Modeling the Effects of Sea Level Rise on Massachusetts Coastal Wetlands

Improving Protection, Management, and Climate Change Adaptation Planning

Photo credit: Mike McHugh, MassDEP

Marc Carullo
Massachusetts Office of Coastal Zone Management
Select adaptation strategies identified for coastal ecosystems:

- Identify and protect undeveloped areas that are upgradient from coastal wetlands to allow wetland migration and buffer intact ecosystems.
- Identify, assess and mitigate existing impediments to inland migration of coastal wetlands.
- Track the movement of tidal resources as they respond to sea level rise.
Project Goals

1. Identify potential changes to wetland type across multiple temporal and spatial scales.

2. Identify barriers to and opportunities for landward marsh migration.

3. Communicate results via web-based maps, reports, and workshops/meetings.

4. Begin to develop and implement adaptation strategies to address potential SLR impacts to coastal wetlands.

5. Establish a network of long-term monitoring stations to measure impacts of sea level rise and potential marsh migration.
1. Identify potential changes to wetland type across multiple temporal and spatial scales.

*North and South Rivers in Marshfield and Scituate*
Model Selection

• Things to consider
  – Time step/simulation period
  – Spatial Resolution
  – Parameters simulated
  – Input data requirements
  – Typical scenarios/applications

• Models considered
  – Salt Marsh Assessment & Restoration Tool (SMART)
  – Polygon-Based Spatial Model (PBS)
  – Everglades Landscape Model (ELM)
  – Marsh Equilibrium Model (MEM)
  – Sea Level Affecting Marshes Model (SLAMM)
Four scenarios with estimates of global SLR by 2100

*Global Sea Level Rise Scenarios for the United States National Climate Assessment* (Parris et al., 2012)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>SLR (m)</th>
<th>SLR (ft)</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest</td>
<td>2.0</td>
<td>6.6</td>
<td>Based on ocean warming and maximum ice sheet loss</td>
</tr>
<tr>
<td>Intermediate-High</td>
<td>1.2</td>
<td>3.9</td>
<td>Based on limited ice sheet loss plus ocean warming</td>
</tr>
<tr>
<td>Intermediate-Low</td>
<td>0.5</td>
<td>1.6</td>
<td>Based primarily on sea level rise from ocean warming</td>
</tr>
<tr>
<td>Lowest</td>
<td>0.2</td>
<td>0.7</td>
<td>Linear extrapolation of historical sea level rise rate</td>
</tr>
</tbody>
</table>

Local vertical land movement at the Boston tide gauge.

Source: NOAA
Using Projections to Bracket Uncertainty and Risk

Graphic courtesy of Woods Hole Group.
Data Compilation

Contributors

- NOAA (CO-OPS)
- MBL/PIE LTER
- USFWS (NWI, PRNWR)
- MassGIS
- USGS
- Waquoit Bay NERR
- NPS (CACO)
- Others

Additional data inputs

- Dam locations
- Dam crest elevations
- SLR historic trend
- Beach sedimentation rate
- MEM accretion rates
- Other

SLAMM 6.2 Data Inputs

- Digital Elevation Model (lidar-derived)
- Wetland Map Data
- Impervious Surface
- Erosion Rates (horizontal)
- Accretion Rates (vertical)
- GD Tide Range (MHHW-MLLW)
- Salt Elevation (+ MTL)
- Freshwater Parameters (flow, etc.)
Model Application to Pilot Site

- Compare 2 m and 5 m grids
- Parameter Sensitivity Analysis
- Elevation Uncertainty Analysis

Parameter [Data Source]
- Discharge [USGS River Gage Data]
- Marsh Accretion [PIE LTER SET Data]
- Marsh Erosion [Leonardi and Fagherazzi 2014]
- Salinity [PIE LTER WQ Data]
- Water Levels (GDTR) [PIE LTER WL Data]

Pilot Study Boundary
Statewide application will include dozens of subsites due to one or more variables (accretion, erosion, tidal range, etc.).
Parameter Sensitivity Analysis

