Sea Level Rise and Future Environmental Trends

A 2019 Best Available Science Synthesis Report. Case Study – Big Pine Key, FL

Lori Miller[1], Hydrologist and Environmental Engineer
Steve Traxler[2], Retired PFLCC Science Coordinator

eMail – lori_miller@fws.gov Phone 772-469-4231

[1-2]U.S. Fish and Wildlife Service
South Florida Ecological Services Office (SFESO), Vero Beach, Florida

U.S. Fish and Wildlife Service

Conserving Our Natural Heritage in South Florida

Defining the Hydrologic and Climatic Issues affecting Biology and Ecology of Big Pine Key:

I. State of the Climate

II. The Influence of Ice Melt

III. Geology

IV. Best Available Science

V. Current Sea Level Rise and Scenarios

VI. Root Zone Inundation

VII. SLAMM Model

VIII. Environmental Trends

IX. Climate Science Summary

State of the Climate in 2017

CO_2 increased to 405 ppm

- Quadrupled since 1960s
- Highest in modern atmospheric records and from ice core samples dating back 800,000 yrs.

Global Land and Ocean Temperatures increased by .43°C (.3°F) from the 1981-2010 average

- Second warmest year since the mid-1800s records

Global Precipitation Increased by up to 3 inches

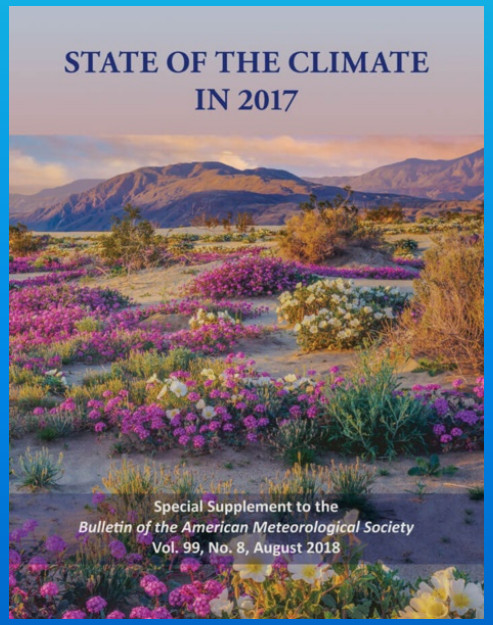
Global Humidity Increased – **Evaporation** Decreased

Arctic Land Surface Temperatures increased by 1.6°C (.9°F)

- Second highest year since 1900

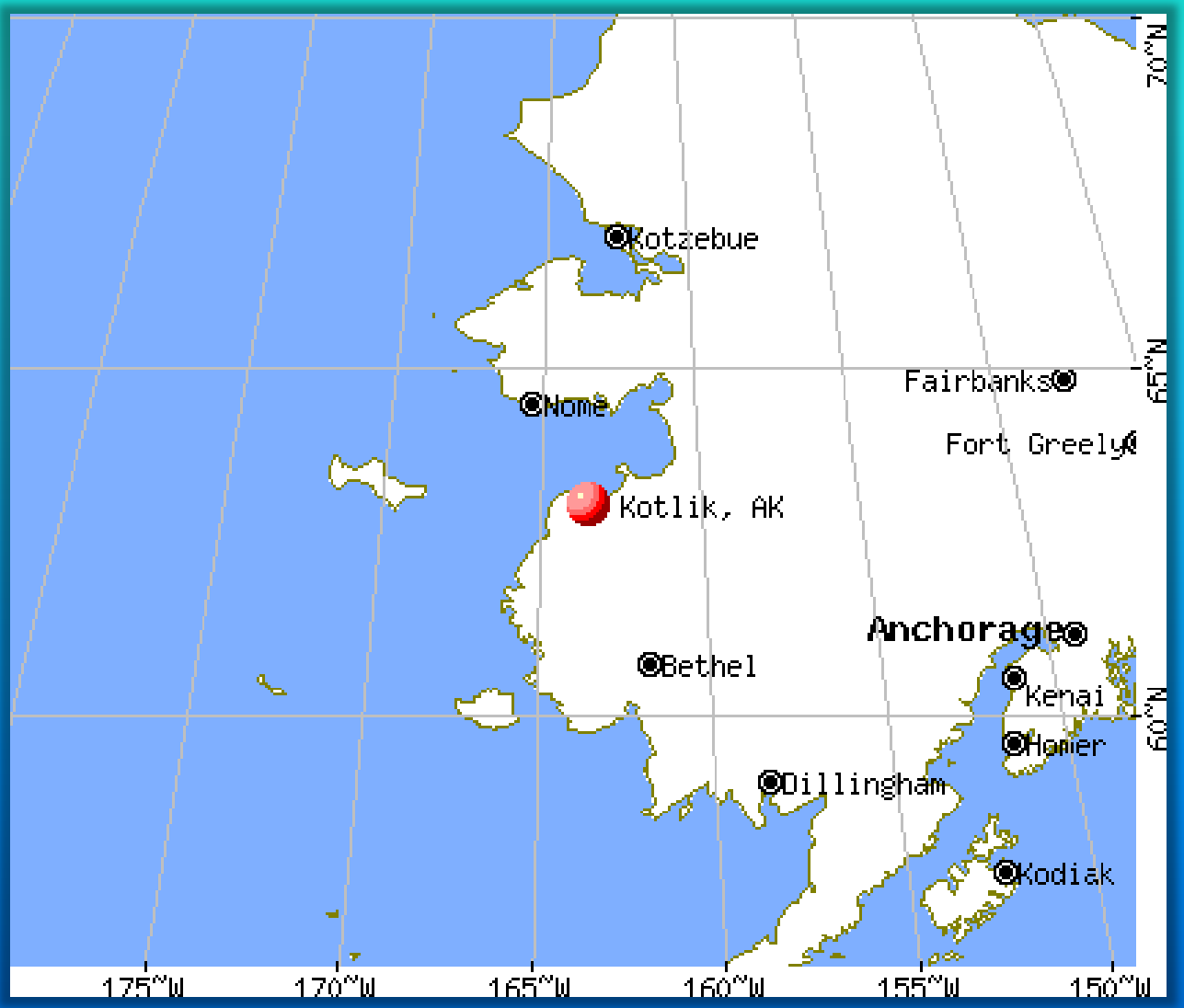
Glaciers lost mass for the 38th consecutive year (2.8 ft.)

Antarctic Sea Ice Melt - Second highest since 2005



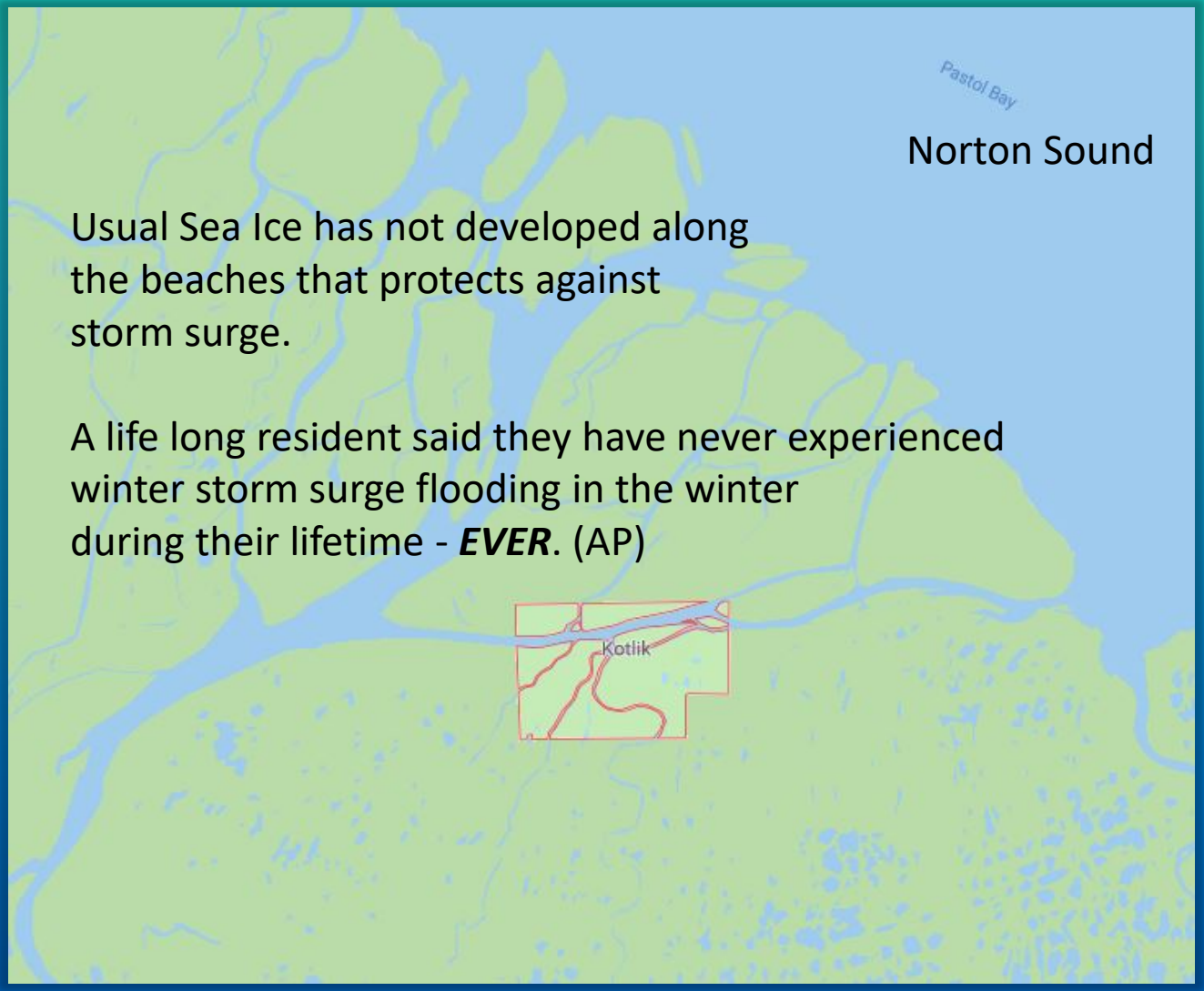
Blunden et al. 2018 (American Meteorological Society)

In the Climate News!



