Impacts from Sea Level Rise in the Albemarle-Pamlico Region: Dare County Peninsula

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Alion Science and Technology

Acknowledgements

- Funding: Department of Defense Legacy Natural Resource Program
  Legacy Project 08-410

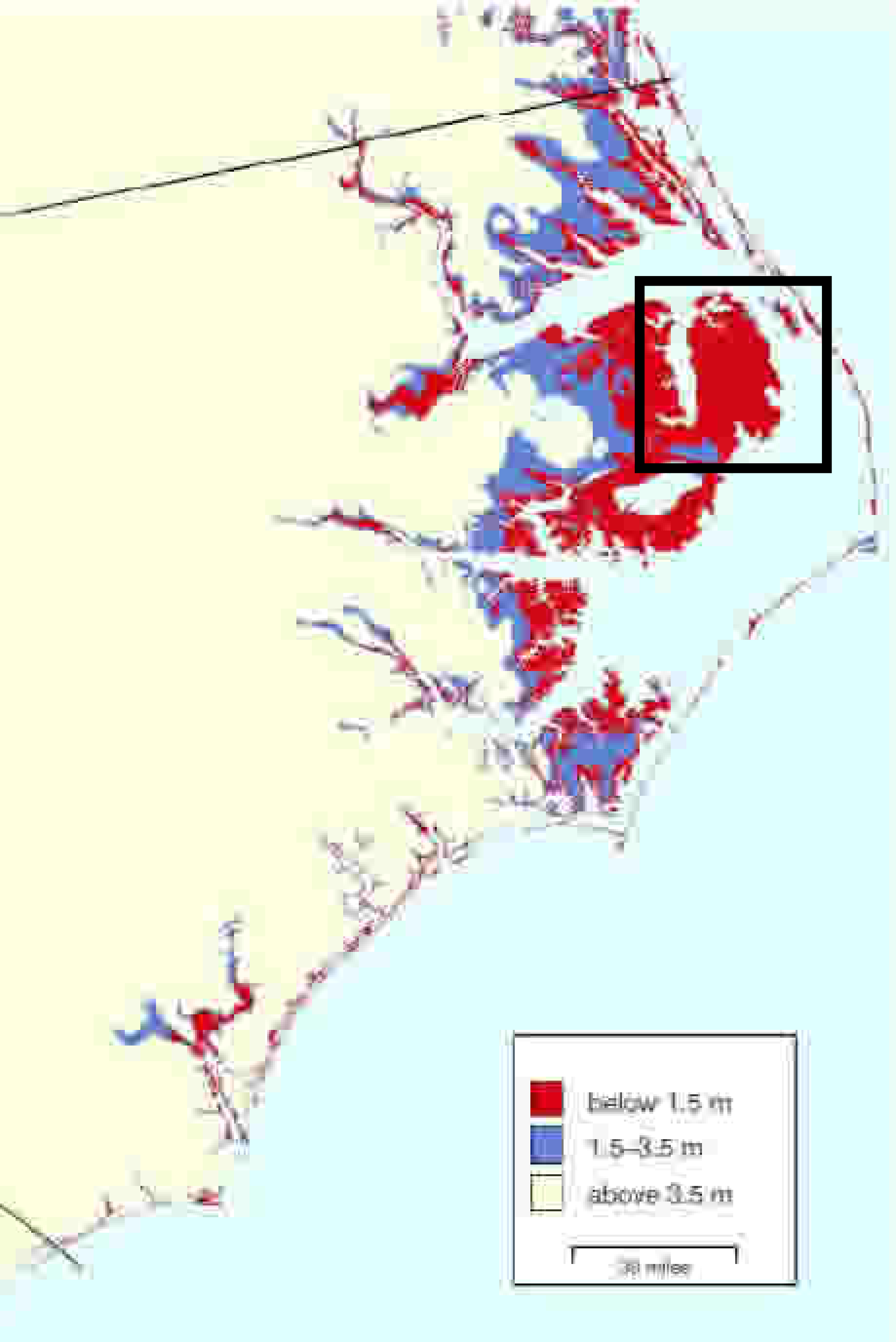
- Alion Science and Technology

Dr. Dean Carpenter, Albemarle-Pamlico National Estuary Program STAC

Objectives

- Sea Level Rise Predictions
- Modeling Impacts of Sea Level Rise
- Model Simulations on Dare County Peninsula
- Discussion:
  - Applying SLR rise models to predict impact of mitigation/ restoration
  - Research needs

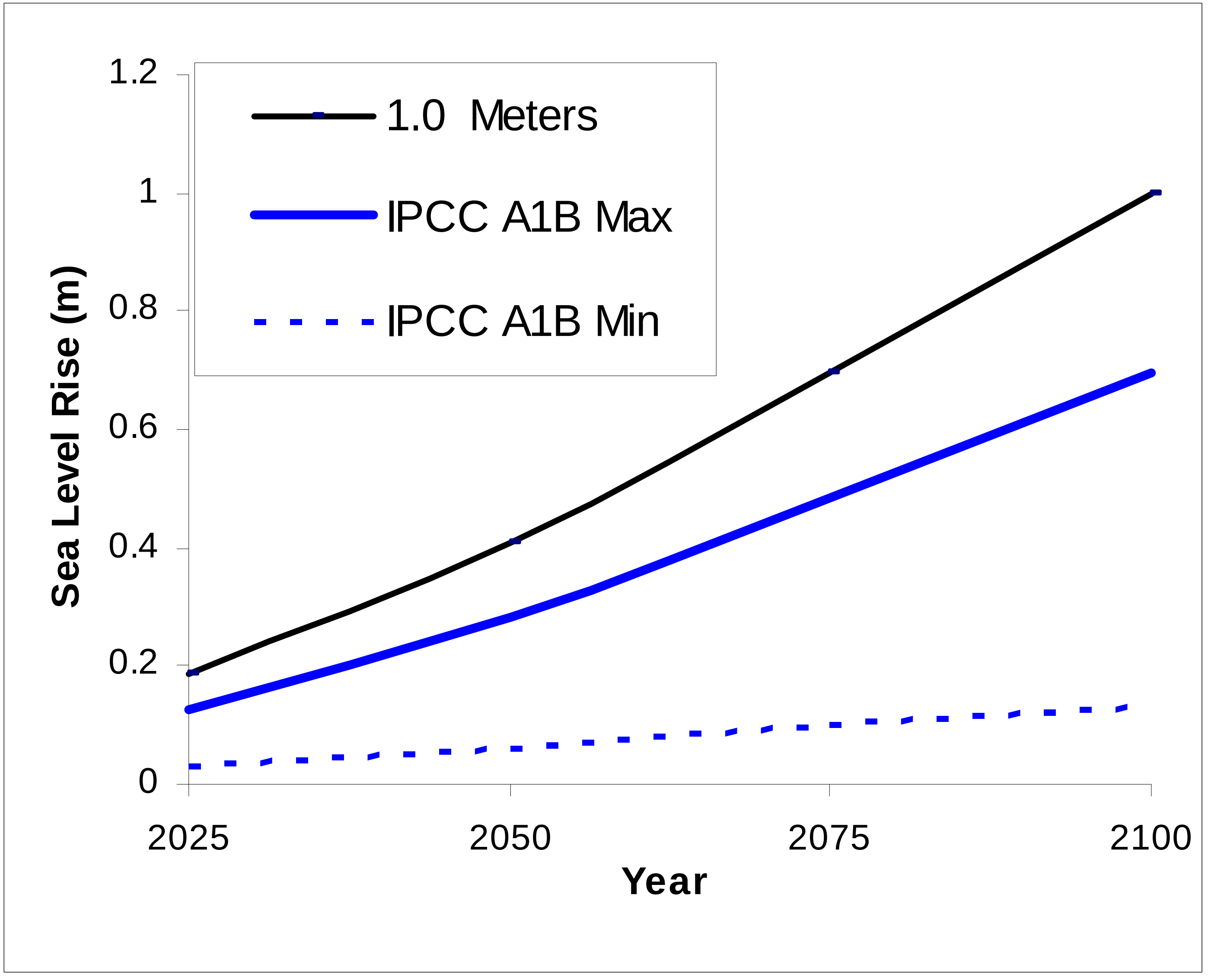
Vulnerability to Sea Level Rise Along the North Carolina Coast, Albemarle-Pamlico Region



Titus and Richman 2001

What will be the change in eustatic sea levels by 2100?

- IPCC Scenarios
  - Various ‘storylines’
  - We chose the ‘A1B’ storyline
    - Max 0.7 m increase from 1990 levels
    - Min 0.13 m increase from 1990 levels
- Recent research: oceans may rise more than a meter / century (Overpeck et al. 2006)



Sea Level Rise Scenarios

Models of Sea Level Rise Impact

- Bathtub models
  - Raise level of the ocean and see what land area floods
  - Coastline studies
  - Global Change
- SLAMM
  - Sea Level Affecting Marsh Model
  - Simulates transitions from one wetland type to another as ocean levels rise (and floods uplands).

Model Development Overview

- 1986 SLAMM developed with EPA funding (Park et al. 1986)
- 1991 SLAMM2 simulated parts of U.S. coast for EPA report to Congress
- 1993 SLAMM3 applied to Puget Sound and Florida (*Geocarto International,* 1993)
- 1998 SLAMM4 improvements in resolution, mapping components added.
- 2008 SLAMM5 more SLR scenarios, refinements such as a salt wedge model in estuaries

SLAMM Model Processes Overview

- Inundation: Calculated based on the minimum elevation and slope of the cell.

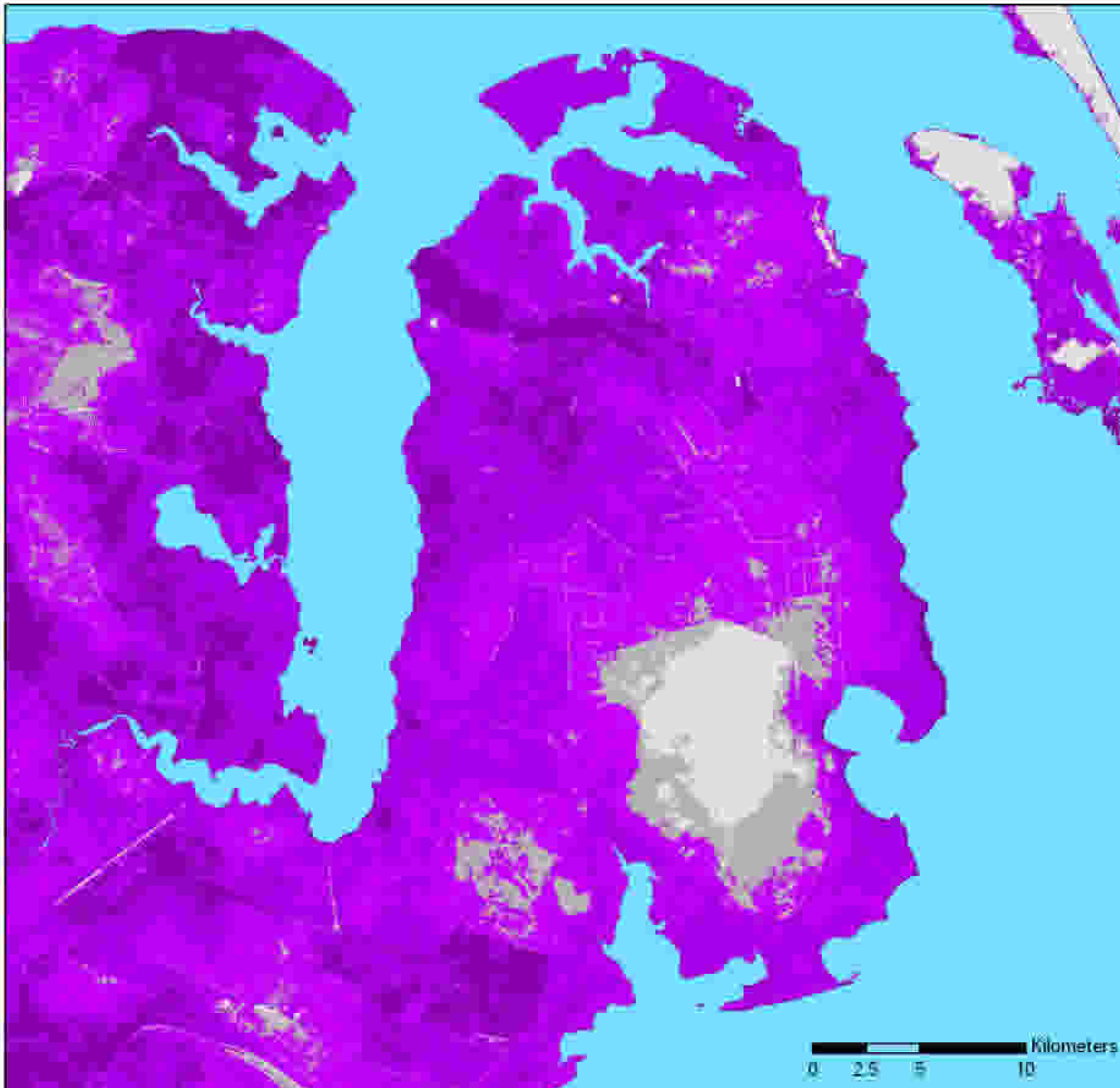
- Erosion: Based on fetch calculation the model performs, user-supplied inputs provide additional information

- Accretion: Vertical rise of marsh due to buildup of organic and inorganic matter on the marsh surface. Rate differs by wetland type.

