# Anticipated Impacts
# of
# Sea Level Rise

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Adapted from presentations by
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Sea Grant
Florida

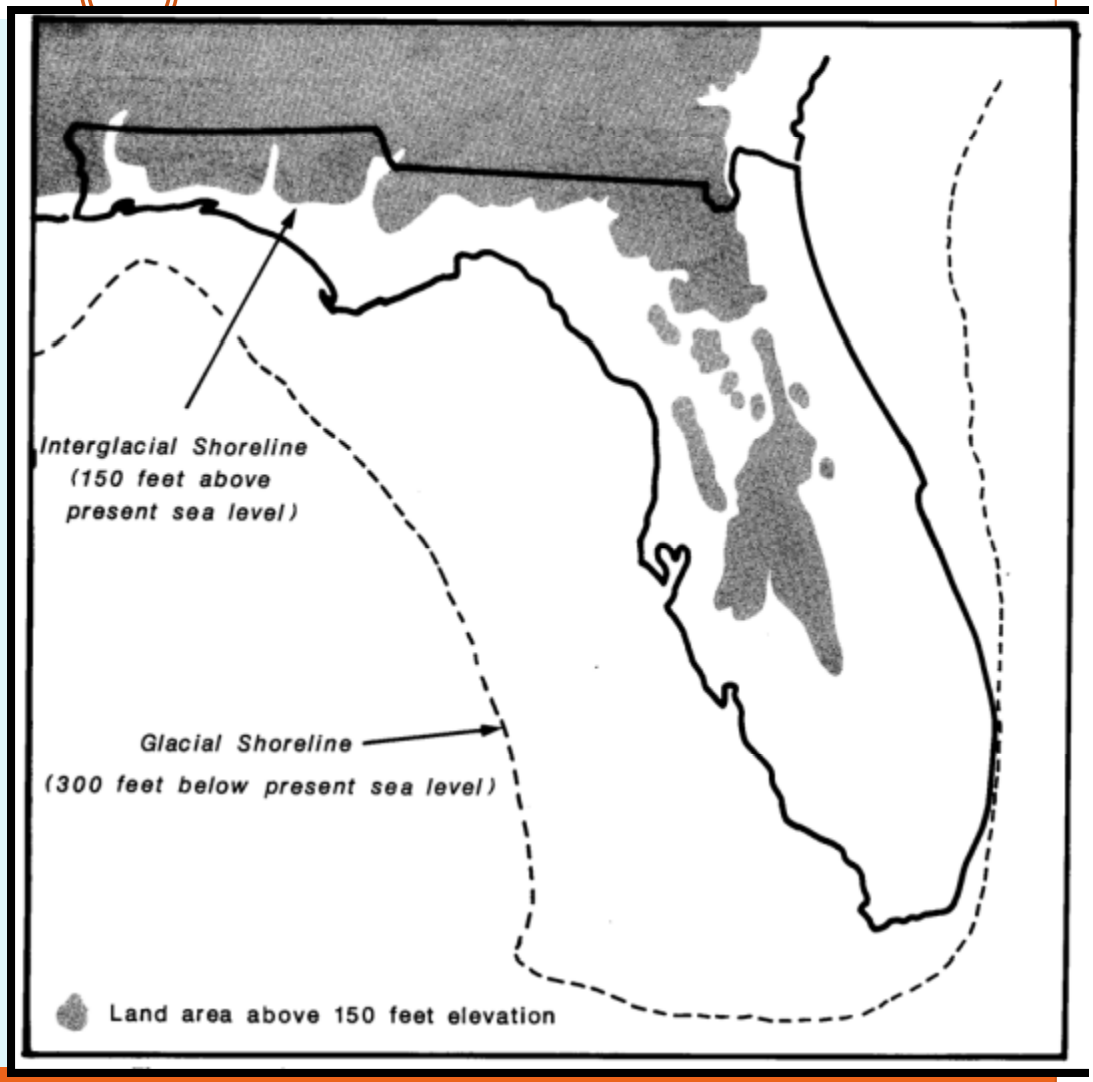
# Goals of today's presentation

- What is the science telling us about sea level rise?
- What are the general effects of sea level rise in Florida?
- How will manmade systems likely be affected by sea level rise?
- How will coastal habitats likely be affected by sea level rise to 2100?
- How can we mitigate for and adapt to sea level rise?

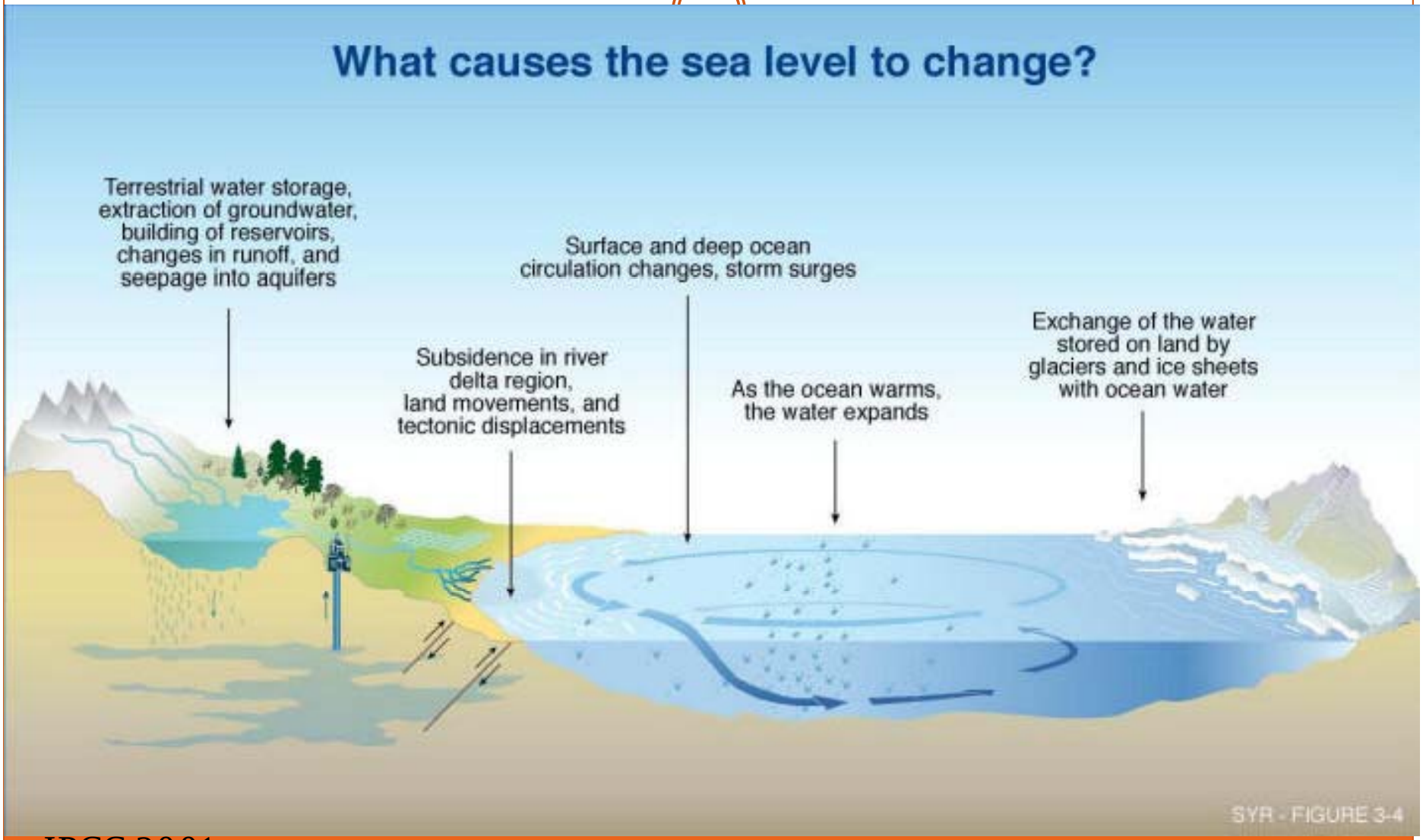
# What is the science telling us about sea level rise?

# Florida's Coastline

- The gray shows the dry land 1.8 million years ago…
- The dotted line shows the shoreline 10,000 years ago.