- Small estuaries
- Variety of wetland classes
- Closed systems with simple hydrology
## Sandwich Estuaries Parameter Sensitivity Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range of Values Tested</th>
<th>Land Types Affected*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Typical</td>
<td>Min</td>
</tr>
<tr>
<td>Historic Trend (mm/yr)</td>
<td>0 - 4</td>
<td>-10</td>
</tr>
<tr>
<td>Great Diurnal Tide Range (% State Max Range)**</td>
<td>10-100</td>
<td>0</td>
</tr>
<tr>
<td>Salt Elevation (% Tide Range)***</td>
<td>40 – 60</td>
<td>0</td>
</tr>
<tr>
<td>Marsh Erosion (m/yr)</td>
<td>0 – 2</td>
<td>-10</td>
</tr>
<tr>
<td>Swamp Erosion (m/yr)</td>
<td>0 – 2</td>
<td>-10</td>
</tr>
<tr>
<td>Tidal Flat Erosion (m/yr)</td>
<td>0 – 2</td>
<td>-10</td>
</tr>
<tr>
<td>Regularly Flood Marsh Accretion (mm/yr)</td>
<td>0 – 4</td>
<td>-25</td>
</tr>
<tr>
<td>Irregularly Flooded Marsh Accretion (mm/yr)</td>
<td>0 – 4</td>
<td>-25</td>
</tr>
<tr>
<td>Tidal/Inland Fresh Marsh Accretion (mm/yr)</td>
<td>0 – 4</td>
<td>-25</td>
</tr>
<tr>
<td>Tidal/Inland Fresh Swamp Accretion (mm/yr)</td>
<td>0 – 40</td>
<td>-250</td>
</tr>
<tr>
<td>Beach Sedimentation Rate (mm/yr)</td>
<td>0 – 10</td>
<td>-1,000</td>
</tr>
<tr>
<td>Frequency of Overwash (yrs)</td>
<td>0 – 100</td>
<td>0</td>
</tr>
</tbody>
</table>

*Land Types Affected: A total of 14 different Land Types are present in the pilot study area. The Land Types Affected are land types that have a larger than 1% difference between the change in percent increase/decrease of that land type over the range of typical values.

** % State Max Range: The maximum tidal range observed on the MA coast is 10.7 ft.

***% Tide Range: The salt elevation is the height above mean tide which was related to the tidal range as opposed to being evaluated independently.
2. **Identify barriers to and opportunities for marsh migration.**

- Coastal structures
- Roads and railroads
- Buildings and parking lots
- Berms and dikes
- Natural features (bank, rock)
- Elevation and slope
3. Communicate results via web-based maps (e.g., MORIS and ArcGIS Online Story Maps), reports, and workshops.

MORIS: CZM’s Online Mapping Tool
4. Begin to develop and implement adaptation strategies to address potential SLR impacts to coastal wetlands.

*Regulatory and Restoration*

a. Support for regulatory decisions, federal consistency determinations, and the interpretation and implementation of specific performance standards.

b. Augmented or new coastal program policies.

c. Determination of priority restoration areas.

d. Assessment of current wetland buffer and setback regulations.
4. Begin to develop and implement adaptation strategies to address potential SLR impacts to coastal wetlands.

**Land Management and Education**

e. Identification of sites for land acquisition, conservation easement actions, and/or changes in land management practices.

f. Improved management of hardened coastal structures (proposal, maintenance, or removal).

g. Better integration of salt marshes into CZM’s StormSmart Coasts program.

h. Public outreach and education on the potential effects of sea level rise on wetlands.
Marsh Restoration/Adaptation Strategies

- Facilitated marsh migration
- Living shorelines
- Thin-layer deposition (beneficial reuse of dredged material)
- Invasive species control (manage *Phragmites* in transition)
- Enhance ecological integrity to increase resilience to SLR
5. Establish a network of long-term monitoring stations.

