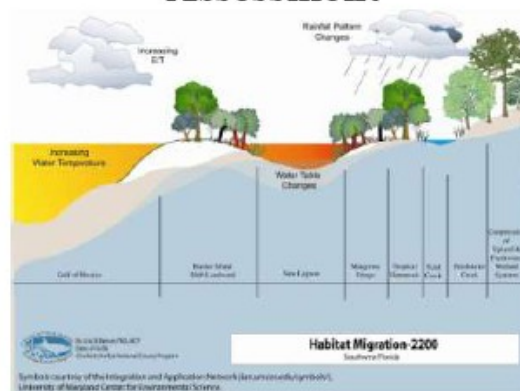# Comprehensive Southwest Florida/Charlotte Harbor Climate Change Vulnerability Assessment

Southwest Florida Regional Planning Council
Charlotte Harbor National Estuary Program
Technical Report 09-3
September 15, 2009

James W. Beever III, Whitney Gray, Daniel Trescott,
Dan Cobb, Jason Utley: SWFRPC
And
Lisa B. Beever: CHNEP

1926 Victoria Avenue
Fort Myers FL 33901
(239) 338-2550

www.SWFRPC.org and www.CHNEP.org

CLIMATE CHANGE PLANNING AT THE SWFRPC

RESOURCE ASSESSEMENTS and CLIMATE READY ESTUARY PROJECTS

CLIMATE CHANGE VULNERABILITY

CLIMATE CHANGE ADAPTATION PLANNING

CLIMATE CHANGE PROSPERITY

Capacity Building at the Regional Level and The Growth Management Challenges Posed by Climate Change.

- Hurricane Preparedness Planning
- Geographic Information System Library
- Regional Wildlife Habitat Plan
- Calusa Regional Restoration Coordination Committee
- East Gulf of Mexico Coastal Conservation Corridor Plan
- Lower West Coast Watershed Subcommittee
- Regional Greenprint
- Southwest Florida Feasibility Study
- Charlotte Harbor National Estuary Program Climate Ready Estuaries Program
- Comprehensive Southwest Florida/Charlotte Harbor Climate Change Vulnerability Assessment
- City of Punta Gorda Climate Change Adaptation Plan
- Climate and Energy Committee