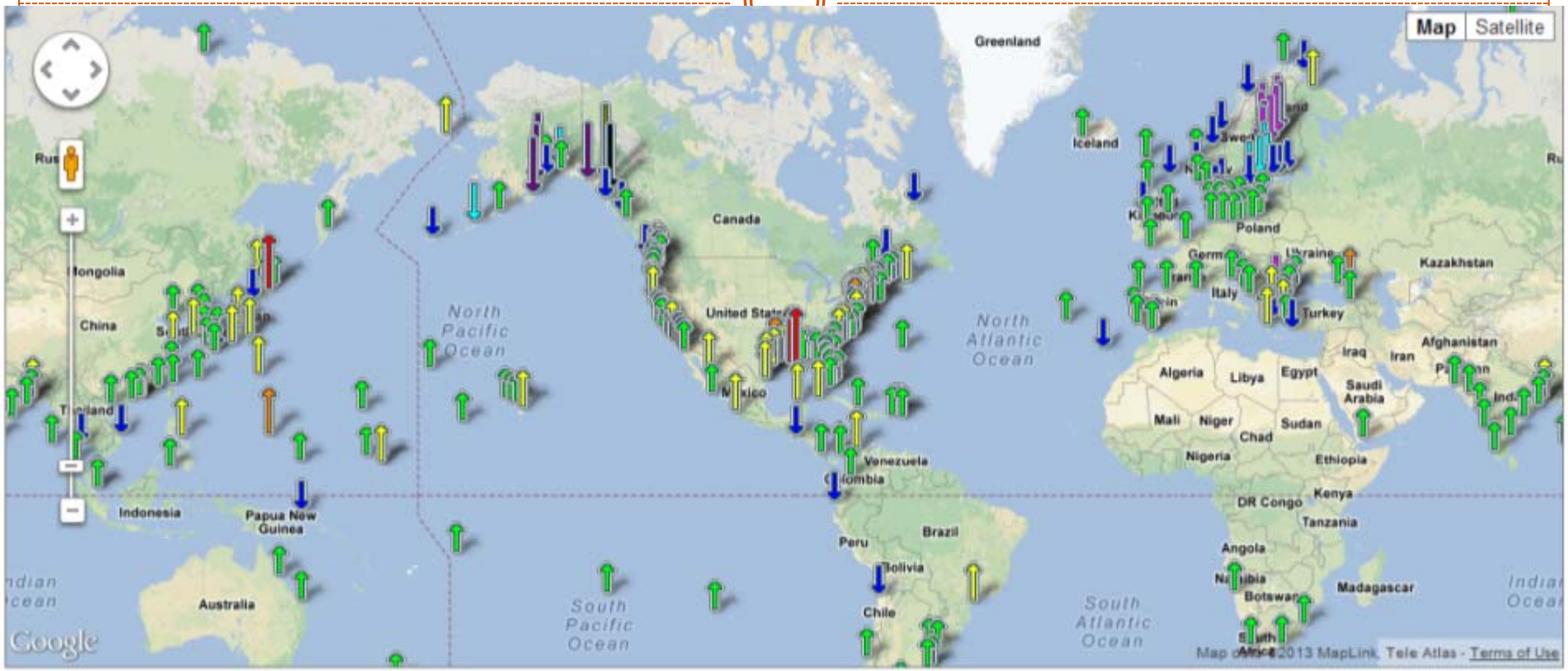


# Causes of Sea Level Rise




IPCC 2001

# Global sea level trends




*The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.*

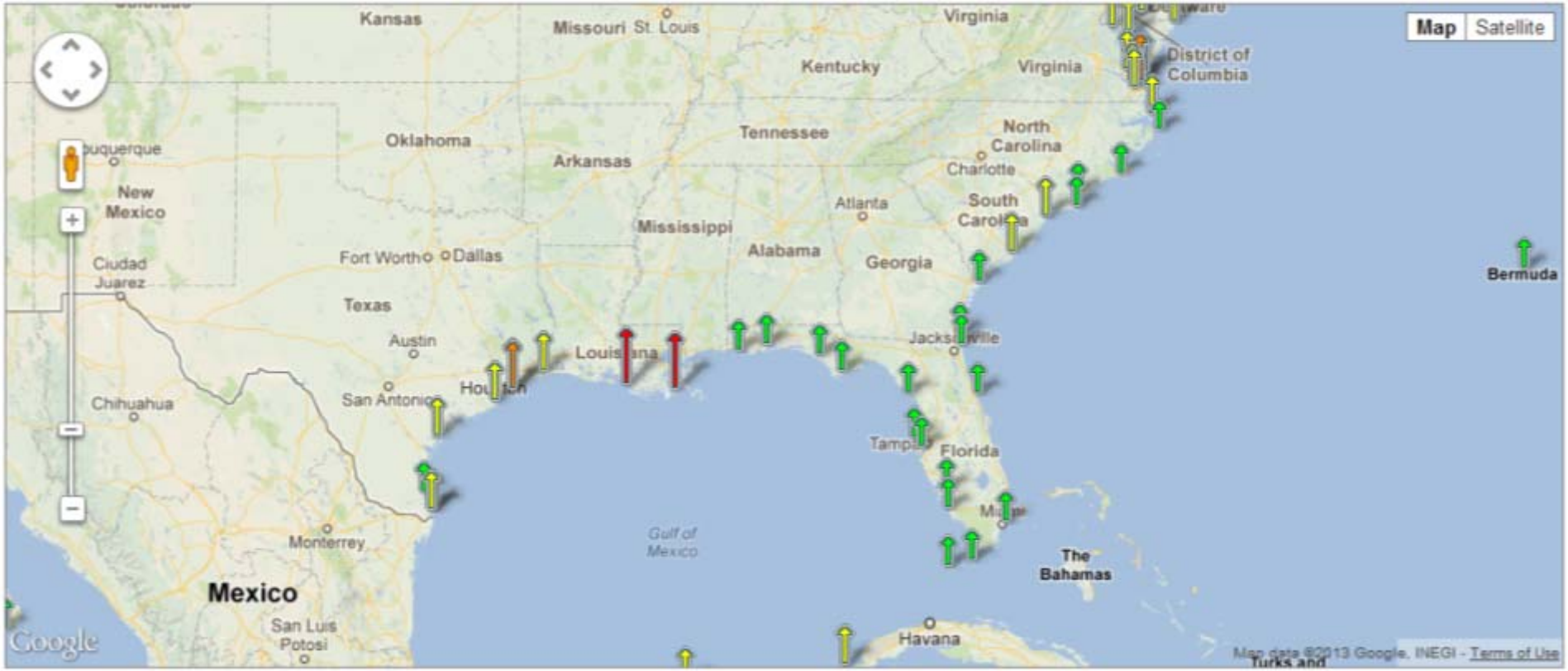
**Sea Level Trends**

mm/yr (feet/century)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 9 to 12 (3 to 4) | 3 to 6 (1 to 2) | -3 to 0 (-1 to 0) | -9 to -6 (-3 to -2) | -15 to -12 (-5 to -4) |
| 6 to 9 (2 to 3) | 0 to 3 (0 to 1) | -6 to -3 (-2 to -1) | -12 to -9 (-4 to -3) | -18 to -15 (-6 to -5) |

http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml

# Zooming in…

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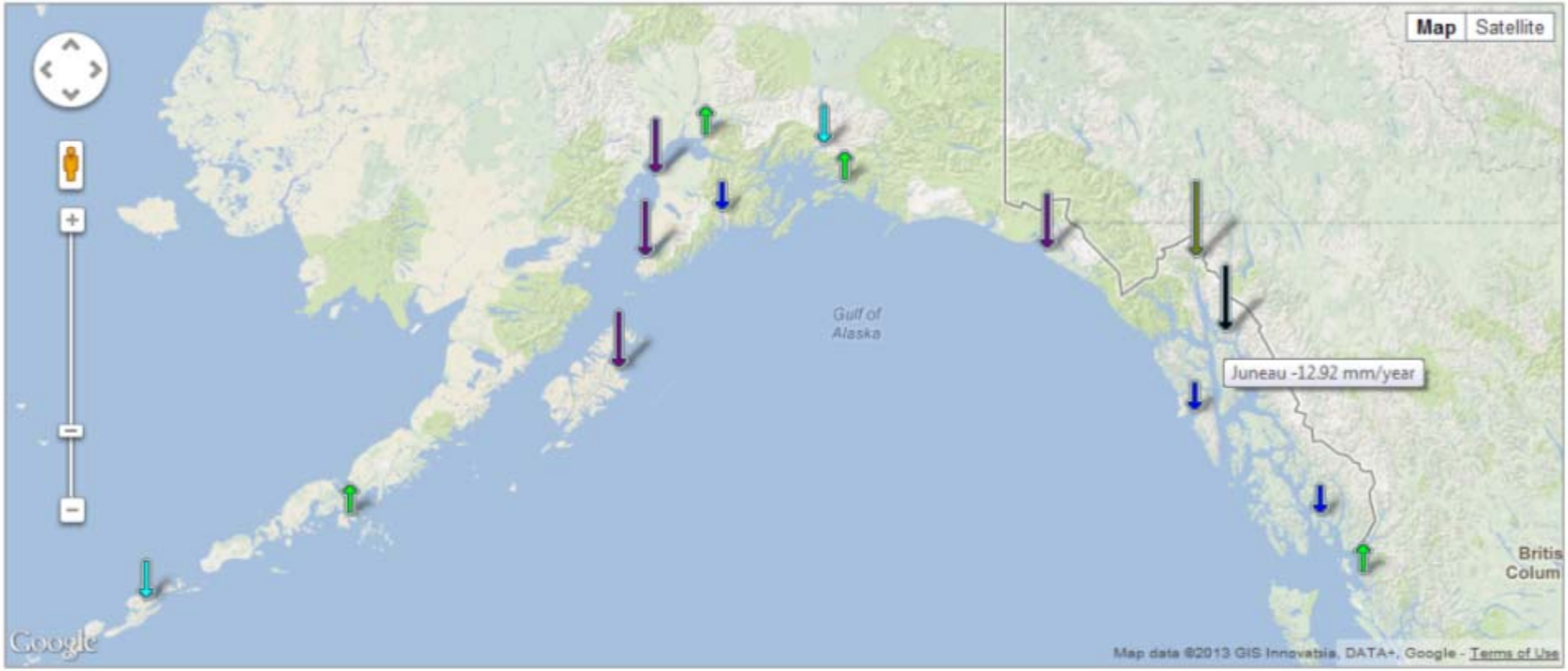


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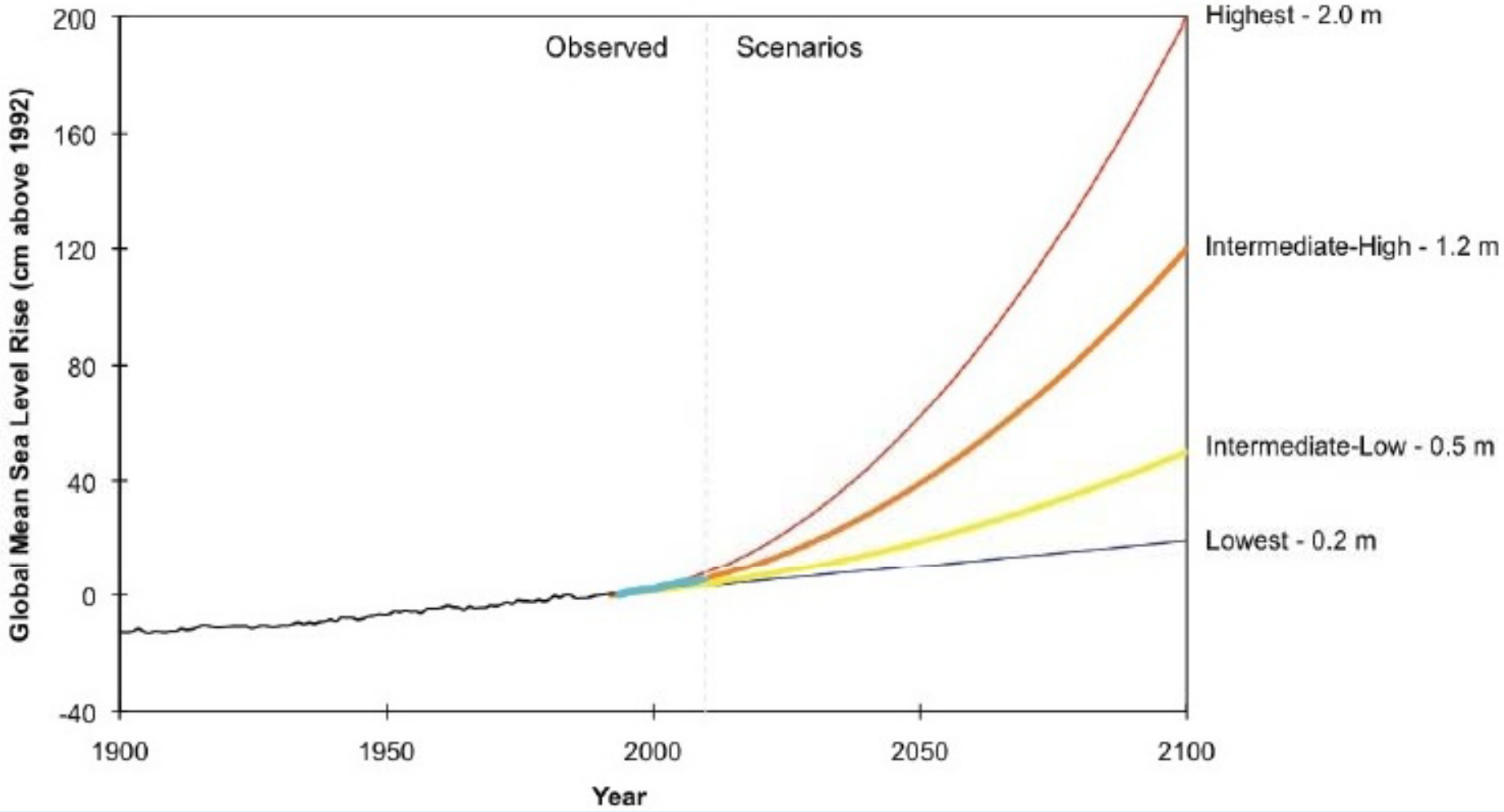
# Global Mean Sea Level Rise Scenarios

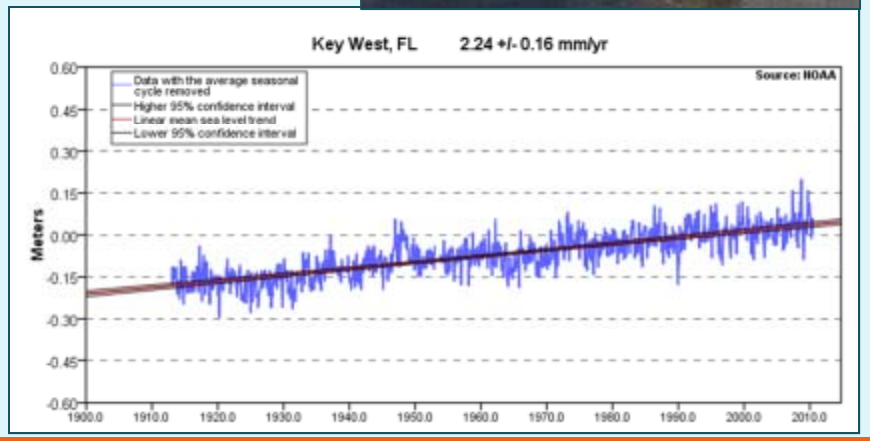



Global SLR Scenarios for the United States National Climate Assessment. Dec, 2012

