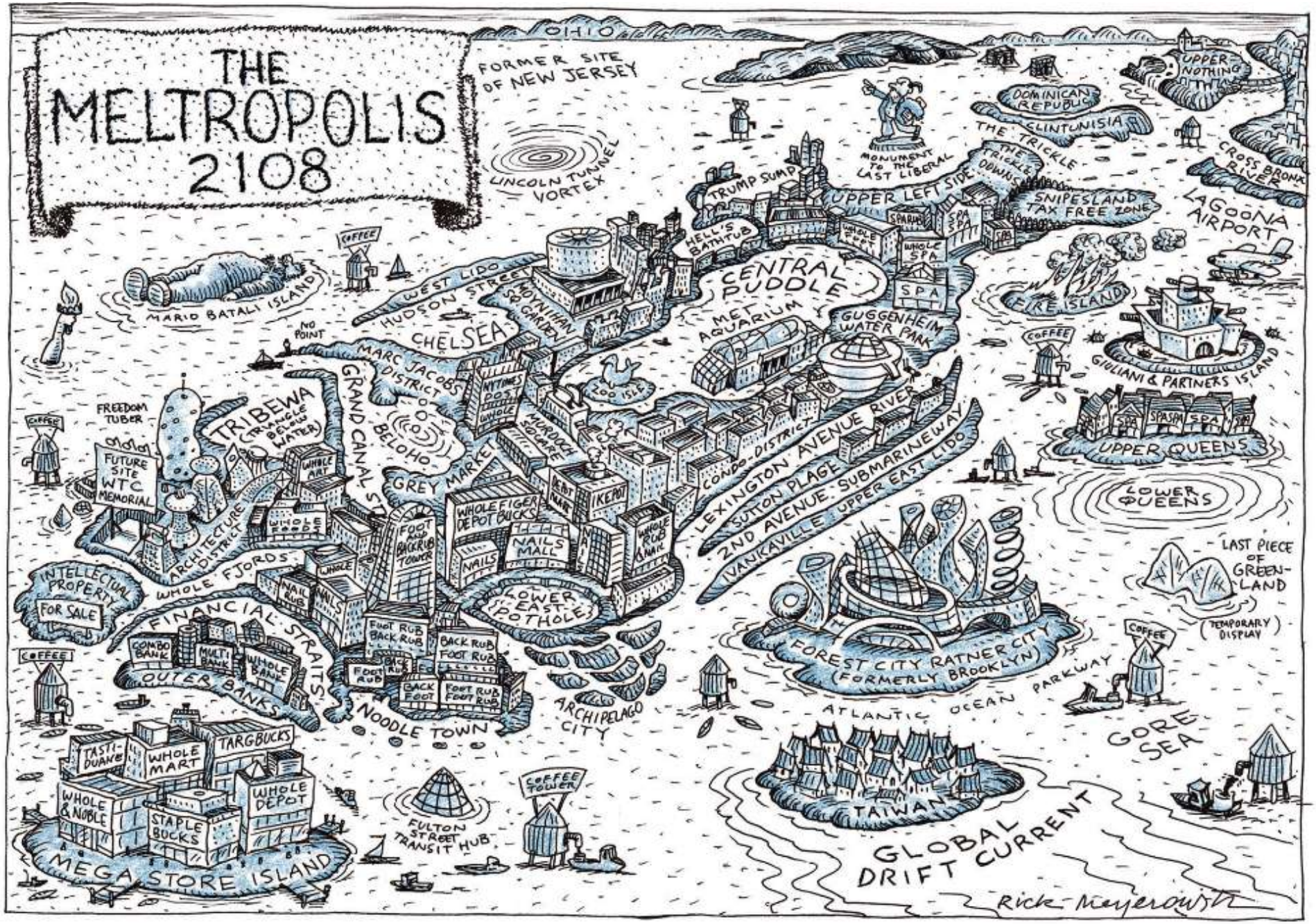
Modeling Sea-Level Rise in Coastal Wetlands:

Understanding Potential Impacts and Their Implications for Management on Cape Cod

Photo credit: Mike McHugh, MassDEP

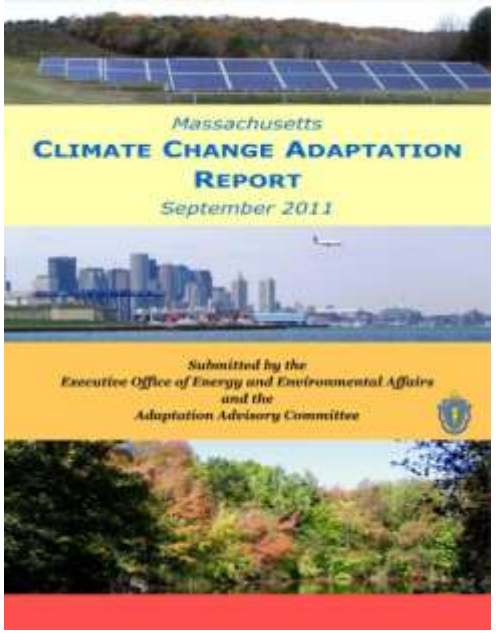
Marc Carullo
Massachusetts Office of Coastal Zone Management



Rick Meyerowitz, 2008. From *Forecast* by Nicholas Blechman.

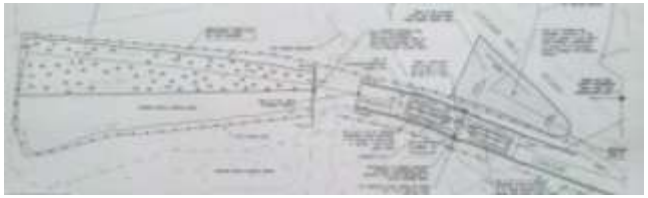
Project Objectives

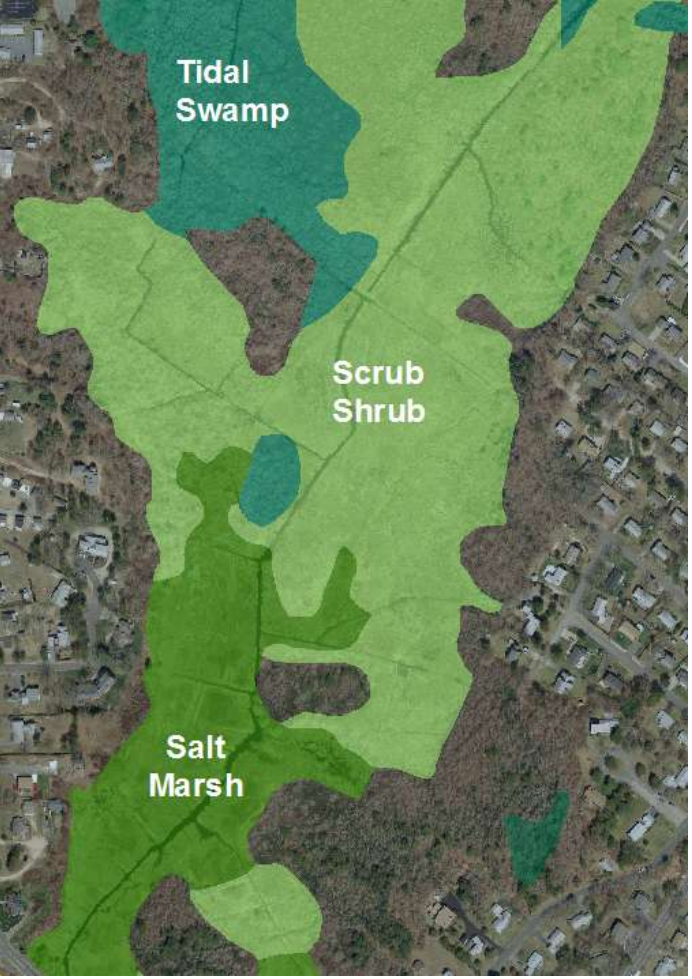
Understand potential for coastal wetland **habitat conversion/loss** under multiple scenarios of SLR