- ~ 20 salt marsh monitoring stations coast-wide.

- Track the movement of plant community structure, especially in the marsh border-upland and marsh-open water ecotones.

- Collect physical data on hydroperiod, surface elevation, relative vertical accretion/erosion, and soil characteristics.

*Possible addition at select sites*
Sea Levels Affecting Marshes Model
Rhode Island SLAMM Project

NROC Marsh Migration Workshop
Hugh Gregg Coastal Conservation Center, Greenland, NH
December 2, 2014

James Boyd, Coastal Policy Analyst
RI Coastal Resources Management Council

Photo: R. Hancock
Rhode Island has lost 53% of its historic salt marshes over the last two centuries* due to man-made alterations (ditching and filling) resulting in a loss of about 4000 acres statewide

* Bromberg and Bertness, 2005
Sea Level Affecting Marshes Model
North Kingstown Pilot Project (2011)

http://seagrant.gso.uri.edu/climate/habitat.html

RI SLAMM Project
RI SLAMM Project Goals

1. Develop marsh migration modeling results (maps)
2. Identify existing vulnerable wetlands
3. Identify affected upland parcels – opportunities and challenges
4. Develop new CRMC coastal program adaptive strategies, policies and standards (Beach SAMP)
5. Increase local capacity to proactively incorporate sea level rise for wetlands within comprehensive plans, zoning overlays, conservation efforts, etc.
All 21 Coastal Communities Completed
Engaging Communities through Stakeholder Input

May 2013 – Regional Meeting

October 2013 Barrington and East Providence meeting
Critical Coastal Wetlands
Accretion = 3.8 mm/yr

- Observations from NBNERR SET monitoring (K. Raposa)
- Consistent with median value from literature

105 Sub-Sites

- Historic SLR Trend to estimate subsidence/lift
- Direction offshore
- Erosion/sedimentation
- Storm Frequency

**Tidal Data**
- Range
- Datum Adjustment

RI SLAMM Project
Model Limitations

Uncertainty in Sea Level Rise Projections

Ground Conditions

- Some uplands may be more suitable than others
- Multiple stressors on salt marshes
- Freshwater wetlands may convert to open water

Model Simplifications

- Accretion rates are variable
- Salinity dynamics are simplified

Changing Coastline

- Storm events
- Barrier migration
Model Input: USGS 2011 LiDAR

Palmer River

LiDAR Elevation Data

Feet Above: Mean Tide

RI SLAMM Project
Model Input: National Wetland Inventory 2010

Palmer River

Current Condition

- Developed Upland
- Undeveloped Upland
- Salt Marsh
- Brackish Marsh
- Scrub/Shrub Transitional Marsh
- Tidal Flat
- Swamp
- Fresh Marsh
- Open Water
- Beach
- Rocky Intertidal

RI SLAMM Project
SLAMM Model Results

Palmer River

1 foot Sea Level Rise Model

- Potential Marsh Zone
- Persistent Marsh Zone
- Potential Marsh Loss
- Open Water and Tidal Flat
- Current Freshwater Wetlands
- Protected Open Space
- Parcel Boundaries
- Developed Land
- Buildings
- Hardened Shores

RI SLAMM Project
SLAMM Model Results

Palmer River
3 foot
Sea Level Rise Model

- Potential Marsh Zone
- Persistent Marsh Zone
- Potential Marsh Loss
- Open Water and Tidal Flat
- Current Freshwater Wetlands
- Protected Open Space
- Parcel Boundaries
- Developed Land
- Buildings
- Hardened Shores

RI SLAMM Project
SLAMM Model Results

Palmer River
5 foot Sea Level Rise Model

- Potential Marsh Zone
- Persistent Marsh Zone
- Potential Marsh Loss
- Open Water and Tidal Flat
- Current Freshwater Wetlands
- Protected Open Space
- Parcel Boundaries
- Developed Land
- Buildings
- Hardened Shores