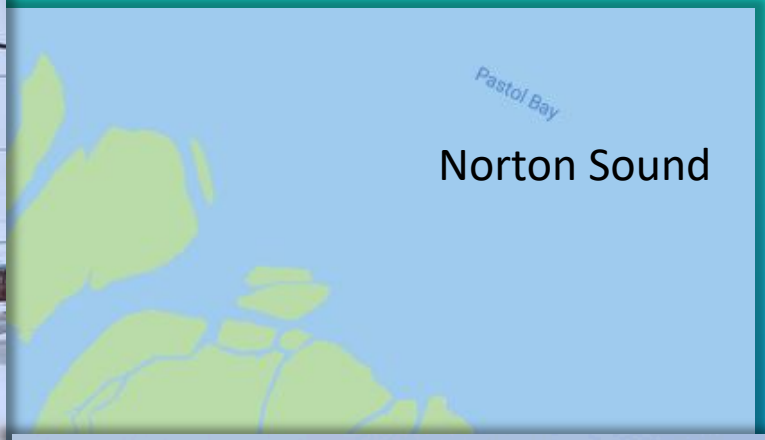
Associated Press 2019

Winter Storm Surge Flooding!
February 12, 2019



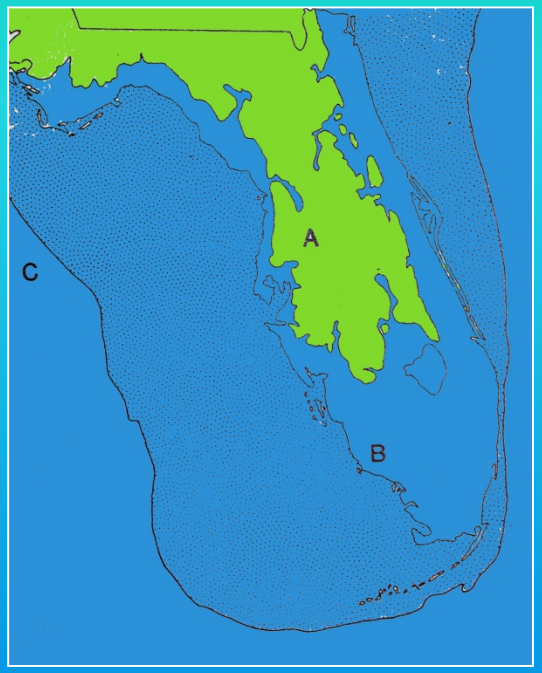
Associated Press 2019

Winter Storm Surge Flooding!
February 12, 2019

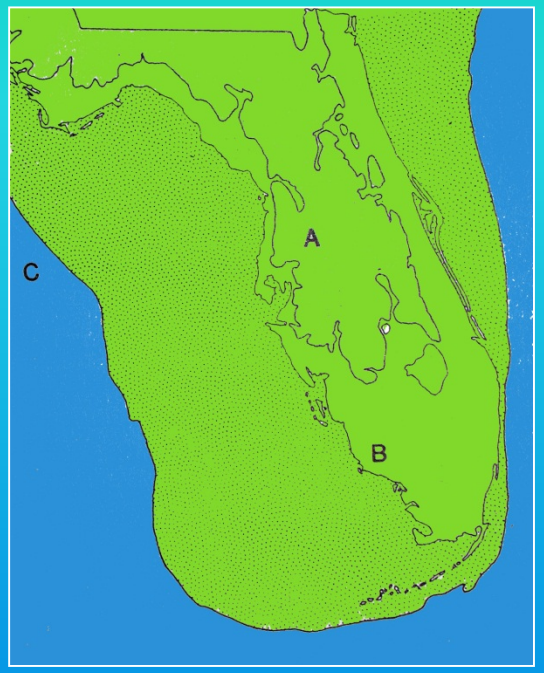


Associated Press 2019

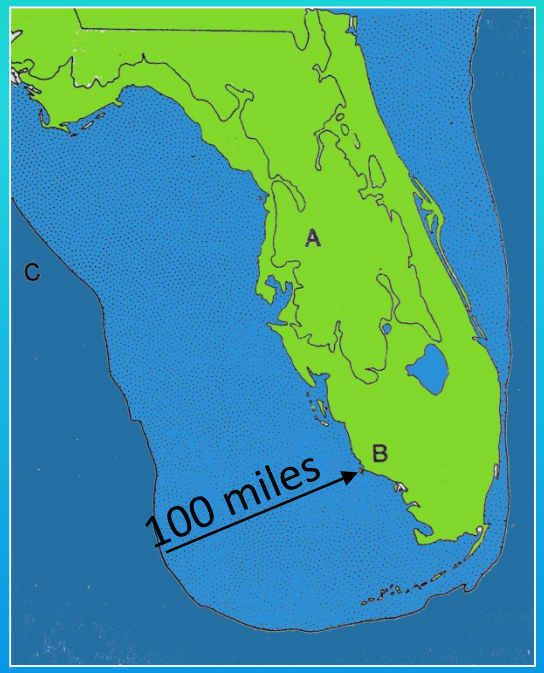
Florida Through Time – Sea Level Variations Happen!



120,000 years ago
+ 6 meters (20')*



18,000 years ago
- 120 meters (420')



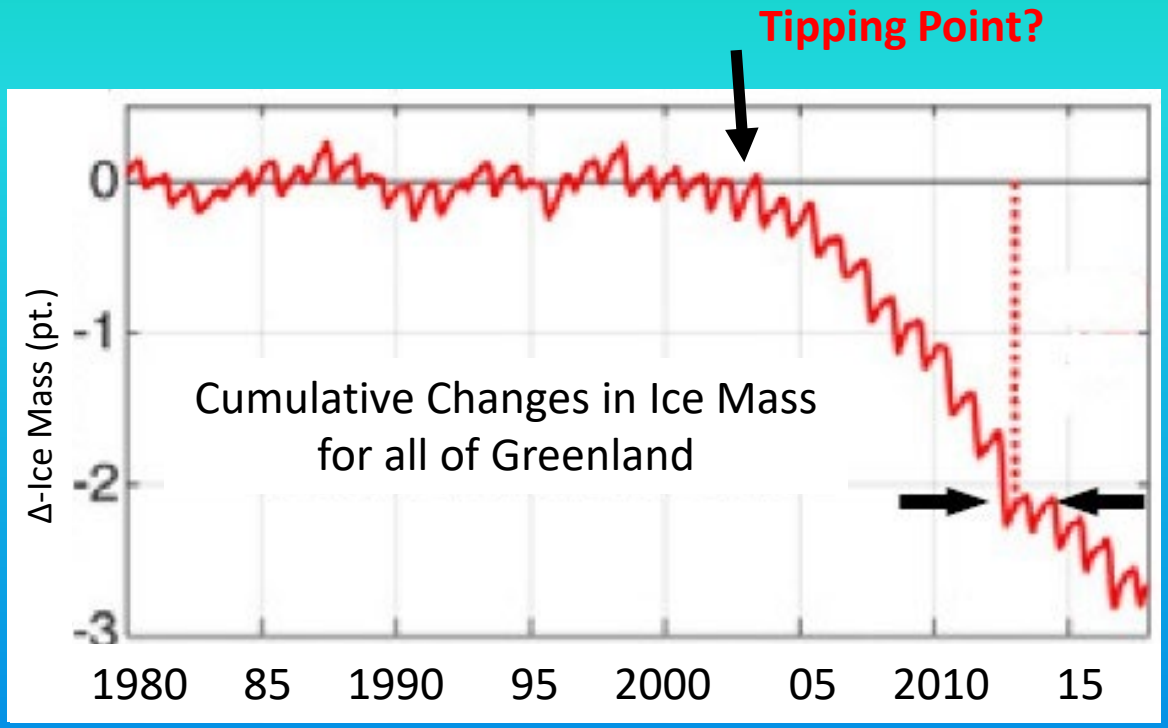
Today

*~ ½ from Greenland Ice Melt

*~ ½ from Antarctica Ice Melt

Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force

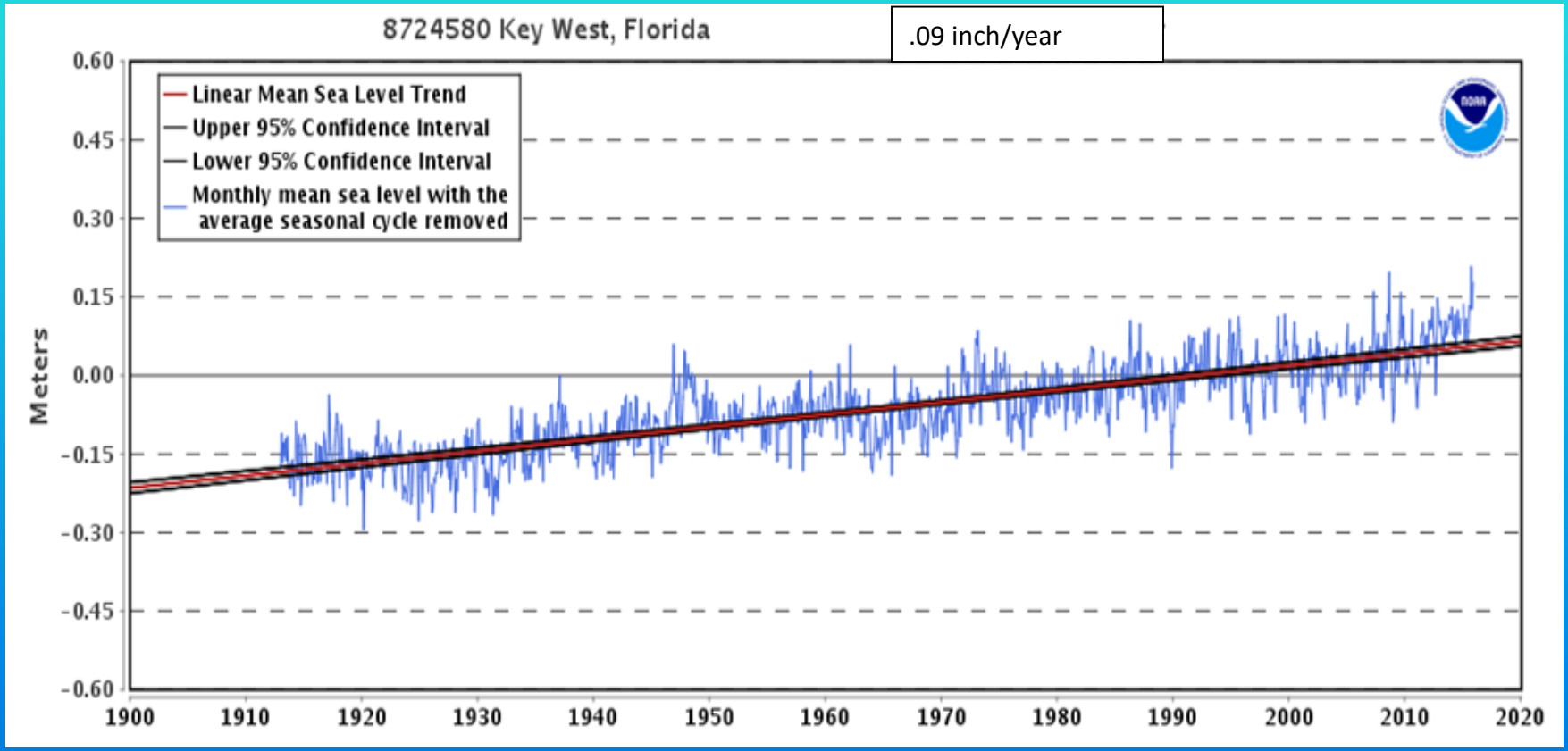
Greenland's Ice is Melting Four Times Faster than Thought!