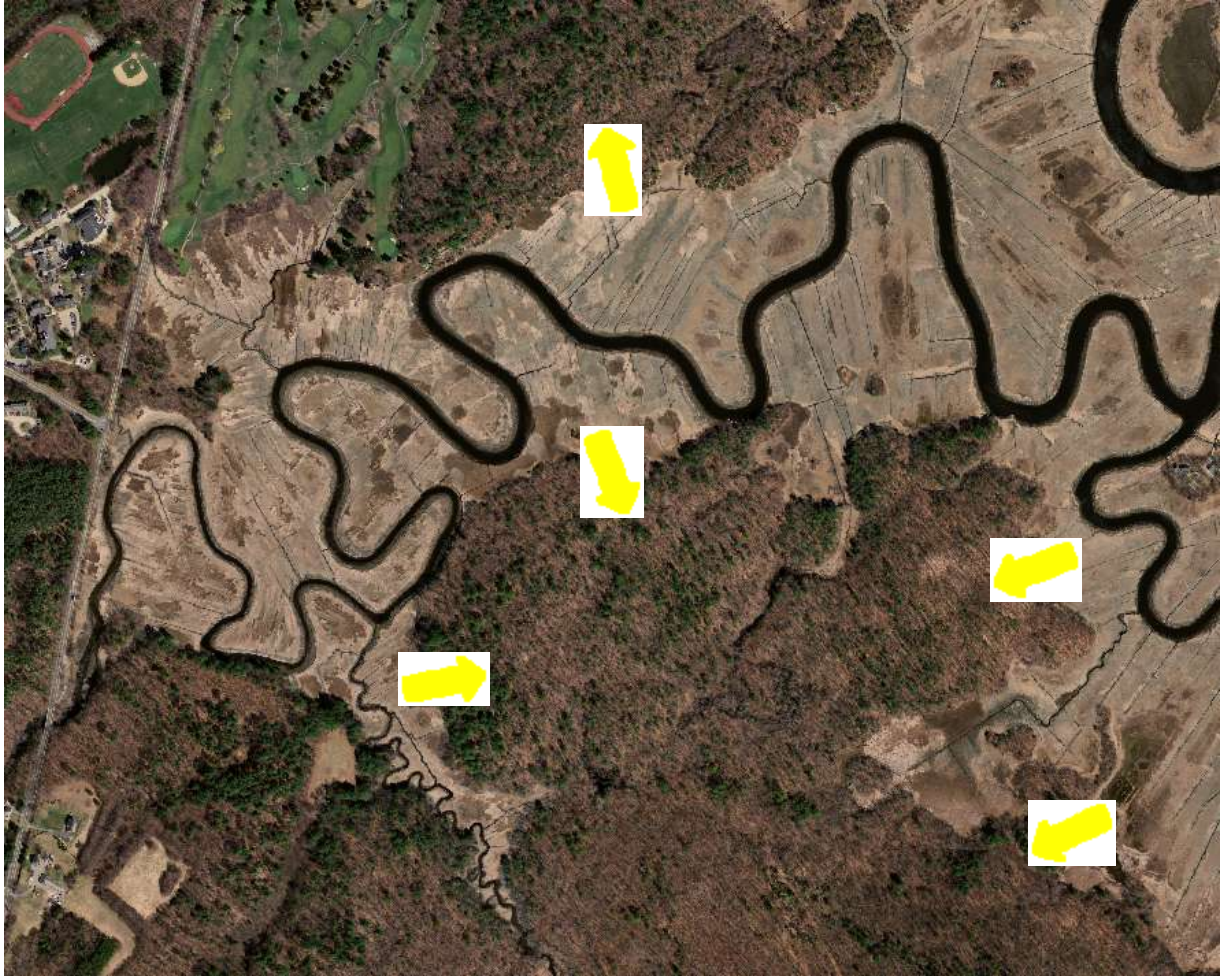


Identify and assess opportunities for and barriers to **marsh migration**

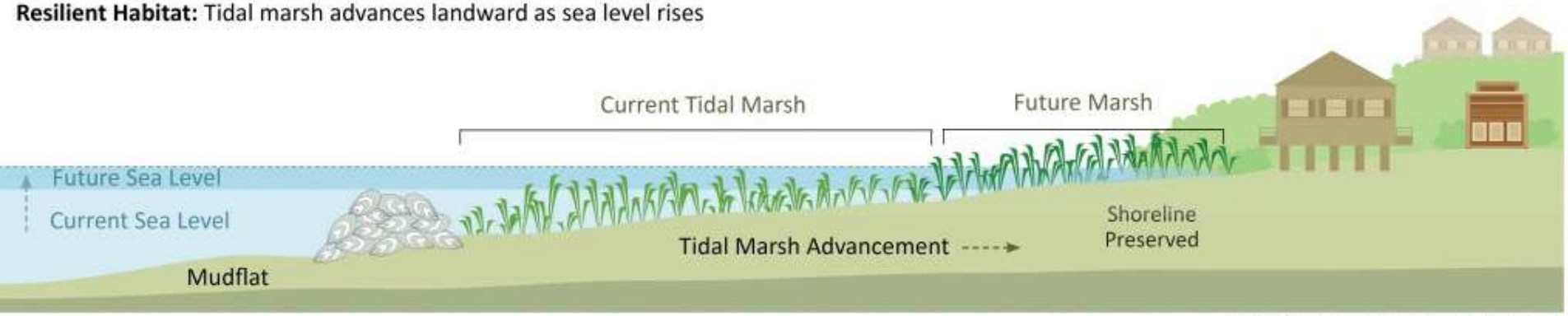
Engage stakeholders to better incorporate wetlands into **adaptation strategies** and planning efforts







Resilient Habitat: Tidal marsh advances landward as sea level rises



Four scenarios with estimates of SLR by 2100

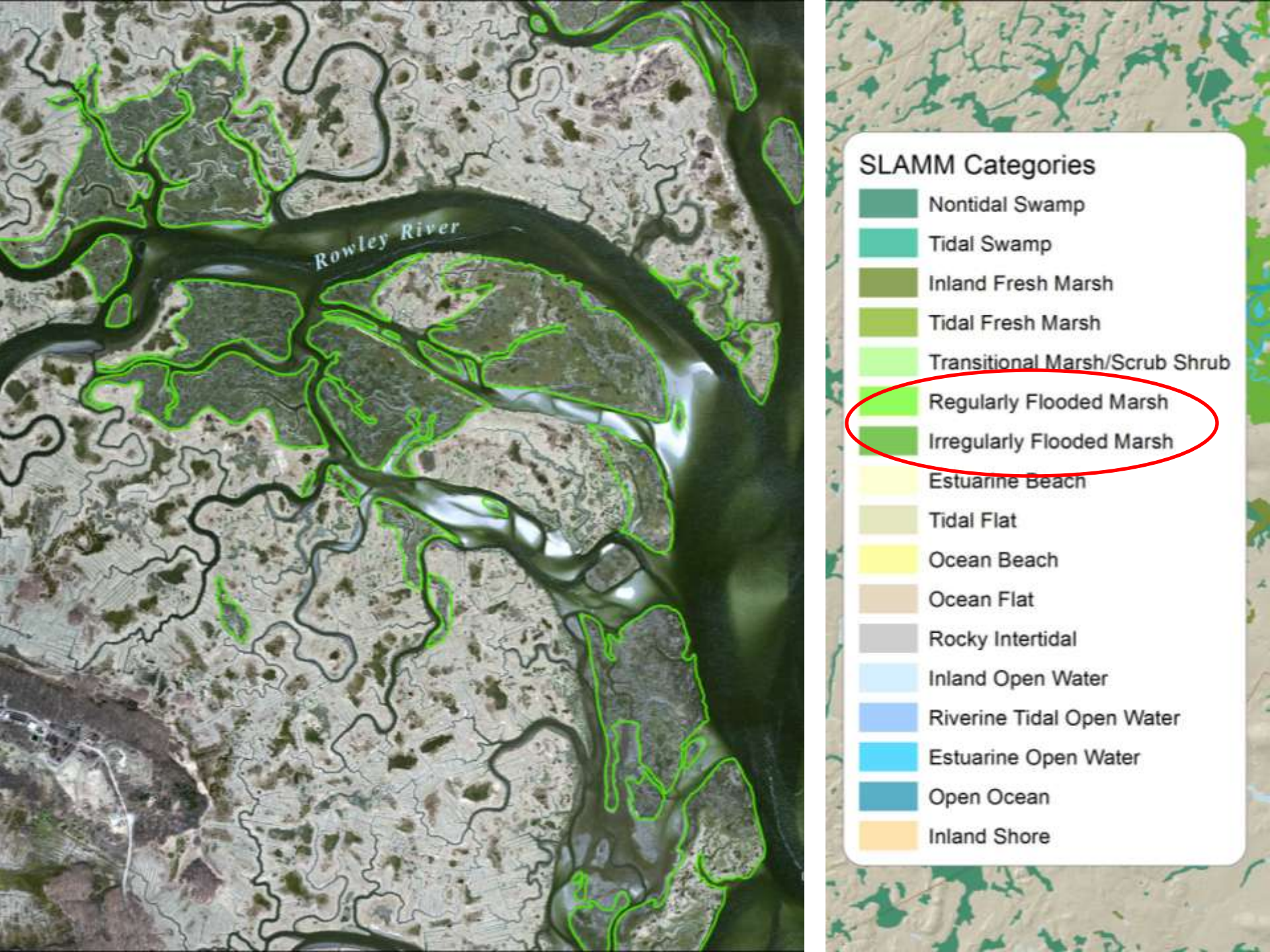
United States National Climate Assessment (Parris et al. 2012), adjusted for local subsidence

Projected Scenario	Total Sea Level Rise (Boston)
Lowest	0.249 m (0.82 feet)
Intermediate Low	0.706 m (2.32 feet)
Intermediate High	1.385 m (4.54 feet)
Highest	2.164 m (7.10 feet)

Models used:

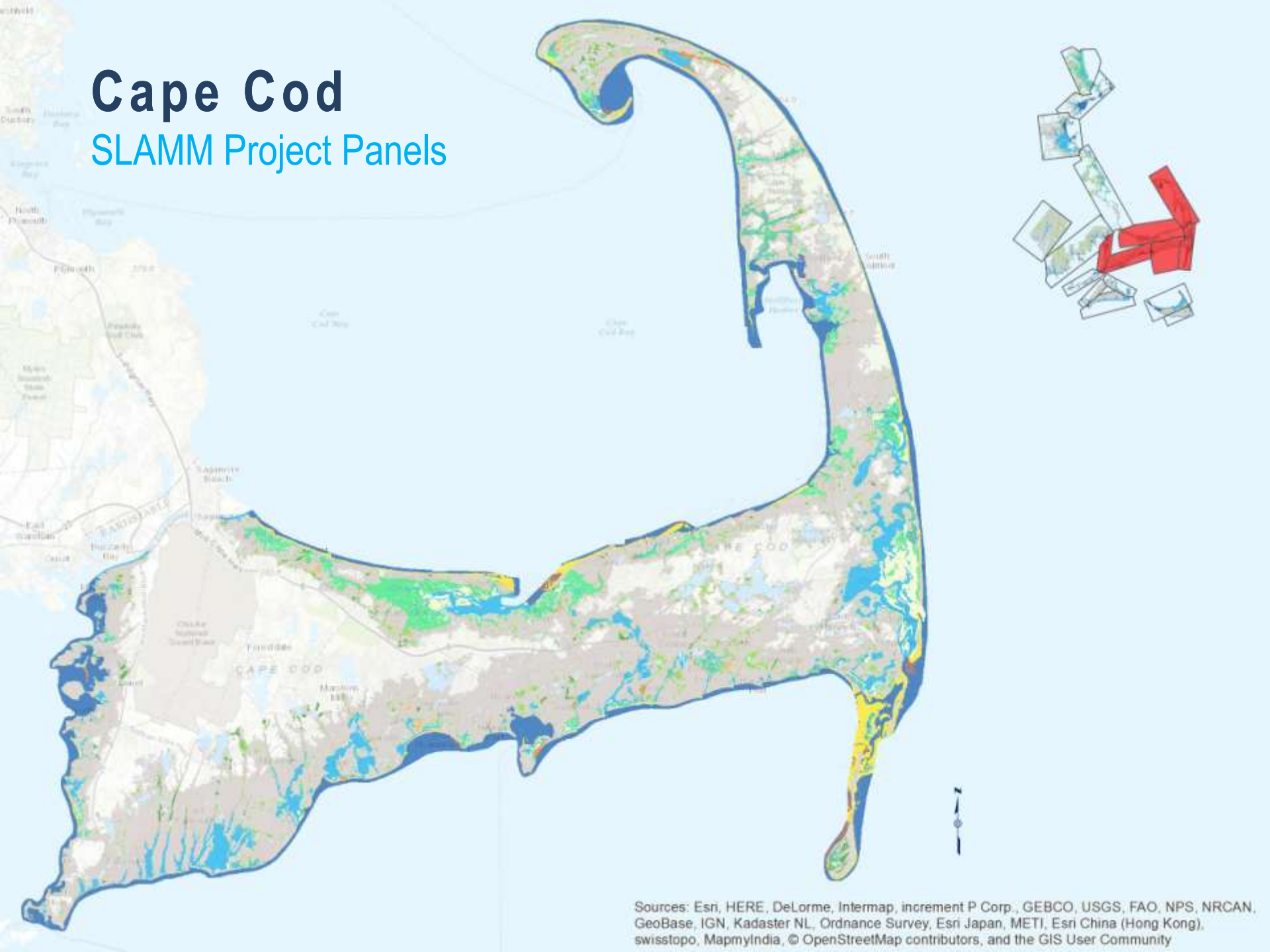
Sea-Level Affecting Marshes Model (SLAMM)

Marsh Equilibrium Model (MEM)*


Rowley River
SLAMM Categories
Nontidal Swamp
Tidal Swamp
Inland Fresh Marsh
Tidal Fresh Marsh
Transitional Marsh/Scrub Shrub
Regularly Flooded Marsh
Irregularly Flooded Marsh
Estuarine Beach
Tidal Flat
Ocean Beach
Ocean Flat
Rocky Intertidal
Inland Open Water
Riverine Tidal Open Water
Estuarine Open Water
Open Ocean
Inland Shore