CHNEP Climate Ready Estuary Projects Overview
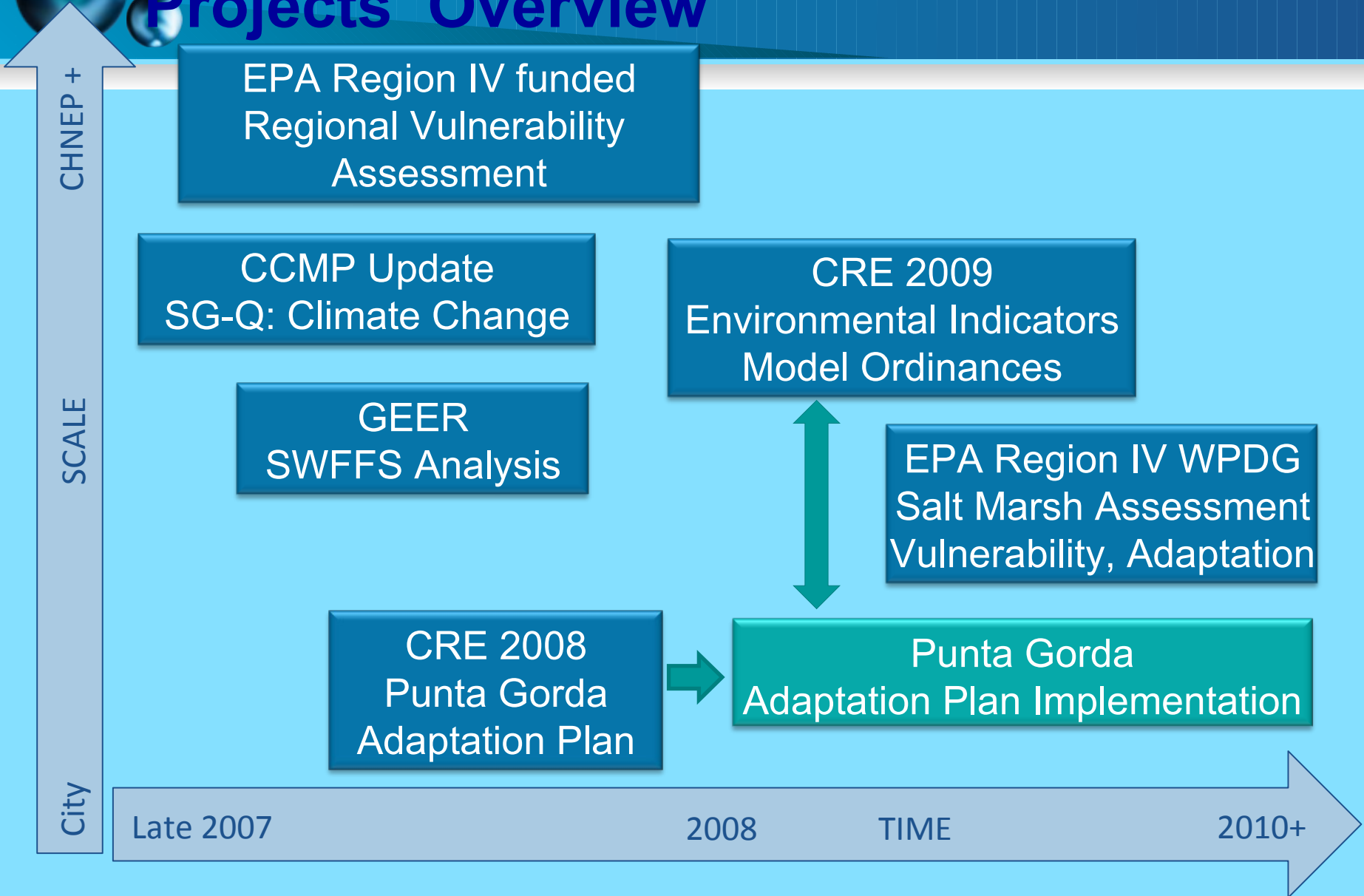
SG-Q

Build capacity for communities and their local leadership to mitigate and adapt to the effects of climate change through joint efforts.

Background

Modifying the successful model of Climate Friendly Parks, EPA's Office of Water, Oceans & Wetlands and Office of Atmospheric Programs will jointly work with interested NEPs to develop and implement "Climate Ready Estuaries." The primary focus will be on adaptation of coasts to climate change as well as actions to reduce greenhouse gas emissions. The national program will designate NEPs and other coastal communities as "climate ready," allowing the coastal leaders to implement climate adaptation within their communities and market their needs and actions to public and private interests. The CHNEP is particularly well poised to implement this model. The CHNEP's host agency, the Southwest Florida Regional Planning Council, has adopted a set of resolutions that have resulted in actions at the city and county levels to protect water quality.

This priority action helps fulfill SG-3.

Strategy

1) Conduct an initial overview of the significant potential human and ecological effects related to climate change from sea level rise, aquatic and atmospheric temperature rise, changes in rainfall patterns, increased storm intensity and ocean acidification. The goal of such an initial overview would be to identify potentially critical areas to be addressed related to adaptation for the Charlotte Harbor area. Subsequent efforts could evaluate options for minimizing the social and environmental costs of anticipated effects.

2) Develop greenhouse gas emission and carbon sequestration inventories for the Charlotte Harbor study area. Results from these inventories could be compared with other areas regarding extent and per capita emissions and sequestration. Potential local and regional policies, consistent with state initiatives, could then be evaluated and promoted by the CHNEP to demonstrate emissions reduction and carbon sequestration.

3) Seek assistance from EPA's Office of Atmospheric Programs (OAP), Climate Change Division (CCD) to assess vulnerabilities to sea level rise and integrating information on climate science, impacts and adaptation. CCD is looking to support application of those tools, particularly in coastal communities.

4) Establish a "Climate Ready Estuaries" program to educate, communicate and mitigate climate change and air pollution.