A short "Pause"

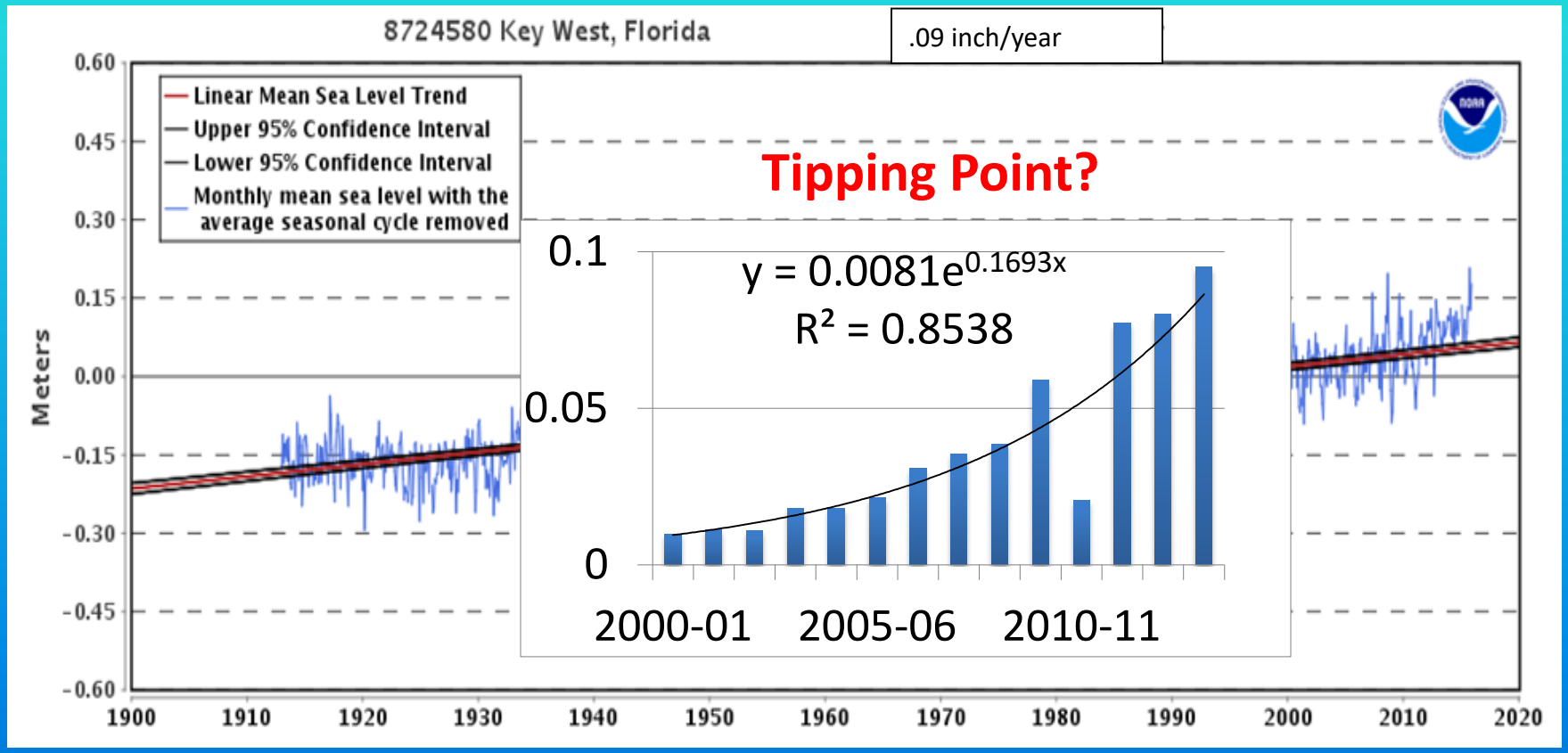
Barletta et al. 2018 – Consortium of Numerous Academia

Rising Seas around the Florida Keys



NOAA 2017

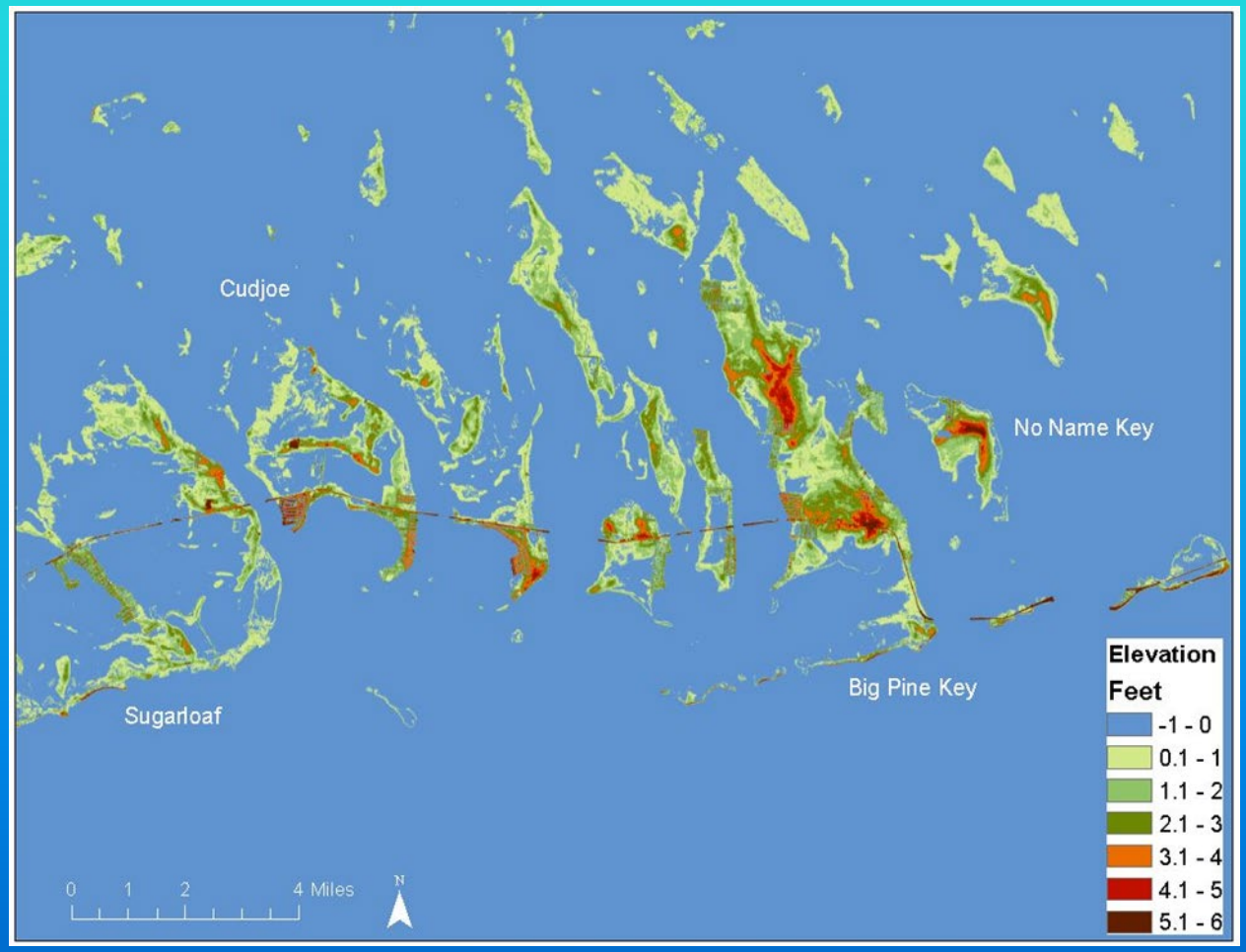
Rising Seas around the Florida Keys



NOAA 2017

Geology of The Florida Keys

Low Elevation Islands
80-90% Land Mass is Below 4 ft. Elevation

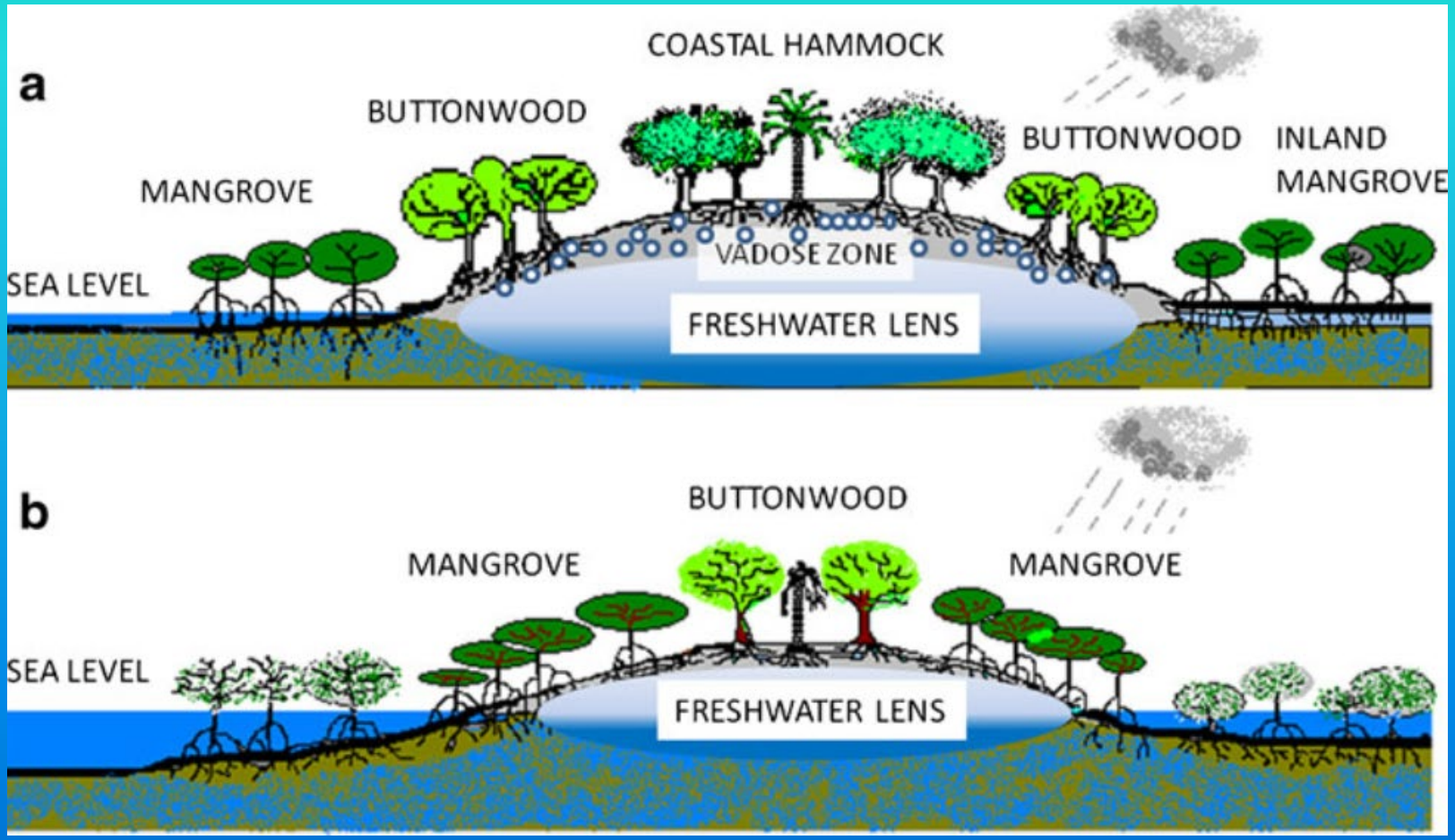


SLAMM Model Run 2018

Pine Rockland Ecosystem
Slash Pine with a 1.5 – 3 ft. deep Root Zone

Photo Credit to Jennifer Possley

Freshwater Lens



A.K. Saha et.al 2011

Best Available Modeling
Sea Level Change and Future Environmental Trends

NOAA Technical Report – 2017

Global and Regional Sea Level Rise Scenarios for the United States

(Authored by Sweet et. al – 2017)