Input Requirements

- GIS Data
  - DEM
    - Elevation
    - Slope
  - National Wetland Inventory: wetland types and upland simplified into general land cover classes
- User-supplied parameters

Dare County Peninsula Elevation Classes



Model inputs: SLAMM Classes Derived from NWI

1. Developed Upland	10. Inland Open Water
2. Undeveloped Upland	11. Riverine Tidal Open Water
3. Swamp, Forested Wetland	12. Estuarine Open Water
4. Cypress Swamp	13. Open Ocean
5. Freshwater Marsh	14. Brackish Marsh
6. Marsh Transition	15. Tidal Swamp
7. Salt Marsh	
8. Estuarine Beach	
9. Tidal Flat	

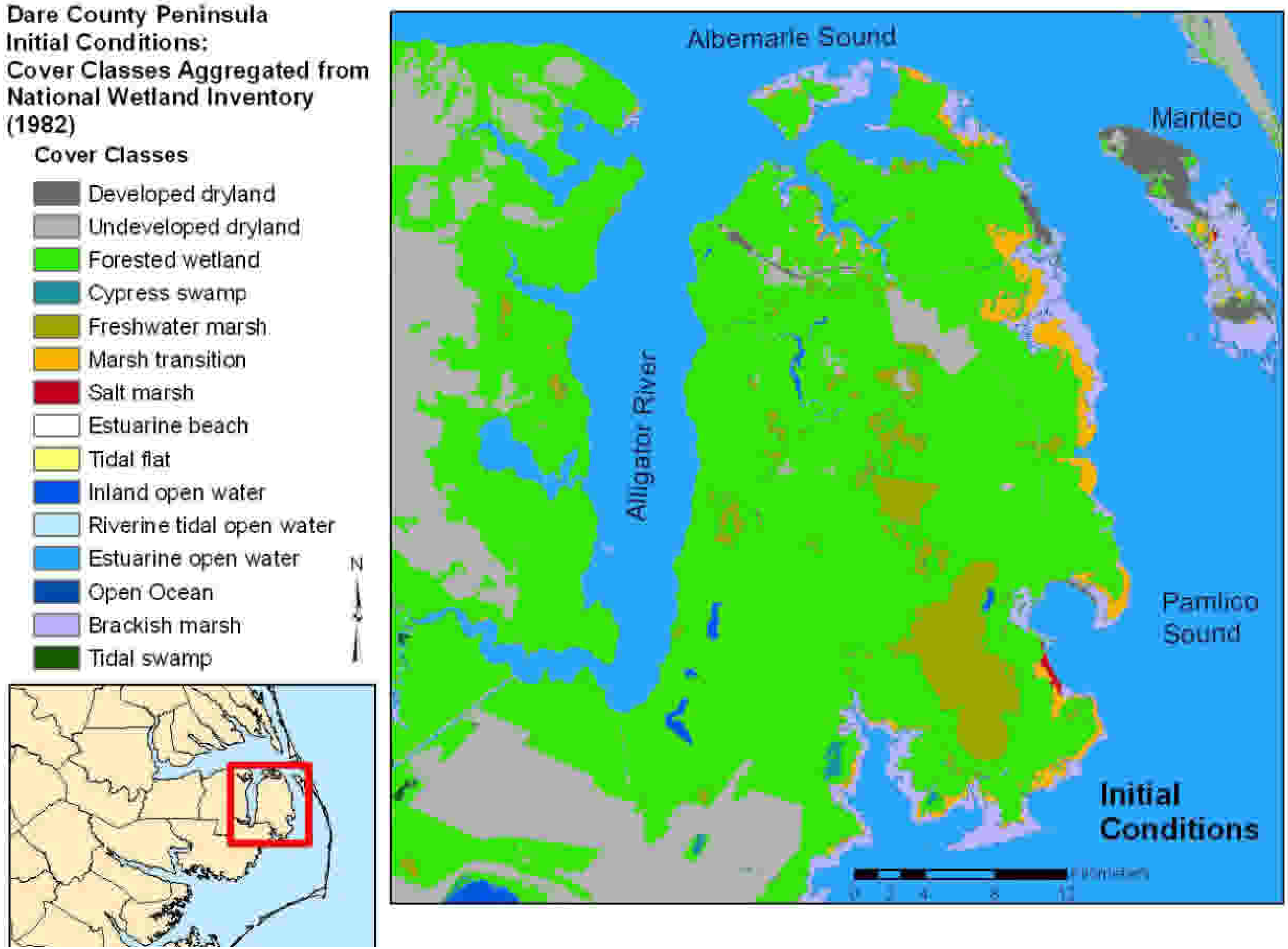
Model Inputs: User-Supplied Parameters

Parameter	Value	Ref.
Historic trend (mm/yr)	-2.82	NOAA tidal datum Oregon Inlet
Marsh erosion (horiz. m/yr)	0.52	Riggs 2001
Swamp erosion (horiz. m/yr)	0.64	Riggs 2001
Salt marsh accretion (mm/yr)	1.2	Craft 1993, Hackney and Cleary 1987
Brackish marsh accretion (mm/yr)	3.1	Craft et al. 2003

Results

- 3 Scenarios
- The ‘Good’ IPCC A1B Minimum (0.13 m sea level rise by 2100)
- The ‘Bad’ IPCC A1B Maximum (0.7 m sea level rise by 2100)
- The ‘Ugly’ 1.0 m by 2100 (Mentioned at IPCC meeting)

IPCC Scenario A1B MINIMUM


Dare County Peninsula
Initial Conditions:
Cover Classes Aggregated from
National Wetland Inventory
(1982)
Cover Classes
Developed dryland
Undeveloped dryland
Forested wetland
Cypress swamp
Freshwater marsh
Marsh transition
Salt marsh
Estuarine beach
Tidal flat
Inland open water
Riverine tidal open water
Estuarine open water
Open Ocean
Brackish marsh
Tidal swamp
N
Albemarle Sound
Manteo
Alligator River
Pamlico
Sound
Initial
Conditions

Dare County Peninsula
IPCC Scenario
A1B Minimum

0.13 m Eustatic
Sea Level Rise
by 2100

Cover Classes

- Developed dryland
- Undeveloped dryland
- Forested wetland
- Cypress swamp
- Freshwater marsh
- Marsh transition
- Salt marsh
- Estuarine beach
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- Inland open water
- Riverine tidal open water
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- Open Ocean
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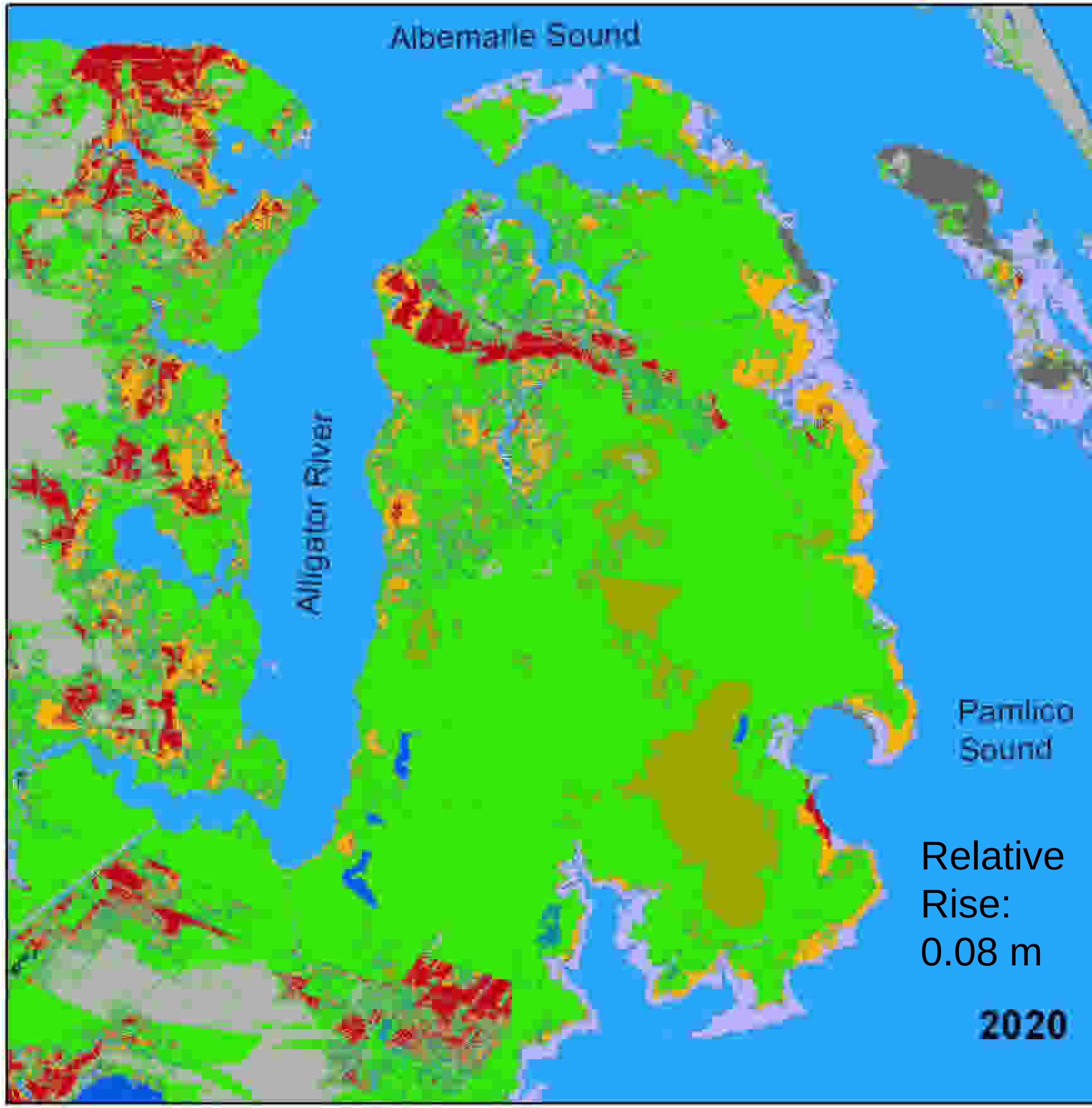
- Tidal swamp