# About 3 mm per year…

About the thickness of a Kraft Single each year

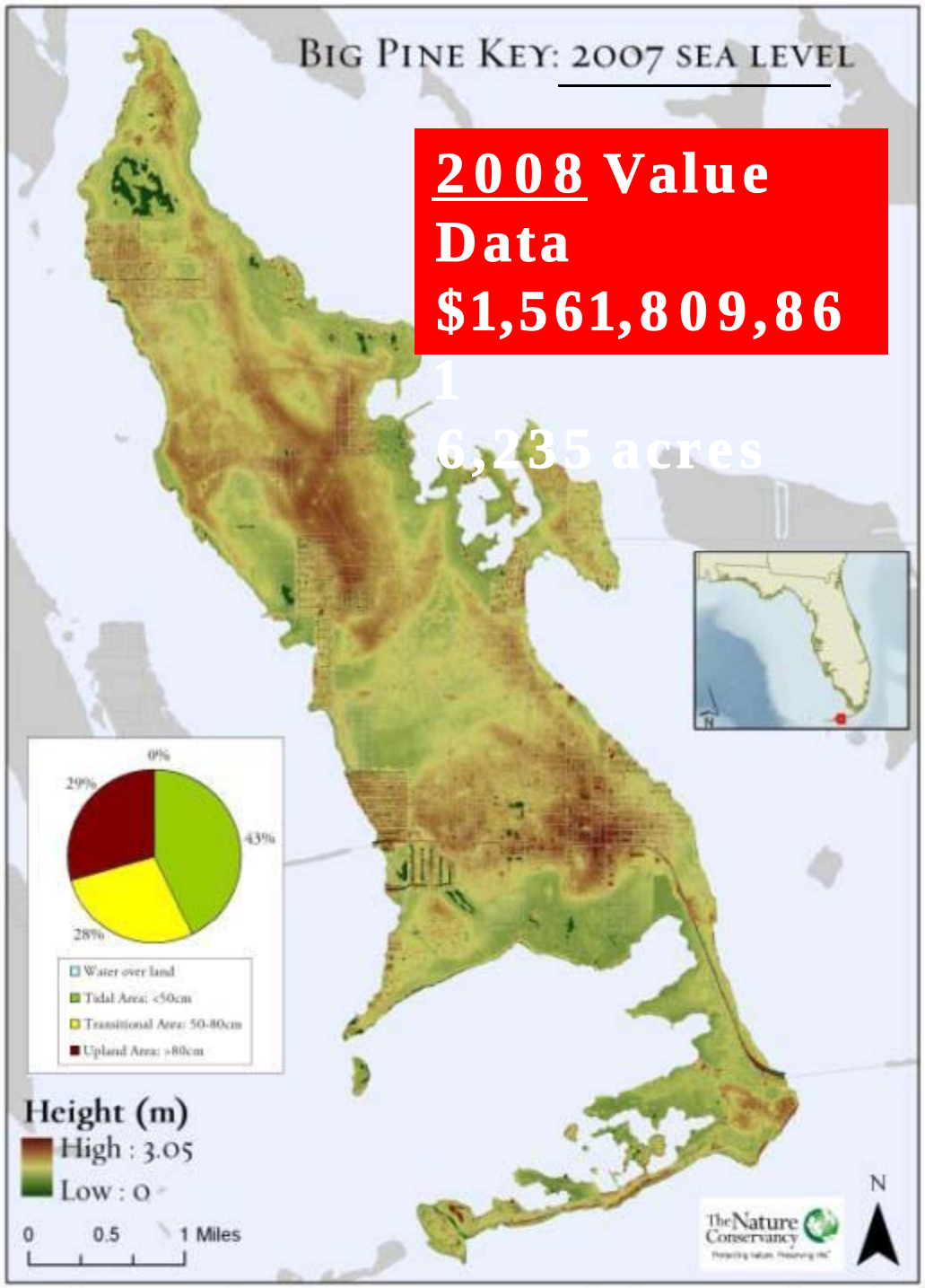
9 inches in Key West in the past 100 years

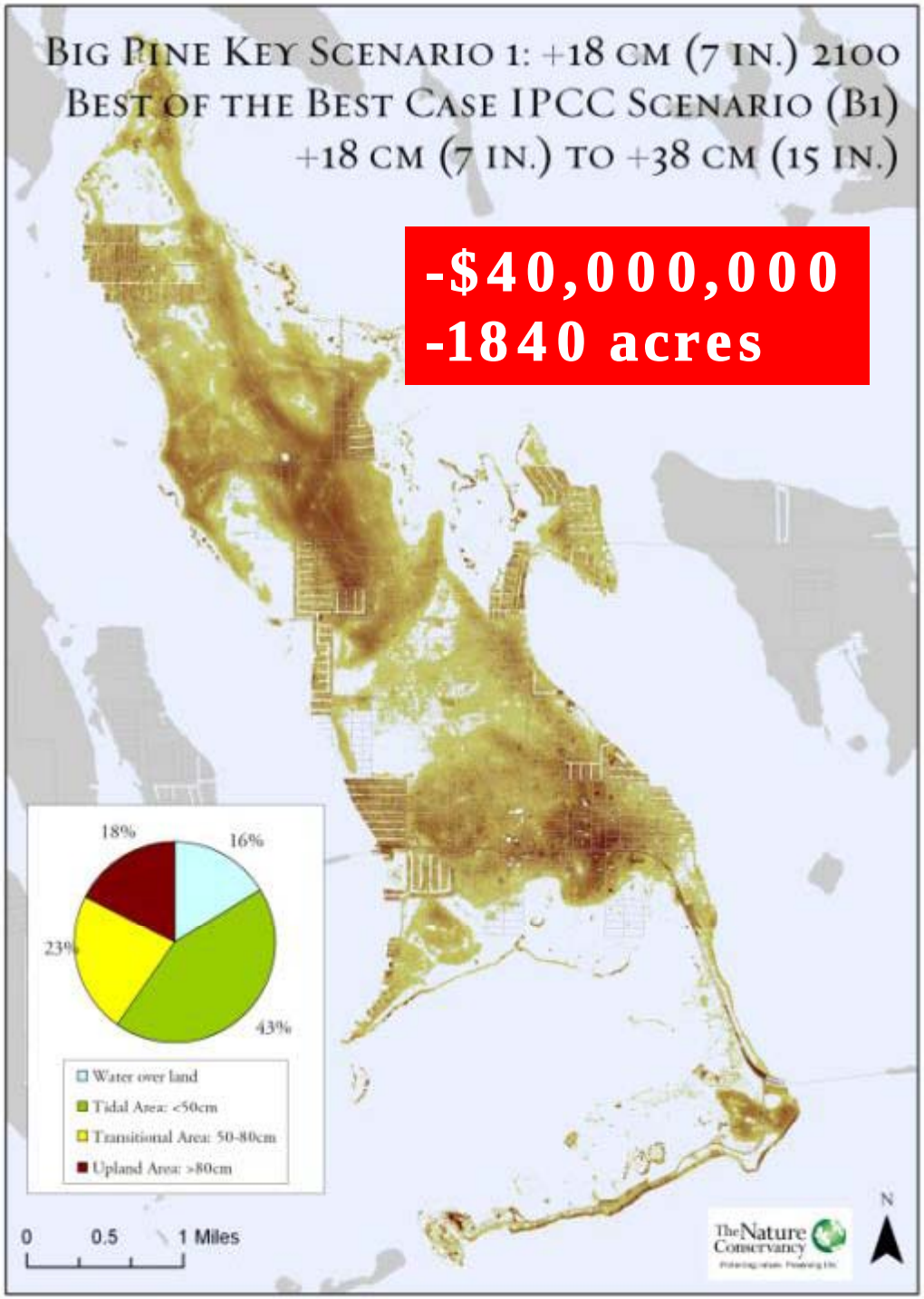


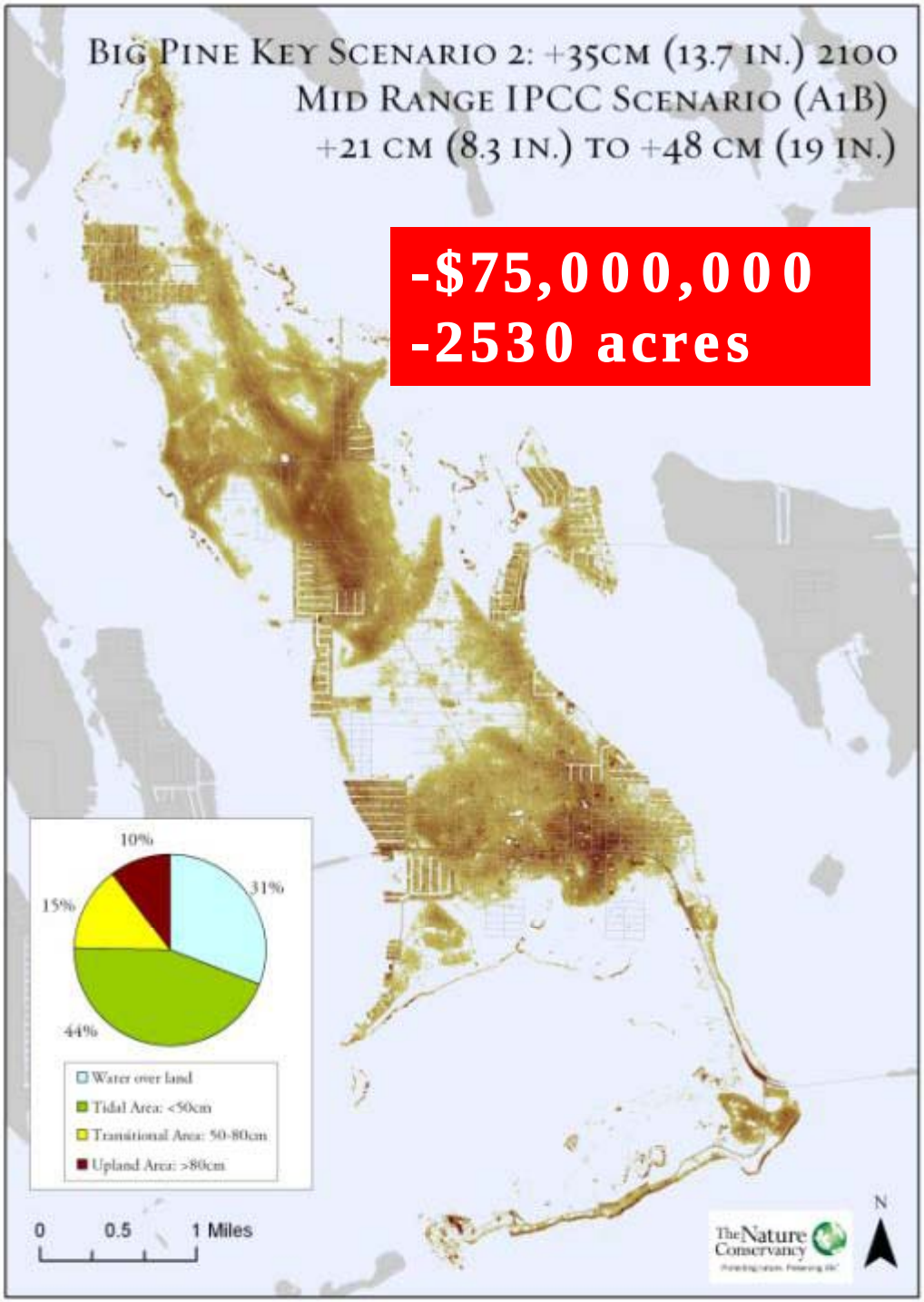
# Big Pine Key Model

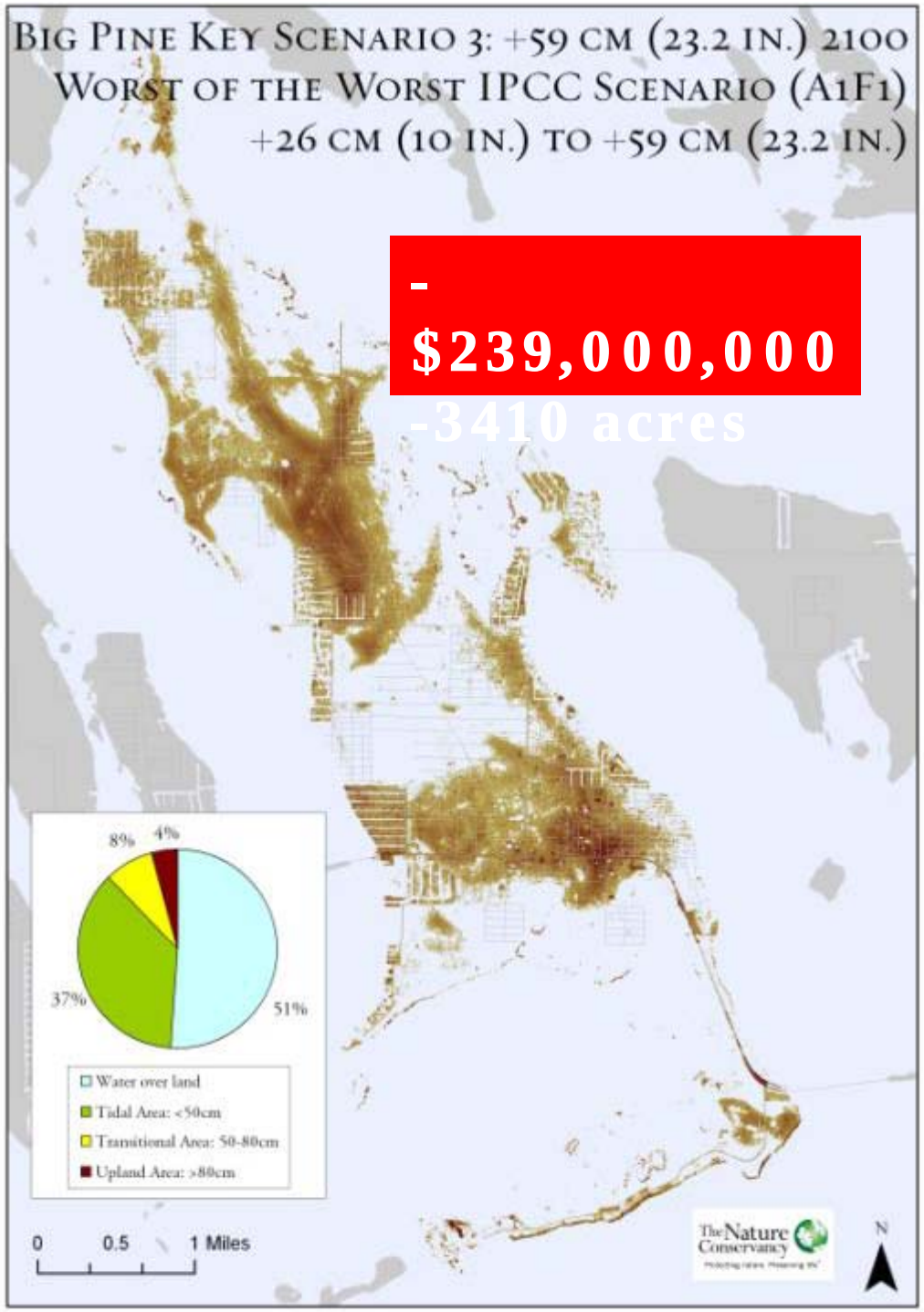
- "Initial Estimates of the Ecological and Economic Consequences of Sea Level Rise on the Florida Keys through the Year 2100"
  - Sea level rise modeling focused on Big Pine Key using fine scale elevation data
  - Sea level rise modeling on the entire Keys using coarse scale elevation data
  - Resilience and adaption responses