The Sea level Rise and Coastal Flood Hazard Scenarios and Tools Interagency Task Force

---

National Climate Assessment (NCA-2018)
Intergovernmental Panel on Climate Change (IPCC-2019)
Special Report – Global Warming of 1.5°C

Introducing:

NOAA Technical Report – 2017

Primary Tasks:

1. Update Scenarios for Global Sea Level Rise
2. Integration of Regional Factors for the U.S. Coastline

Introducing:

NOAA Technical Report – 2017

Primary Tasks:

1. Update Scenarios for Global Sea Level Rise
2. Integration of Regional Factors for the U.S. Coastline
   - Shifts in Oceanic Circulations

Introducing:

NOAA Technical Report – 2017

Primary Tasks:

1. Update Scenarios for Global Sea Level Rise
2. Integration of Regional Factors for the U.S. Coastline
   - Shifts in Oceanic Circulations
   - Changes in Earth's Gravitational Field – Fluxing of the Crust and Mantle

Introducing:

NOAA Technical Report – 2017

Primary Tasks:

1. Update Scenarios for Global Sea Level Rise
2. Integration of Regional Factors for the U.S. Coastline
   - Shifts in Oceanic Circulations
   - Changes in Earth's Gravitational Field – Fluxing of the Crust and Mantle
   - Subsidence or Uplift due to Glacial Changes

Introducing:

NOAA Technical Report – 2017

Primary Tasks:

1. Update Scenarios for Global Sea Level Rise
2. Integration of Regional Factors for the U.S. Coastline
   - Shifts in Oceanic Circulations
   - Changes in Earth's Gravitational Field – Fluxing of the Crust and Mantle
   - Subsidence or Uplift due to Glacial Changes
   - Sediment Compaction

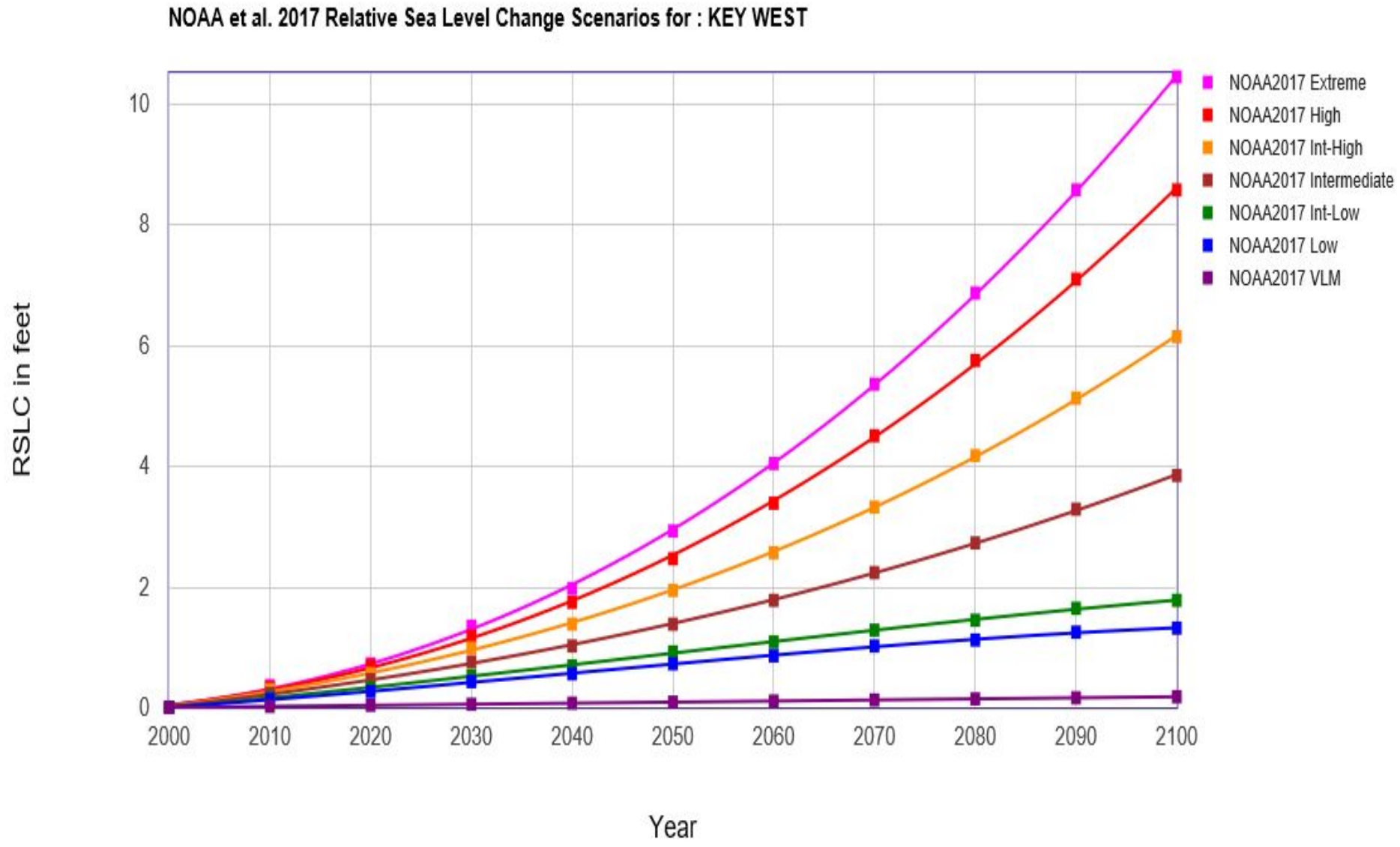
Introducing:

NOAA Technical Report – 2017

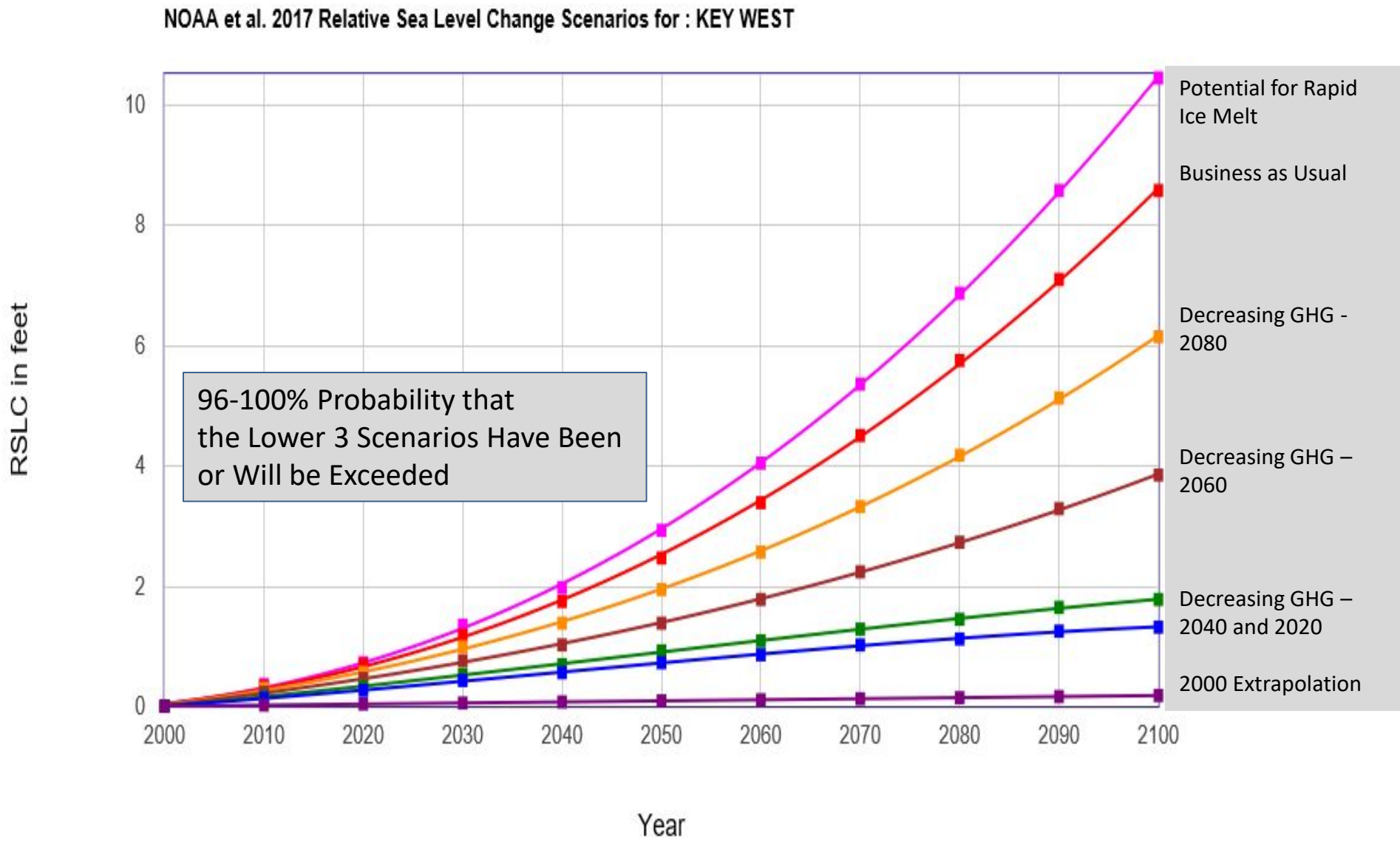
Primary Tasks:

1. Update Scenarios for Global Sea Level Rise
2. Integration of Regional Factors for the U.S. Coastline
   - Shifts in Oceanic Circulations
   - Changes in Earth's Gravitational Field – Fluxing of the Crust and Mantle
   - Subsidence or Uplift due to Glacial Changes
   - Sediment Compaction
   - Groundwater and Fossil Fuel Withdrawals