N

Kilometers
0 2 4 8 12



Dare County Peninsula
IPCC Scenario
A1B Minimum

0.13 m Eustatic
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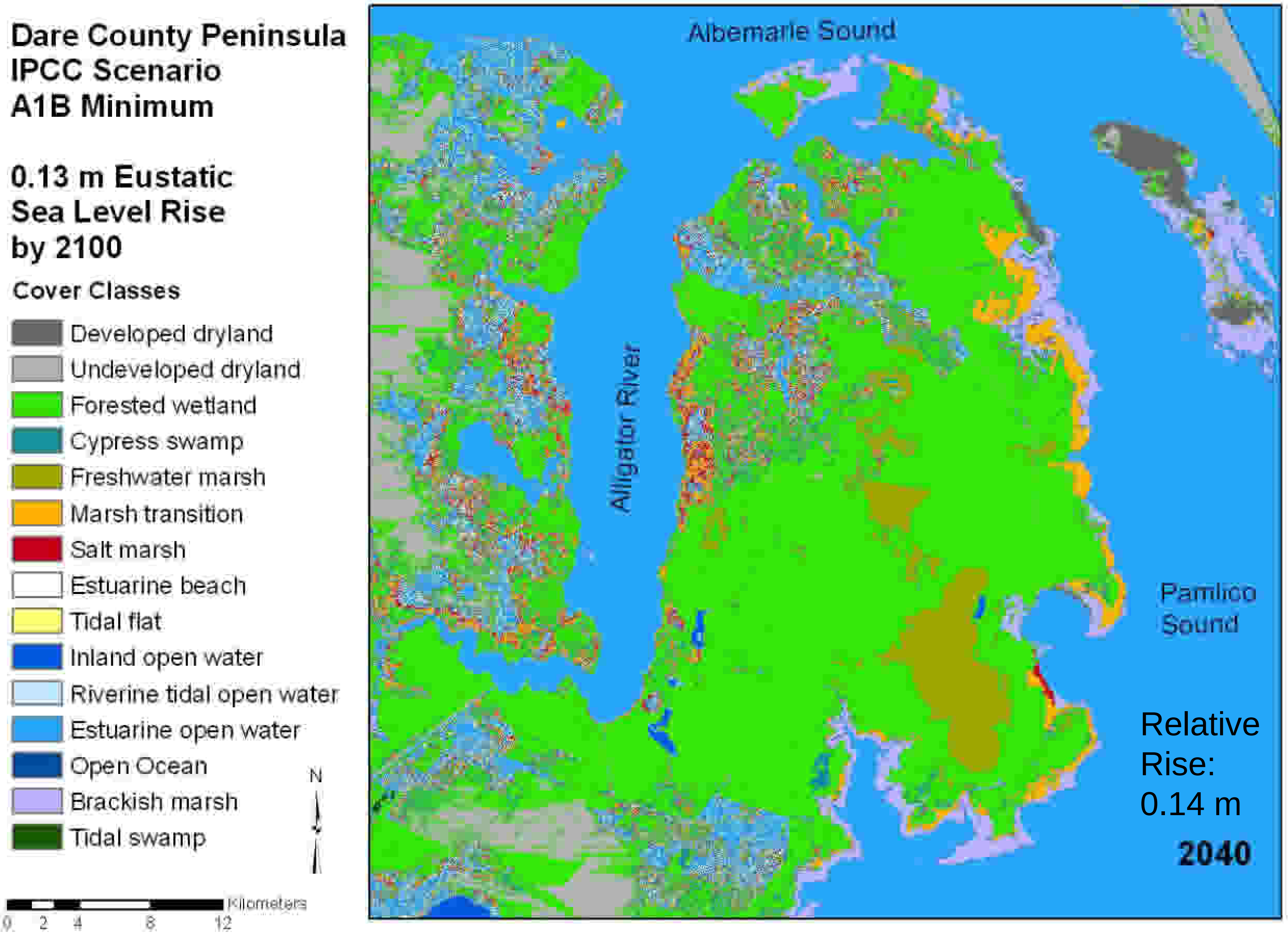

Dare County Peninsula IPCC Scenario A1B Minimum

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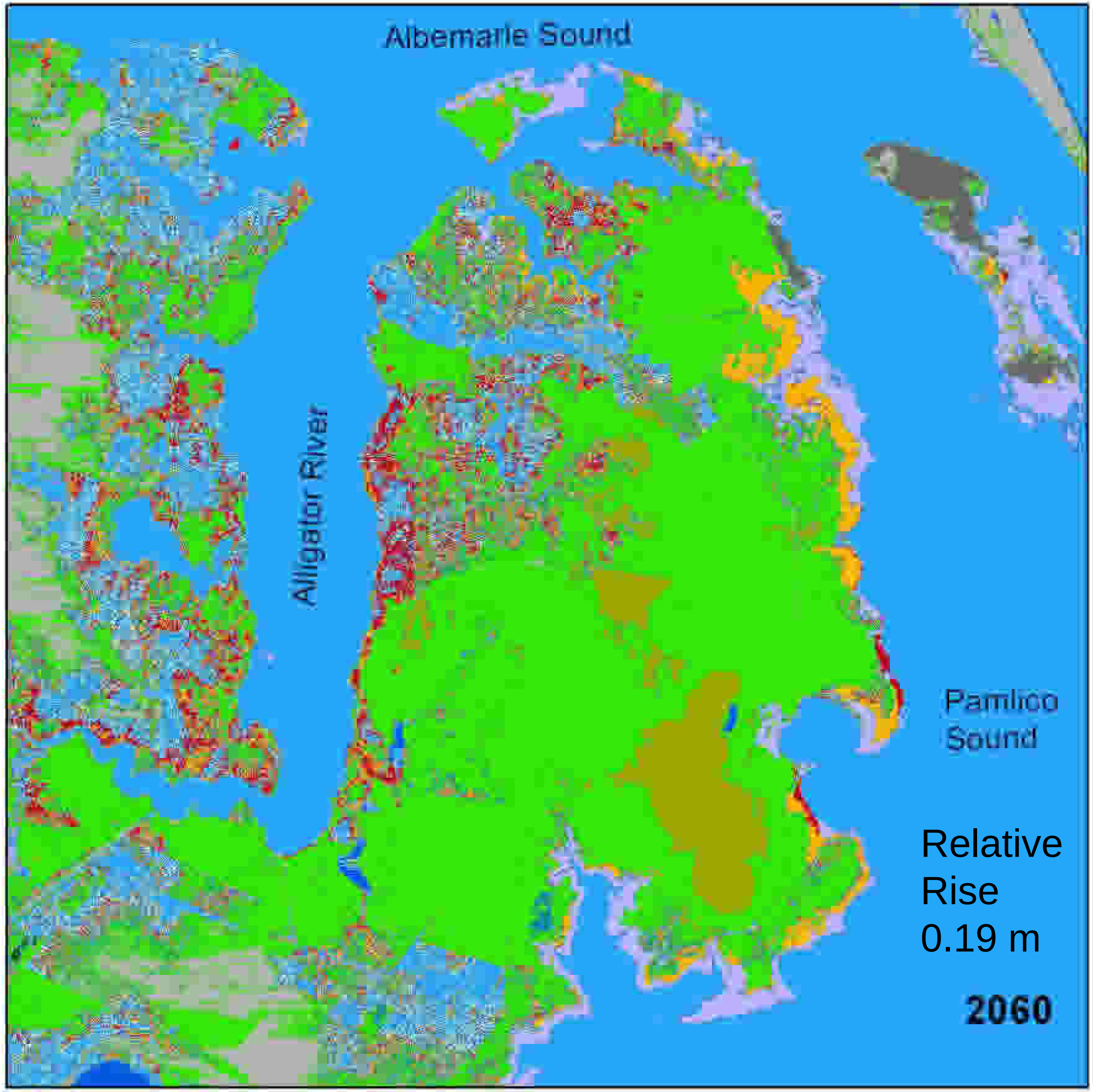

Dare County Peninsula
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A1B Minimum

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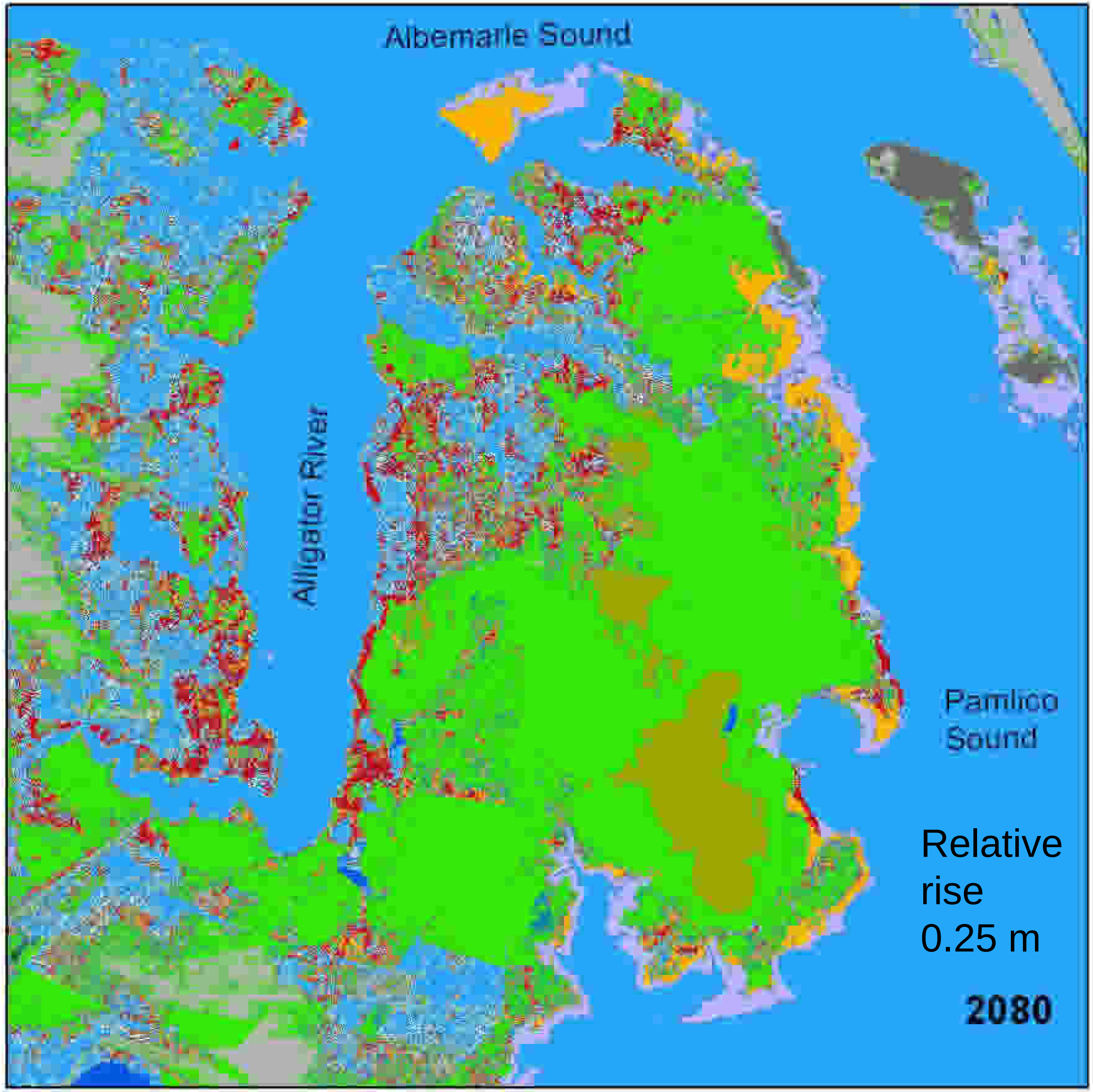

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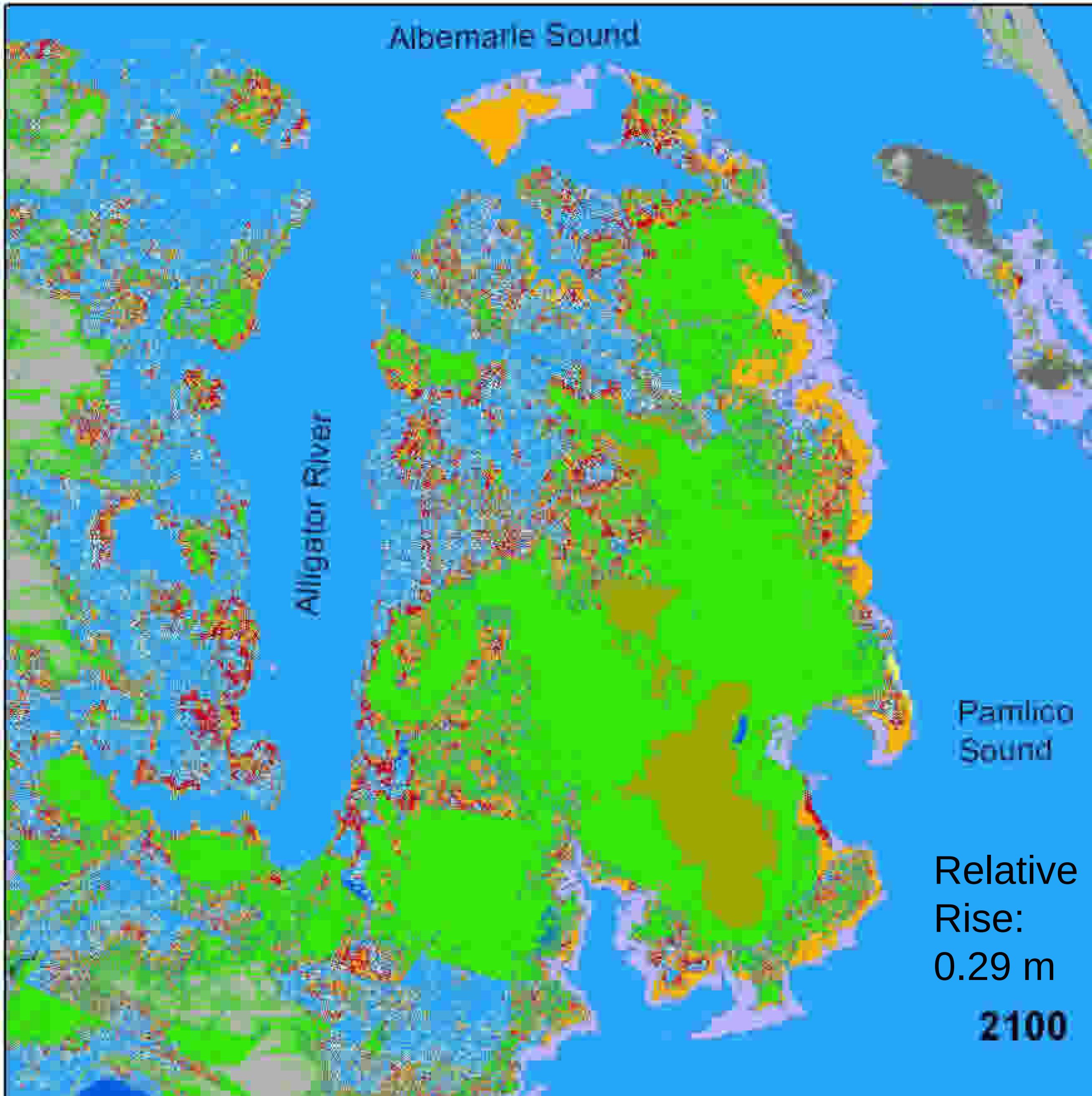