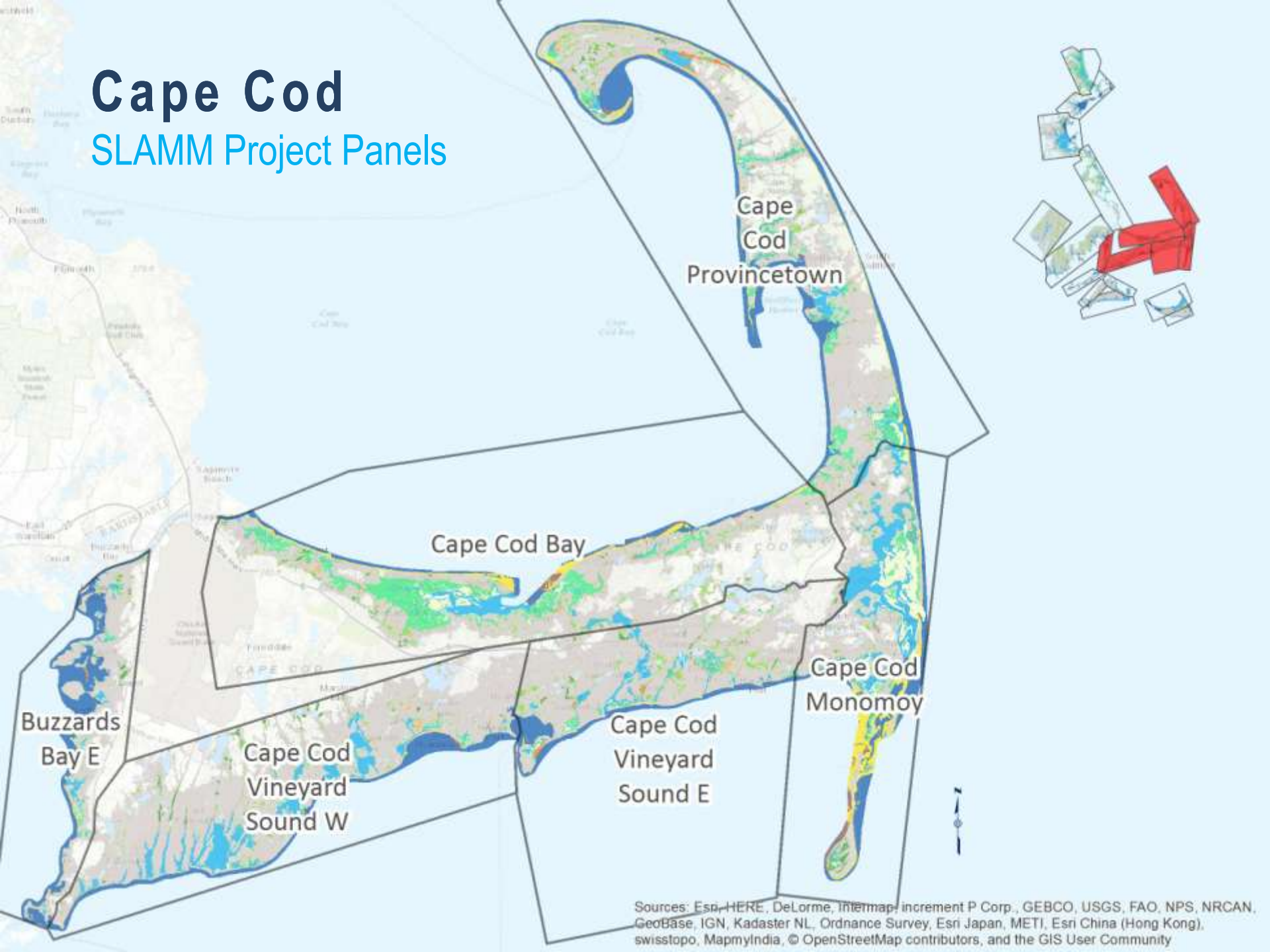
Cape Cod

SLAMM Project Panels

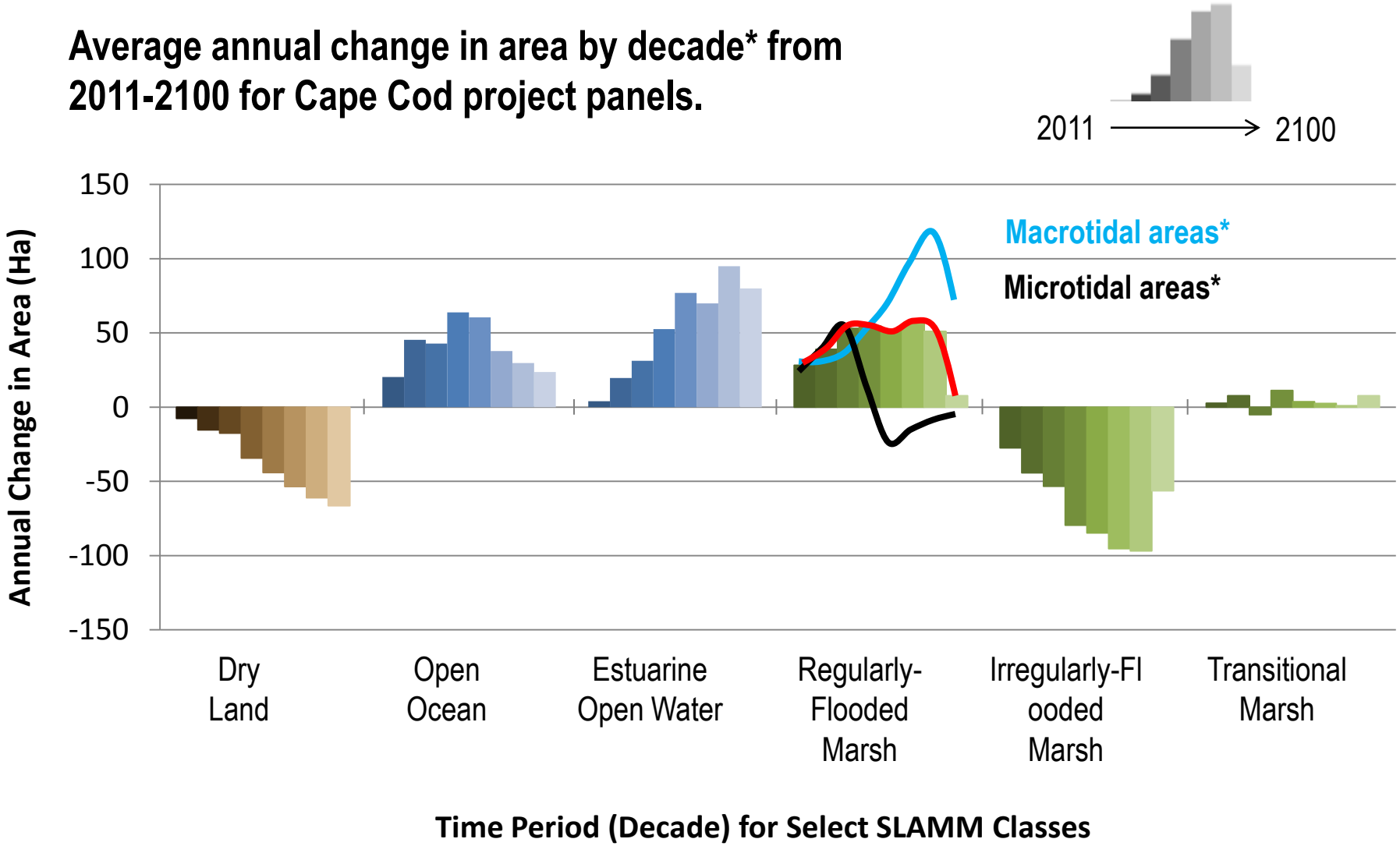


Cape Cod

SLAMM Project Panels



Average annual change in area by decade* from 2011-2100 for Cape Cod project panels.



Potential Salt Marsh Trends from 2011-2100

Cape Cod | **Intermediate High SLR Scenario**

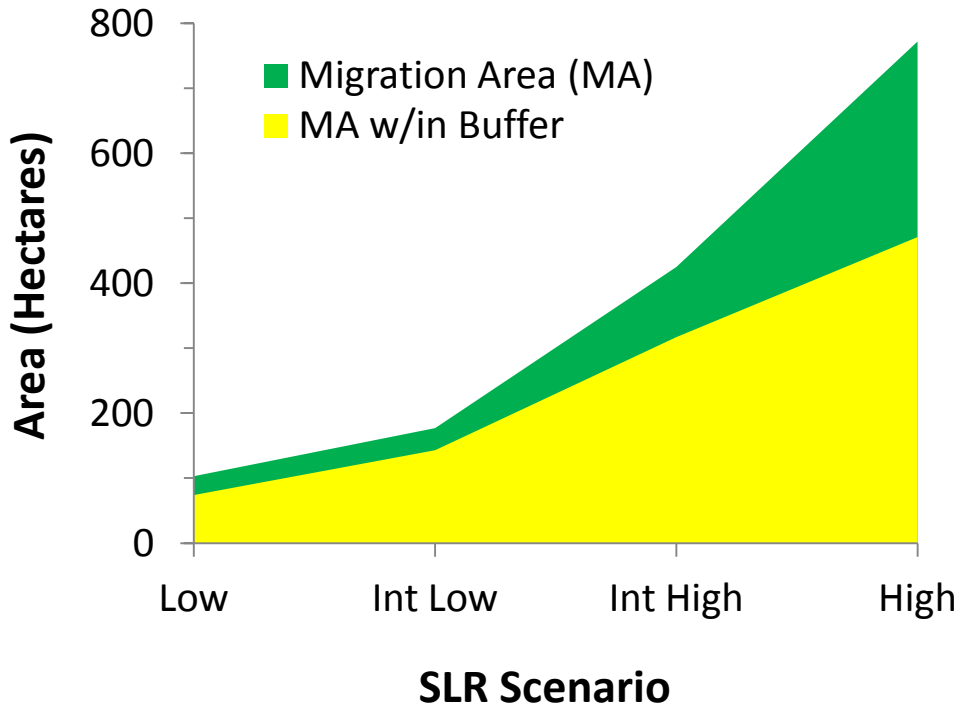
- > 3500 ha increase in reg-flooded marsh (low marsh zone), 225% ↑
- > 5500 ha decrease in irreg-flooded marsh (high marsh zone), 87% ↓
- Total loss of approximately 2000 ha of salt marsh, 25% ↓
- Marshes draining to Vineyard and Nantucket Sounds are potentially more susceptible to loss from SLR than those draining to Cape Cod Bay (i.e., tidal range sensitivity).