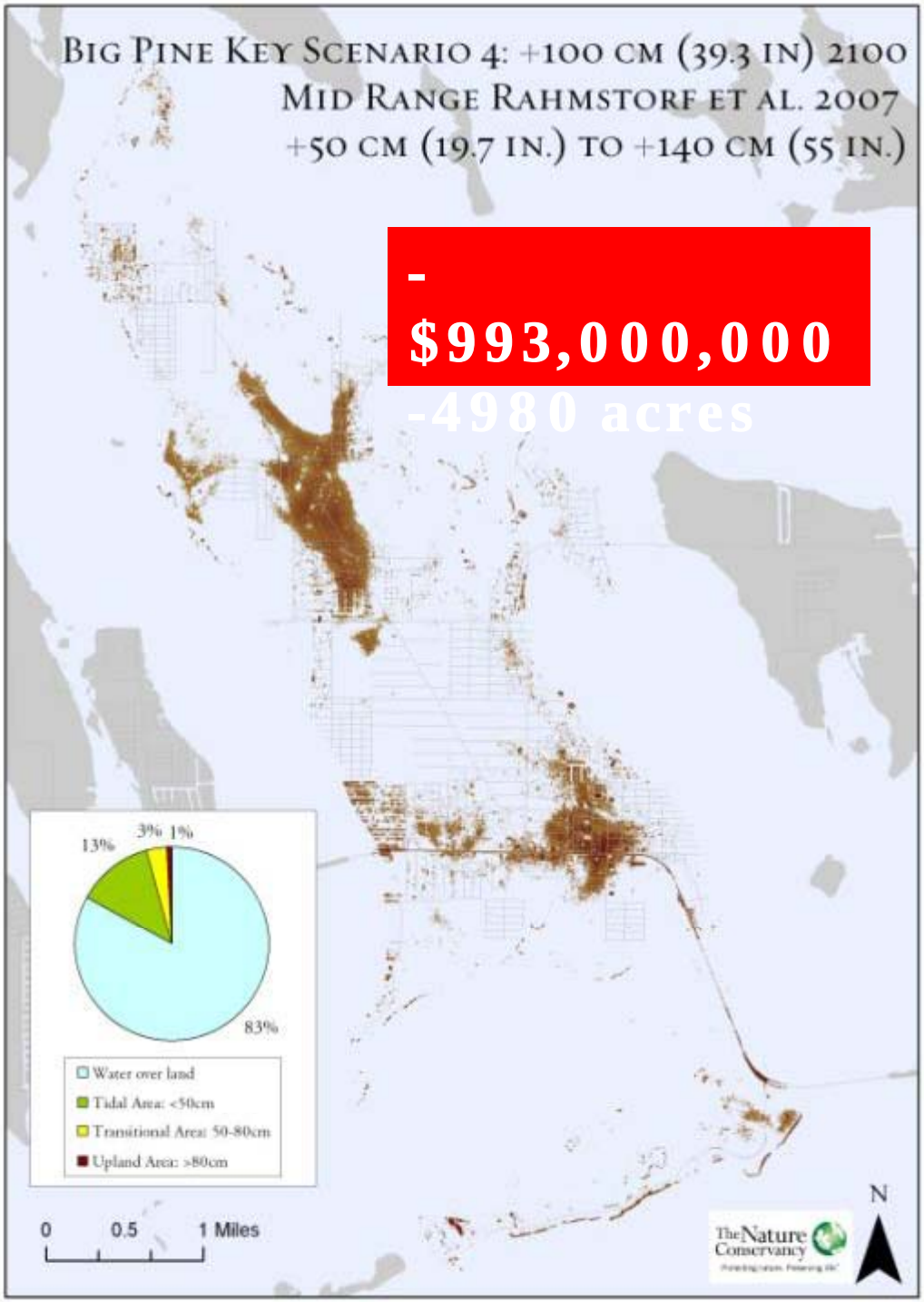
The Nature Conservancy
Protecting nature. Preserving life.™
nature.org

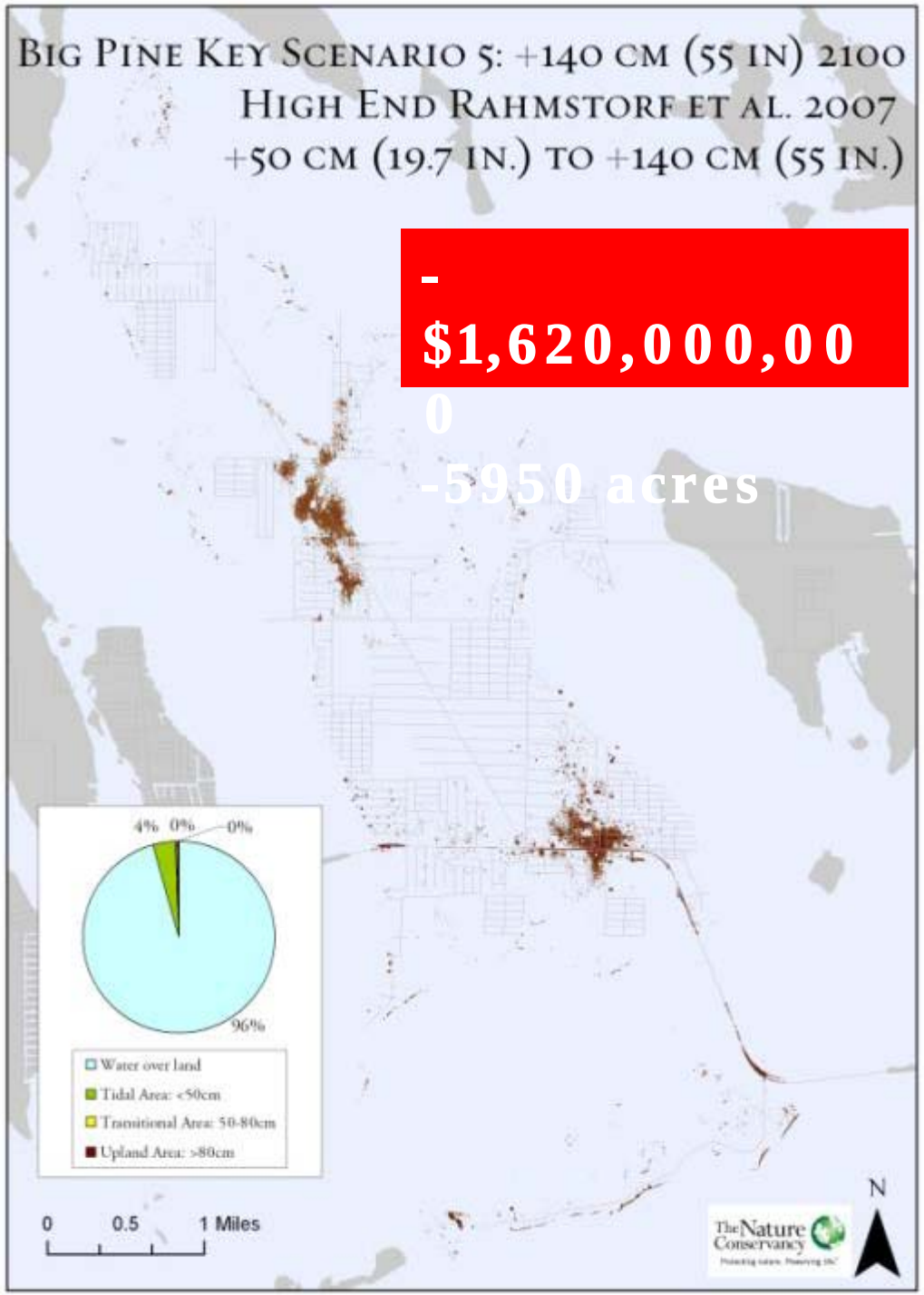

Big Pine Key: 2007 sea level
2008 Value Data
$1,561,809,86
1
6,235 acres
0%
29%
43%
28%
Water over land
Tidal Area: <50cm
Transitional Area: 50-80cm
Upland Area: >80cm
Height (m)
High : 3.05
Low : 0
0
0.5
1 Miles
N
The Nature Conservancy

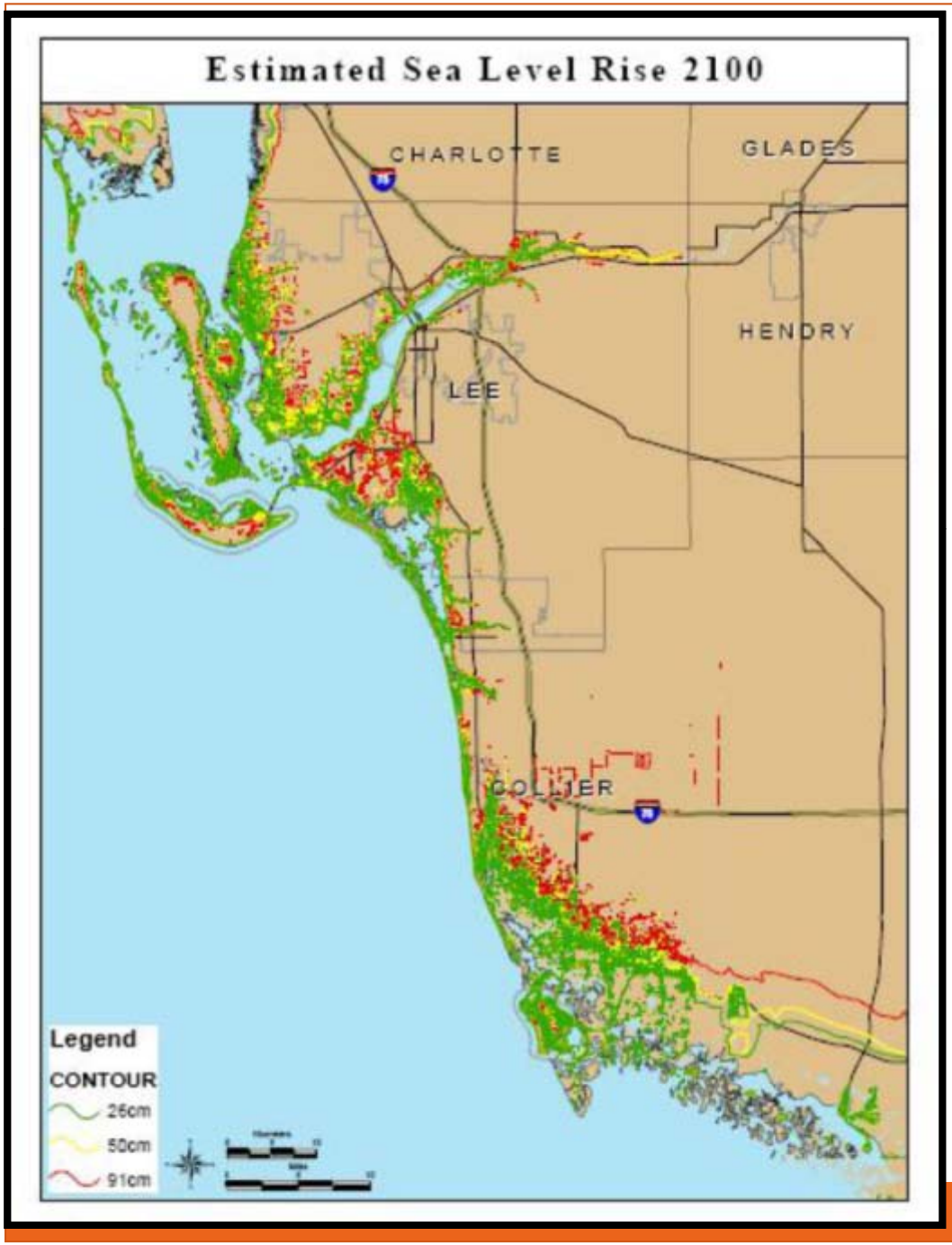

Big Pine Key Scenario 1: +18 cm (7 in.) 2100
Best of the Best Case IPCC Scenario (B1)
+18 cm (7 in.) to +38 cm (15 in.)
-$40,000,000
-1840 acres
18%
16%
23%
43%
Water over land
Tidal Area: <50cm
Transitional Area: 50-80cm
Upland Area: >80cm
0
0.5
1 Miles
The Nature Conservancy
N