IPCC A1 B Minimum Results:

Land Cover Category	% Loss From Initial Conditions Year					Total Loss in Land Area: Initial Conditions to 2100
	2020	2040	2060	2080	2100	
Developed Upland Change	-2%	-2%	-3%	-5%	-7%	-160 ha
Undeveloped Upland Change	-35%	-42%	-46%	-50%	-53%	-19,000 ha
Forested Wetland Change	-9%	-13%	-20%	-27%	-34%	-36,000 ha

IPCC Scenario A1B MAXIMUM

Dare County Peninsula
IPCC Scenario
A1B Maximum

0.7 m Eustatic Sea Level Rise by 2100

Legend

- Current shoreline
- Developed dryland
- Undeveloped dryland
- Forested wetland
- Cypress swamp
- Freshwater marsh
- Marsh transition
- Salt marsh
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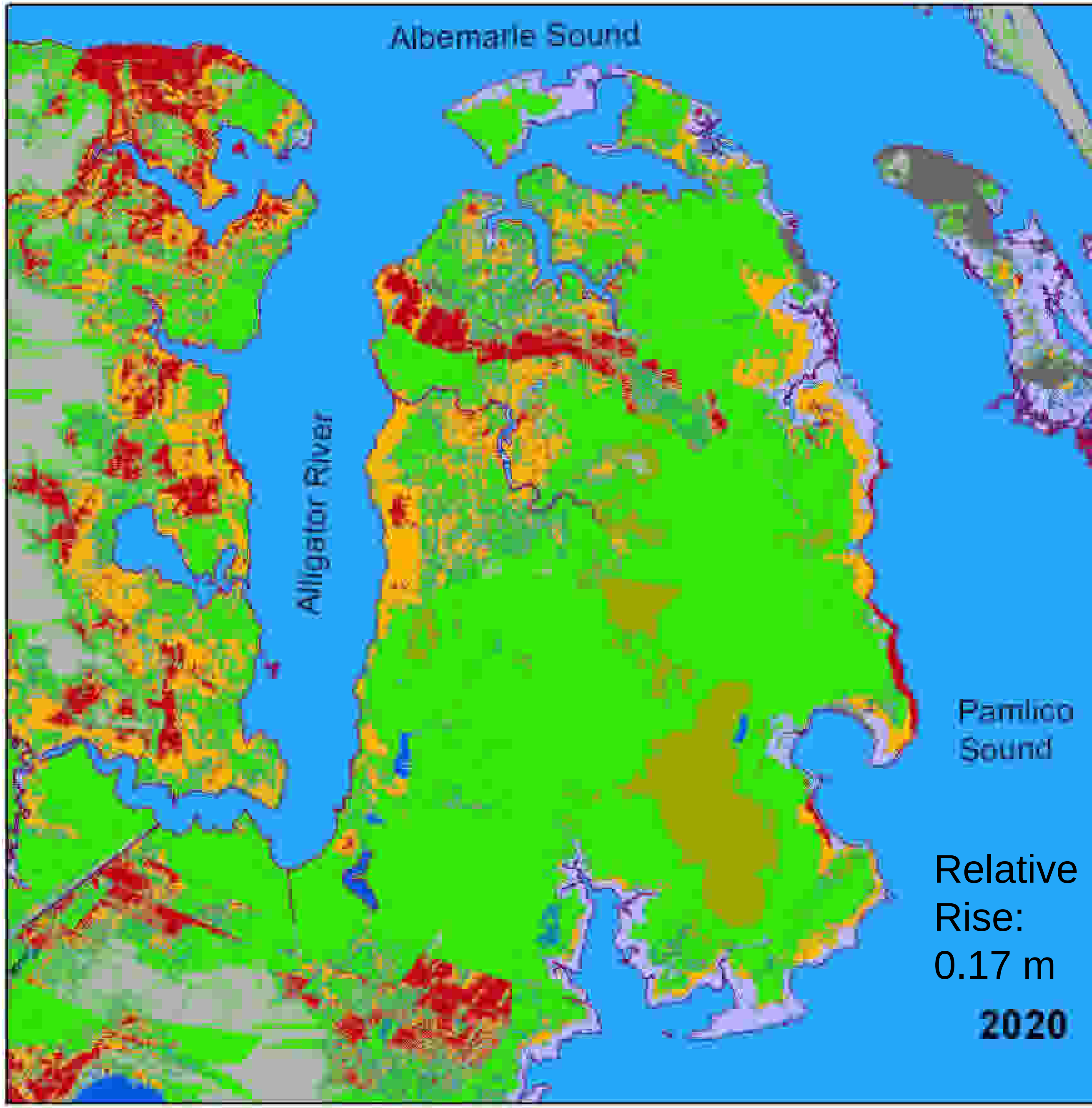
0 2 4 8 12 Kilometers



Dare County Peninsula
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A1B Maximum

0.7 m Eustatic
Sea Level Rise
by 2100

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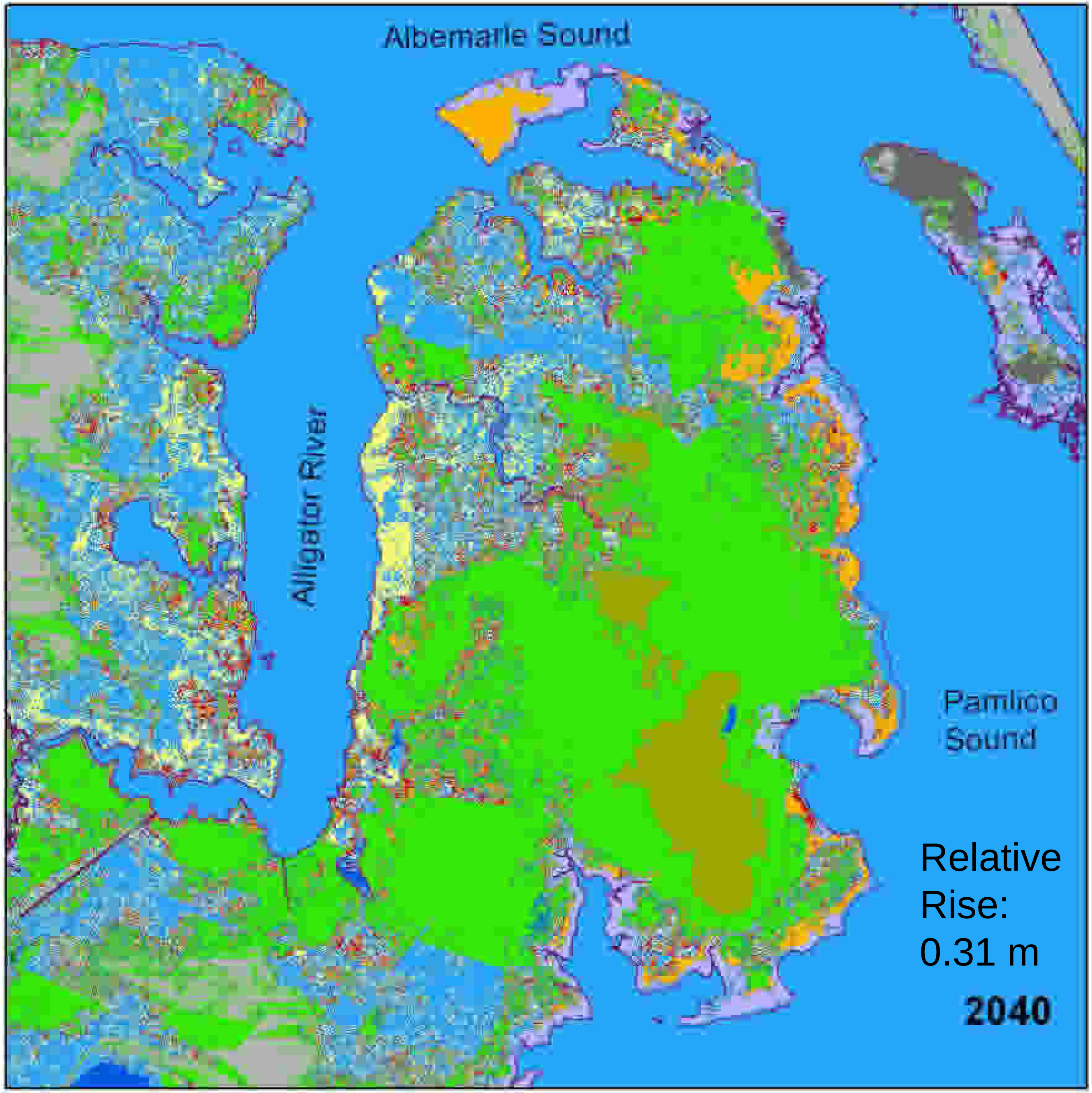