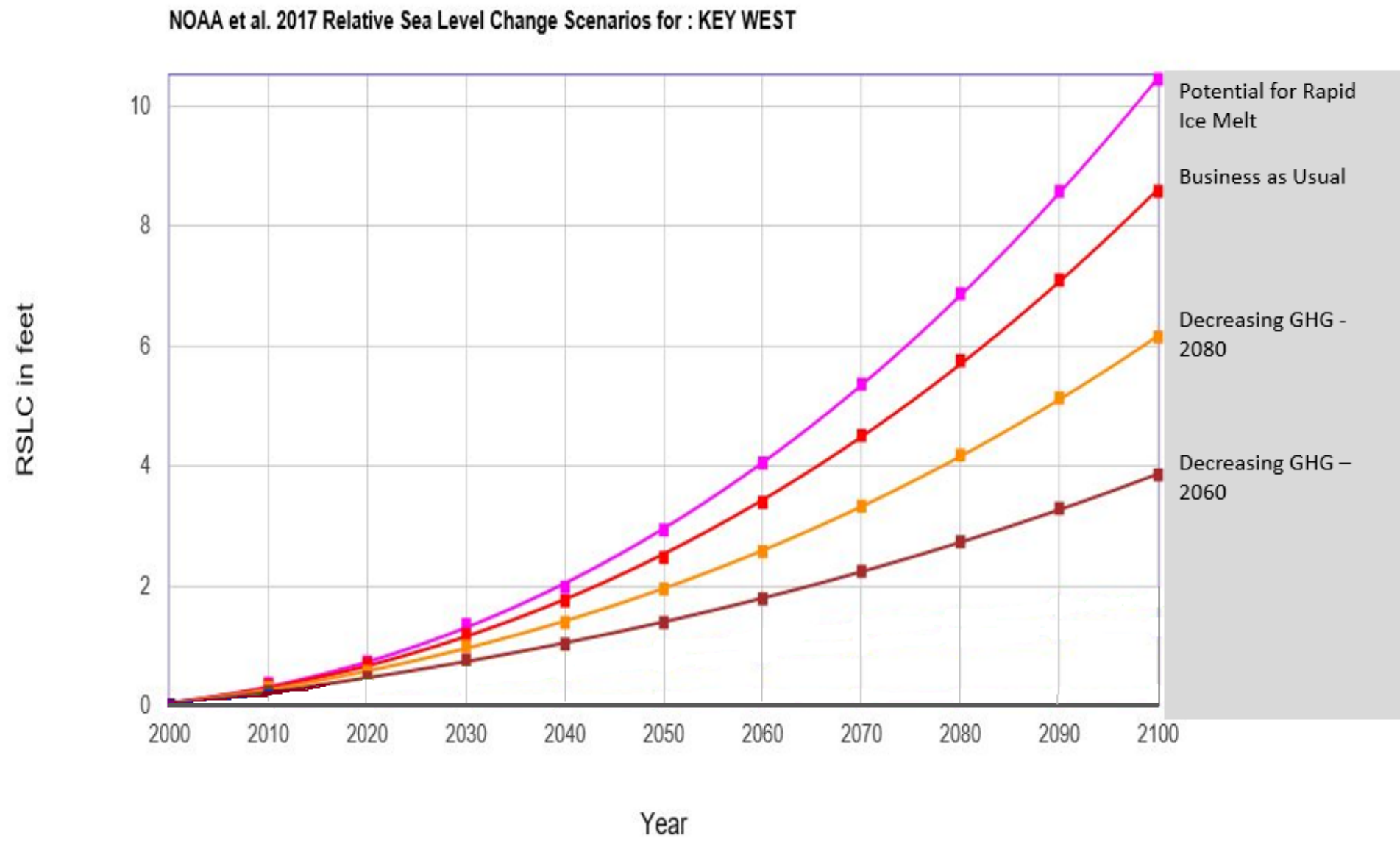
NOAA 2017 Scenarios



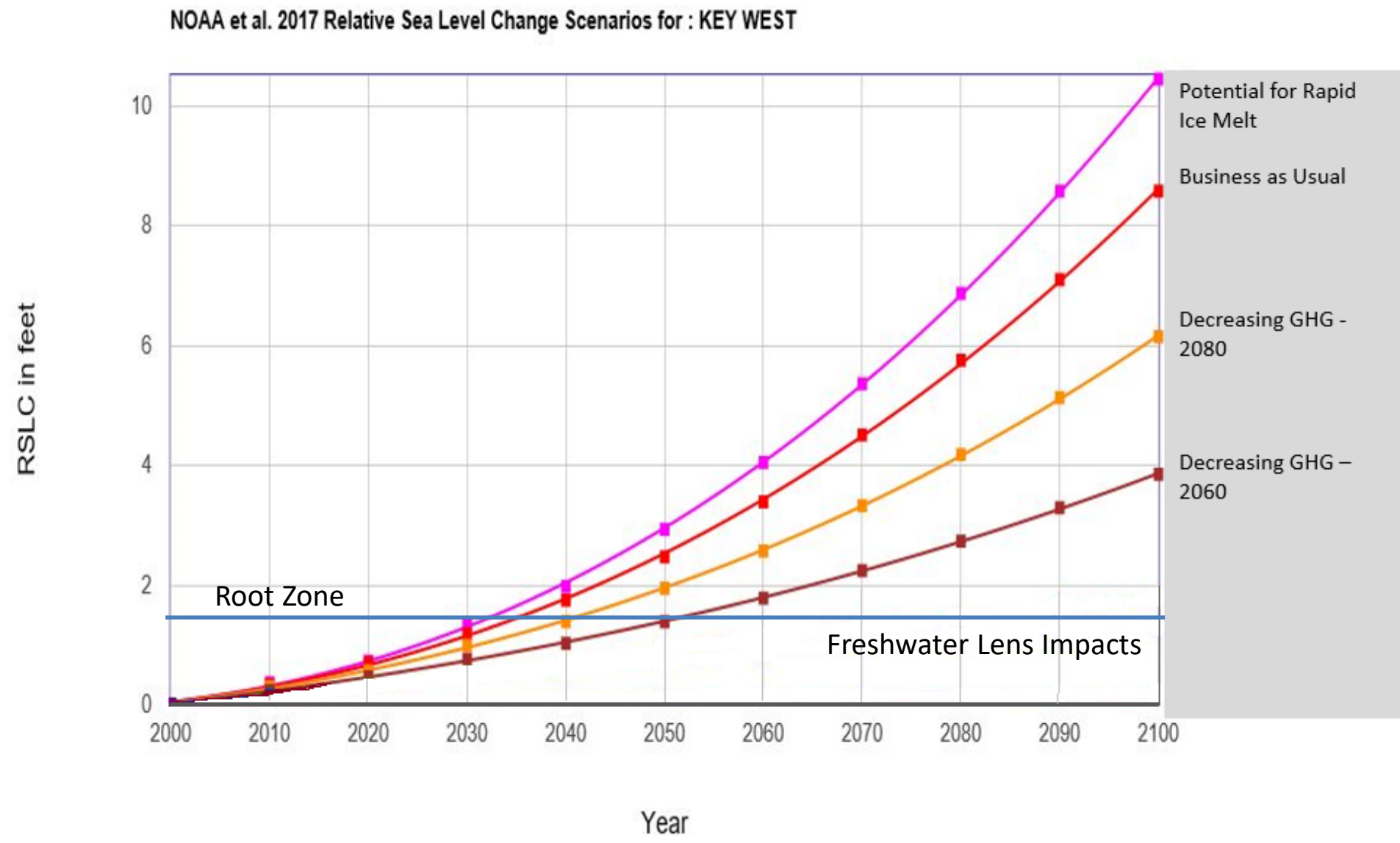
NOAA 2017 Scenarios



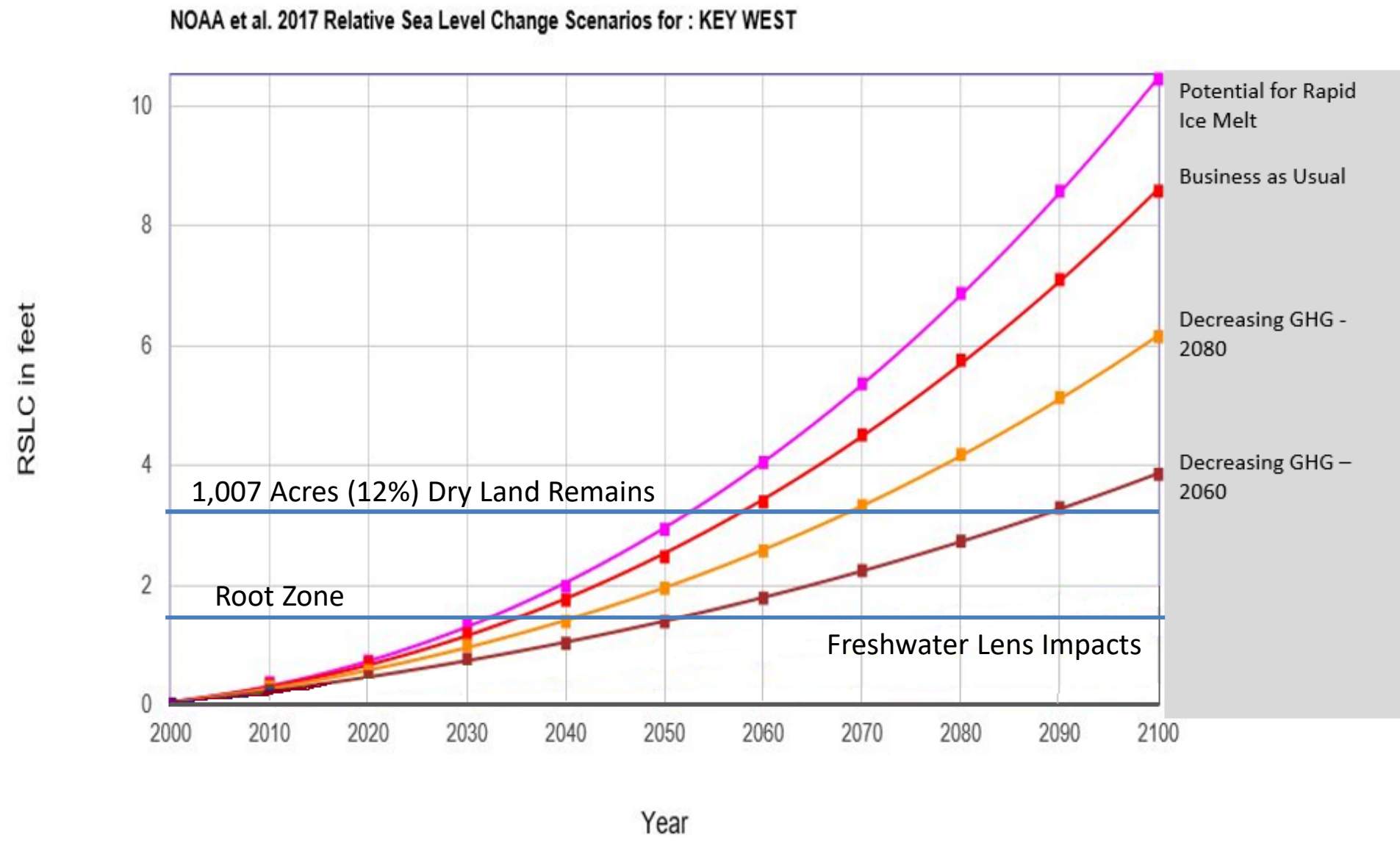
NOAA 2017 Scenarios



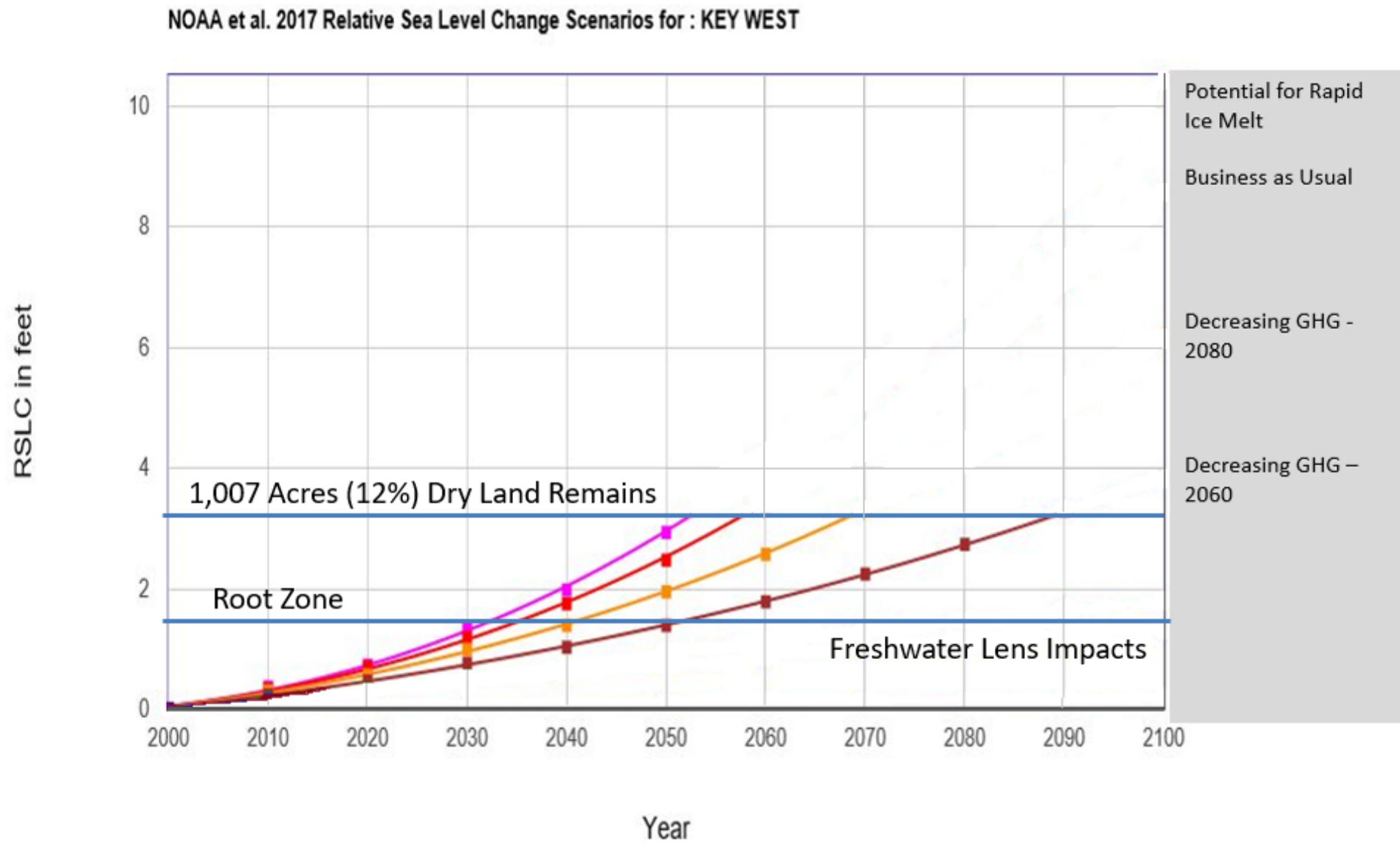
NOAA 2017 Scenarios



NOAA 2017 Scenarios

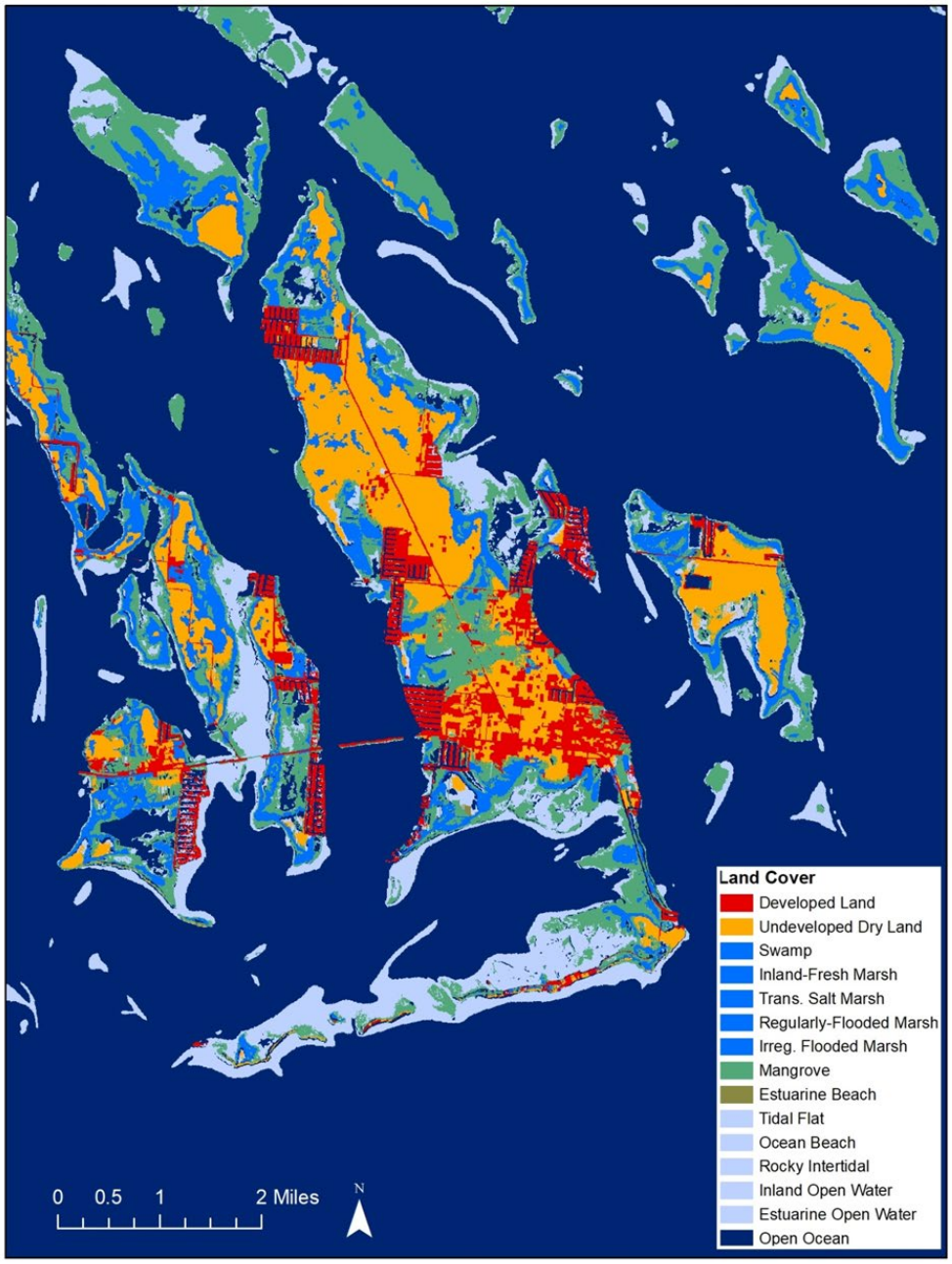


NOAA 2017 Scenarios

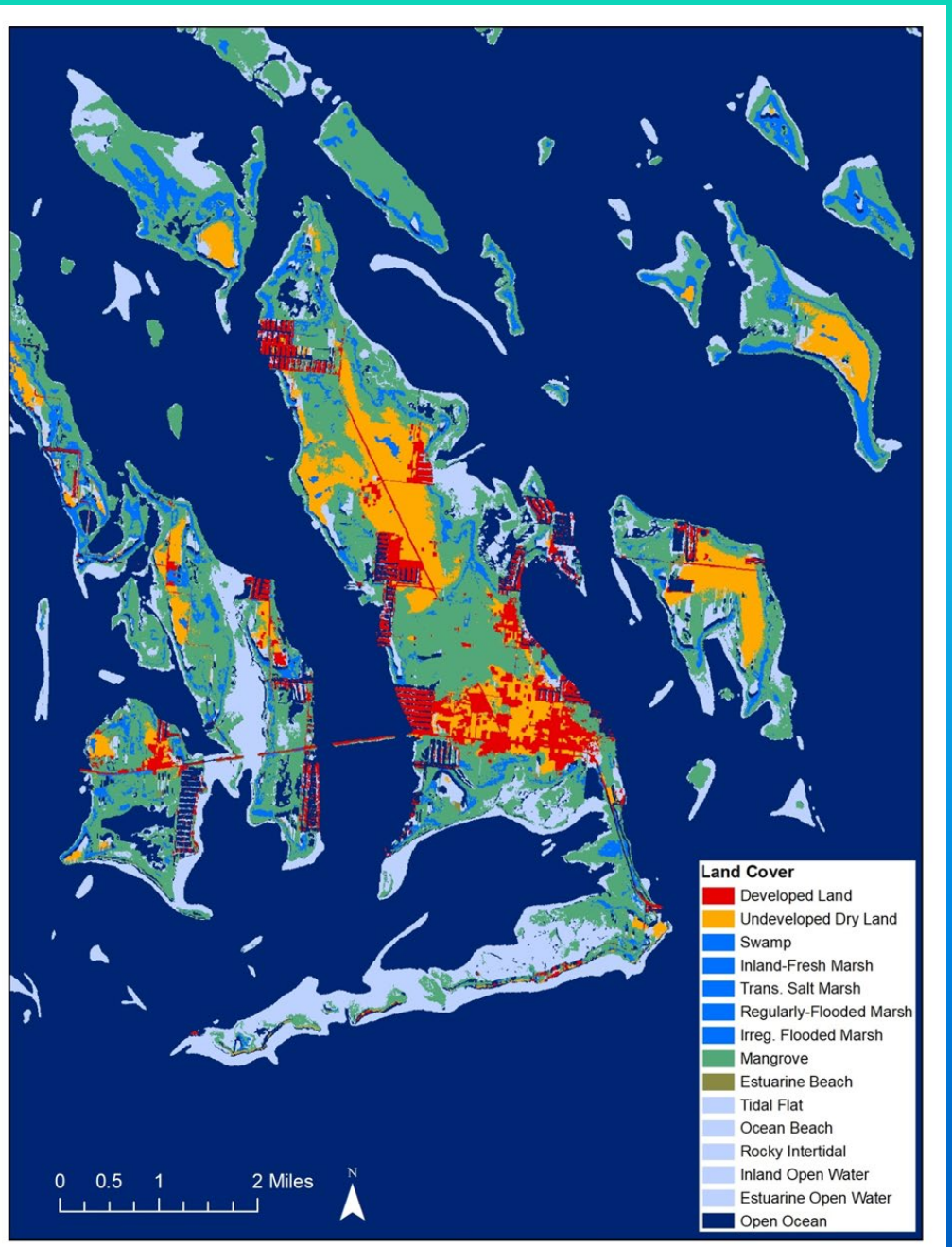


Sea Level Affecting Marshes Model (SLAMM)
2018 Modeling Results

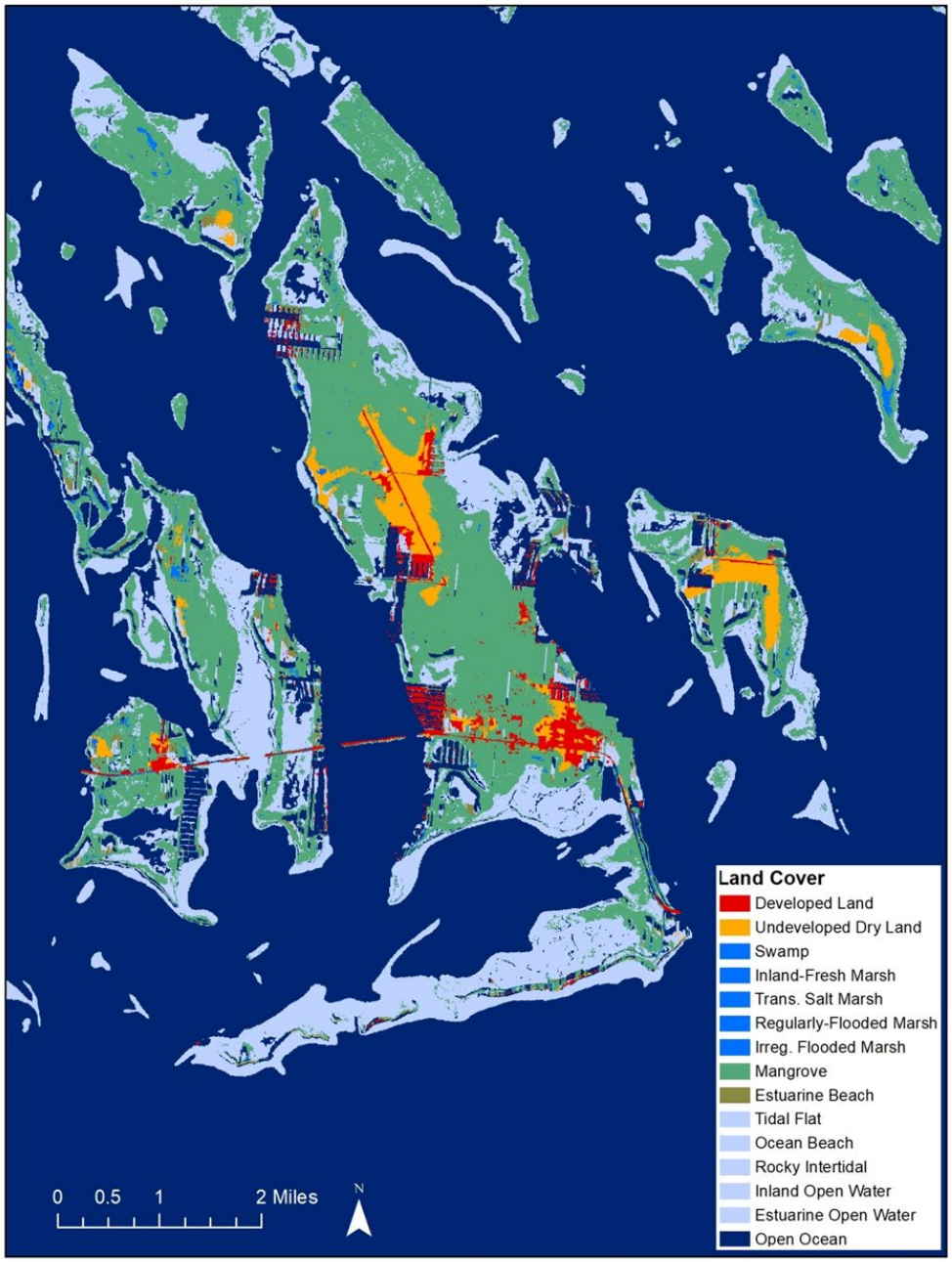
SLAMM 2018 Modeling Results – 1 ft. SLR



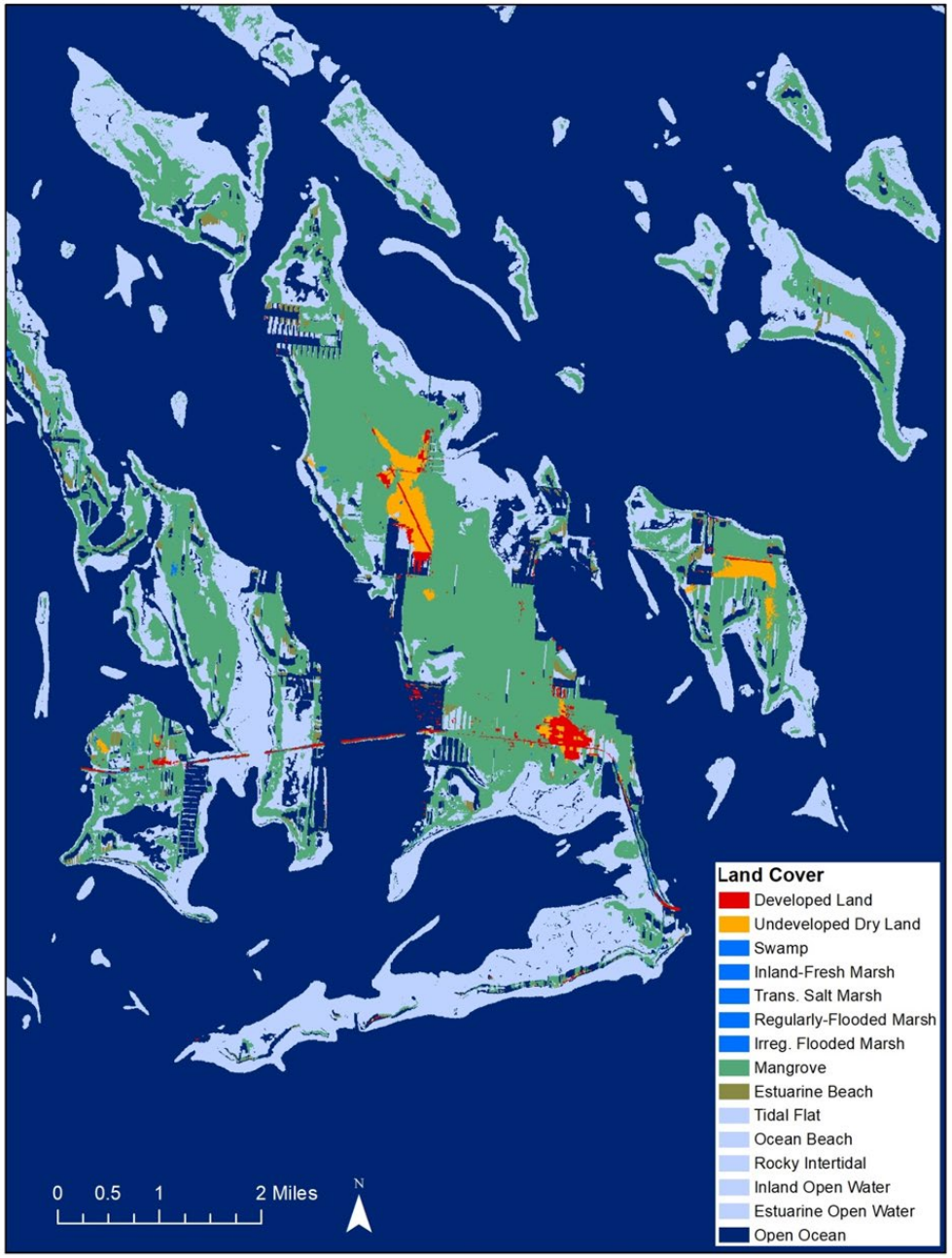
SLAMM 2018 Modeling Results – 2 ft. SLR



SLAMM 2018 Modeling Results – 3 ft. SLR



SLAMM 2018 Modeling Results – 4 ft. SLR



SLAMM 2018 Model Calculations

	Current Baseline		1 ft. SLR (2030-2040)	
Land Cover	**Acres - Current**	**Percentage %**	**Acres - 1 ft. SLR**	**Percentage %**