RI SLAMM Project
SLAMM Model Results

Palmer River
5 foot
Sea Level Rise Model

- Potential Marsh Zone
- Persistent Marsh Zone
- Open Water and Tidal Flat
- Current Freshwater Wetlands
- Protected Open Space
- Parcel Boundaries
- Developed Land
- Buildings
- Hardened Shores

RI SLAMM Project
SLAMM Model Results

Palmer River

5 foot Sea Level Rise Model

- Marsh Lost at 5ft SLR
- Marsh Migration Corridor
- Marsh Migration Corridor (unrestricted)
- Affected Parcels
  - Buildings
- Hardened Shorelines

RI SLAMM Project
SLAMM Model Results

Palmer River
1 foot
Sea Level Rise Model

- Potential Marsh Zone
- Persistent Marsh Zone
- Potential Marsh Loss
- Open Water and Tidal Flat
- Current Freshwater Wetlands
- Protected Open Space
- Parcel Boundaries
- Developed Land
- Buildings
- Hardened Shores

RI SLAMM Project
SLAMM Model Results

Palmer River
3 foot
Sea Level Rise Model

- Potential Marsh Zone
- Persistent Marsh Zone
- Potential Marsh Loss
- Open Water and Tidal Flat
- Current Freshwater Wetlands
- Protected Open Space
- Parcel Boundaries
- Developed Land
- Buildings
- Hardened Shores

RI SLAMM Project
SLAMM Model Results

Palmer River
5 foot
Sea Level Rise Model

Potential Marsh Zone
Persistent Marsh Zone
Potential Marsh Loss
Open Water and Tidal Flat
Current Freshwater Wetlands
Protected Open Space
Parcel Boundaries
Developed Land
Buildings
Hardened Shores

RI SLAMM Project
SLAMM Model Results

Palmer River

5 foot Sea Level Rise Model

- Marsh Lost at 5ft SLR
- Marsh Migration Corridor
- Marsh Migration Corridor (unrestricted)
- Affected Parcels
  - Buildings
- Hardened Shorelines

RI SLAMM Project
SLAMM Projected Statewide Salt Marsh Changes due to Sea Level Rise

<table>
<thead>
<tr>
<th>SLR</th>
<th>1 Ft.</th>
<th>3 Ft.</th>
<th>5 Ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss (Acres)</td>
<td>450</td>
<td>1895</td>
<td>3189</td>
</tr>
<tr>
<td>Gain (Acres)</td>
<td>1057</td>
<td>1148</td>
<td>2151</td>
</tr>
<tr>
<td>Net Change (Acres)</td>
<td>607</td>
<td>-747</td>
<td>-1038</td>
</tr>
</tbody>
</table>

50% of Current Salt Marshes

Photo: J. Boyd
<table>
<thead>
<tr>
<th>Town</th>
<th>Coastal Wetland Loss (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrington</td>
<td>330.5</td>
</tr>
<tr>
<td>Bristol</td>
<td>99.2</td>
</tr>
<tr>
<td>Charlestown</td>
<td>321.9</td>
</tr>
<tr>
<td>Cranston</td>
<td>2.3</td>
</tr>
<tr>
<td>East Greenwich</td>
<td>0.4</td>
</tr>
<tr>
<td>East Providence</td>
<td>71.1</td>
</tr>
<tr>
<td>Jamestown</td>
<td>116.0</td>
</tr>
<tr>
<td>Little Compton</td>
<td>96.5</td>
</tr>
<tr>
<td>Middletown</td>
<td>42.6</td>
</tr>
<tr>
<td>Narragansett</td>
<td>354.0</td>
</tr>
<tr>
<td>New Shoreham</td>
<td>61.4</td>
</tr>
<tr>
<td>Newport</td>
<td>19.1</td>
</tr>
<tr>
<td>North Kingstown</td>
<td>148.6</td>
</tr>
<tr>
<td>Pawtucket</td>
<td>0.1</td>
</tr>
<tr>
<td>Portsmouth</td>
<td>357.6</td>
</tr>
<tr>
<td>Providence</td>
<td>3.1</td>
</tr>
<tr>
<td>South Kingstown</td>
<td>275.9</td>
</tr>
<tr>
<td>Tiverton</td>
<td>273.9</td>
</tr>
<tr>
<td>Warren</td>
<td>242.4</td>
</tr>
<tr>
<td>Warwick</td>
<td>195.9</td>
</tr>
<tr>
<td>Westerly</td>
<td>246.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3,258.8</td>
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</tbody>
</table>
Freshwater (palustrine) wetland losses due to SLR