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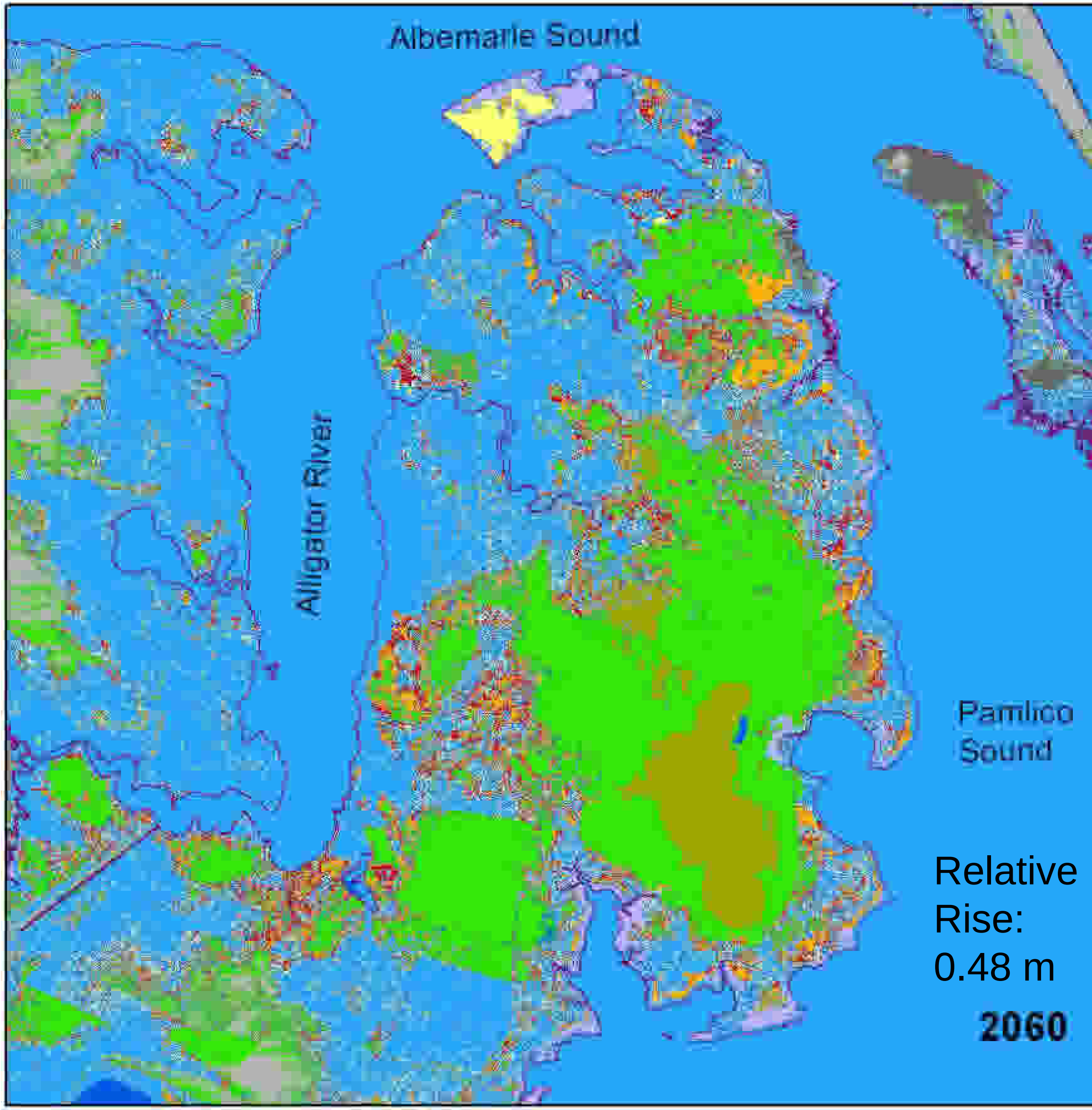
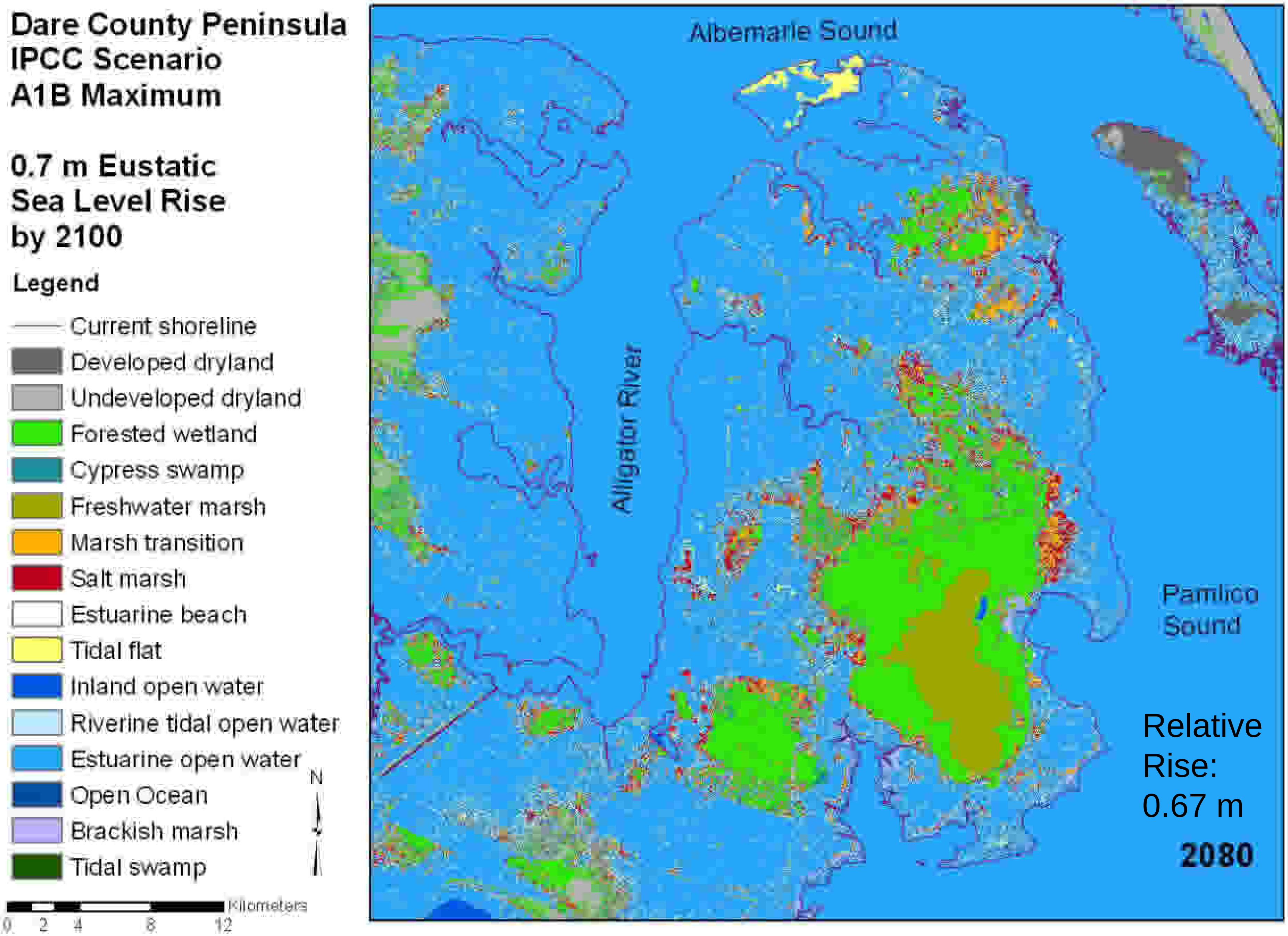


Dare County Peninsula IPCC Scenario A1B Maximum

0.7 m Eustatic Sea Level Rise by 2100



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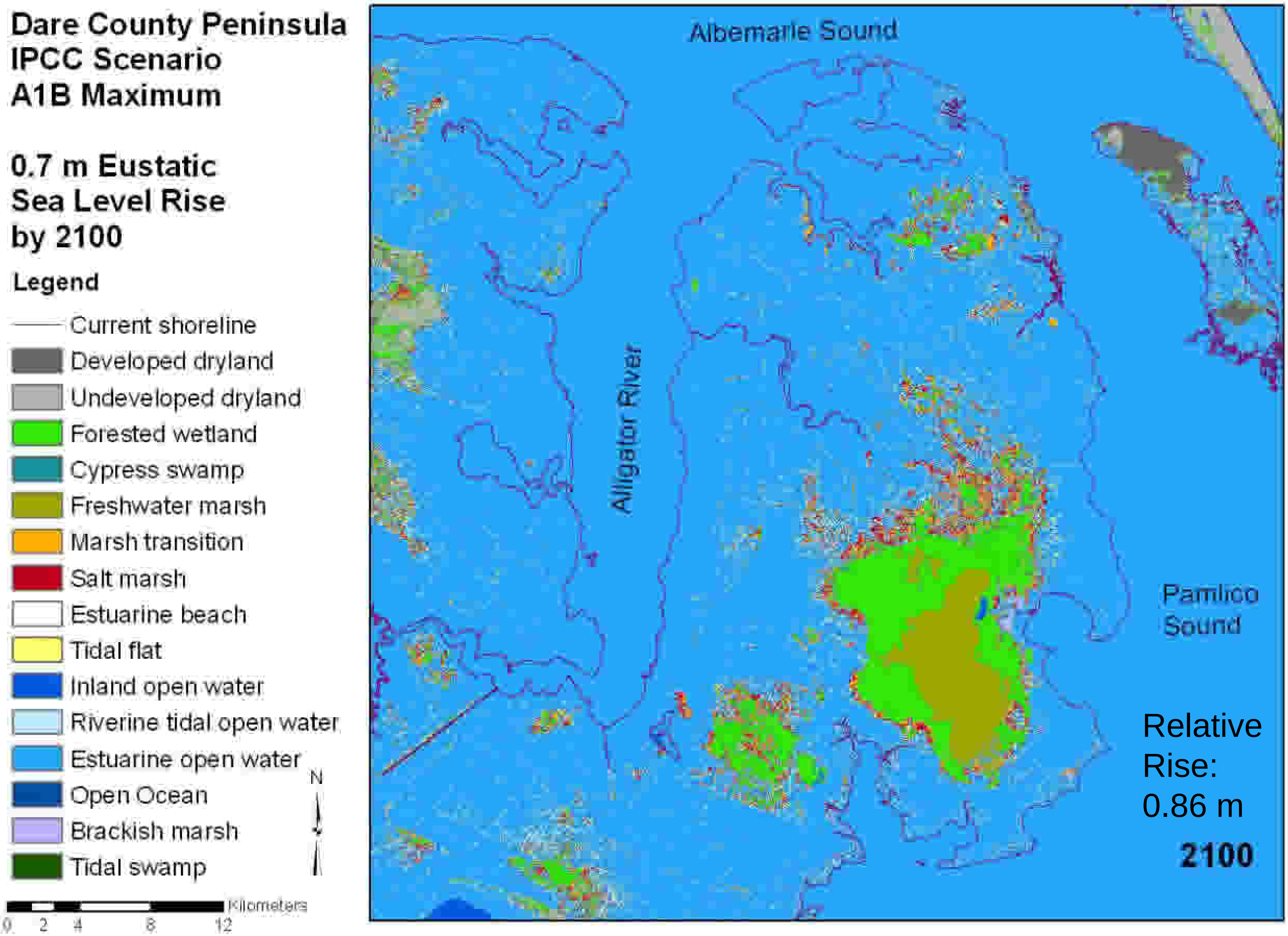
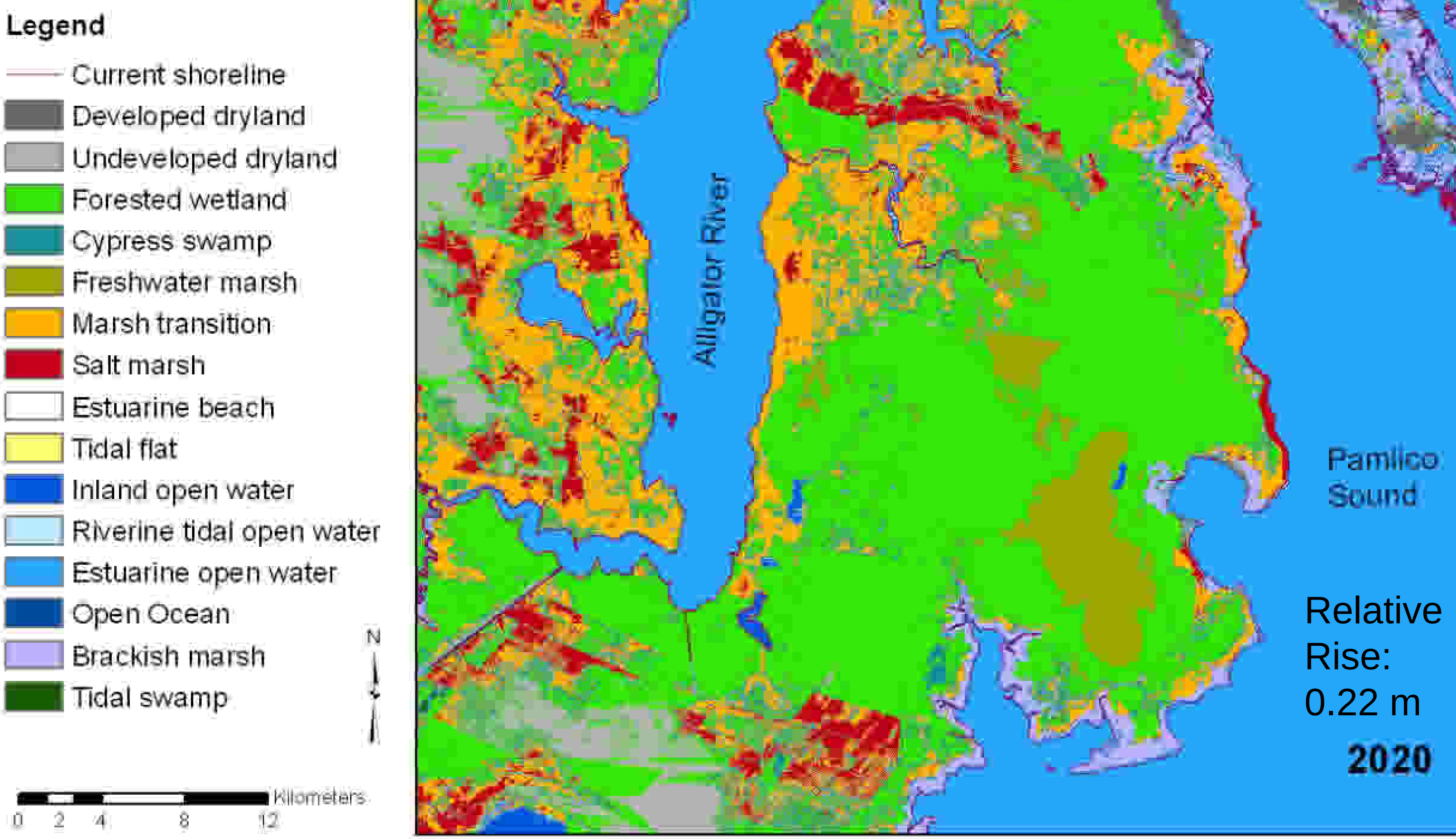