100 Years of Estuarine Marsh Trends in Massachusetts (1893 to 1995)

Potential Upland Marsh Migration w/in 100 ft Buffer

South Shore | 2030-2100

Intermediate High SLR Scenario



North River, Marshfield

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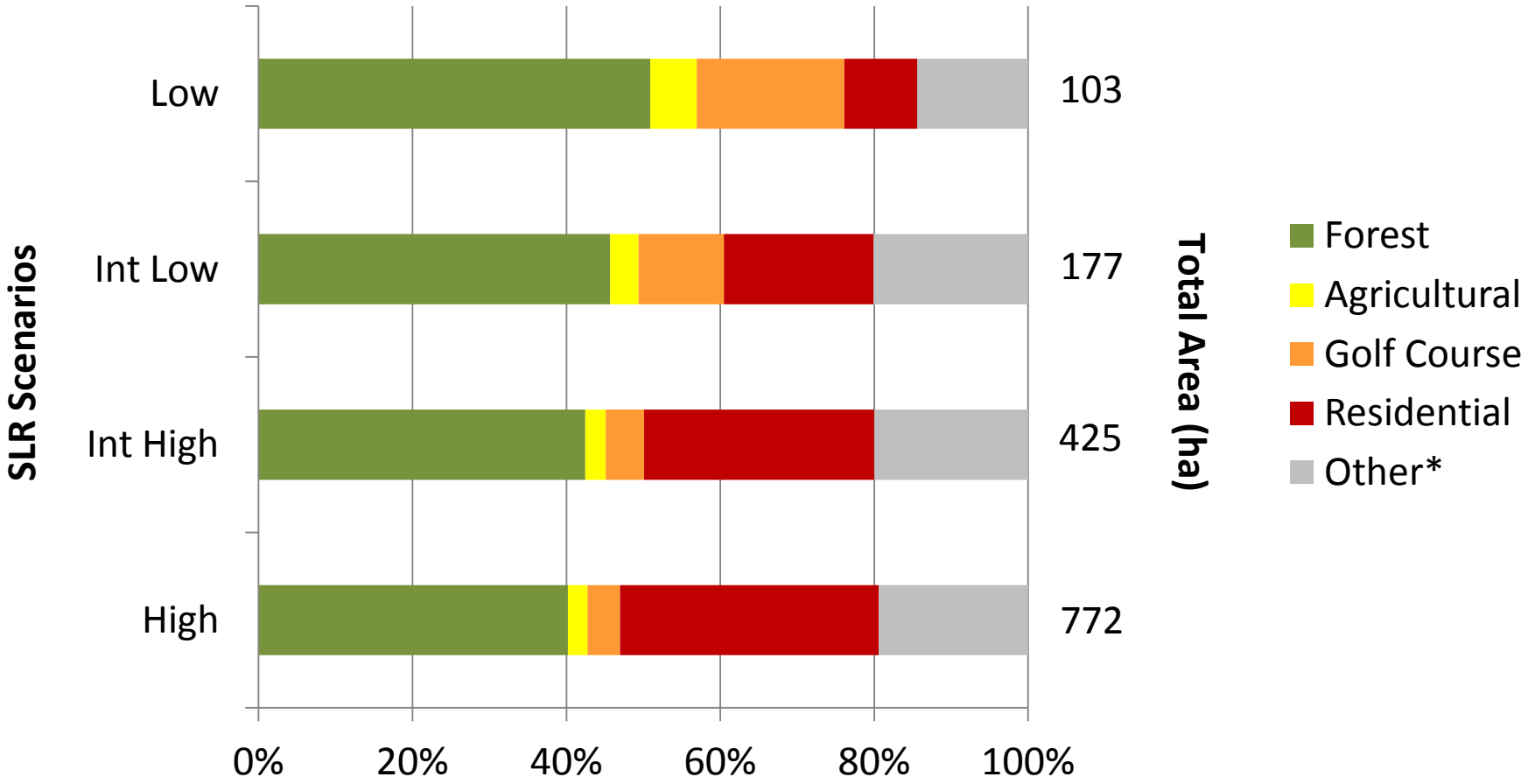
Land Use / Land Cover Distribution of Potential Migration Areas



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Marsh Migration Potential

**For illustrative purposes only*

Lidar DEM

12 m

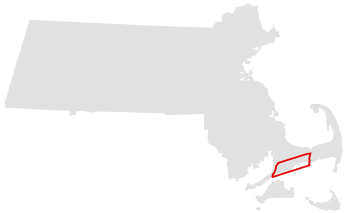
5 m

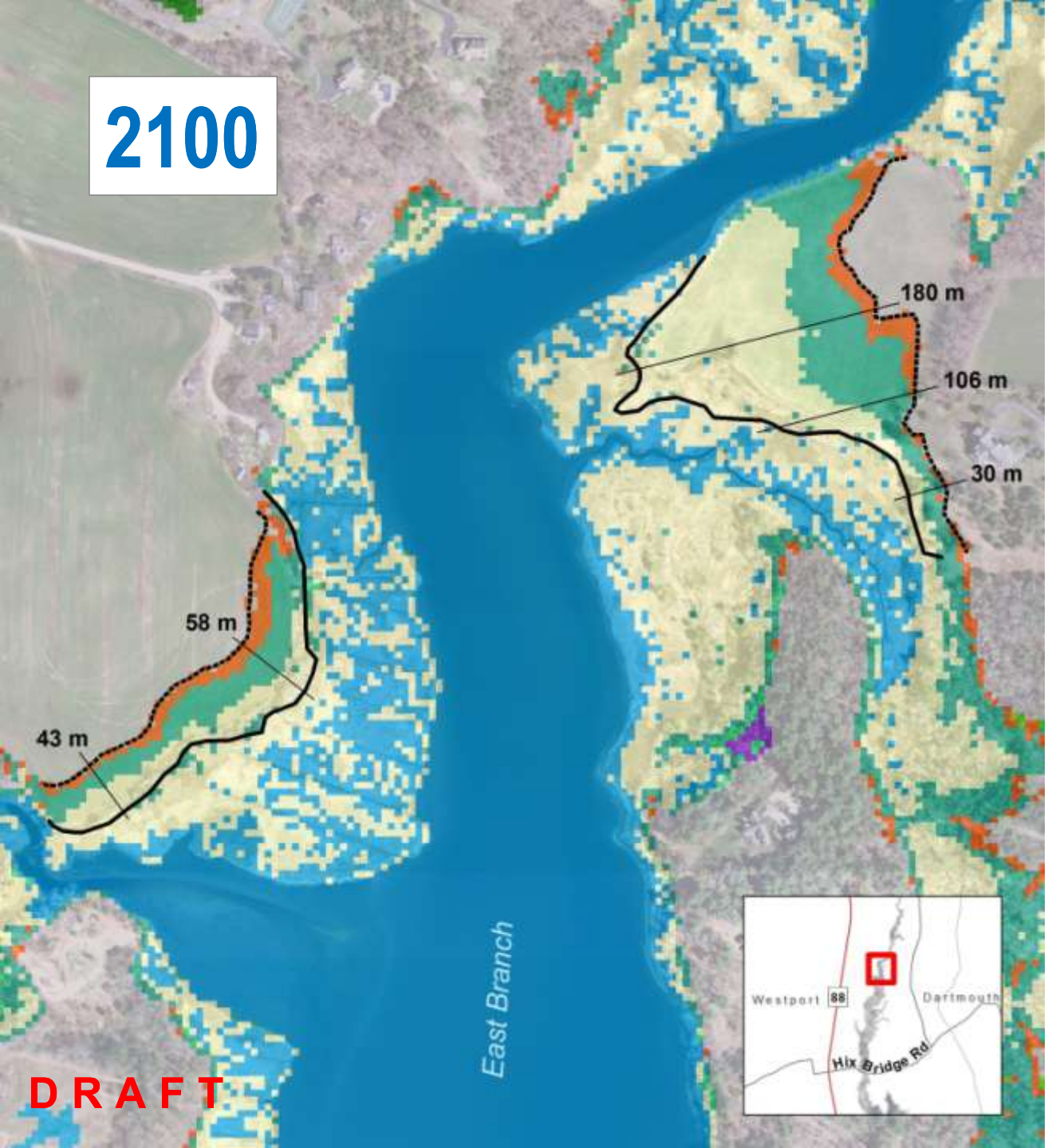
-2 m

Marsh-Upland Border

2011

2100





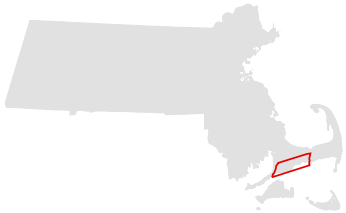
Marsh Migration Potential

**For illustrative purposes only*

COASTAL SQUEEZE

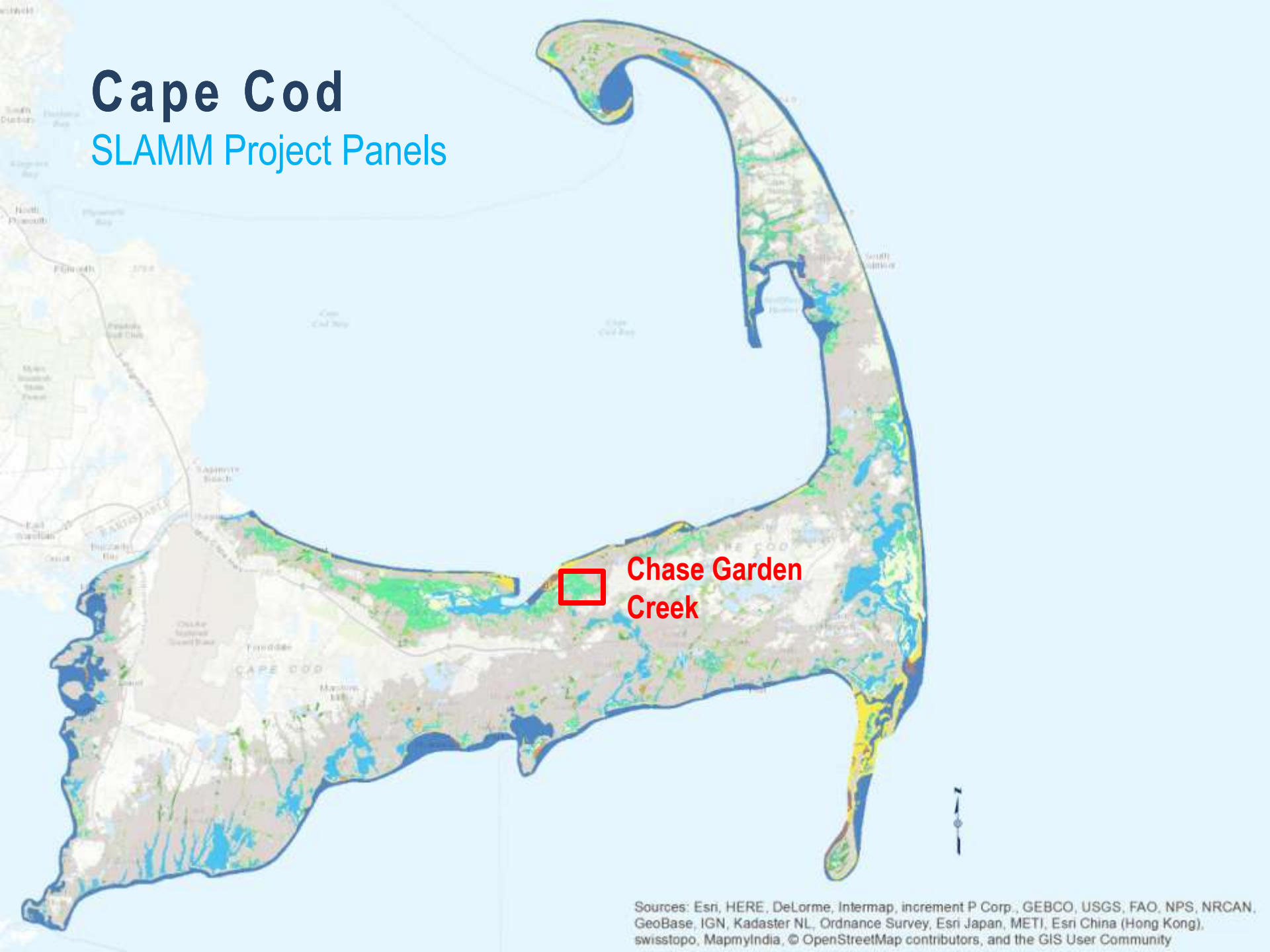
Select SLAMM Classes

- Trans. Marsh/Scrub-Shrub
- Regularly-Flooded Marsh
- Irregularly-Flooded Marsh
- Tidal Flat