5) Develop local tools to address climate change such as:

   a. Conceptual ecological models that display the dynamics and interactions of climate change.

   b. Narrative and graphic representation for habitat succession in response to anticipated effects.

   c. Identification of conflicts in the existing federal wetlands regulatory permitting decision framework, including mitigation practices with the potential to increase the potential for negative climate change wetland losses.

   d. Best management practices (BMP) methods manual for habitat restoration design that will be resilient and achieve success in the face of a changing climate.

   e. Coastal management elements and comprehensive plan language and model local ordinances.

6) Consider resolutions supporting Florida Governor Crist's Executive Order 07-126.

7) Establish an environmental statement or policy for the CHNEP committees to reduce, reuse and recycle. Share the policy with suppliers, facilities and speakers so they can help implement this policy.

8) Follow the suggestions from *www.epa.gov/oppt/greenmeetings/* including increasing conference call, video conferencing and other remote participation methods when available.

9) Work with hotel industry to gain green lodging certification (*www.dep.state.fl.us/greenlodging/*) by the state of Florida.

Potential coordinating organizations

Charlotte Harbor National Estuary Program
County and municipal governments
Florida Department of Environmental Protection
Organizations: Conservation
Organizations: Nonprofit research
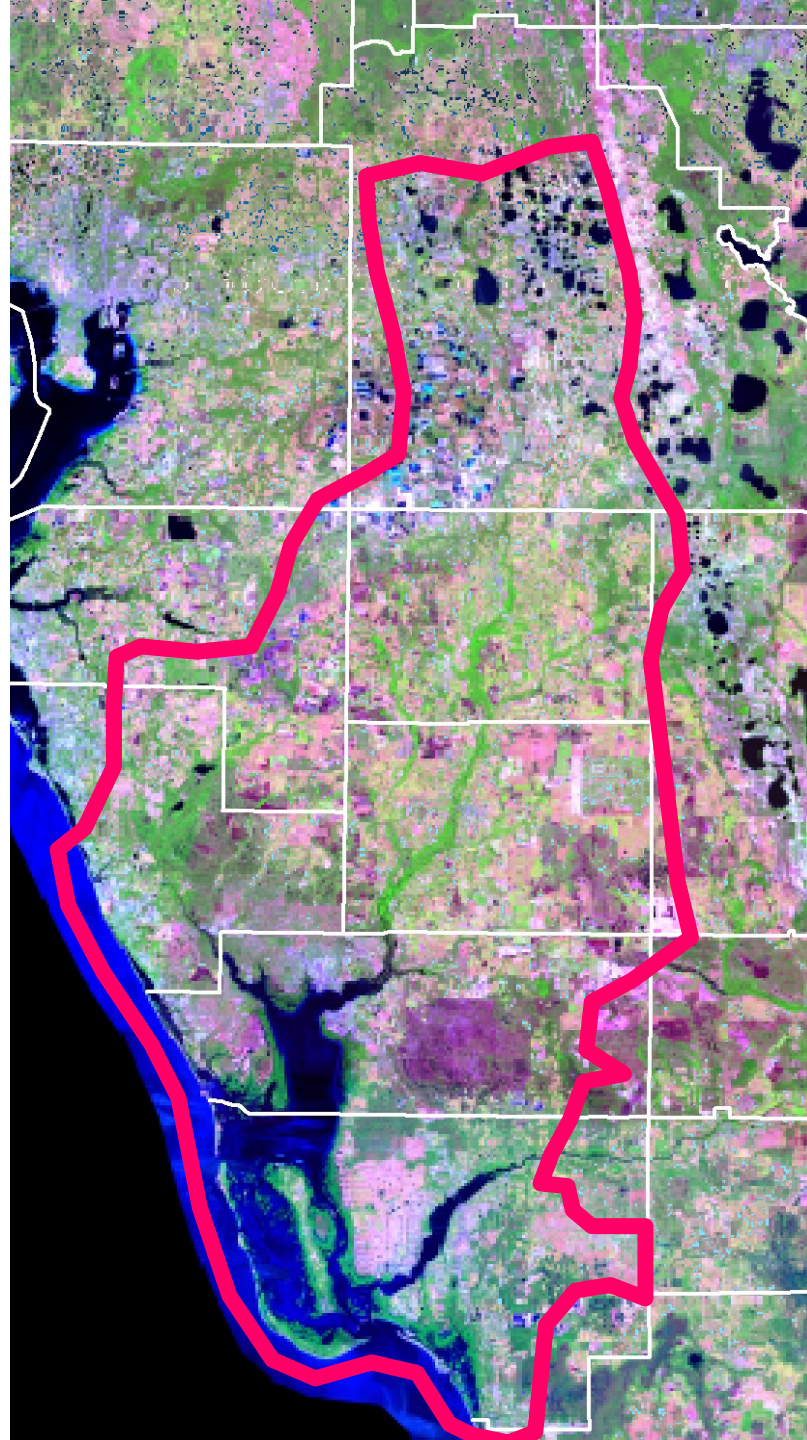
Study Area for the Climate Change Vulnerabilities Assessment
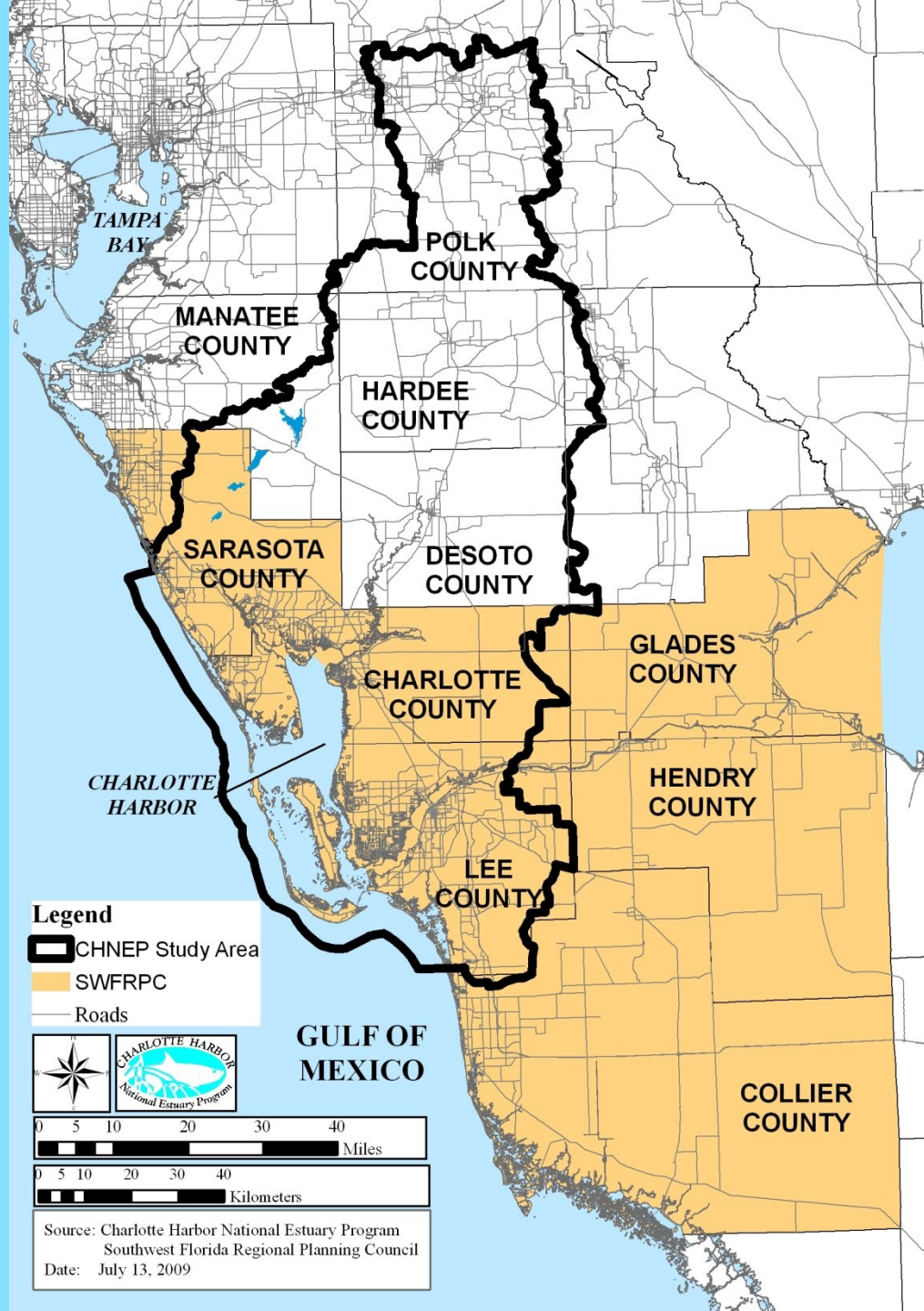
The question for Southwest Floridians is not *whether* they will be affected by climate change, but *how much* they will be affected and in what ways including the *degree* to which it will continue, *how rapidly* change will occur, *what type* of climate changes will occur, and what the *long-term effects* of these changes will be.
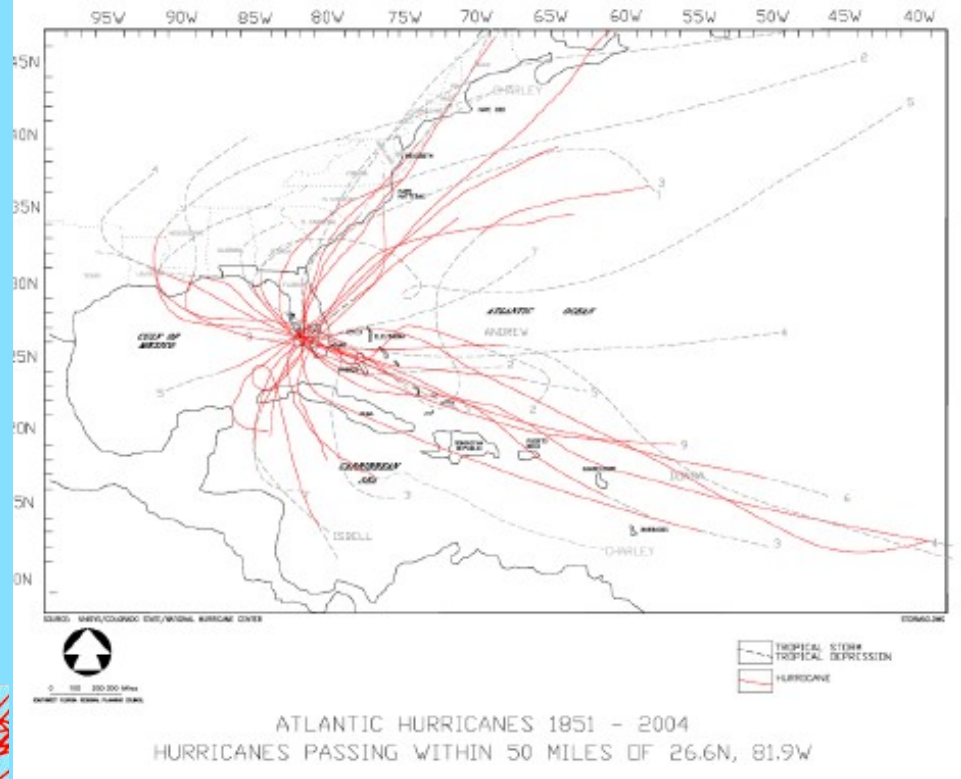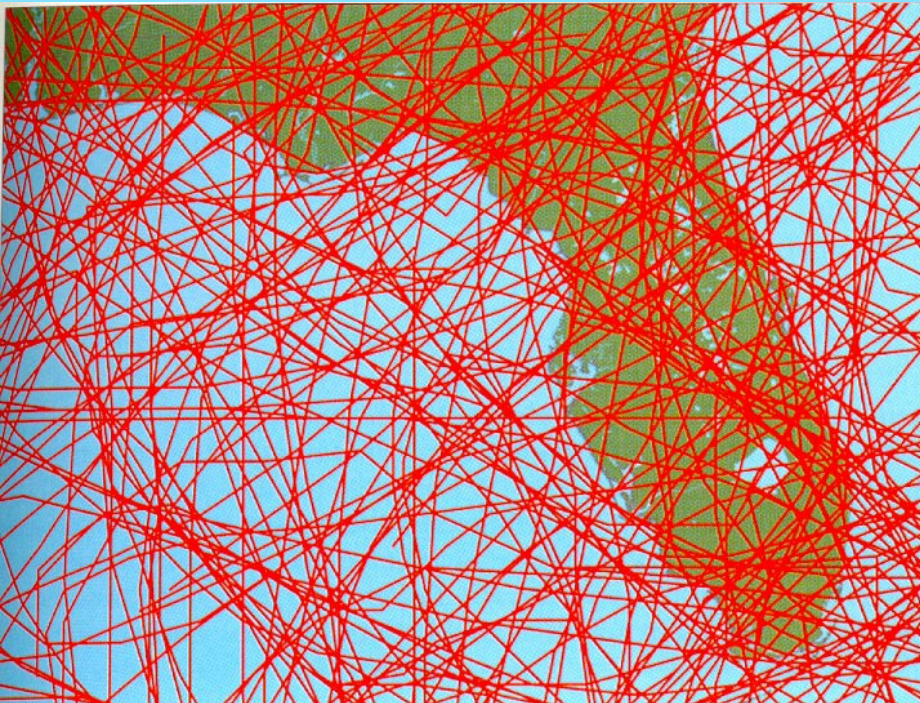
- Ocean Economy and Coastal Economy