Big Pine Key Scenario 2: +35cm (13.7 in.) 2100
Mid Range IPCC Scenario (A1B)
+21 cm (8.3 in.) to +48 cm (19 in.)
-$75,000,000
-2530 acres
10%
31%
15%
44%
Water over land
Tidal Area: <50cm
Transitional Area: 50-80cm
Upland Area: >80cm
0
0.5
1 Miles
N
The Nature Conservancy


Big Pine Key Scenario 3: +59 cm (23.2 in.) 2100
Worst of the Worst IPCC Scenario (A1F1)
+26 cm (10 in.) to +59 cm (23.2 in.)
-
$239,000,000
-3410 acres
8%
4%
37%
51%
Water over land
Tidal Area: <50cm
Transitional Area: 50-80cm
Upland Area: >80cm
0
0.5
1 Miles
The Nature Conservancy
N


Big Pine Key Scenario 4: +100 cm (39.3 in) 2100
Mid Range Rahmstorf et al. 2007
+50 cm (19.7 in.) to +140 cm (55 in.)
-
$993,000,000
-4980 acres
13%
3%
1%
83%
Water over land
Tidal Area: <50cm
Transitional Area: 50-80cm
Upland Area: >80cm
0
0.5
1 Miles
N
The Nature Conservancy


Big Pine Key Scenario 5: +140 cm (55 in) 2100
High End Rahmstorf et al. 2007
+50 cm (19.7 in.) to +140 cm (55 in.)
-
$1,620,000,00
0
-5950 acres
4%
0%
0%
96%
Water over land
Tidal Area: <50cm
Transitional Area: 50-80cm
Upland Area: >80cm
0
0.5
1 Miles
N
The Nature Conservancy




# What does the modeling show for SWFL?

- Modeling shows tidal inundation reaching inland between the red and yellow zones in Southwest Florida.
- Different regions of Florida will have different results...

# What are the general effects of sea level rise in Florida?

# What is the situation in Florida?

- 2.4 million people in Florida live below an elevation of 4 feet; 840,000 below 3 feet.
- In Miami-Dade county, over 250,000 residential structures valued over $50 billion are vulnerable to storm surge
- Florida has 30 energy facilities less than 5 feet above local high tide

# What are the general effects of sea level rise?

- Increased vulnerability to coastal flooding and storm surge
- Increased shoreline erosion
- Salt water intrusion into fresh water sources
- Changes to tides and tidal regimes
- Increased inundation
- Deterioration of coastal infrastructure

http://eyeonmiami.blogspot.com/2008/10/sea-level-rise-in-miami-here-now-by.html

# Projected impacts for FL

- A 0.49 foot rise in sea level will result in flooding in SE coastal FL leading to water use cutbacks and the need for additional freshwater deliveries from other areas (SFWMD)
- A 1-foot rise in sea level will erode most FL beaches by at least 100-200 feet unless mitigation measures are used (US EPA)

# Projected impacts for FL

- A 15-inch rise in sea level
  - Loss of about 50% of saltmarshes
  - Loss of 84% of tidal flats
  - About 30% of ocean beaches and 67% of estuarine beaches will disappear. (NWF)

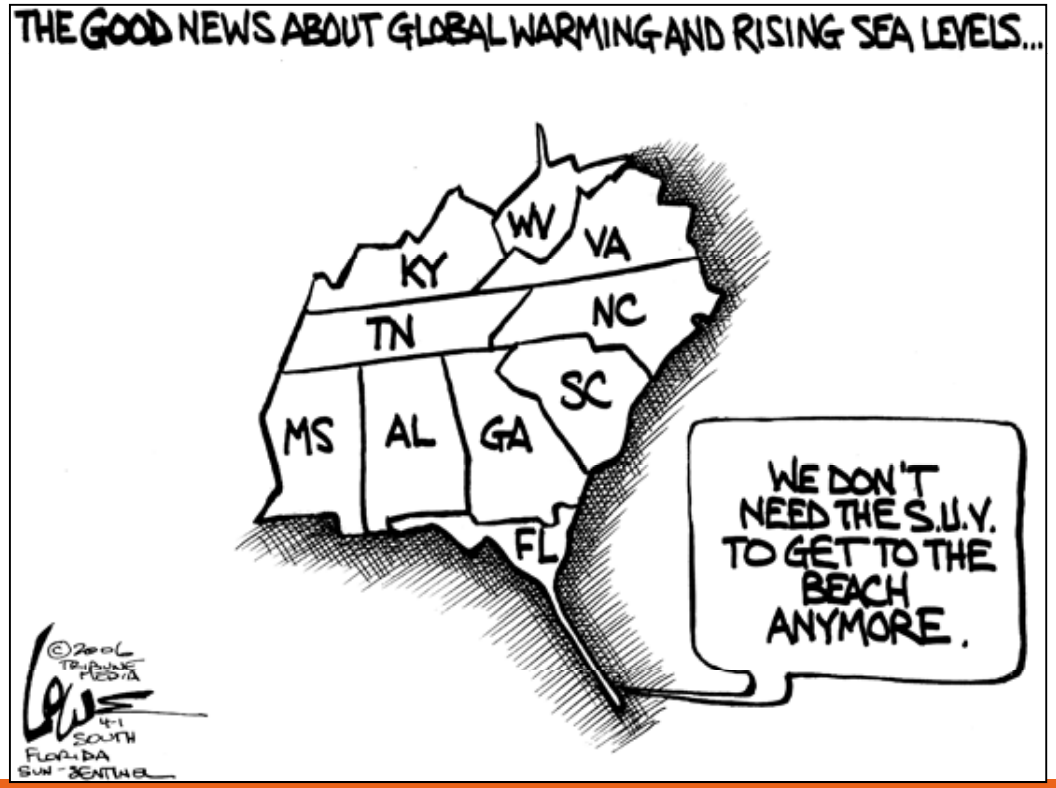
# Economic impacts

**Table 9. Value of land at risk in Dade, Duval, and Escambia counties using IPCC's SLR scenarios (in 2005$)**

| | | SLR scenarios[a] | | | | |
|---|---|---|---|---|---|---|
| **County** | **Variable** | **0.16 feet** | **0.33 feet** | **0.49 feet** | **0.98 feet** | **2.13 feet** |
| Dade | Value of land at risk | $1.05 B | $1.4 B | $2.33 B | $4.81 B | $12.3 B |
| | Area at risk[b] | 5,486 | 5,861 | 7,903 | 11,627 | 26,467 |
| | Per-acre value | $0.19 M | $0.24 M | $0.29 M | $0.41 M | $0.47 M |
| Duval | Value of land at risk | $10.4 M | $13.7 M | $19.6 M | $344 M | $572 M |
| | Area at risk[b] | 1,855 | 1,868 | 1,878 | 10,625 | 18,743 |
| | Per-acre value | $5,624 | $7,354 | $10,462 | $32,384 | $30,508 |
| Escambia | Value of land at risk | $126 M | $136 M | $148 M | $194 M | $499 M |
| | Area at risk[b] | 798 | 899 | 962 | 1,863 | 5,209 |
| | Per-acre value | $0.16 M | $0.15 M | $0.15 M | $0.10 M | $95,760 |

a. Values calculated for years 2030 and 2080. However, the overlap between the mid-2030 scenario and the low 2080 scenario (both 0.33 ft, or 0.1 m) is redundant, and since property value changes over time are not considered, the years are not shown here.
b. Unit: acres.

# How will manmade systems likely be affected by sea level rise?



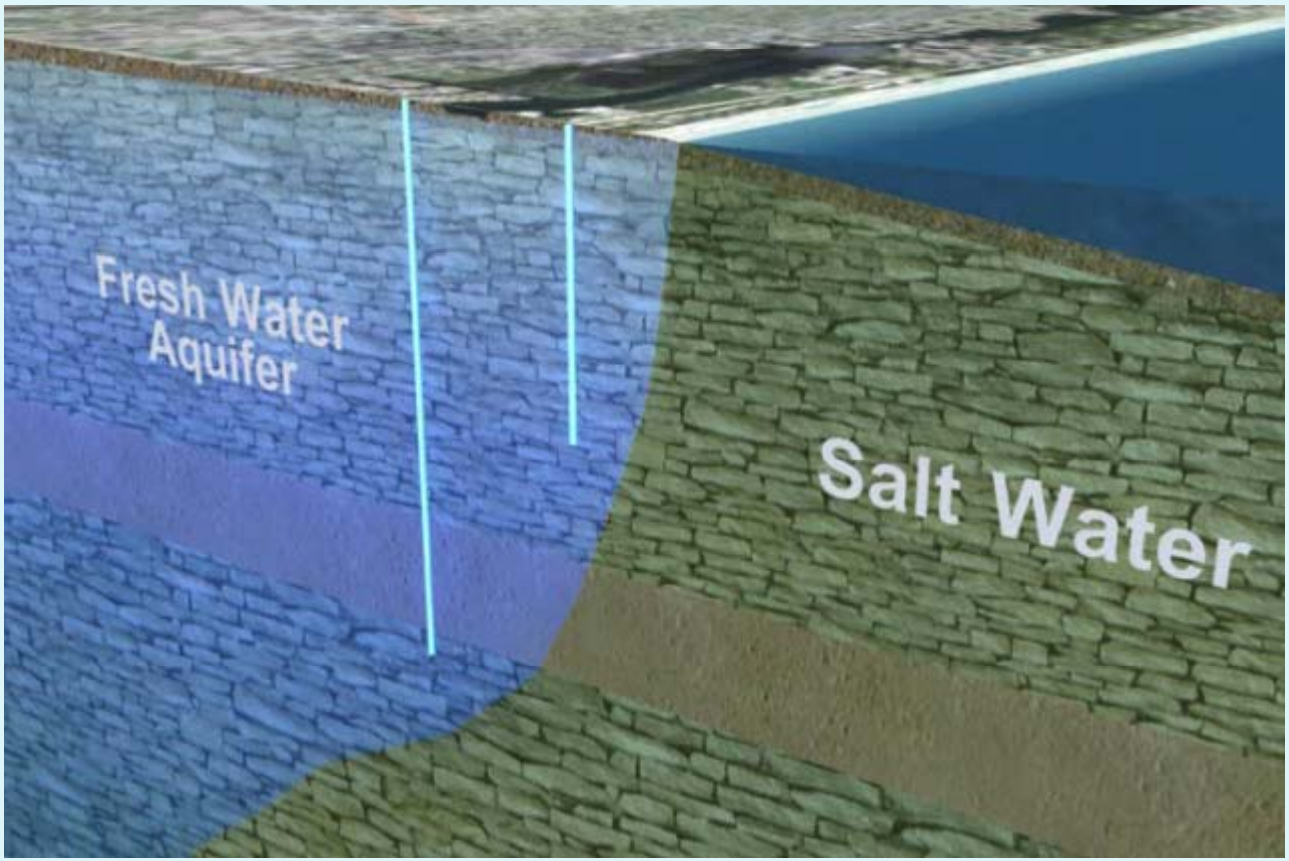
# Increased coastal flooding

- Inability of stormwater systems to drain
- Saturation of road beds leading to collapse