Cape Cod

SLAMM Project Panels



Chase Garden Creek

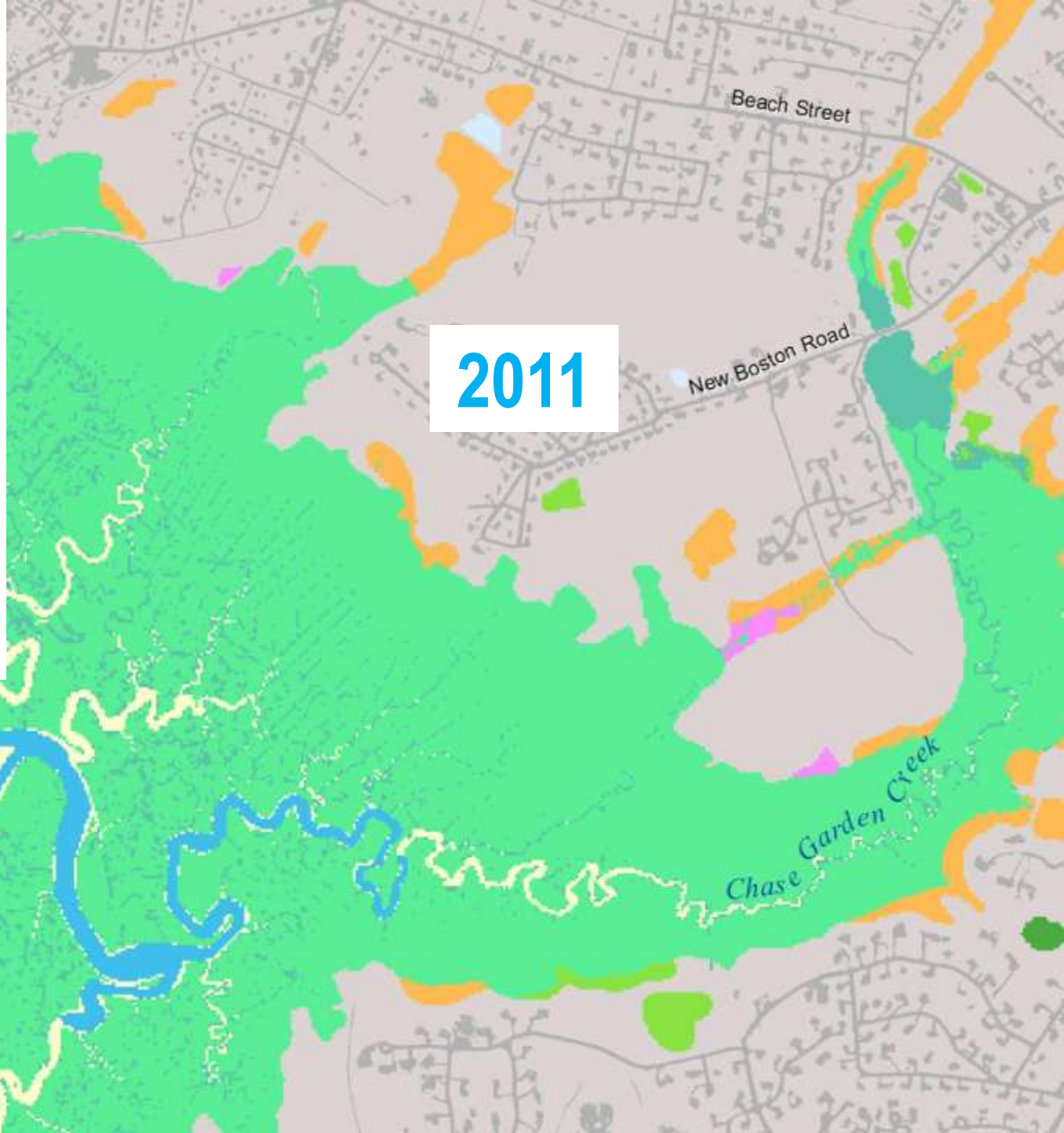
Dennis

Intermediate High SLR
Static accretion

Impervious Surface

Select SLAMM Classes

- Upland
- Tidal Swamp
- Trans. Marsh/Scrub-Shrub
- Regularly-Flooded Marsh
- Irregularly-Flooded Marsh
- Non-tidal Swamp
- Inland Fresh Marsh



DRAFT

Chase Garden Creek

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Static accretion

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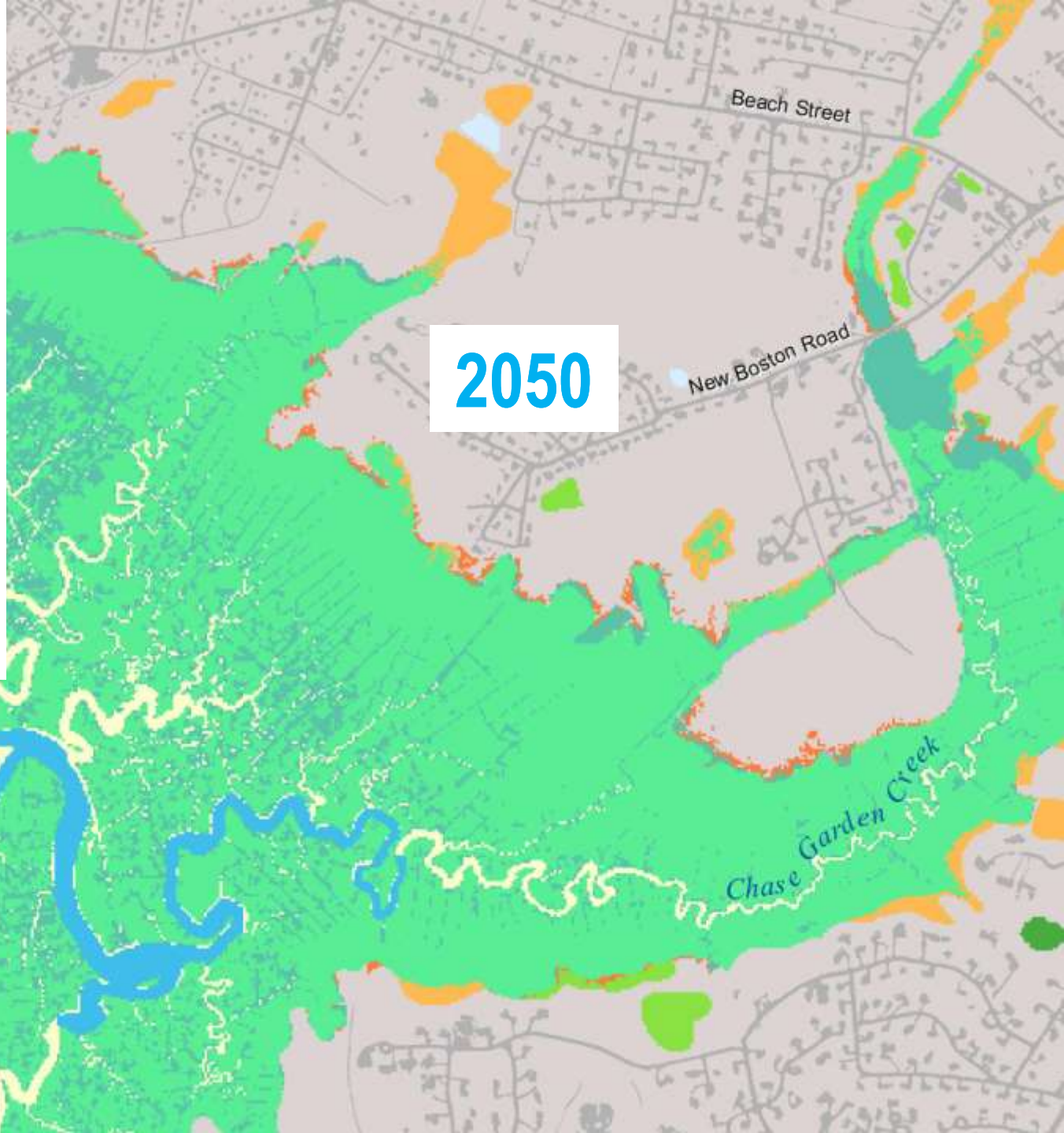

DRAFT

Chase Garden Creek

Dennis

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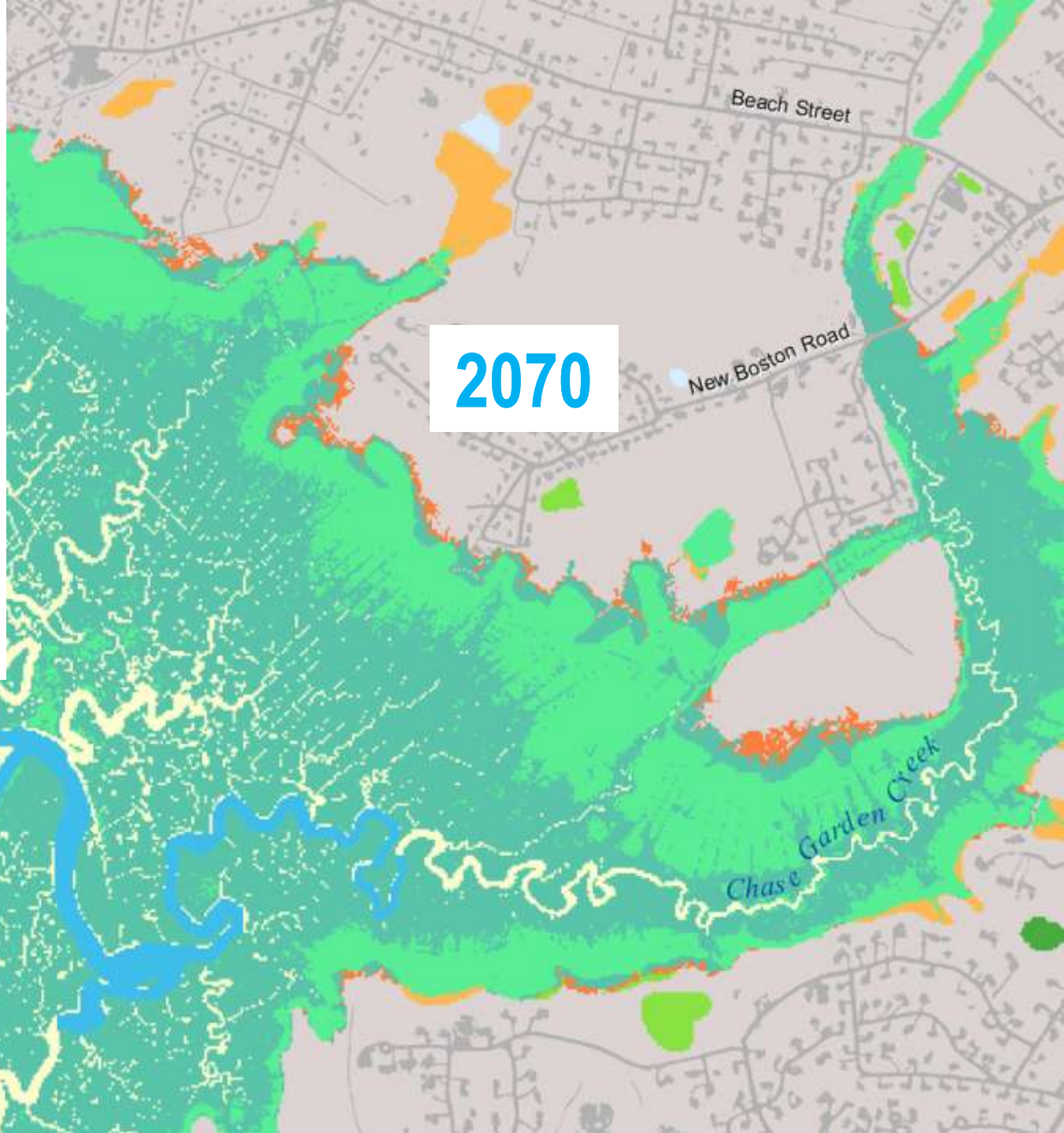