Middlebridge

3 foot
Sea Level Rise Model

- Potential Marsh Zone
- Persistent Marsh Zone
- Potential Marsh Loss
- Open Water and Tidal Flat
- Current Freshwater Wetlands
- Protected Open Space

- Parcel Boundaries
- Developed Land
- Buildings
- Hardened Shores

RI SLAMM Project
<table>
<thead>
<tr>
<th>Town</th>
<th>1ft SLR</th>
<th>3ft SLR</th>
<th>5ft SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrington</td>
<td>32.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bristol</td>
<td>5.9</td>
<td></td>
<td></td>
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<tr>
<td>Charlestown</td>
<td>7.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cranston</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>East Providence</td>
<td>2.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jamestown</td>
<td>5.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little Compton</td>
<td>12.1</td>
<td></td>
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</tr>
<tr>
<td>Middletown</td>
<td>9.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Narragansett</td>
<td>5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Shoreham</td>
<td>26.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newport</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Kingstown</td>
<td>9.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portsmouth</td>
<td>7.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Kingstown</td>
<td>9.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tiverton</td>
<td>32.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warren</td>
<td>13.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warwick</td>
<td>4.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Westerly</td>
<td>15.6</td>
<td></td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>203.8</strong></td>
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</table>

Rhode Island
Freshwater Wetland Losses due to SLR

Narrow River Cattail Marsh
Photo: J. Boyd – 09/12/2014
SLAMM maps on CRMC web page

RI SLAMM Project
Action 6.5.3 - Adopt Sea Level Affecting Marshes Model (SLAMM) data and projections as planning and decision-making support tool in statewide coastal wetland monitoring, protection and restoration strategy

http://www.planning.ri.gov/statewideplanning/climate/index.php

RI SLAMM Project
Please join us for a workshop on...

**Protecting Coastal Wetlands in Your Community in Consideration of Sea Level Rise**

~~~~~~~~~

**Tuesday, October 28, 2014**
9:00 am to 12:00 pm
RWU School of Law
Bristol, RI

**OR**

Thursday, October 30, 2014
9:00 am to 12:00 pm
URI Coastal Institute
Narragansett, RI

~~~~~~3 AICP credits offered~~~~~~

Our coastal wetlands are some of the most productive ecosystems on Earth. They are extremely important for wildlife, contributing greatly to Rhode Island's valuable commercial and recreational fisheries, they purify water, and they help reduce storm damage to our valuable coastal areas by absorbing high wind and wave energy. Unfortunately, our coastal wetlands are very susceptible to impacts from climate change, particularly sea level rise. Projections show that RI could lose one-half of its existing coastal wetlands with 3 feet of sea level rise.

Please join us to learn about the results of a project investigating the potential impacts to our coastal wetlands resulting from climate change-induced sea level rise and the landward migration possibilities of these wetlands in RI’s coastal communities. Hear from experts about how to access and use new maps showing upland areas in your community that may provide the best opportunity for wetland migration and how to incorporate the new information and tools into your community’s plans and initiatives while aligning them with state efforts. Also learn about specific adaptation strategies that can be used to help protect and restore our coastal wetlands into the future.

This workshop is free of charge. A light breakfast will be provided from 8:30-9:00 am. Please register [here](https://www.surveymonkey.com/s/5KDOPLN) to attend (or copy and paste https://www.surveymonkey.com/s/5KDOPLN into your browser). Please register by Tuesday, October 21.