Developed Dry Land	1368	15	1223	14
Undeveloped Dry Land	2837	32	2311	16
Mangrove	1392	16	1933	22
	2 ft. SLR (2050-2060)		**3 ft. SLR (2060-2080)**	
Land Cover	**Acres - 2 ft. SLR**	**Percentage %**	**Acres - 3 ft. SLR**	**Percentage %**
Developed Dry Land	886	10	406	5
Undeveloped Dry Land	1381	15	601	7
Mangrove	3444	39	3859	43
	4 ft. SLR (2070-2100)			
Land Cover	**Acres - 4 ft. SLR**	**Percentage %**		
Developed Dry Land	175	2		
Undeveloped Dry Land	277	3		
Mangrove	3959	44		

SLAMM 2018 Model Calculations

	Current Baseline		1 ft. SLR (2030-2040)	
Land Cover	**Acres - Current**	**Percentage %**	**Acres - 1 ft. SLR**	**Percentage %**
Developed Dry Land	1368	15	1223	14
Undeveloped Dry Land	2837	32	2311	16
Mangrove	1392	16	1933	22
	2 ft. SLR (2050-2060)		**3 ft. SLR (2060-2080)**	
Land Cover	**Acres - 2 ft. SLR**	**Percentage %**	**Acres - 3 ft. SLR**	**Percentage %**
