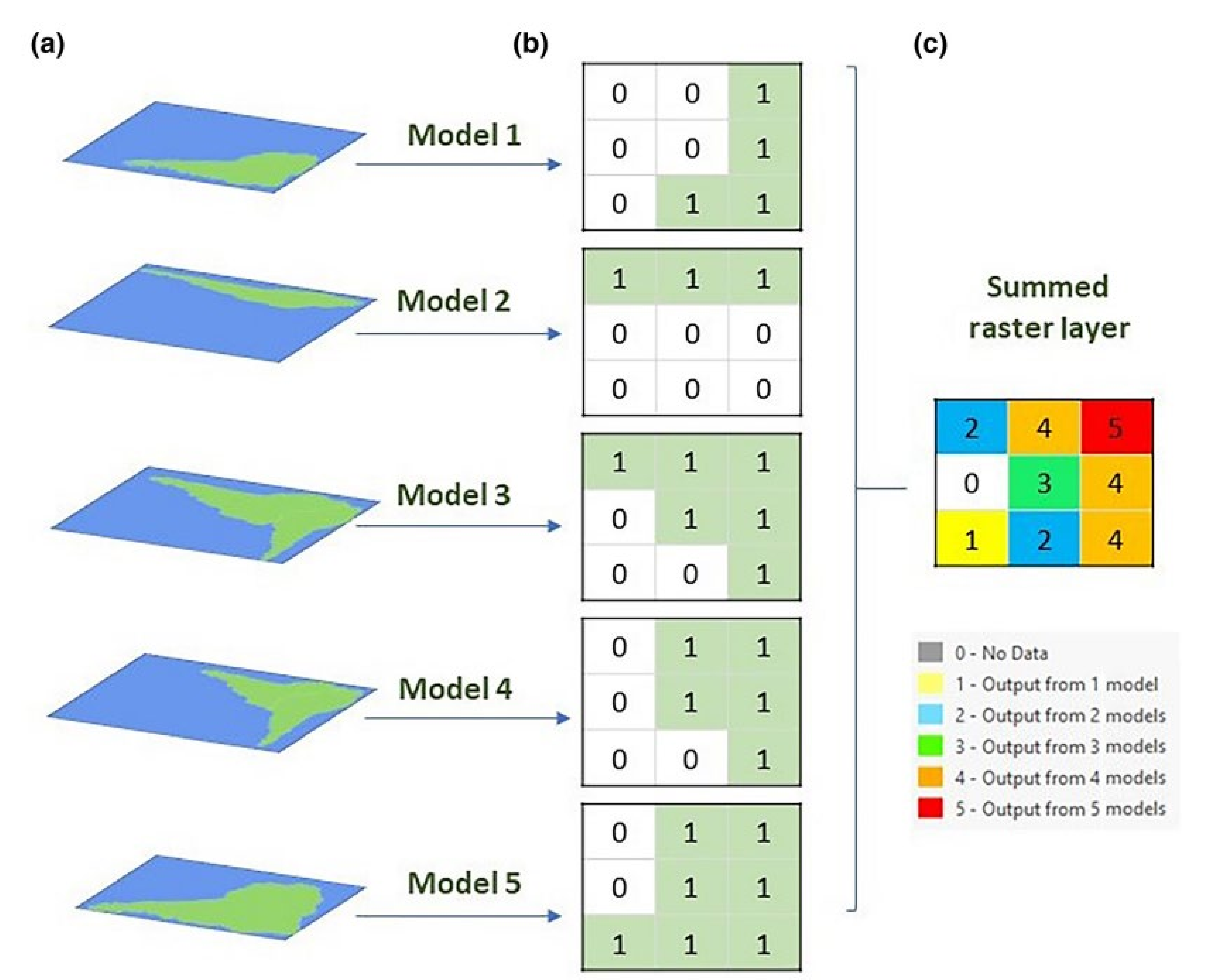
- 2 ft increase in MSL
- 4 ft increase in MSL