IPCC A1B Maximum Results:

Land Cover Category	% Loss From Initial Conditions Year					Total Loss in Land Area: Initial Conditions to 2100
	2020	2040	2060	2080	2100	
Developed Upland Change	-2%	-8%	-15%	-23%	-30%	-690 ha
Undeveloped Upland Change	-42%	-53%	-62%	-73%	-83%	-30,300 ha
Forested Wetland Change	-20%	-39%	-62%	-77%	87%	-94,000 ha

1.0 m by 2100

Dare County Peninsula Scenario:
1.0 m Sea Level Rise by 2100



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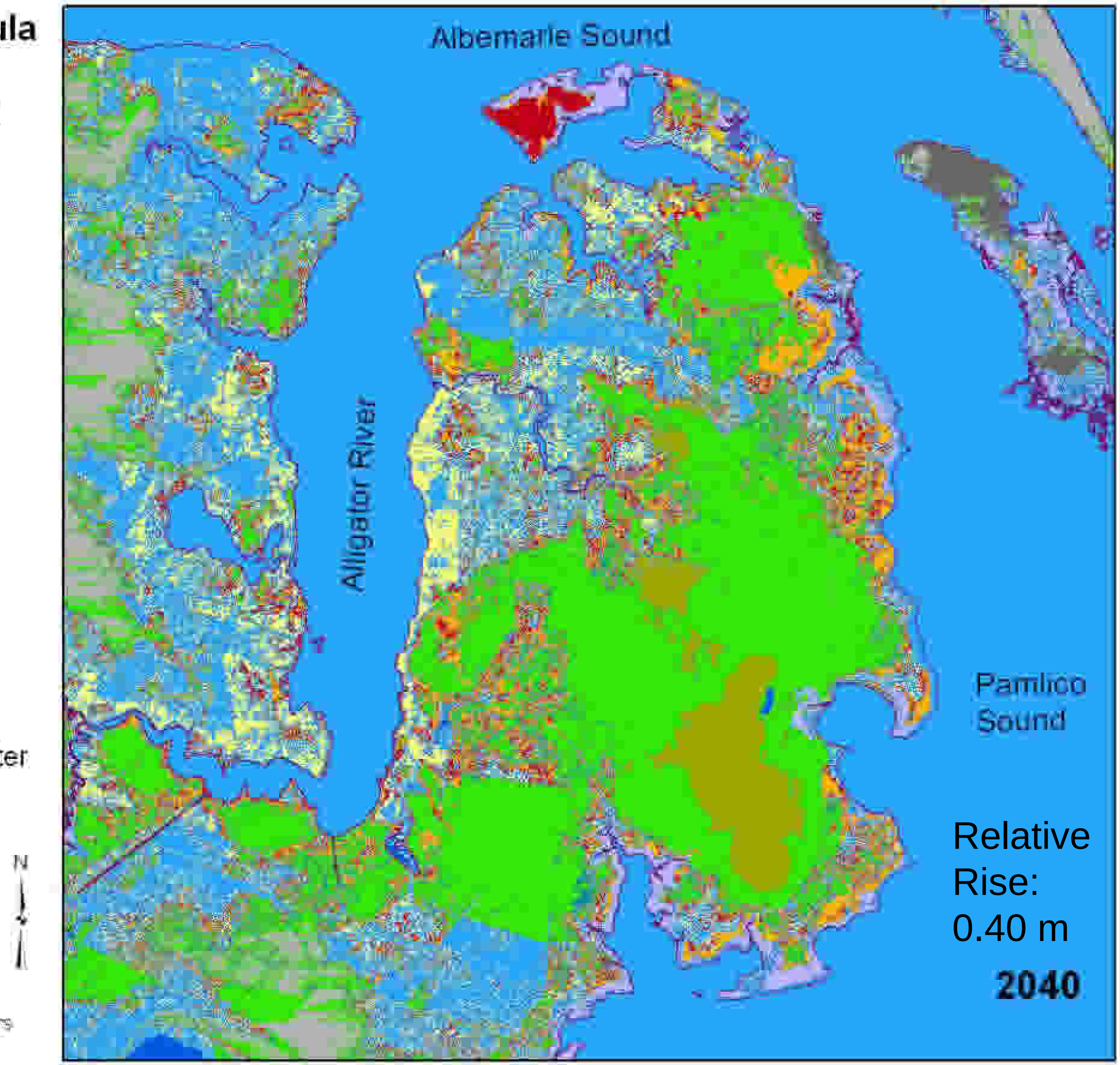

Dare County Peninsula Scenario: 1.0 m Sea Level Rise by 2100

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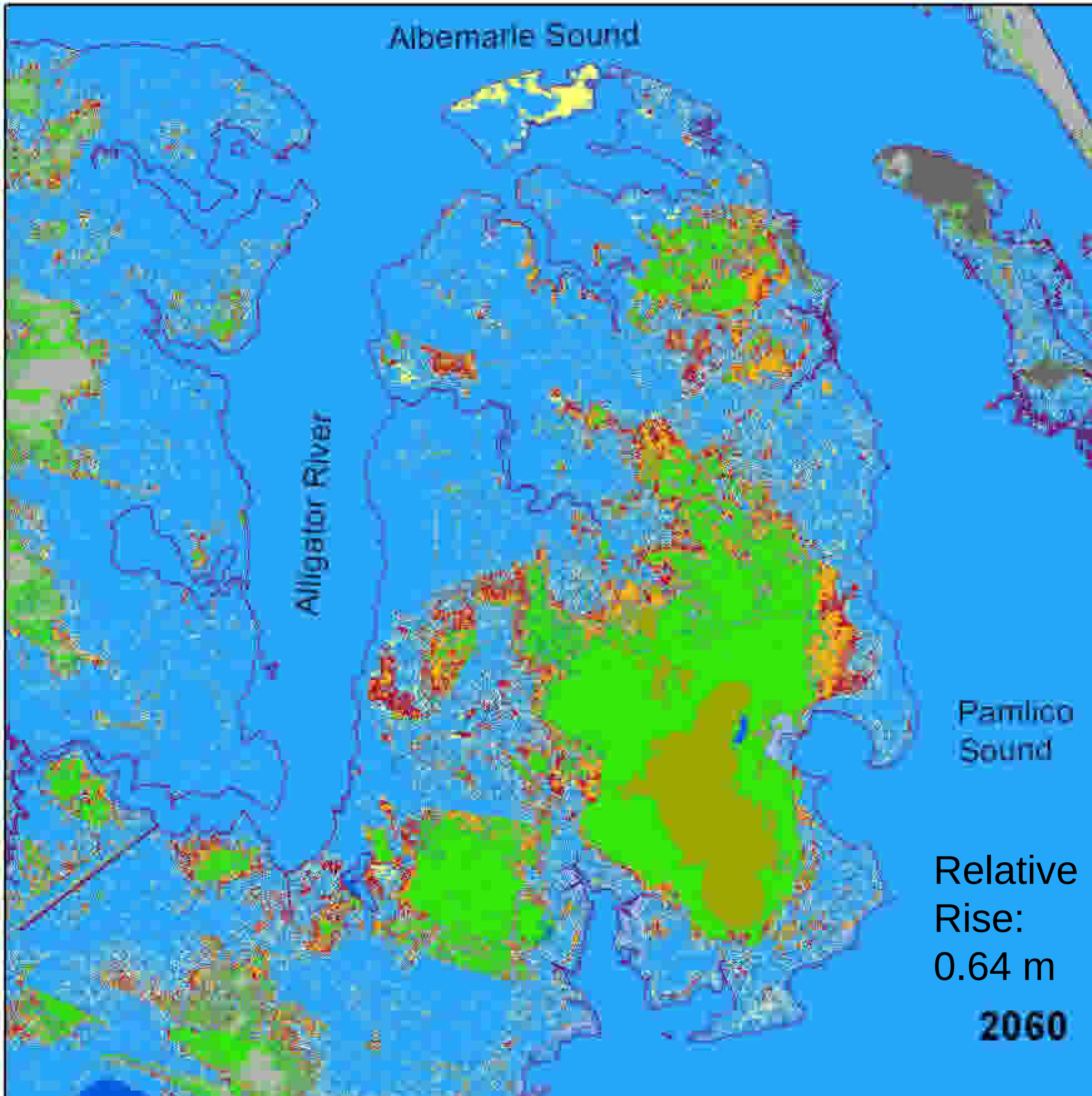
Kilometers

0 2 4 8 12



Dare County Peninsula Scenario: 1.0 m Sea Level Rise by 2100

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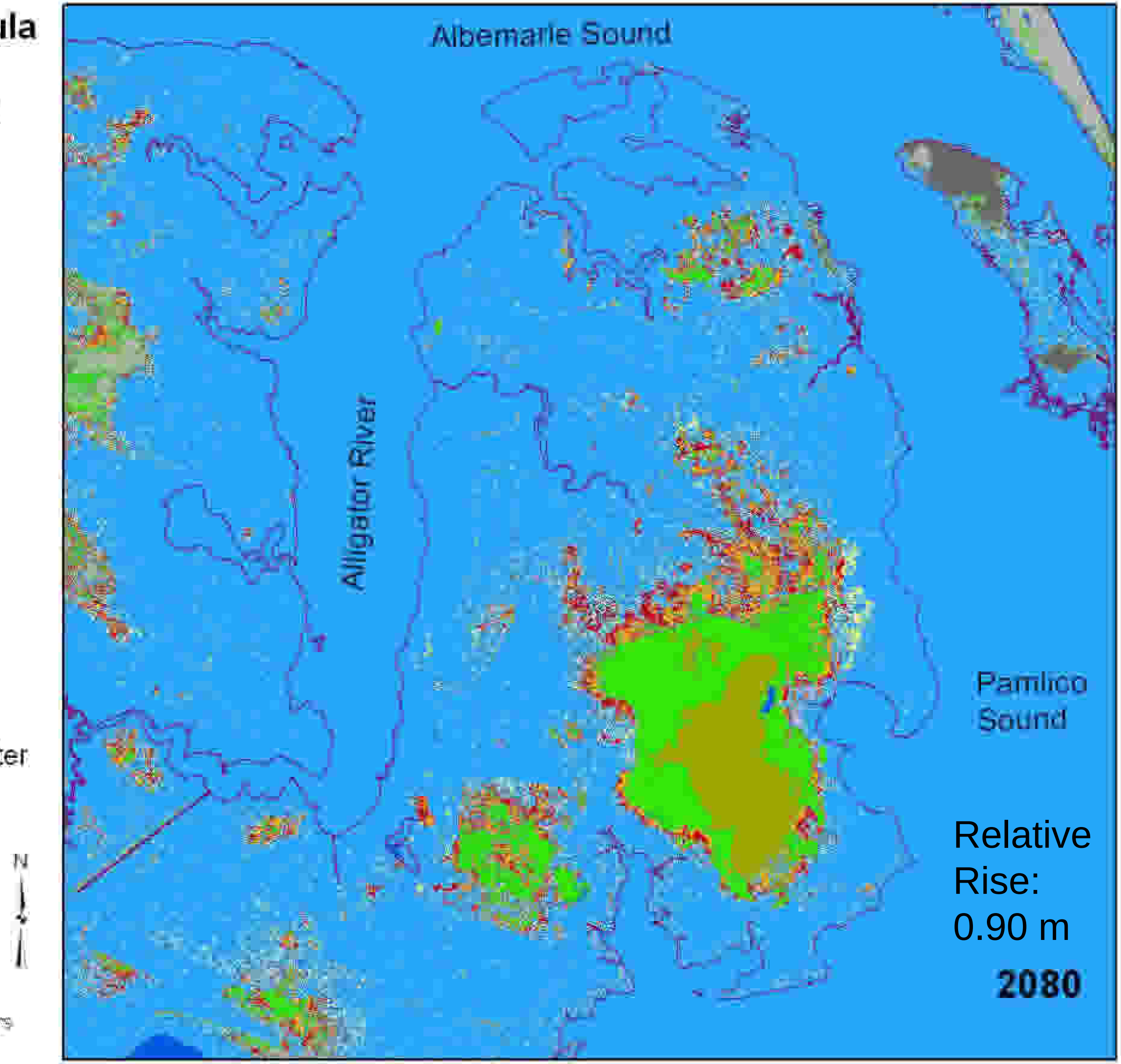