Developed Dry Land	886	10	406	5
Undeveloped Dry Land	1381	15	601	7
Mangrove	3444	39	3859	43
	4 ft. SLR (2070-2100)			
Land Cover	**Acres - 4 ft. SLR**	**Percentage %**		
Developed Dry Land	175	2		
Undeveloped Dry Land	277	3		
Mangrove	3959	44		

SLAMM 2018 Model Calculations

	Current Baseline		1 ft. SLR (2030-2040)	
Land Cover	**Acres - Current**	**Percentage %**	**Acres - 1 ft. SLR**	**Percentage %**
Developed Dry Land	1368	15	1223	14
Undeveloped Dry Land	2837	32	2311	16
Mangrove	1392	16	1933	22
	2 ft. SLR (2050-2060)		**3 ft. SLR (2060-2080)**	
Land Cover	**Acres - 2 ft. SLR**	**Percentage %**	**Acres - 3 ft. SLR**	**Percentage %**
Developed Dry Land	886	10	406	5
Undeveloped Dry Land	1381	15	601	7
Mangrove	3444	39	3859	43
	4 ft. SLR (2070-2100)			
Land Cover	**Acres - 4 ft. SLR**	**Percentage %**		
Developed Dry Land	175	2		
Undeveloped Dry Land	277	3		
Mangrove	3959	44		