**Questions?** Please contact Jennifer West at [jennifer@nbnerr.org](mailto:jennifer@nbnerr.org) or 401-222-4700, ext 7413.

~~~~~~~~~Please spread the word!~~~~~~~~~
SLAMM Project is part of the Shoreline Change (Beach) SAMP

http://seagrant.gso.uri.edu/climate/habitat.html www.beachsamp.org

RI SLAMM Project
A Very Big Thank You to NOAA for Funding the RI SLAMM Project with a Coastal and Ocean Climate Applications Grant!
Marsh Migration Modeling in Long Island Sound

David Kozak <david.Kozak@ct.gov>, CT DEEP-Office of Long Island Sound Program
Kevin O’Brien <kevin.Obrien@ct.gov>, CT DEEP- Office of Long Island Sound Program

Saltmarsh sparrows waits as Black grass invades forest understory, photos by Scott Warren and Paul Fusco
Long Island Sound – America’s Urban Sea
Long Island Sound – By the Numbers

Area of the Long Island Sound ................................................. 1,320 square miles
Area of the drainage basin or watershed ................................ 16,820 square miles
Average Depth ................................................................. 63 feet (60-120 feet)
Water Volume ............................................................... 18 trillion gallons
Length of Coastline ......................................................... 600 miles
Salinity range at the western end ........................................... 23 parts per thousand
Salinity range at the eastern end ........................................... 35 parts per thousand
% of fresh water that comes from three major rivers .................. 90%
Avg. winter and summer water temperatures (2011) .............. 37°F winter/69°F summer
No. of tides each day (greatest tides in the west) ....................... 4 tides (2 high, 2 low)
Population living within 50 miles ....................................... more than 23 million people
Estimated value to the local economy per year ....................... $8.91 billion (2011 dollars)
No. of finfish species found in the Sound ................................. More than 120 finfish species
No. of tropical species that stray here seasonally .................... 21 tropical species
No. of species that spawn in the Sound ................................ at least 50 species
Long Island Sound (LIS) Tidal Marshes-West

Legend
- NY Marsh Wetlands - NWI
- Estuarine and Marine Wetland
- Freshwater Emergent - NWI
- CT Marsh Wetlands - NWI
- Estuarine and Marine Wetland
- Freshwater Emergent - NWI
- CT Marsh High Priority Sites
  - Brokered Marsh
  - Freshwater Marsh
  - Salt Marshs
  - LIS Sound East-West  .Join
  - LIGS Coastal Boundary
  - Urban Areas

Total Western Marsh Wetlands from NWI
- Count = 720 sites
- Sum = 5,800 Acres
- Connecticut - West
  - Count = 270 NWI wetland sites
  - Sum = 2,800 Acres
  - Mean 10 Acres
- New York - West
  - Count = 450 NWI wetland sites
  - Sum = 3,000 Acres
  - Mean 7 Acres

Western Long Island Sound Marsh Wetlands
Modeling Approach

• SLR Affecting Marsh Migration (SLAMM) with uncertainty analysis*

• Study period: 4 time-steps 2010 → 2100

• SLR scenarios: 0.4 ft → 5.6 ft
   (2025) → (2100)

• Area of study: Area up to +5 meters (MSL)

CT’s SLAMM Study Area: + 5 meters (MSL)

~575 sq mi of land area (grey)
## Sea-Level-Rise Scenarios

SLR scenarios relative to the base year of (2002) in meters / feet

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2025</th>
<th>2055</th>
<th>2085</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Climate Model Maximum</td>
<td>.13 / .4</td>
<td>.31 / 1.0</td>
<td>.58 / 1.9</td>
<td>.72 / 2.4</td>