above the current tidal datum



Methodology

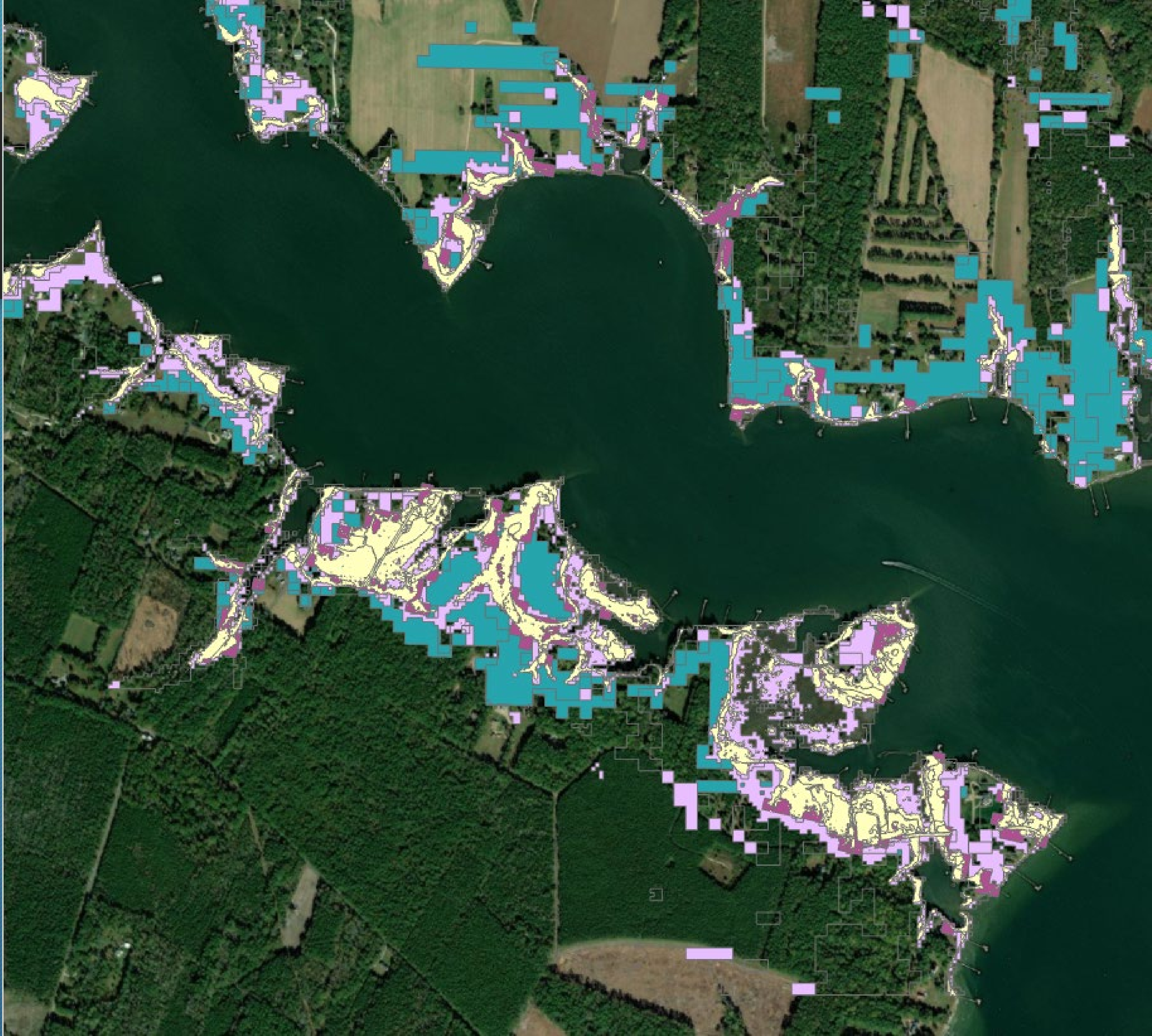
A) Migrated areas of marsh are mapped for each model individually
B) Maps are converted to rasters and each pixel is coded (presence of marsh = 1, all other land/water = 0).
C) The coded raster layers are summed to create a single layer showing the number of models that identify each pixel as marsh.