DRAFT

Chase Garden Creek

Dennis

Intermediate High SLR
Static accretion

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Select SLAMM Classes

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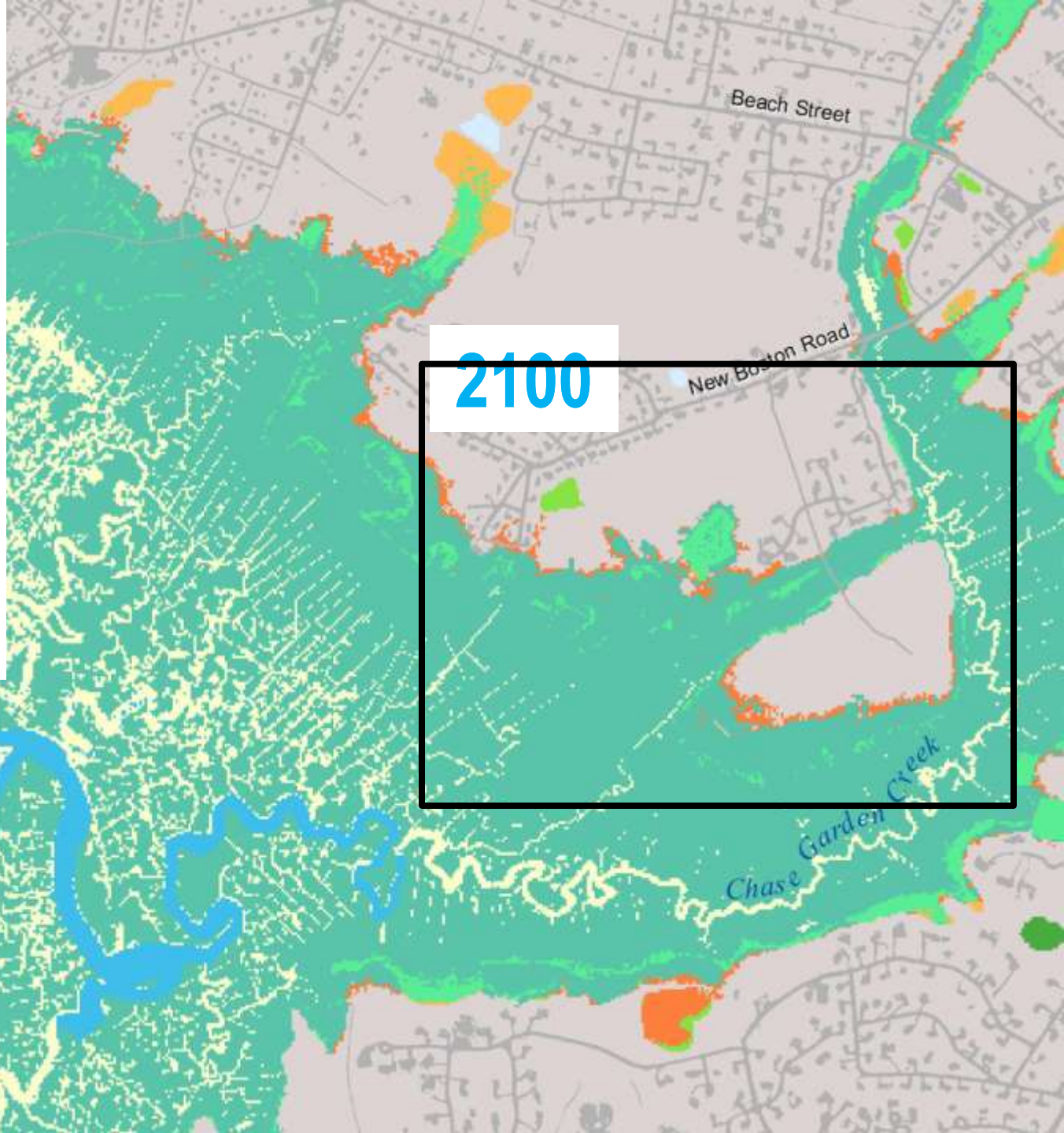

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Marsh Migration Potential

Intermediate High SLR
Static accretion

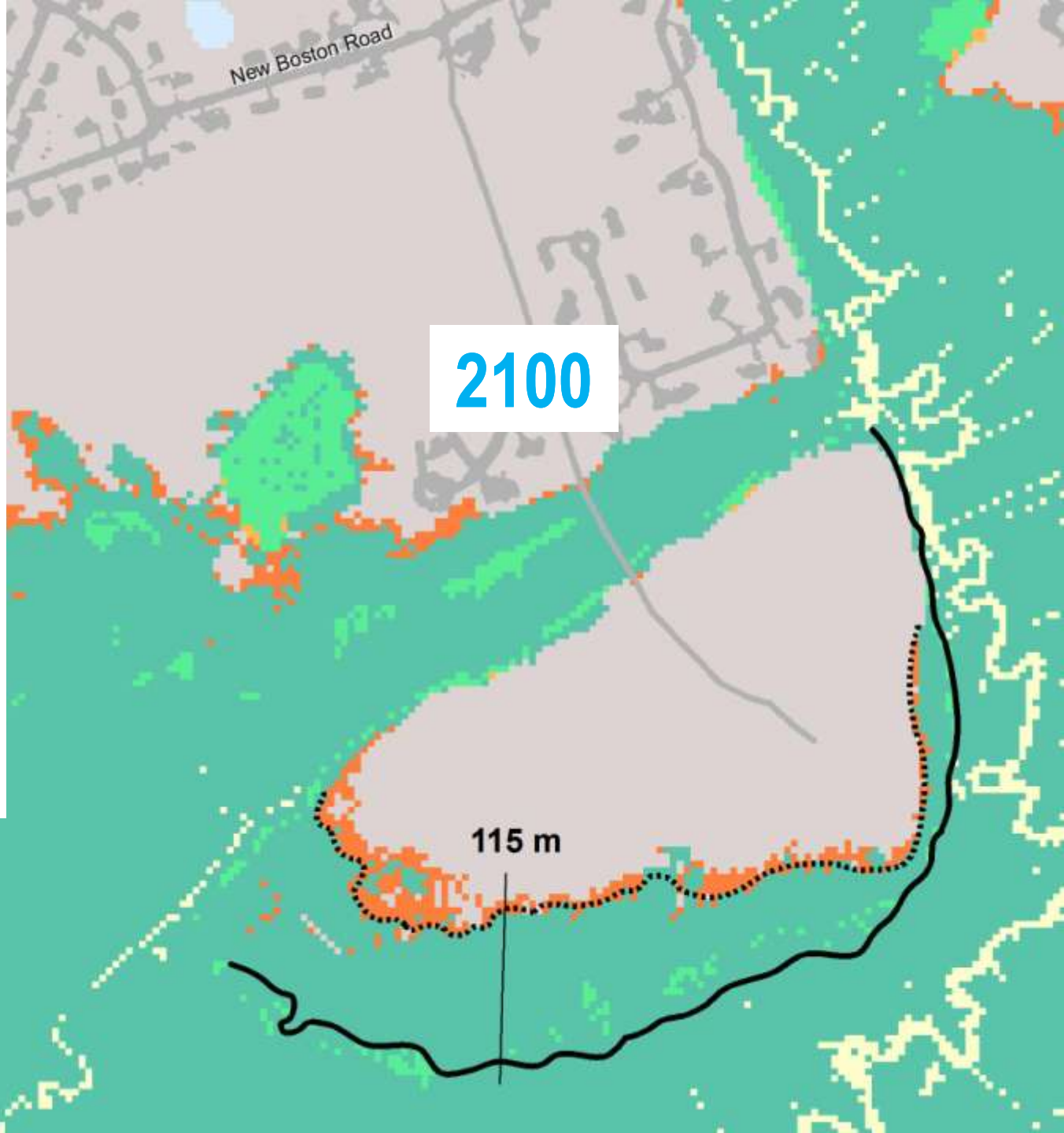
Impervious Surface

Select SLAMM Classes

- Upland
- Tidal Swamp
- Trans. Marsh/Scrub-Shrub
- Regularly-Flooded Marsh
- Irregularly-Flooded Marsh
- Non-tidal Swamp
- Inland Fresh Marsh