Photo credit: Nancy Gassman


Photo credits: St Augustine Record

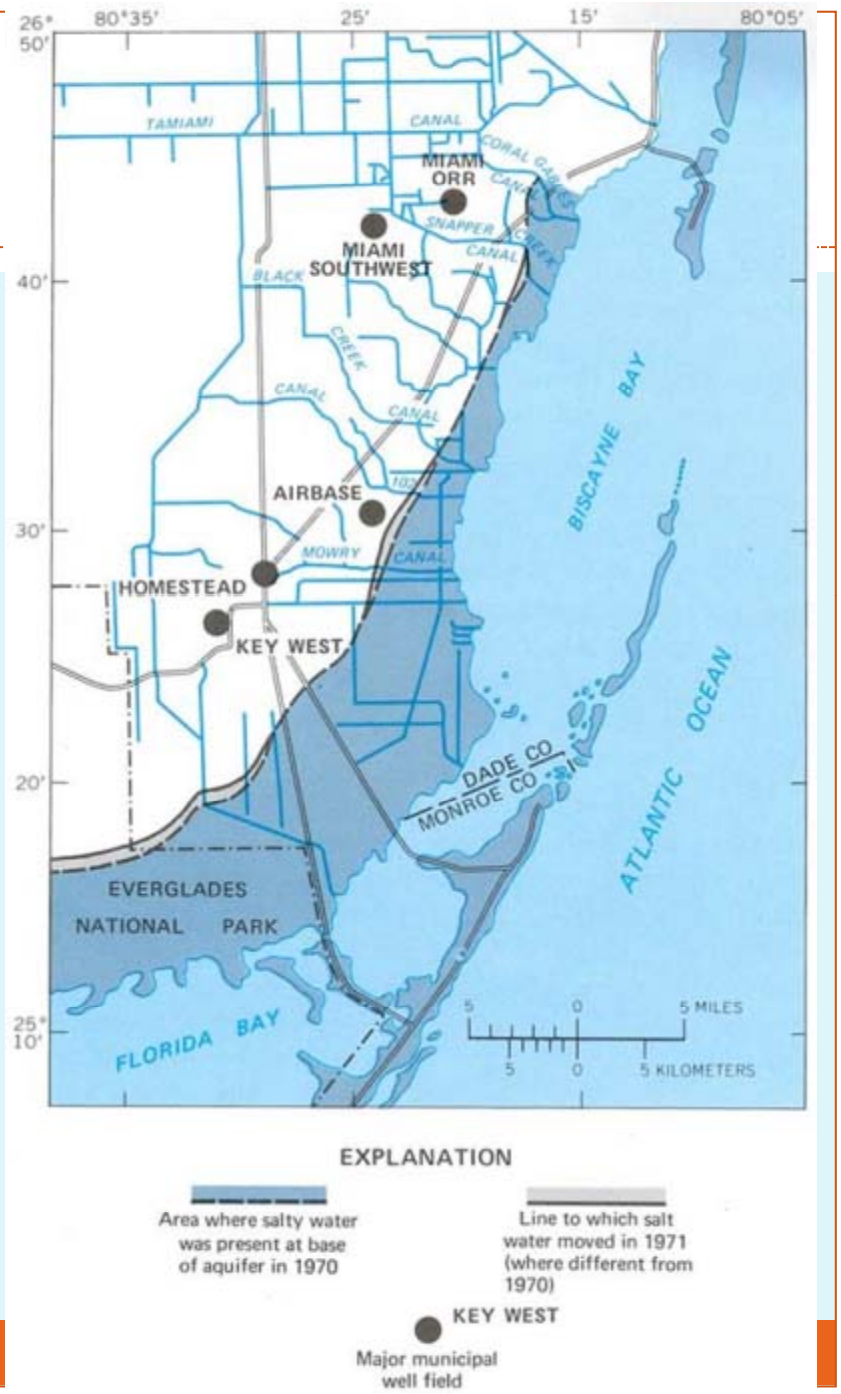
# Saltwater intrusion




Animation courtesy of South Florida Water Management District

# South Florida

- 90% of south Florida residents get water from groundwater
- 6 out of 8 wells supplying Hallandale Beach have been shut down because of saltwater intrusion

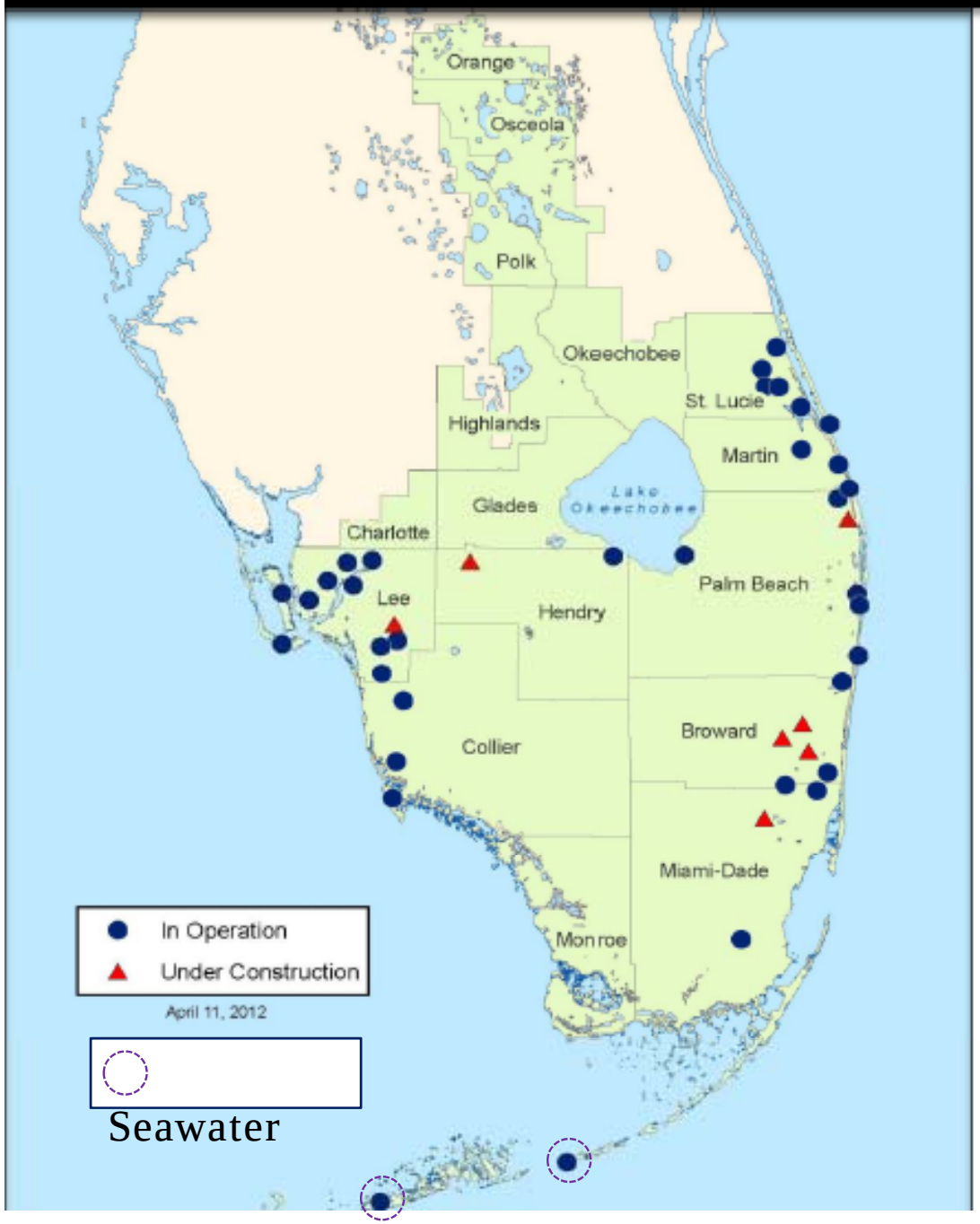


# Options for dealing with saltwater intrusion

- Drill new wells
  - Approx. $435,000/well, plus $50 million for a nanofiltration plant to remove organics
- Desalination of brackish wellwater
  - Approx. $80 million for desal plant plus $5.5 million per well for deep injection wells (brine)
- Desalination of ocean water
  - Approx. $115 million for desal plant plus $5.5 million per well for deep injection wells (brine)

Plus operating & maintenance costs of $6-15 million/year…

SOUTH FLORIDA WATER MANAGEMENT DISTRICT




# Facilities Using Brackish Groundwater and Seawater in South Florida

**Number of Facilities:**

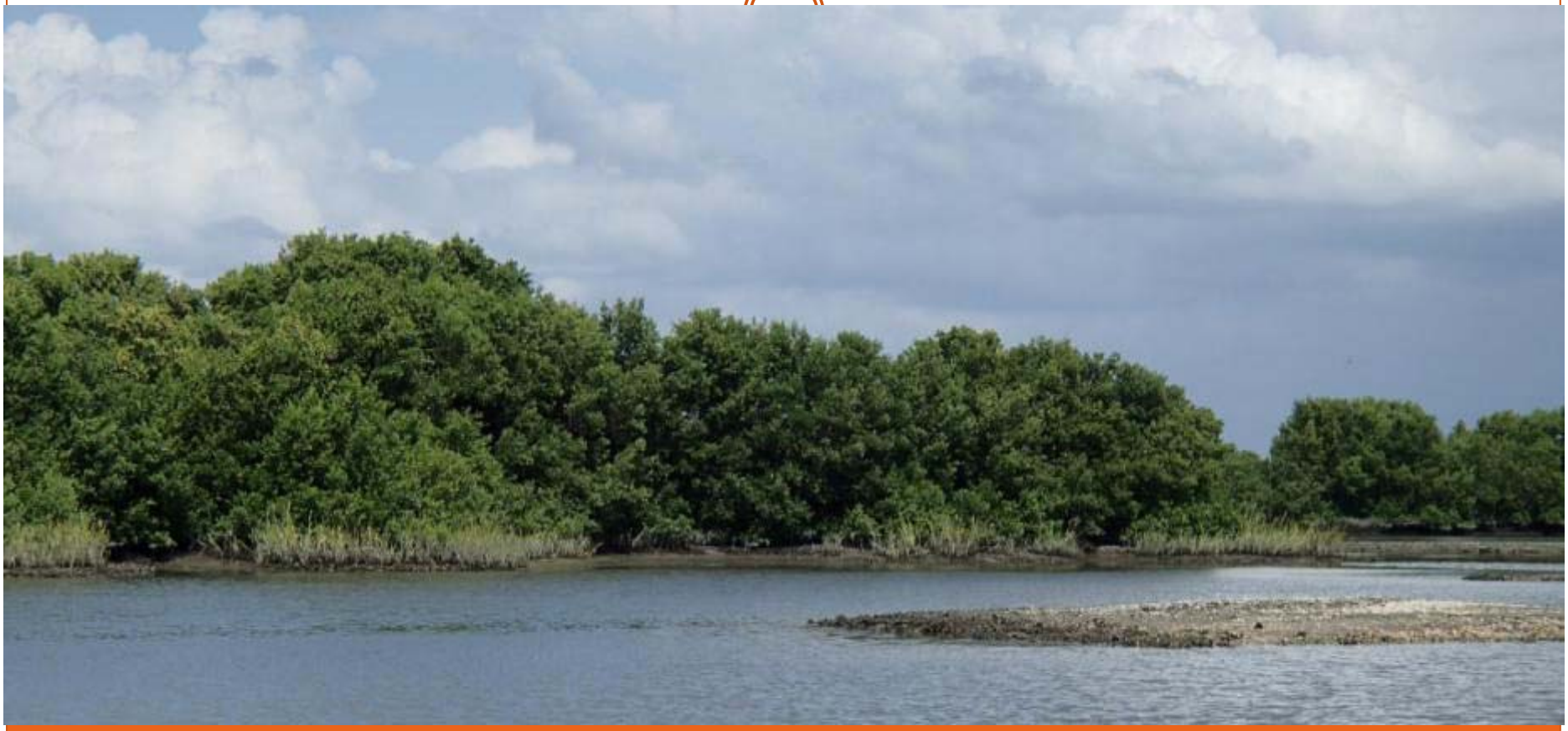
- Operating 35
- Under construction 7

**Total Capacity (MGD):**

- Operating 245
- Under Construction 36.5

sfwmd.gov

# How will coastal habitats likely be affected by sea level rise to 2100?



# What are the effects of sea level rise on **coastal habitats** in Florida?

- Increased vulnerability to flooding/storm surge
- Increased inundation
- Salt water intrusion into fresh water sources
- Changes to tides and tidal regimes
- Increased shoreline erosion