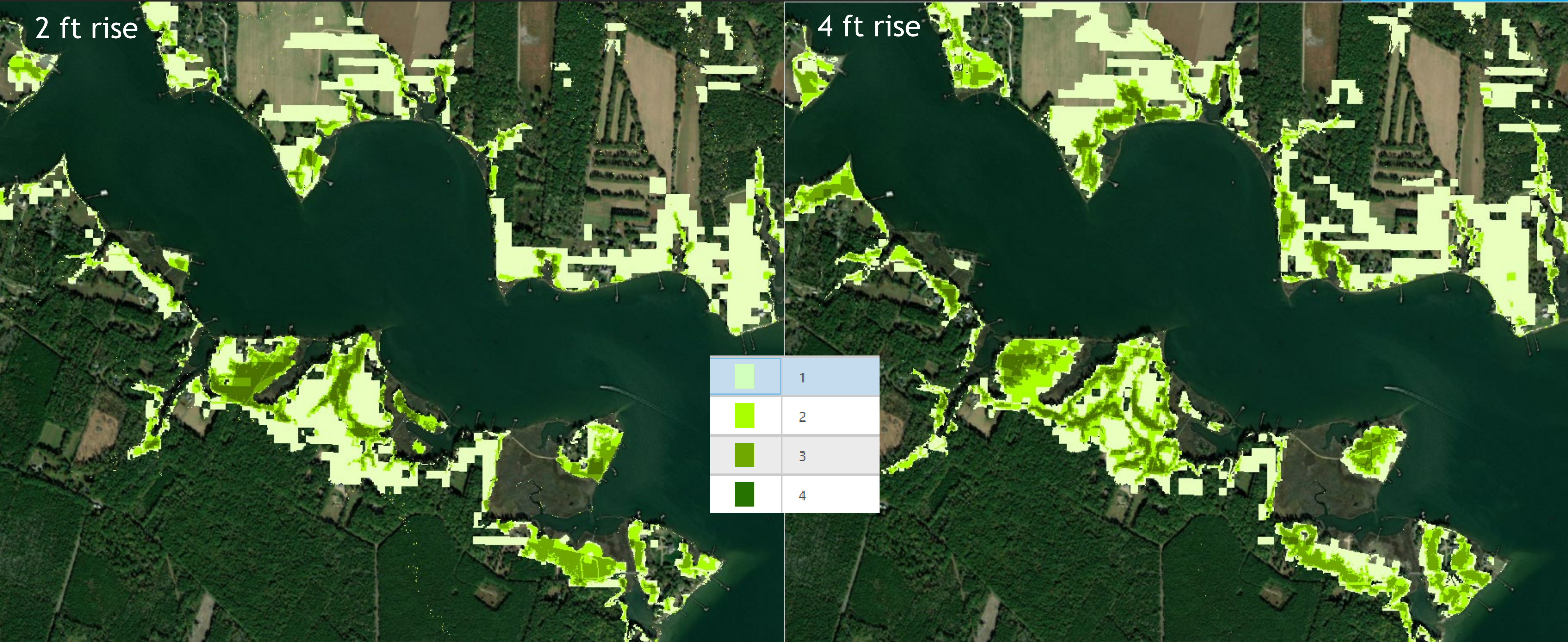
Mitchell, M., Nunez, K., Herman, J., Tombleson, C. and Mason, P., 2023. A marsh multimodel approach to inform future marsh management under accelerating sea-level rise. *Ecological Solutions and Evidence*, *4*(4), p.e12285.