Dare County Peninsula Scenario:
1.0 m Sea Level Rise by 2100

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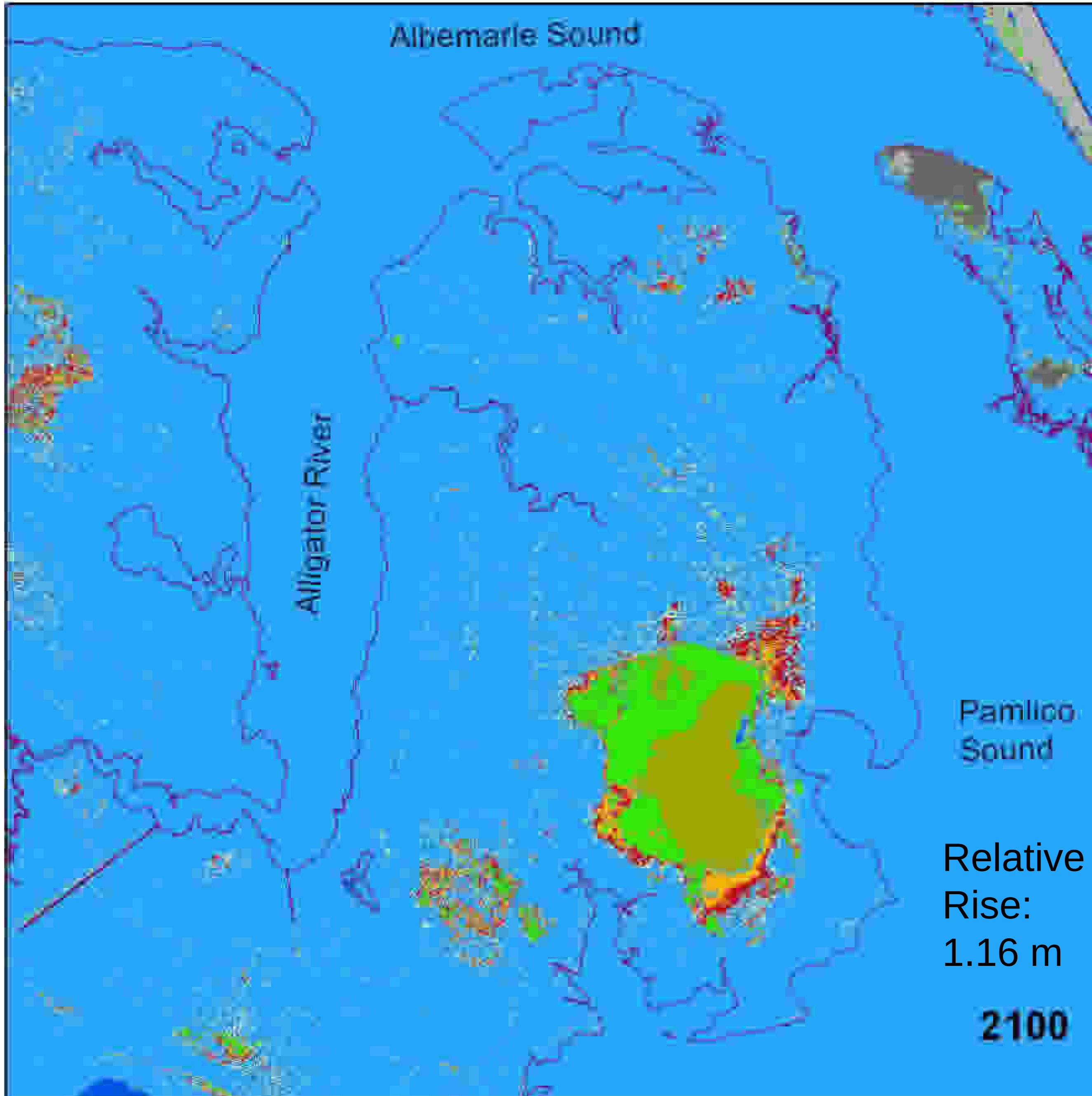
N

Kilometers
0 2 4 8 12



1.0 m Rise by 2100 Scenario Results

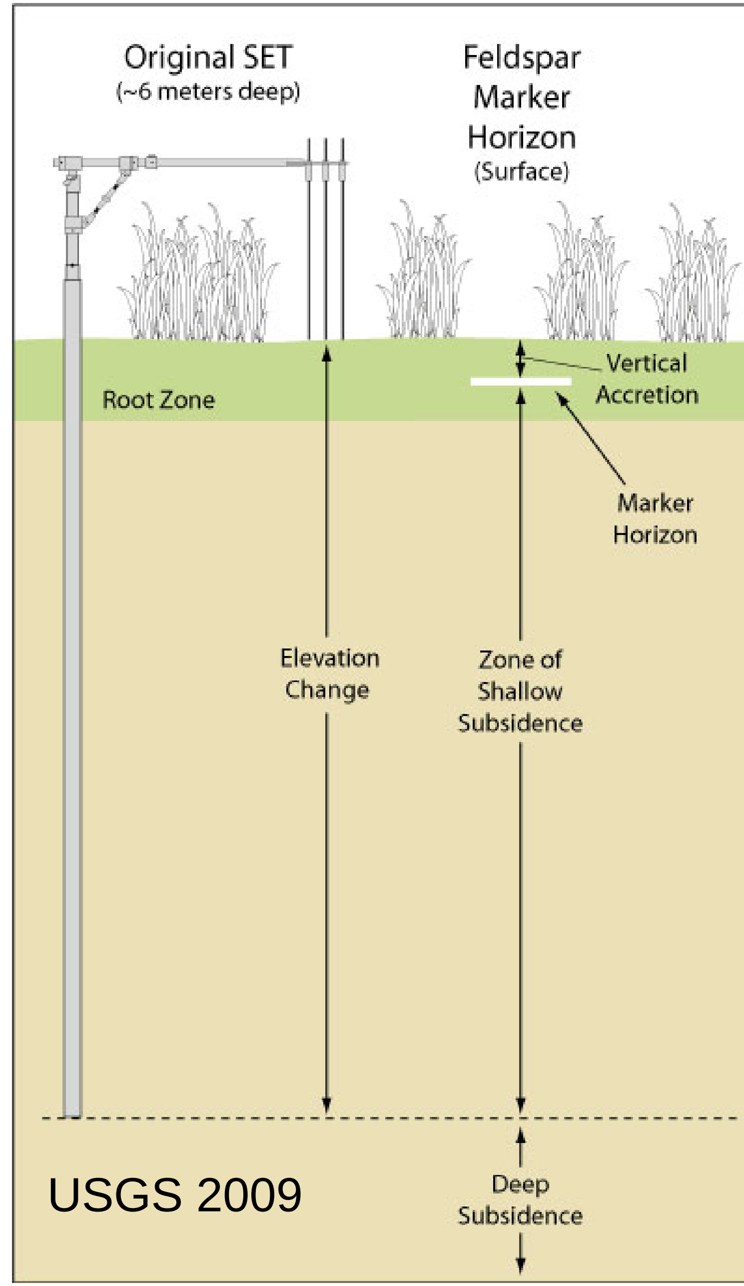
Land Cover Category	% Loss From Initial Conditions Year					Total Loss in Land Area: Initial Conditions to 2100
	2020	2040	2060	2080	2100	
Developed Upland Change	-4%	-12%	-22%	-31%	-40%	-913 ha
Undeveloped Upland Change	-46%	-60%	-72%	-85%	-93%	-34,000 ha
Forested Wetland Change	-27%	-54%	-76%	-89%	-95%	-102,000 ha

Discussion

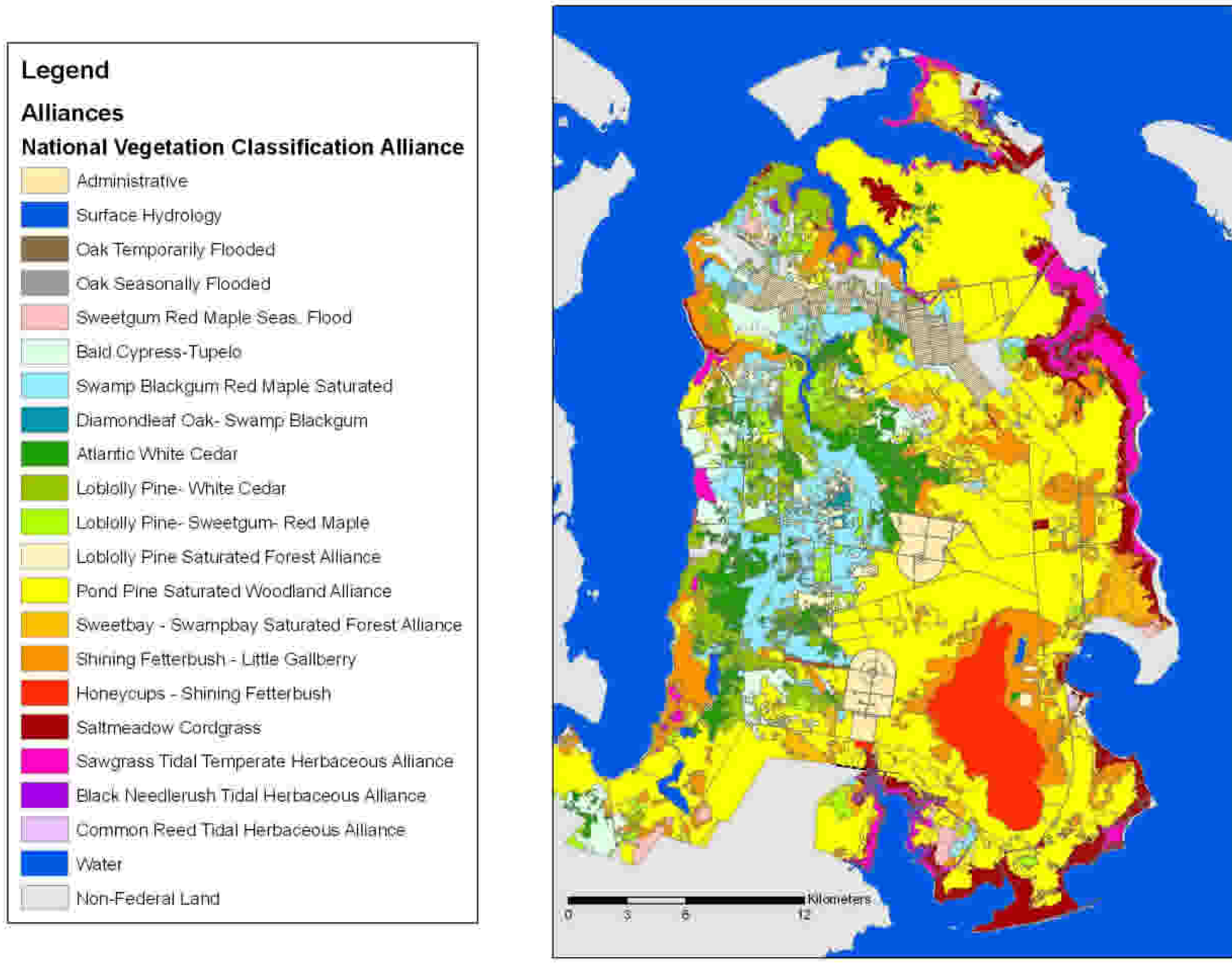
- Further Research/Questions
  - Accretion in wetland ecosystems
  - Influence of drainage canals
- Mitigation/Restoration Strategies

Swamp and Marsh Accretion

- Studies of marsh accretion on Dare County Peninsula
- Swamp accretion under rising seas: SLAMM hardwires swamp accretion. (0.3 mm/yr non-tidal, 1.1 mm / yr tidal: Craft 2008)



Field Measures of Accretion


Legend
Alliances
National Vegetation Classification Alliance
Administrative
Surface Hydrology
Oak Temporarily Flooded
Oak Seasonally Flooded
Sweetgum Red Maple Seas. Flood
Bald Cypress-Tupelo
Swamp Blackgum Red Maple Saturated
Diamondleaf Oak- Swamp Blackgum
Atlantic White Cedar
Loblolly Pine- White Cedar
Loblolly Pine- Sweetgum- Red Maple
Loblolly Pine Saturated Forest Alliance
Pond Pine Saturated Woodland Alliance
Sweetbay - Swampbay Saturated Forest Alliance
Shining Fetterbush - Little Gallberry
Honeycups - Shining Fetterbush
Saltmeadow Cordgrass
Sawgrass Tidal Temperate Herbaceous Alliance
Black Needlerush Tidal Herbaceous Alliance
Common Reed Tidal Herbaceous Alliance
Water
Non-Federal Land
Kilometers
0
3
6
12

Canals and Ditches

- Botanists have observed more salt tolerant spp. near canals on this peninsula

- Model runs with and without canals

Drainage Canal System

Canals accelerate impacts of SLR in SLAMM runs

Runs with 20 ft cell size do not represent canals which are typically 10 ft wide

•Tide gates

Mitigation / Restoration Strategies

- Prescribed fires and marsh productivity
- Establishment of salt-tolerant plant communities
- Marsh fertilization?