Marsh-Upland Border

- 2011
- 2100



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Marsh Migration Potential

Intermediate High SLR
Static accretion

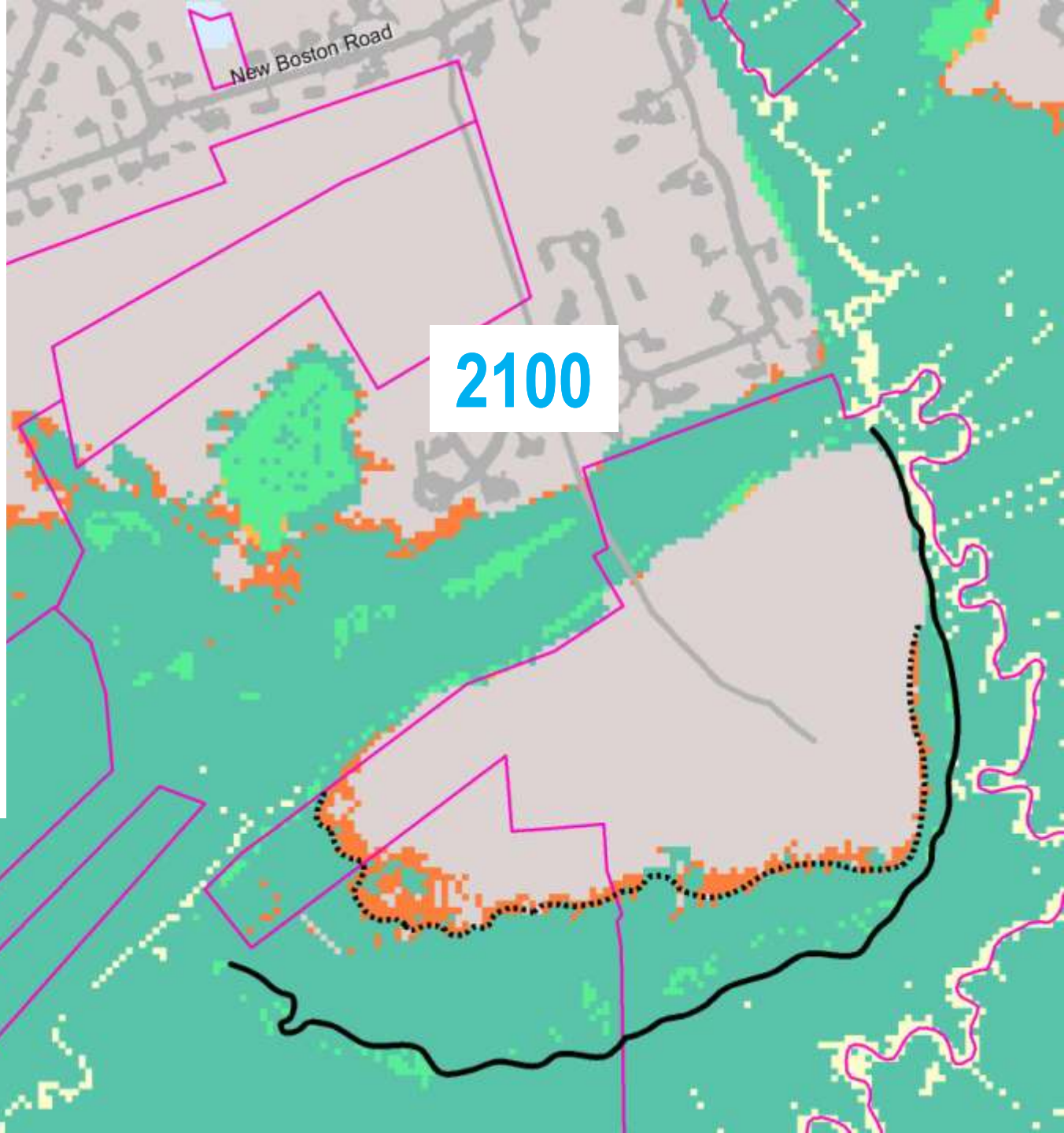
Impervious Surface

Select SLAMM Classes

- Upland
- Tidal Swamp
- Trans. Marsh/Scrub-Shrub
- Regularly-Flooded Marsh
- Irregularly-Flooded Marsh
- Non-tidal Swamp
- Inland Fresh Marsh

Marsh-Upland Border

- 2011
- 2100



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Marsh Migration Potential

Intermediate High SLR
Static accretion

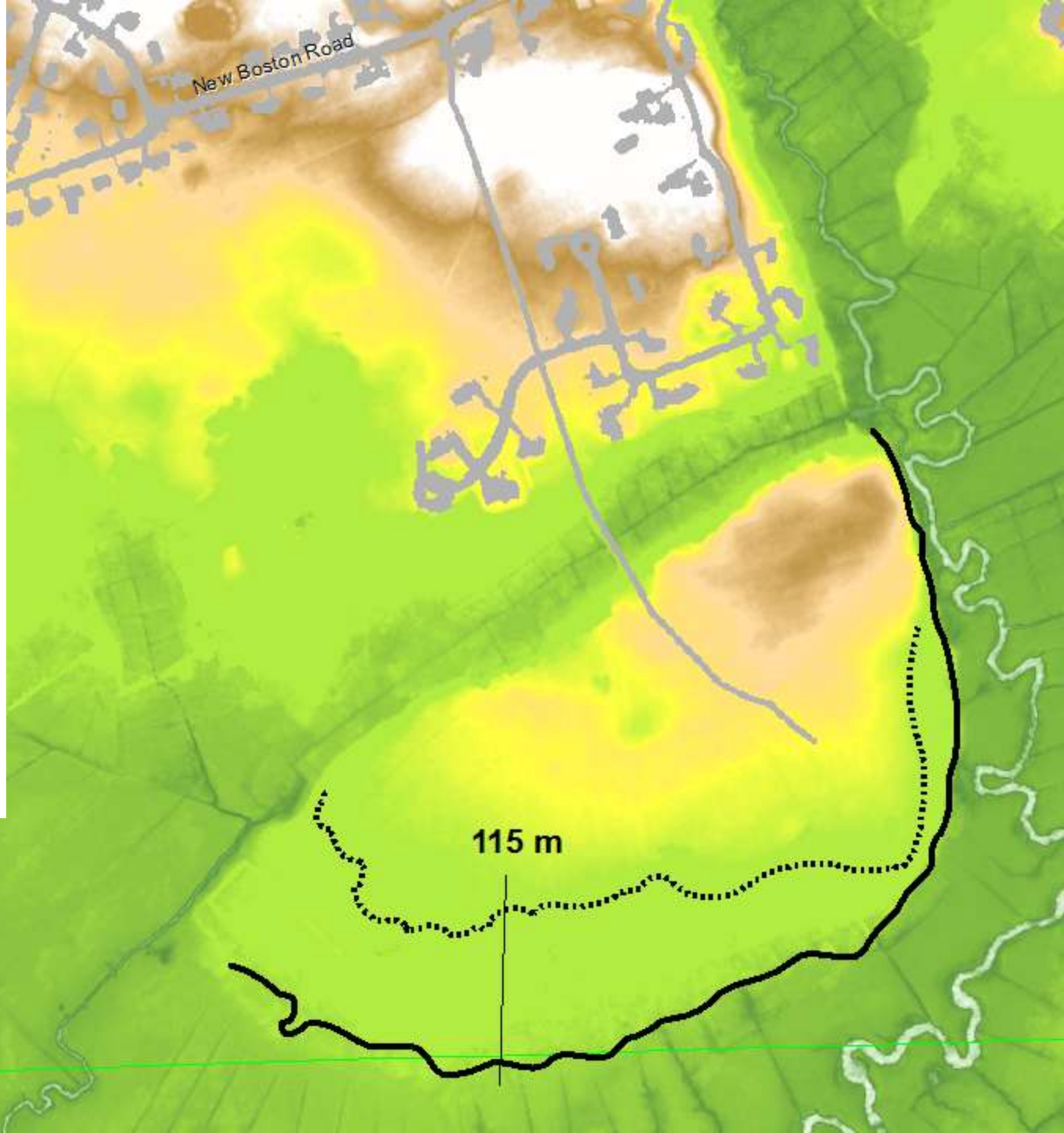
Lidar DEM

10 m
5 m
-0.5 m

Marsh-Upland Border

2011
2100

Impervious Surface



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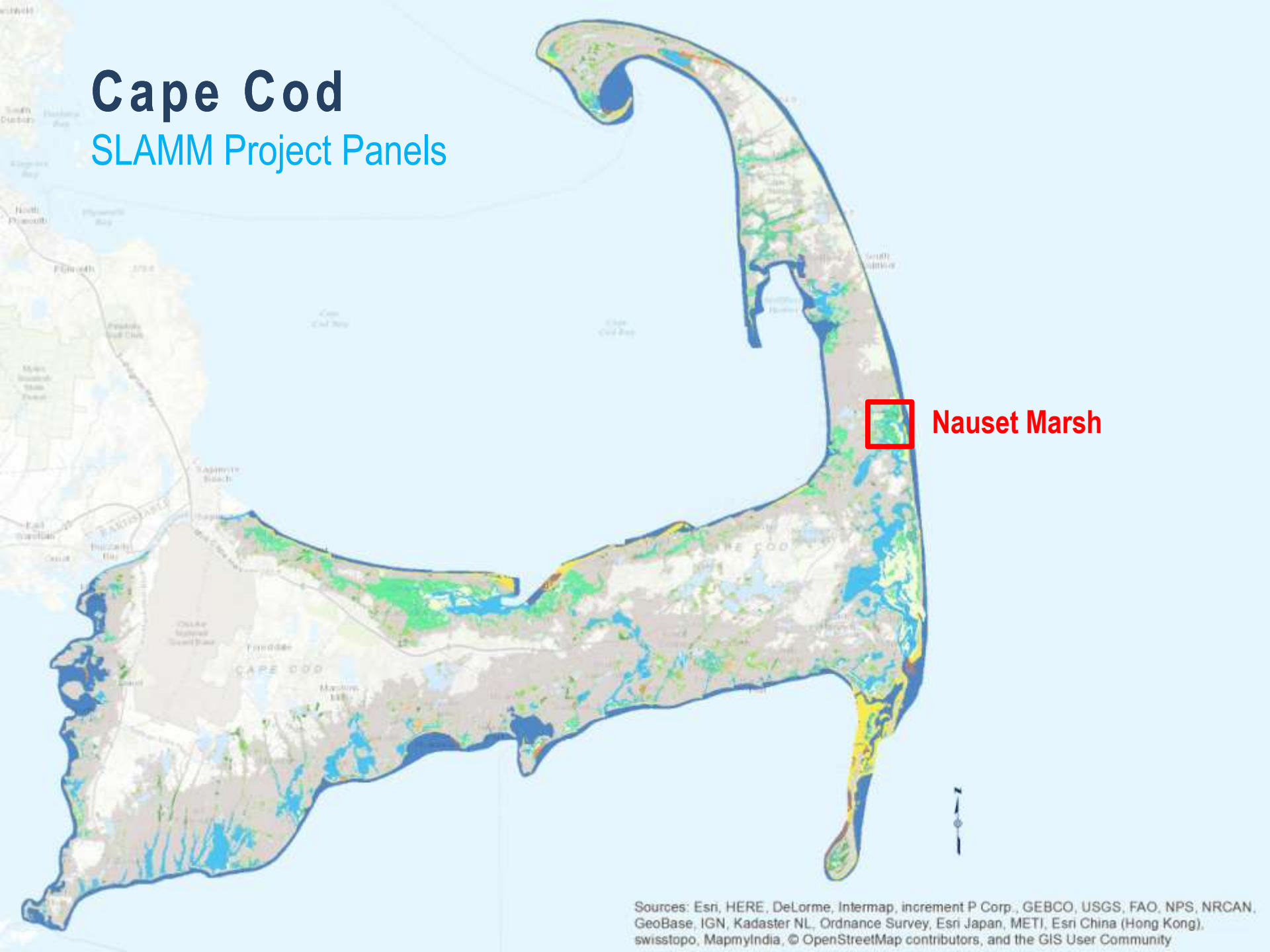
Cape Cod

SLAMM Project Panels



Nauset Marsh

Eastham

Intermediate High SLR
Static accretion

Impervious Surface

Select SLAMM Classes

- Upland
- Tidal Swamp
- Trans. Marsh/Scrub-Shrub
- Regularly-Flooded Marsh
- Irregularly-Flooded Marsh
- Non-tidal Swamp
- Inland Fresh Marsh

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Nauset Marsh

Eastham

Intermediate High SLR
Static accretion

Impervious Surface

Select SLAMM Classes

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Nauset Marsh

Eastham

Intermediate High SLR
Static accretion

Impervious Surface

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Nauset Marsh

Eastham

Intermediate High SLR
Static accretion

Impervious Surface

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Nauset Marsh

Eastham

Intermediate High SLR
Static accretion

Impervious Surface

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- Non-tidal Swamp
- Inland Fresh Marsh