</tr>
<tr>
<td>1 m by 2100</td>
<td>.13 / .4</td>
<td>.43 / 1.4</td>
<td>.81 / 2.7</td>
<td>1.0 / 3.3</td>
</tr>
<tr>
<td>Rapid Ice Melt Minimum</td>
<td>.13 / .4</td>
<td>.48 / 1.6</td>
<td>1.0 / 3.3</td>
<td>1.3 / 4.3</td>
</tr>
<tr>
<td>Rapid Ice Melt Maximum</td>
<td>.25 / .8</td>
<td>.74 / 2.4</td>
<td>1.40 / 4.6</td>
<td>1.72 / 5.6</td>
</tr>
</tbody>
</table>
# North Shore LIS SLAMM Results CT + Westchester, NY

## Modeled land cover change 2010 - 2100

<table>
<thead>
<tr>
<th>Land cover category</th>
<th>Acres in 2010</th>
<th>Percent land cover change from 2010 to 2100</th>
<th>CT Acres in 2100 (1m)</th>
<th>Westchester 2100 (1m)</th>
<th>Acres No. Shore LIS 2100 (1m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>GCM Max</td>
<td>1m</td>
<td>RIM Min</td>
<td>RIM Max*</td>
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<tr>
<td>Undeveloped Dry Land</td>
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<tr>
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<td><em><em>Σ</em> (RIM Max.)</em>*</td>
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</tr>
</tbody>
</table>

1. Includes 223 acres in Westchester
Sample Model Output Data - CT River Estuary

Land Cover Classes:

- Developed Dry Land
- Undeveloped Dry Land
- Swamp
- Inland Fresh Marsh
- Tidal Fresh Marsh
- Transitional Salt Marsh
- Regularly-flooded Marsh
- Estuarine Beach
- Tidal Flat
- Rocky Intertidal
- Inland Open Water
- Riverine Tidal
- Estuarine Open Water
- Irregularly-flooded Marsh
- Inland Shore
- Tidal Swamp
- Flooded Developed Dry Land

SLR: 0.81m (2.7ft)
Time step - 2085
Sample Model Output Data - CT River Estuary

Uncertainty Range:

- High: 100
- Low: 0

Land Cover Classes:
- Developed Dry Land
- Undeveloped Dry Land
- Swamp
- Inland Fresh Marsh
- Tidal Fresh Marsh
- Transitional Salt Marsh
- Regularly-flooded Marsh
- Estuarine Beach
- Tidal Flat
- Rocky Intertidal
- Inland Open Water
- Riverine Tidal
- Estuarine Open Water
- Irregularly-flooded Marsh
- Inland Shore
- Tidal Swamp
- Flooded Developed Dry Land

SLR: 0.81m (2.7ft)
Time Step - 2085
Rates of Saltmarsh Migration?

Can’t ya migrate any faster?!
Modeling Limitations/Considerations

• LiDAR error/accuracy (what is acceptable std. dev. with actual bare earth elevation?)

• Limited IFM accretion (SET) data spanning entire elevation range

• NWI \(\rightarrow\) SLAMM wetland/land cover codes

• Not all model data sets (e.g. impervious cover) had the same 5m LiDAR resolution

• Variation in state wetland and SLAMM nomenclature /classification (e.g., tidal swamp)

• Insufficient SET data low in the tidal frame (RFMs)
Modeling Limitations/Considerations (cont.)

- Hydraulic connectivity may not be corrected through hydro-modifications
- Not a hydrodynamic model (accurate river/embayment predictions?)
- Incomplete accretion rates for RFMs using MEM

**Key MEM data deficiencies:**

- Suspended sediment concentration
- Standing biomass density
- Organic matter decay rates
- Below ground biomass contribution parameters
- Sediment settling velocities
- Partition between organic and non-organic accretion components
LIS SLAMM II?

What Would We Do Differently?

- Re-evaluate how SLAMM converts dry land to saltmarsh based on results of forthcoming research by Anisfeld, et al.

- Assemble more robust data for RFM accretion

- Re-examine MEM model assumptions and input values

- More detailed short term modeling (2020-2025?) with field monitoring to test accuracy of predictions (or hind-casting?)
Don’t Get Caught with Your Back to a Rising Tide

Use SLAMM!