Sea Level Rise and Future Environmental Trends

Case Study – Big Pine Key, FL

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South Florida Ecological Services Office (SFESO), Vero Beach, 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

**CO₂** 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!
Winter Storm Surge Flooding!
February 12, 2019

Usual Sea Ice has not developed along the beaches that protects against storm surge.

A life long resident said they have never experienced winter storm surge flooding in the winter during their lifetime - \textit{EVER}. (AP)
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’)

*~ 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!

Barletta et al. 2018 – Consortium of Numerous Academia

Cumulative Changes in Ice Mass for all of Greenland

Δ-Ice Mass (pt.)

1980 85 1990 95 2000 05 2010 15

Tipping Point?

A short “Pause”
Rising Seas around the Florida Keys

8724580 Key West, Florida

- Linear Mean Sea Level Trend
- Upper 95% Confidence Interval
- Lower 95% Confidence Interval

Monthly mean sea level with the average seasonal cycle removed

0.09 inch/year

NOAA 2017
Rising Seas around the Florida Keys

\[ y = 0.0081e^{0.1693x} \]

\[ R^2 = 0.8538 \]

Tipping Point?

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

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   • Sediment Compaction
   • Groundwater and Fossil Fuel Withdrawals
NOAA 2017 Scenarios

NOAA et al. 2017 Relative Sea Level Change Scenarios for: KEY WEST

- NOAA2017 Extreme
- NOAA2017 High
- NOAA2017 Int-High
- NOAA2017 Intermediate
- NOAA2017 Int-Low
- NOAA2017 Low
- NOAA2017 VLM
NOAA 2017 Scenarios

NOAA et al. 2017 Relative Sea Level Change Scenarios for: KEY WEST

RSLC in feet

Year

Potential for Rapid Ice Melt
Business as Usual
Decreasing GHG – 2080
Decreasing GHG – 2060
Decreasing GHG – 2040 and 2020
2000 Extrapolation

96-100% Probability that the Lower 3 Scenarios Have Been or Will be Exceeded
NOAA 2017 Scenarios

NOAA et al. 2017 Relative Sea Level Change Scenarios for: KEY WEST

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- Decreasing GHG - 2080
- Decreasing GHG – 2060

Graph showing RSLC in feet against years from 2000 to 2100.
NOAA 2017 Scenarios

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Root Zone

Freshwater Lens Impacts
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- 1,007 Acres (12%) Dry Land Remains
- Root Zone
- Freshwater Lens Impacts

Year

RSLC in feet
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Root Zone

Freshwater Lens Impacts

Year

RSLC in feet

2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
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 vs. 1 ft. SLR (2030-2040)

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>Acres - Current</th>
<th>Percentage %</th>
<th>Acres - 1 ft. SLR</th>
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<tbody>
<tr>
<td>Developed Dry Land</td>
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#### 2 ft. SLR (2050-2060) vs. 3 ft. SLR (2060-2080)

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<th>Acres - 3 ft. SLR</th>
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<tbody>
<tr>
<td>Developed Dry Land</td>
<td>886</td>
<td>10</td>
<td>406</td>
<td>5</td>
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<tr>
<td>Undeveloped Dry Land</td>
<td>1381</td>
<td>15</td>
<td>601</td>
<td>7</td>
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<td>3444</td>
<td>39</td>
<td>3859</td>
<td>43</td>
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#### 4 ft. SLR (2070-2100)

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<td>175</td>
<td>2</td>
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<td>277</td>
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*SLR = Sea Level Rise*
Environmental Trends

Development in Big Pine Key
Development on Big Pine Key
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

U.S. FISH & WILDLIFE SERVICE
Environmental Trends
Vegetation Succession
Vegetation Succession

Big Pine Key - Acres of Land vs. Mangrove

- Acres - Current
- Acres - 1 ft. SLR
- Acres - 2 ft. SLR
- Acres - 3 ft. SLR
- Acres - 4 ft. SLR

Legend:
- Developed Dry Land
- Undeveloped Dry Land
- Mangrove

Graph showing the comparison of developed dry land, undeveloped dry land, and mangrove acres across different sea level rise scenarios.
Environmental Trends

Temperature
Environmental Trends
Temperature

South Florida Temperatures $+1.9^\circ F$ since 1991

South Florida Temperatures $+4$ to $+8^\circ F$ by 2100
Environmental Trends

Rainfall
## Environmental Trends

### Rainfall

<table>
<thead>
<tr>
<th>State Region</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
</tr>
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<tbody>
<tr>
<td>Panhandle</td>
<td>0 to -10%</td>
<td>0 to +10%</td>
<td>0 to -10%</td>
<td>+10 to +20%</td>
</tr>
<tr>
<td>North Florida</td>
<td>0 to -10%</td>
<td>0 to +10%</td>
<td>-10 to -20%</td>
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<tr>
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<td>0 to +10%</td>
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<td>0 to +10%</td>
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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)**
  – 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
We do not inherit the Earth from our Ancestors, we borrow it from our Children.

The End


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The End