Example results

- ETM
- INVEST
- NOAA
- SLAMM



Example results



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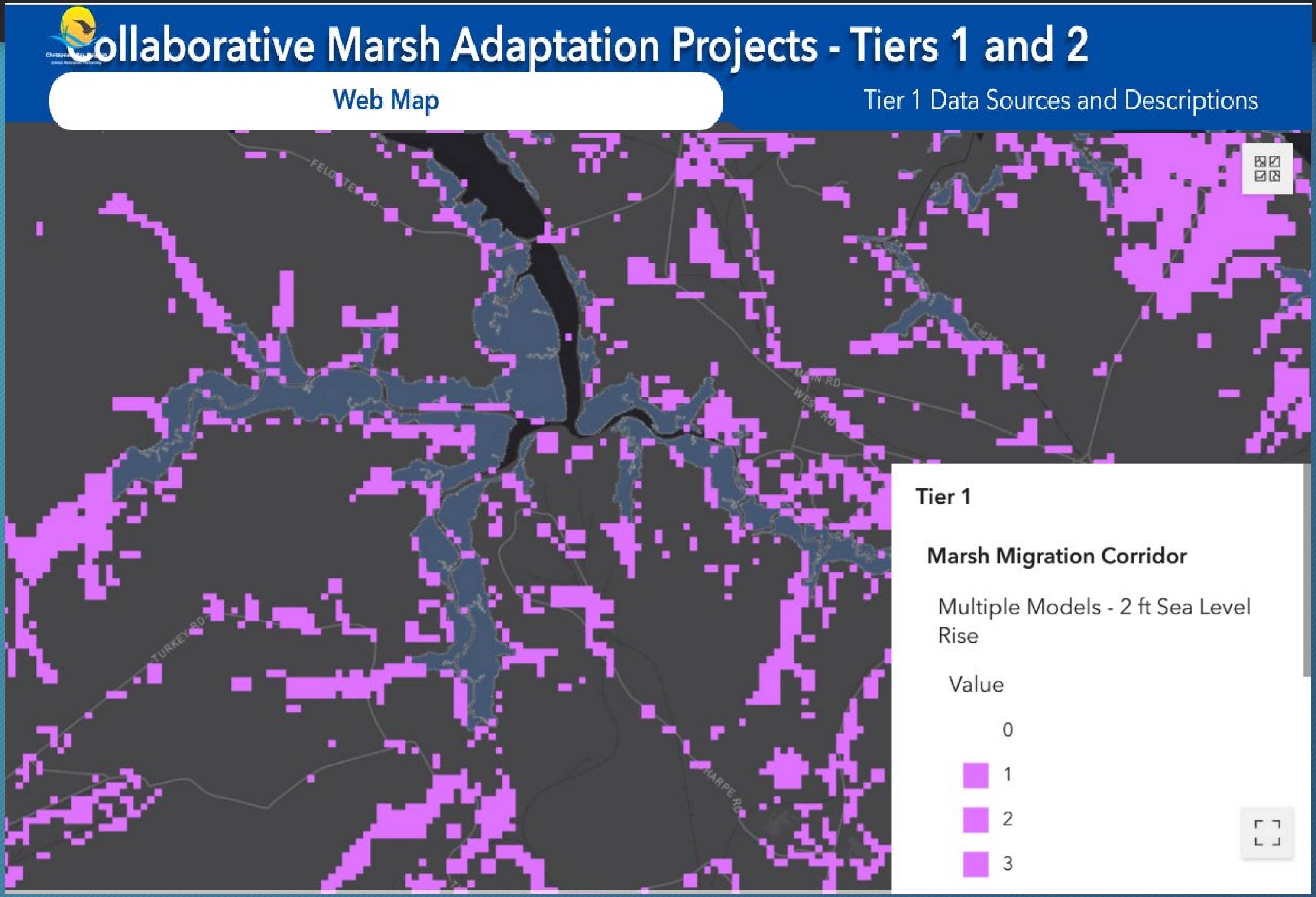
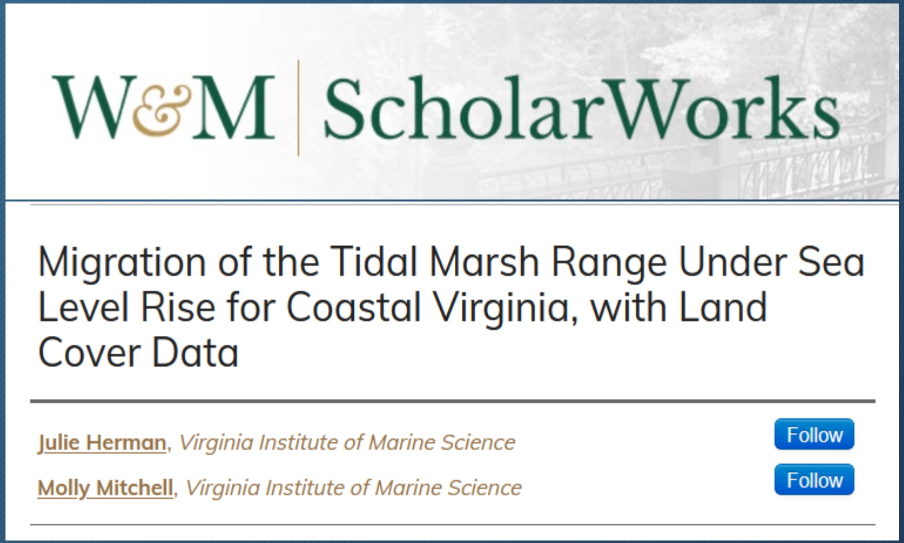
CBP --> Marsh Migration Corridor Envelope for Maryland and Virginia (large pixels)



VIMS --> Marsh Migration for Virginia (small pixels)