Environmental Trends

Development in Big Pine Key

Development on Big Pine Key

1959

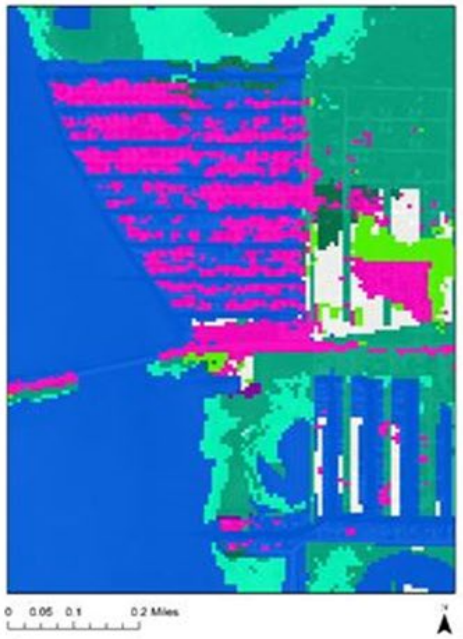
2002

2015

3 Feet SLR

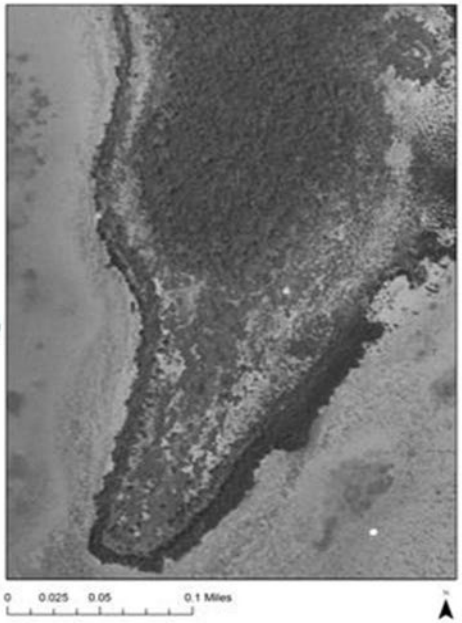
Land Cover

- Developed Land
- Undeveloped Dry Land
- Swamp
- Inland-Fresh Marsh
- Trans. Salt Marsh
- Regularly-Flooded Marsh
- Mangrove
- Estuarine Beach
- Tidal Flat
- Ocean Beach
- Rocky Intertidal
- Inland Open Water
- Estuarine Open Water
- Open Ocean
- Irreg. Flooded Marsh

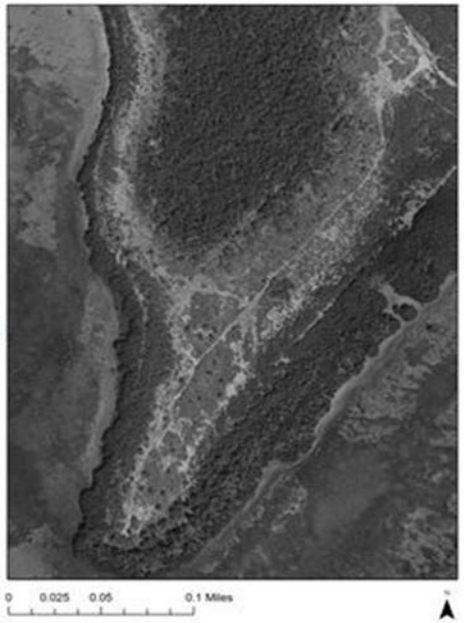


Southern No Name Key

1959



2002

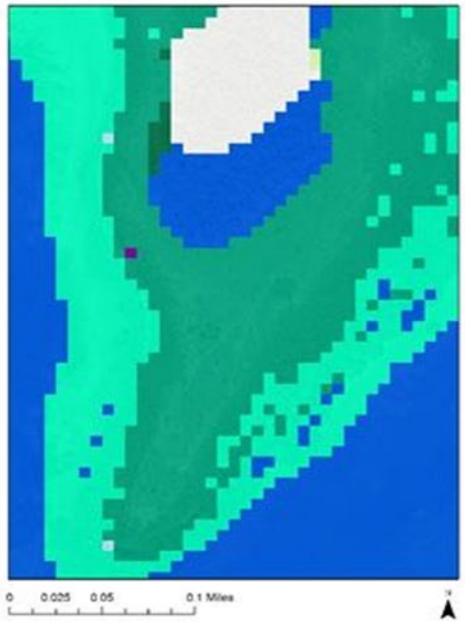


2015

3 Feet SLR

Land Cover

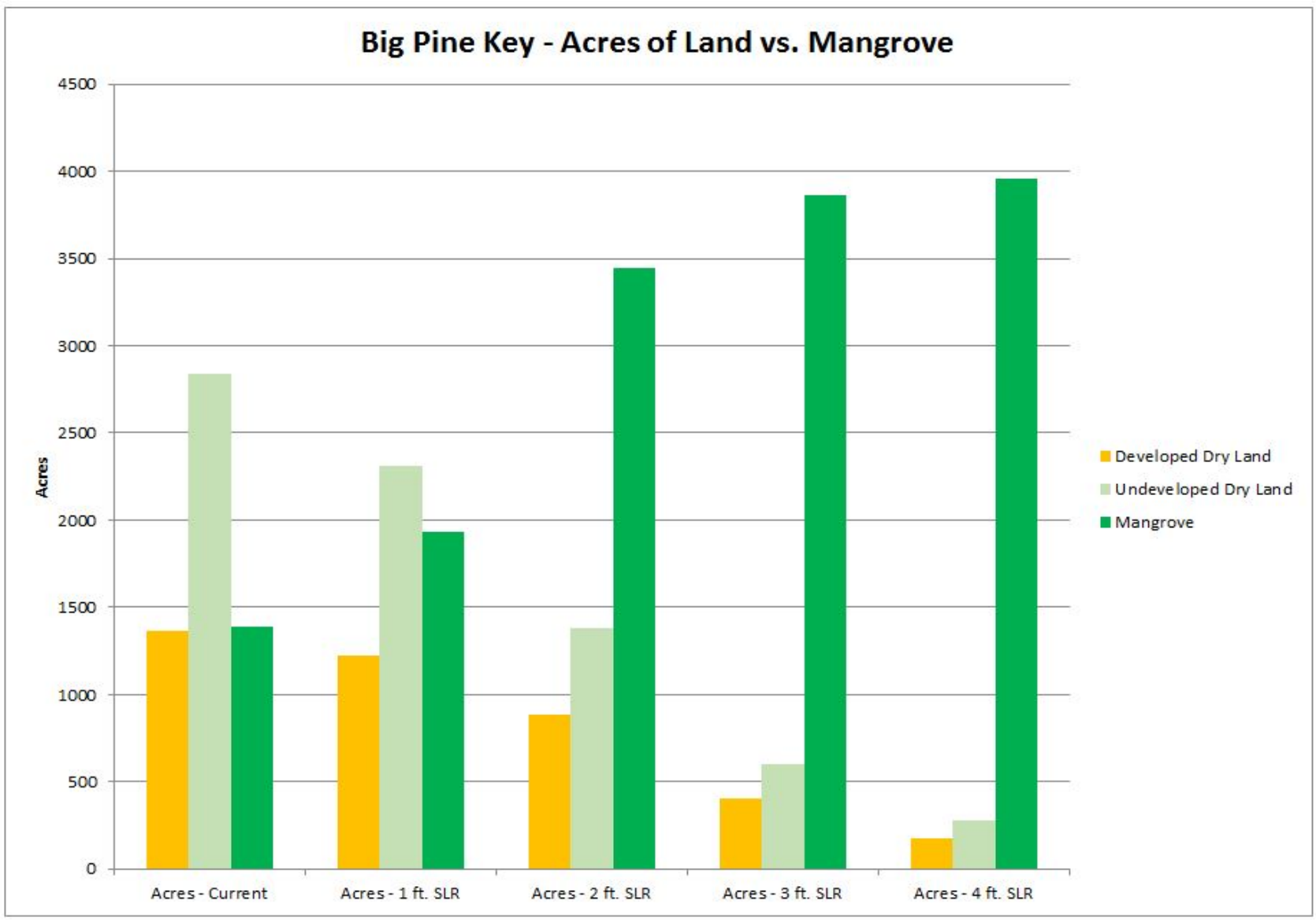
- Developed Land
- Undeveloped Dry Land
- Swamp
- Inland-Fresh Marsh
- Trans. Salt Marsh
- Regularly-Flooded Marsh
- Mangrove
- Estuarine Beach
- Tidal Flat
- Ocean Beach
- Rocky Intertidal
- Inland Open Water
- Estuarine Open Water
- Open Ocean
- Irreg. Flooded Marsh



Environmental Trends

Vegetation Succession

Vegetation Succession



Environmental Trends

Temperature

Environmental Trends
Temperature

South Florida Temperatures +1.9^{o}F since 1991

South Florida Temperatures +4 to +8^{o}F by 2100

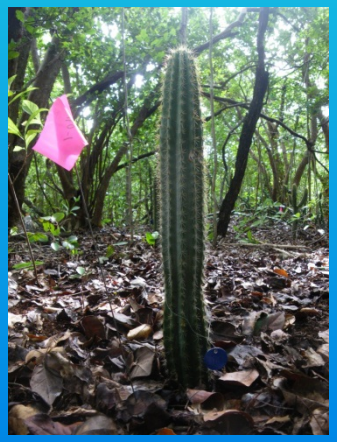
Environmental Trends

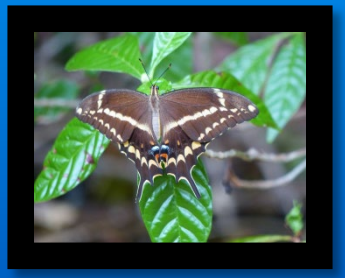
Rainfall

Environmental Trends
Rainfall
By 2100

State Region	Winter	Spring	Summer	Fall
Panhandle	0 to -10%	0 to +10%	0 to -10%	+10 to +20%
North Florida	0 to -10%	0 to +10%	-10 to -20%	+10 to +20%
Central Florida	0 to +10%	0 to -10%	-10 to -20%	+10 to +20%
South Florida	0 to +10%	0 to -10%	-20 to -30%	+10 to +20%

Environmental Trends
Species will be Significantly Affected or Disappear by 2100





Climate Science Summary
Recommendations at USFWS SFESO:

- **Modeling (Vetted and Accepted Best Available Science)**
  - The NOAA 2017 Technical Report.
  - Sea Level Affecting Marshes Model (SLAMM) 2018 modeling.

- **Sea Level Rise Trends**
  - Use the NOAA Intermediate (4 ft. SLR), Intermediate-High (6 ft. SLR), and High (8.5 ft. SLR) scenarios.

  - **Focus on** root zone salinization elevations (10 in. to 2 ft.) and timelines, rather than solely focusing on surface inundation. ***This will affect Big Pine Key's last upland vegetation between 2030 and 2050. The island will be mostly underwater by 2050 to 2080***.

- **Temperature Trends**
  - Increased Temperatures in the State of Florida of +4 to +8° F by 2100 depending on the scenario.

- **Precipitation Trends**
  - Higher fall and winter rainfall (dry season) (+~20 percent)
  - Lower spring and summer rainfall (wet season) (-~30 percent) by 2100.

- **Uncertainty**
  - Certainty improves from 2050-2100 with 4 ft. - 8 ft. of SLR in the Florida Keys. Uncertainty in model projections is higher from 2020-2050 due to global model uncertainty of acceleration.

What Do We Do With This?

Big Pine Key: Today

Simulation of
Big Pine Key: 2100

A 2019 Best Available Science Synthesis Report. Case Study – Big Pine Key, FL

Lori Miller[1], Hydrologist and Environmental Engineer
Steve Traxler[2], Retired PFLCC Science Coordinator

eMail – lori_miller@fws.gov Phone 772-469-4231

U.S. Fish and Wildlife Service
South Florida Ecological Services Office, Vero Beach, Florida

The End