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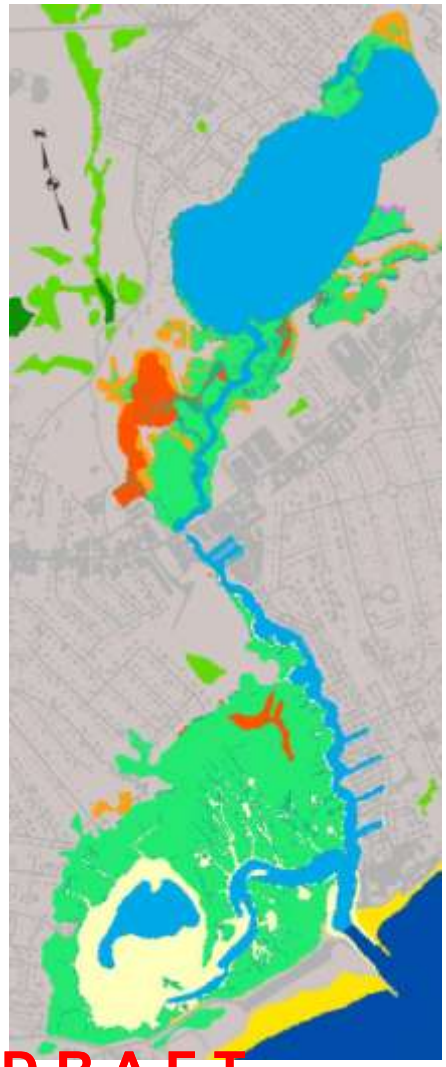
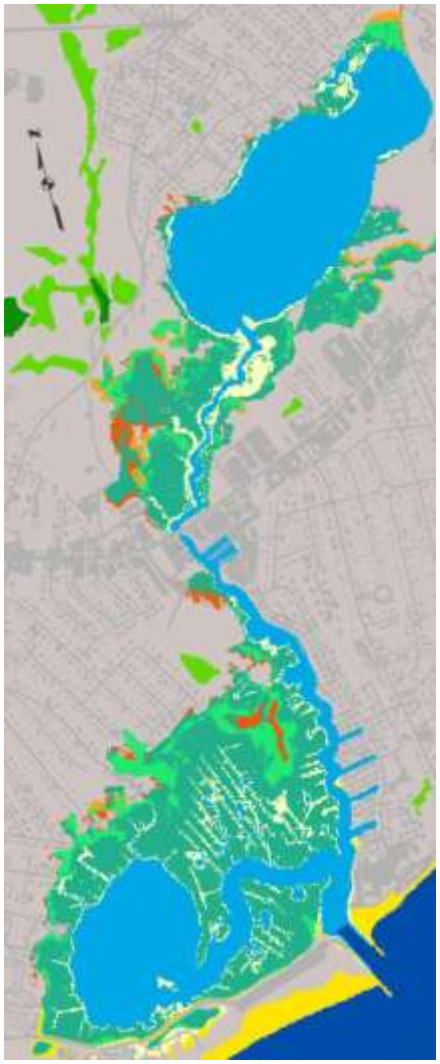
Potential Wetland Distribution by 2100 Under Four SLR Scenarios

Parkers River, Yarmouth

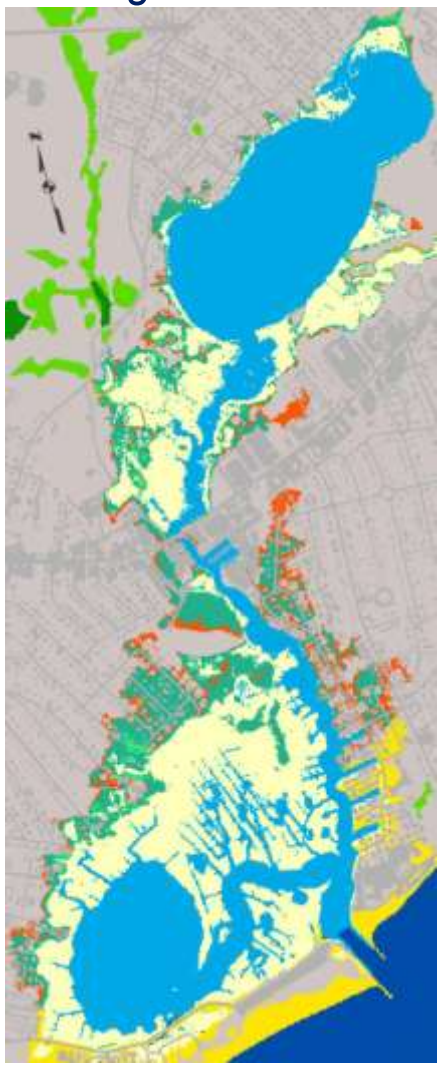
Low ~ 0.8 ft



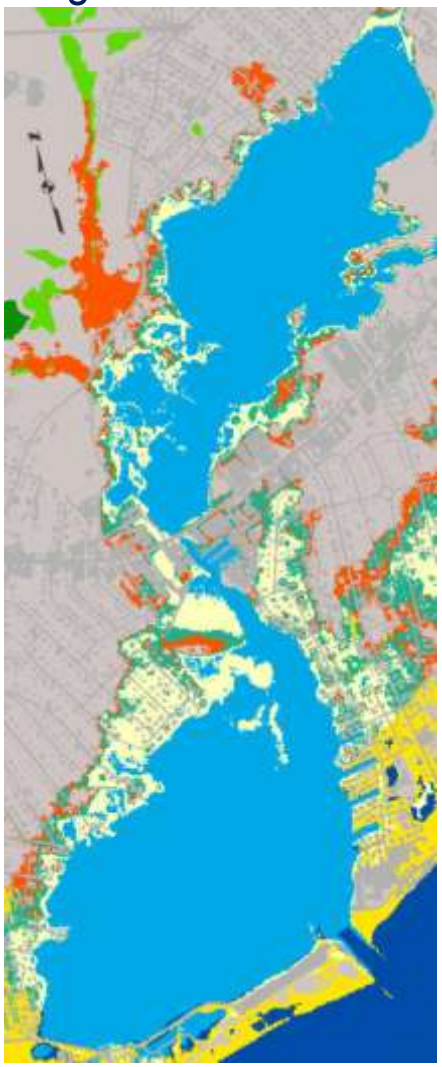
Int Low ~ 2.3 ft



Int High ~ 4.5 ft



High ~ 7.1 ft



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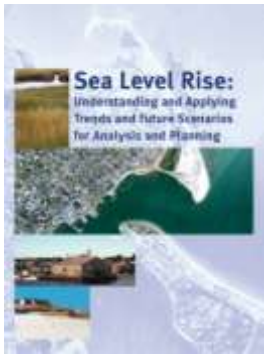
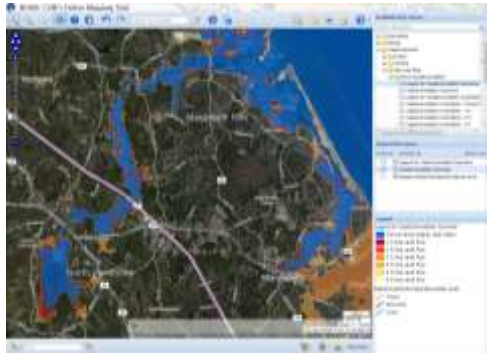
Anticipated Outcomes

- Outreach & Education
- Policy
- Land Conservation & Management
- Restoration
- Species Conservation
- Blue Carbon Accounting





Anticipated Outcomes

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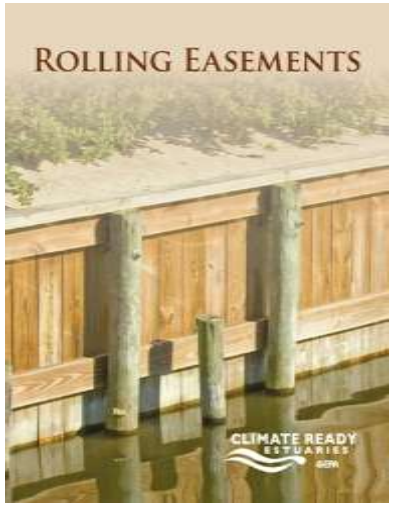

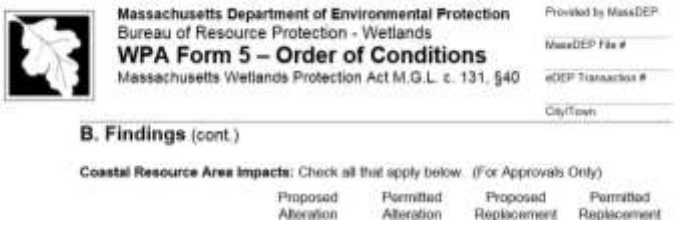
Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands
WPA Form 5 – Order of Conditions
Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

Provided by MassDEP
MassDEP File #
eDEP Transaction #
City/Town

B. Findings (cont.)

Coastal Resource Area Impacts: Check all that apply below. (For Approvals Only)

Proposed Alteration	Permitted Alteration	Proposed Replacement	Permitted Replacement

Anticipated Outcomes

- Outreach & Education
- Policy
- Land Conservation & Management
- Restoration
- Species Conservation
- Blue Carbon Accounting

Massachusetts Land Trust Coalition

Anticipated Outcomes

- Outreach & Education
- Policy
- Land Conservation & Management
- Restoration
- Species Conservation
- Blue Carbon Accounting

Photo: Delaware DNREC

Anticipated Outcomes

- Outreach & Education
- Policy
- Land Conservation & Management
- Restoration
- **Species Conservation**
- Blue Carbon Accounting

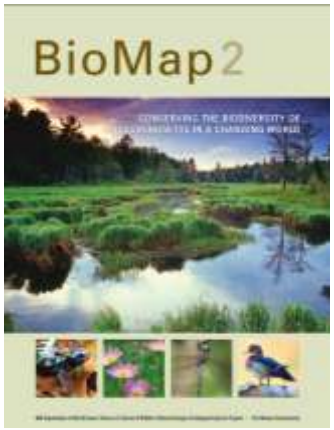

Illustration: Mass Audubon

Photo: David Johnson

Anticipated Outcomes

- Outreach & Education
- Policy
- Land Conservation & Management
- Restoration
- Species Conservation
- Blue Carbon Accounting

Illustration:
The Blue Carbon Initiative's *Coastal Blue Carbon*

Next Steps

- Project website
  - Final SLAMM report
  - Overview and highlights
  - Additional data analyses and summaries
- Esri Story Map and MORIS web tools
- Stakeholder meetings
- Long-term monitoring projects
  - Remote sensing and field-based

Acknowledgements

Funding

- U.S. EPA Region 1
- NOAA Office for Coastal Management

Project Team

- MA CZM
- MA DFG - Division of Ecological Restoration (MA DER)
- Marine Biological Laboratory (MBL)
  - Plum Island Ecosystems Long Term Research (PIE LTER) Project
- MassDEP
- Woods Hole Group

Data Contributors

- MBL/PIE LTER
- USFWS – Parker River NWR
- NPS – Cape Cod NS
- MassDOT
- MA DER
- Waquoit Bay NERR
- NOAA (CO-OPS)
- Woods Hole Group
- University of South Carolina
  - Jim Morris

Warren Pinnacle Consulting, Inc. – SLAMM 6.2
James Morris, University of South Carolina – MEM 5.4.1

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