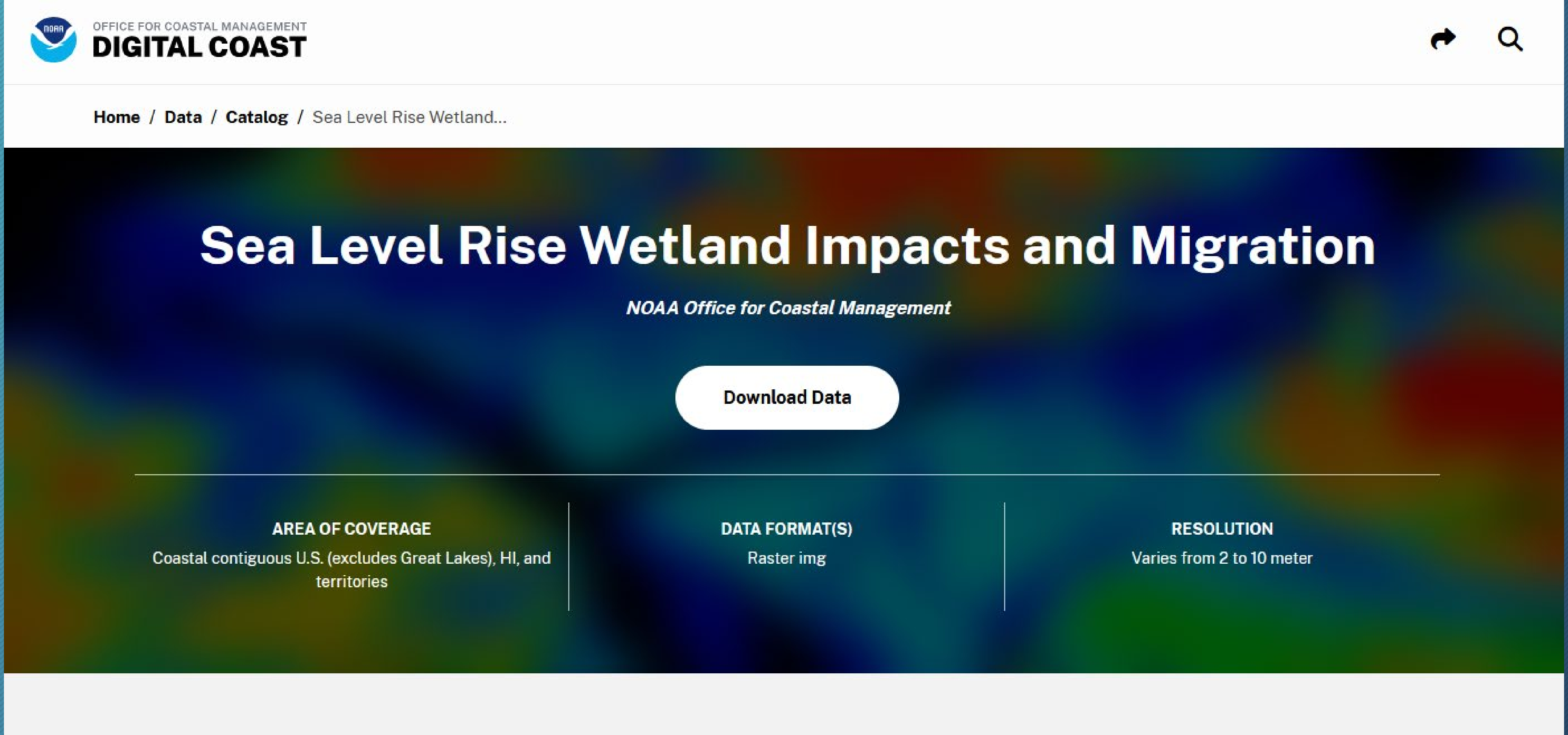

W&M | ScholarWorks

Migration of the Tidal Marsh Range Under Sea Level Rise for Coastal Virginia, with Land Cover Data

Julie Herman, *Virginia Institute of Marine Science* Follow

Molly Mitchell, *Virginia Institute of Marine Science* Follow

NOAA sea level rise model --> Marsh Migration around the coastline



Summary

What we know	What we are unsure about
Areas with high potential for marsh migration	Exactly when and where the future marsh will be
There are several different models that can be used to assess this question	The data needed to accurately parameterize them is limited and there is very limited validation of the models
Multi-model approaches can provide the information at a zoomed out scale (e.g. target conservation efforts)	They can't assess overall future marsh acreage or be used in a parcel-scale regulatory sense
Variability in projections in the next 30-50 years is constrained	Beyond that variation in sea level projections and land use change projections get big, making it difficult to land on concrete management strategies

Questions?

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