- Habitat damage/destruction
- Habitat loss/migration
- Changes to plant and animal communities
- Changes to plant and animal communities
- Habitat loss/migration

# Coastal ecosystems…so what?

- Value of wetlands
  - Flood storage capacity
  - Storm surge buffering
  - Erosion control
  - Water quality maintenance
  - Fish & wildlife habitat

# What are some of our coastal ecosystems?

- Submerged habitats
  - Seagrass beds
  - Oyster reefs
- Emergent habitats
  - Salt marsh
  - Mangroves

# Seagrass

Sea level rise is expected to cause migration of seagrass beds landward

Where natural shoreline exists, seagrass beds are expected to migrate into appropriate depths

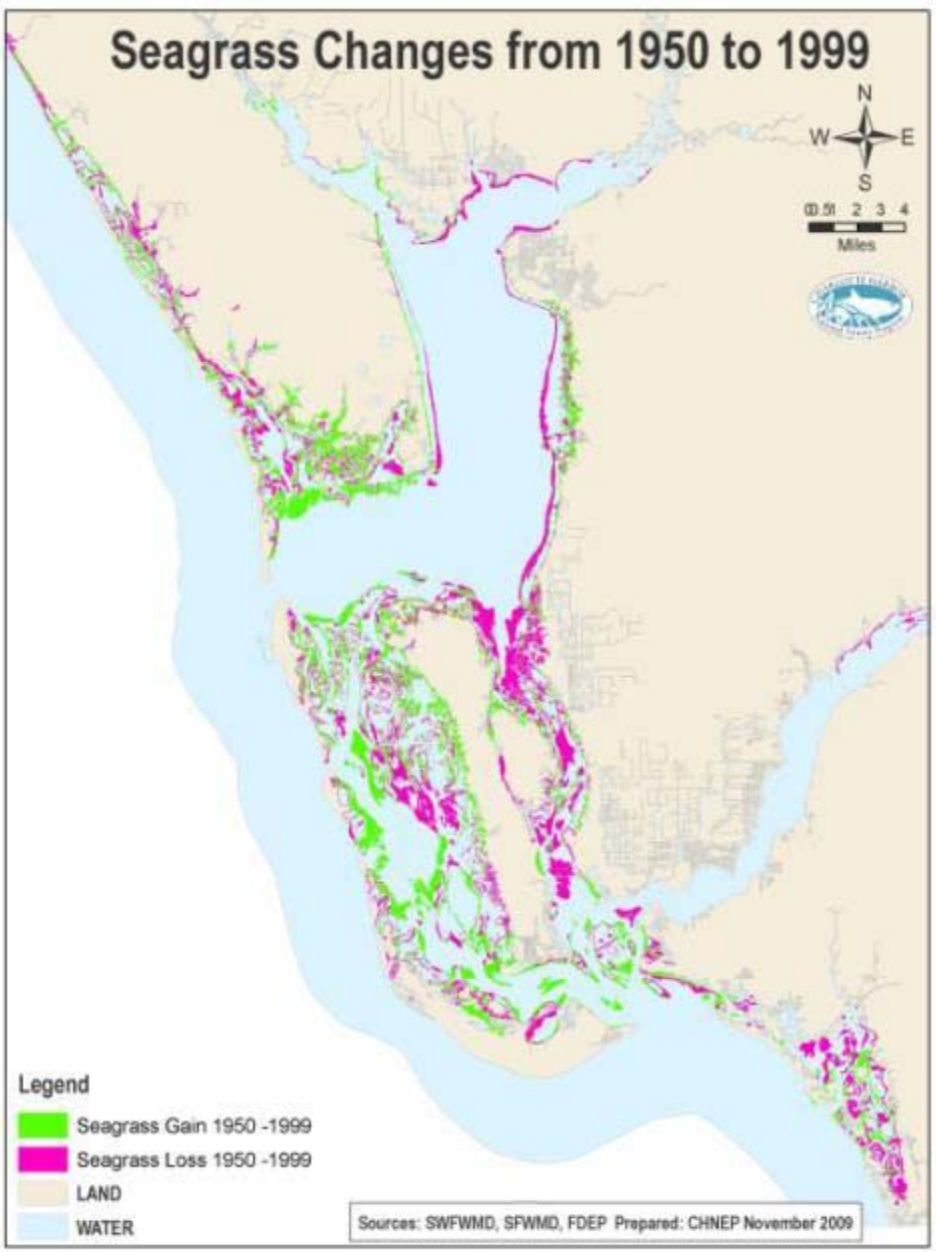
Where opportunities for landward migration is blocked the seagrass beds will be reduced and may disappear

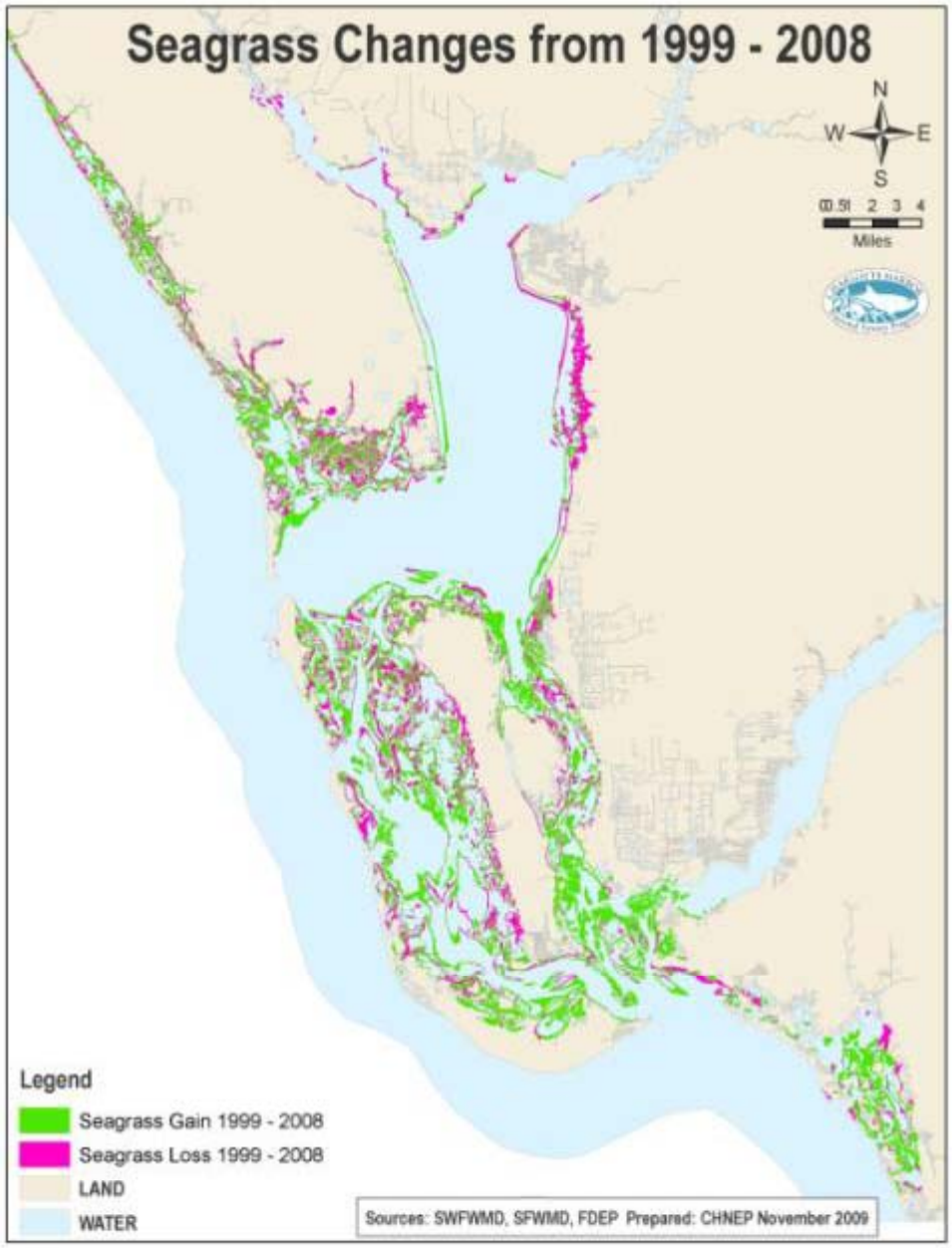
Vulnerable Species:

*Argopectin irradians*

Beever et al. 2009

http://www.tbep.org/portrait/featured_creature_12.html


Seagrass Changes from 1950 to 1999
N
W
E
S
0 0.5 1 2 3 4
Miles
Legend
Seagrass Gain 1950 -1999
Seagrass Loss 1950 -1999
LAND
WATER
Sources: SWFWMD, SFWMD, FDEP Prepared: CHNEP November 2009


Seagrass Changes from 1999 - 2008
N
W
E
S
0 0.5 1 2 3 4
Miles
Legend
Seagrass Gain 1999 - 2008
Seagrass Loss 1999 - 2008
LAND
WATER
Sources: SWFWMD, SFWMD, FDEP Prepared: CHNEP November 2009

# Oysters

http://www.dep.state.fl.us/northwest/ecosys/section/restorationoyster.htm

Oyster restoration used as protection for the shoreline against SLR

- Sea level rise will change salinity regimes for oysters
- Reefs may shift upstream to narrow portions of estuaries and rivers
- Reefs will be less productive and prolific
- Possible alteration of estuarine ecology

Savarese and Volety, 2001

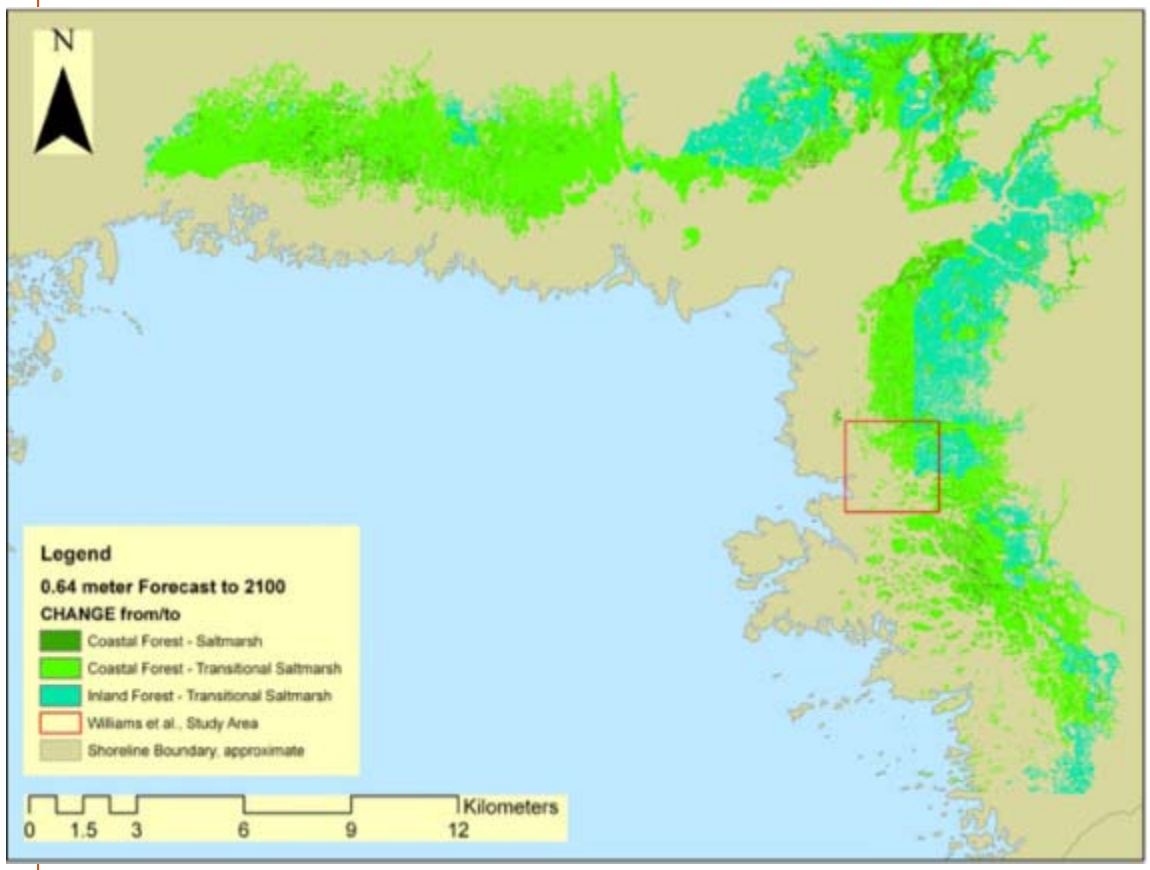
# Mangroves

Can migrate landward

Sediment surface elevations are not keeping pace with current rate of SLR
(Gilman et al. 2008)