Mitigation/restoration strategy

- Oyster shell reefs

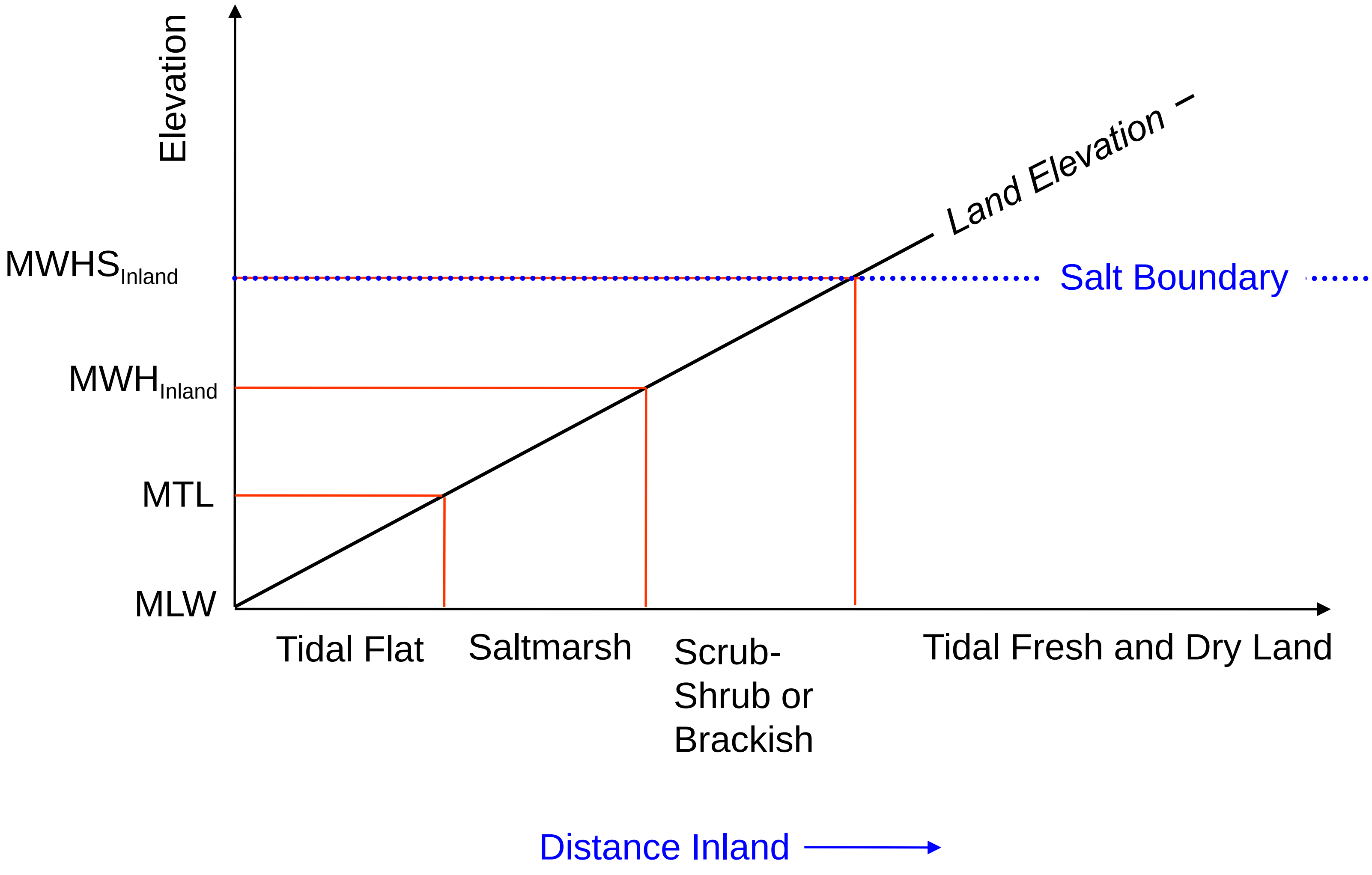
Bottom line

- SLAMM is an important step in modeling the impacts from SLR
- Better field data should improve model accuracy
- SLAMM can contribute to SLR mitigation by modeling the impacts of these efforts

Mitigation and Restoration

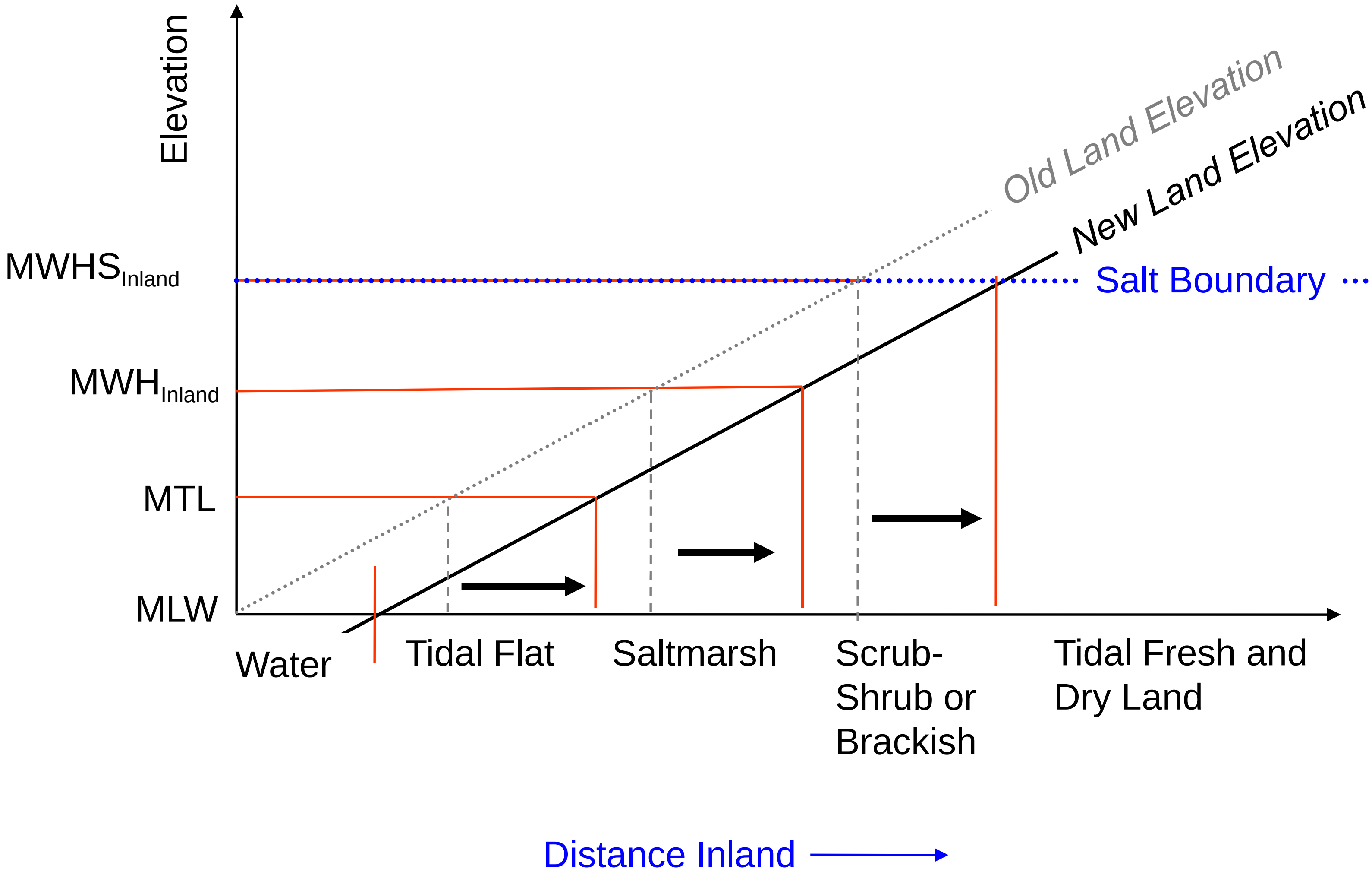
- Planting salt tolerant species
- Fertilization of marsh plants (to increase accretion)
- Oyster bed establishment (SLAMM modeling)
- Potential funding sources

SLAMM 5 Inundation Model

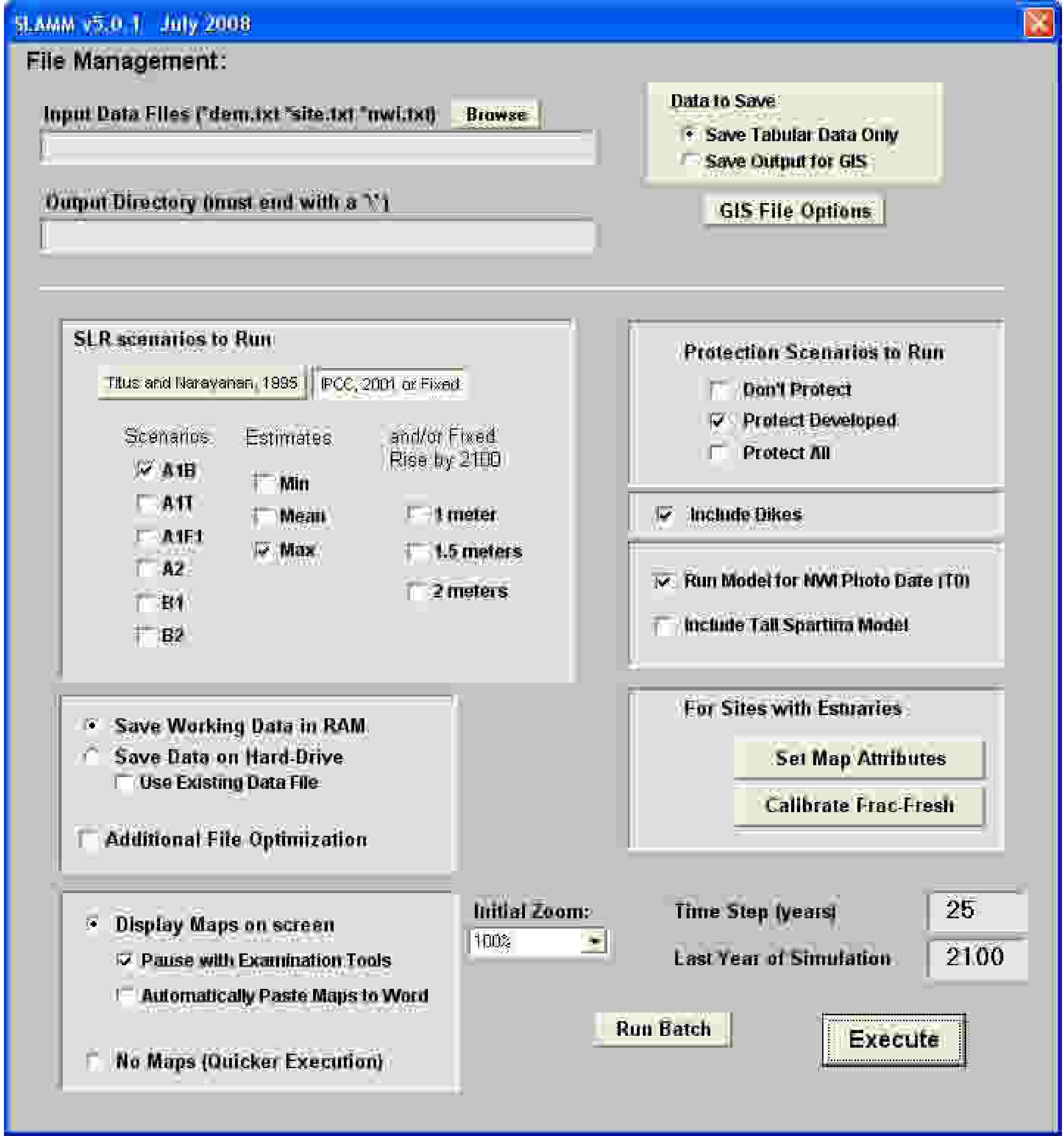


SLAMM 5 Inundation Model

(Migration of Wetlands Boundaries due to Sea Level Rise)



SLAMM interface



Study area: Geological Aspects

Riggs 2001, 2003