Because mangroves may replace other species, overall coverage may increase

# Salt Marsh

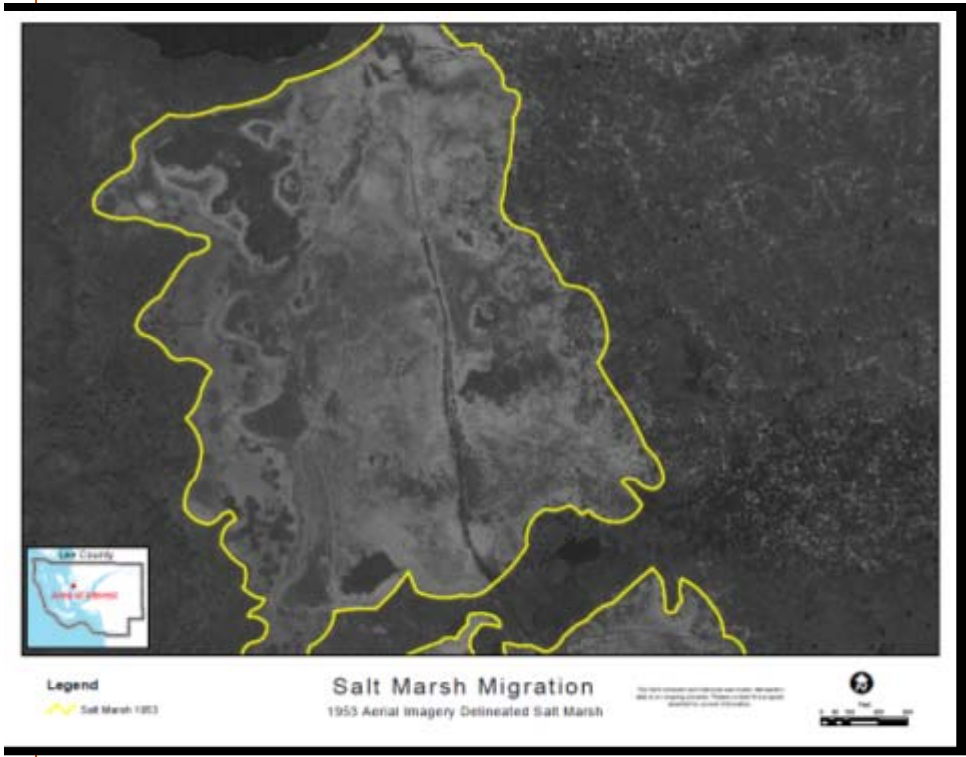


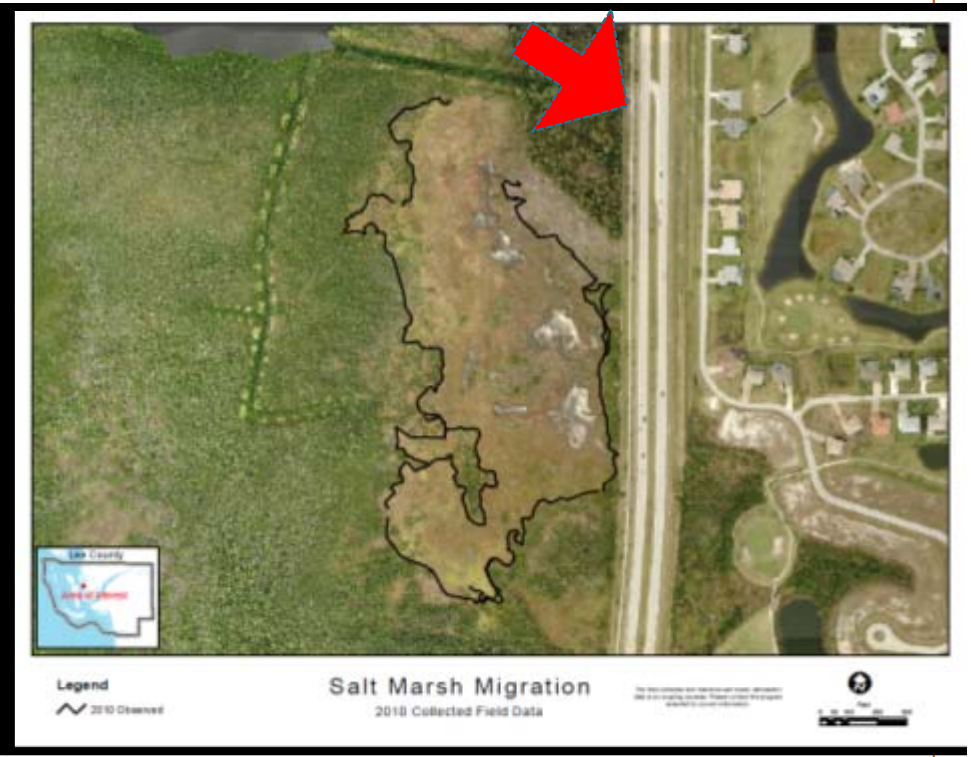

If no accretion of sediment, seaward portions of the salt marsh flood, marsh grass drowns and marsh soils erode

If sea level rise rates are slow enough, marshes may migrate up-gradient until they encounter an obstacle

***Potentially 89% loss of salt marsh acreage in Charlotte Harbor by 2100, but a 372% gain in Hernando County.***

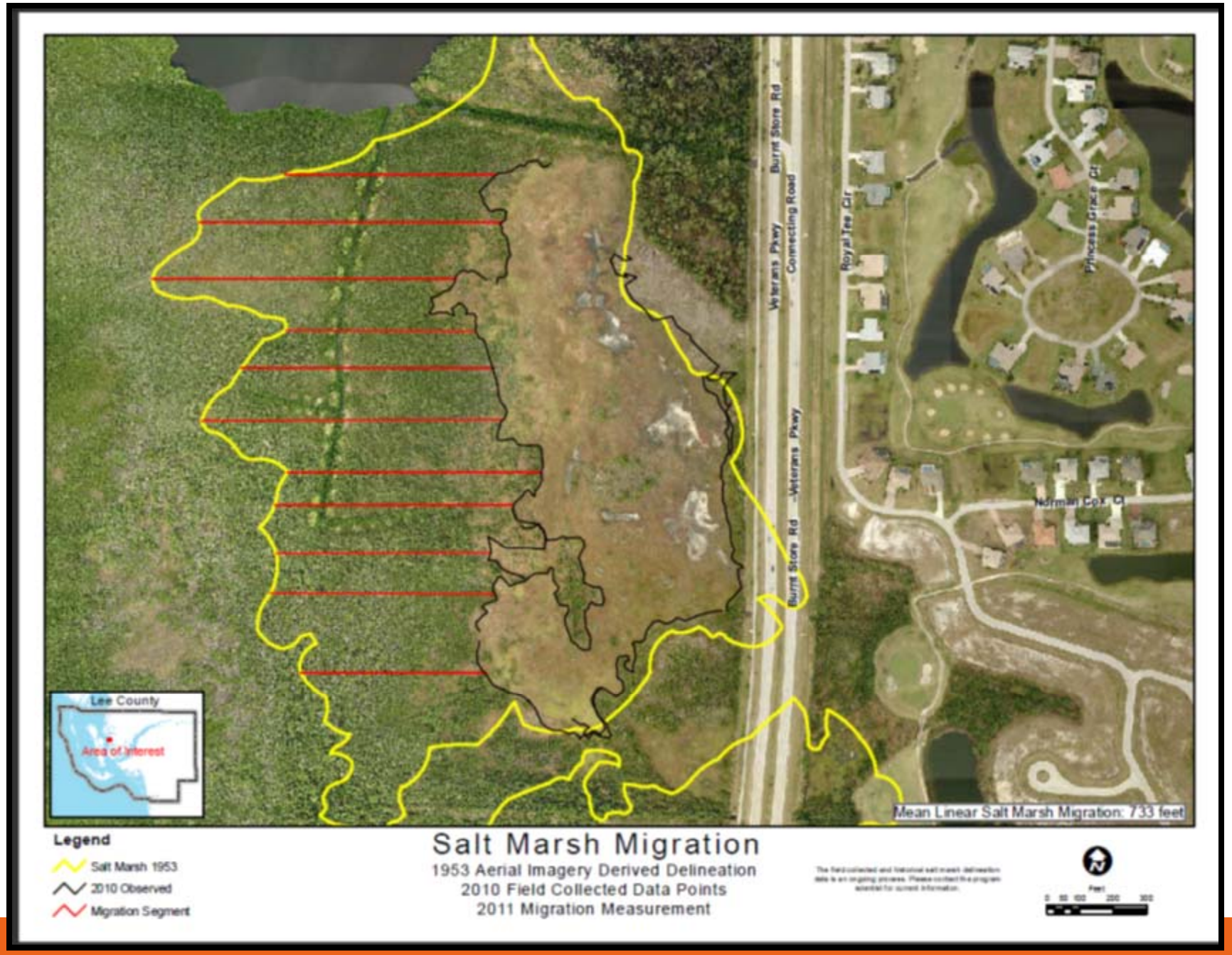
# Salt Marsh Migration



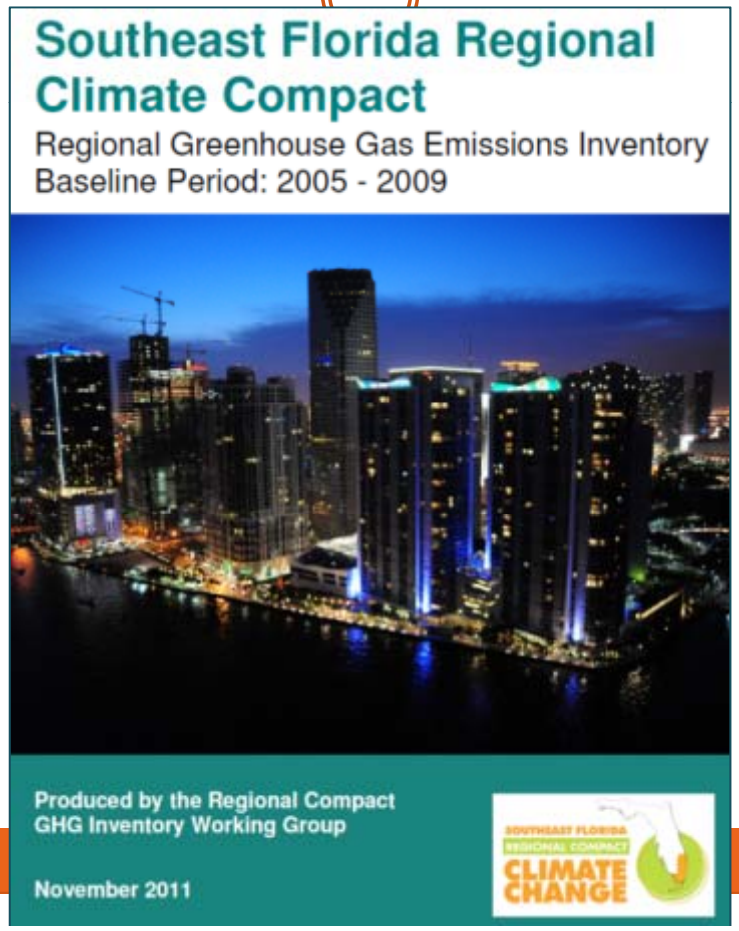




**1953** **2010**

SWFRPC 2011


Lee County
Area of Interest
Mean Linear Salt Marsh Migration: 733 feet
Legend
Salt Marsh 1953
2010 Observed
Migration Segment
Salt Marsh Migration
1953 Aerial Imagery Derived Delineation
2010 Field Collected Data Points
2011 Migration Measurement

# How can we mitigate for and adapt to sea level rise?



# Adaptation strategies

- Municipalities are starting to look at longer-scale planning efforts (30-40 years)
- Need to assess critical infrastructure within potential flood/erosion areas and plan to relocate

# Mitigation strategies

- Taking steps to reduce greenhouse gas emissions
- Energy reduction is part of many municipal comprehensive plans

# How can we preserve coastal ecosystems?

- Identify and maintain places where ecosystems can move upland
  - Planning/Zoning
  - Natural Resource Adaptation Action Areas (Comprehensive Plan)
  - Removal of abandoned infrastructure
- Restore degraded habitats
  - Seagrass/0yster reef restoration
  - Exotic species removal
  - Living shorelines

# References

Unless otherwise noted, all photos were taken by the author.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# Thank You!

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