- Commercial and sport fisheries and shellfish harvesting

- Agriculture

- Forestry

- Other Economic Activities.

- Tourism

- Mining

- Water Supply and Use

- Power and Energy

- The economic value of the CHNEP study area

Current Climate of Southwest Florida

Paths of All Recorded Hurricanes

Paths of All Hurricanes Passing Within 50 miles of the Center of the Mid-Point Bridge, Caloosahatchee River

Vulnerability Assessment Database

- 84 Potential Effects of Climate Change (e.g. increased precipitation) from literature
- Hydrologic, Habitat, Water Quality Impacts
- This study examines the current climate and ongoing climate change in southwest Florida along with five future scenarios of climate change into the year 2200. These scenarios include:
  - 1) a condition that involves a future in which mitigative actions are undertaken to reduce the human influence on climate change (Stanton and Ackerman 2007),
  - 2) a 90% probable future predicted by the Intergovernmental Panel on Climate Change (IPCC 2007b),
  - 3) a 50% probable future predicted by IPCC,
  - 4) a 5% probable future predicted by the IPCC, and
  - 5) a very worst future in which no actions are taken to address climate change (Stanton and Ackerman 2007). This fifth scenario also corresponds with some of the other worst case scenarios postulated by scientists who think the IPCC estimations are under-estimated (USEPA CRE 2008).
- Analysis of effects with no action and with various adaptations
- Source material citation and PDF library
- Each section discusses existing and potential futures.

Climate Effects

Climate Effect

Sea level rise resulting from increased temperature and expansion of water volume

Resources Affected

Coastal Shorelines: Beaches, Mangroves, Low Marsh River and Creek Shorelines: Beaches, Mangrove, Low Marsh, Bare Shorelines

Description of the geographic area affected

All coasts not behind a control structure exceed sea-level rise increase.

Estimated number of acres affected

0

ID

2

Hydrologic Effects ?
☑

Description of Hydrologic Effects

Higher tides including higher high tides, higher normal tides, and higher low tides

Water Quality Effects?
☑

Description of Water Quality Effects

Areas that were above wave action zone will become unstabilized. Depending on content of shoreline increased turbidity from destabilized soil particles with increase turbidity, total suspended solids, and nutrient levels

Habitat Effects?
☑

Description of Habitat Effects

Mangroves and Spartina will be unable to establish in water deeper than the ordinary high tide line so an apparent retreat of the waterward edge of the mangrove fringe with occur; coastal forest loss, die off of Sabal palmetto and other shoreline species

Potential Adaptations to the Climate Change Effect

local master plans should explicitly indicate which areas will retain natural shorelines

Potential Adaptations to the Climate Change Effect 2

reduce C emission

Record: |◄ ◄ 1 ► ►| ►* of 71

A name of the Climate Change Effect

NUM

# Significant Potential Climate Changes & Grouped Effects

- Air Temperature and Chemistry
- Water Temperature and Chemistry
- Climate Instability
- Altered Hydrology
- Sea Level Rise
- Geomorphic Changes
- Habitat and Species Changes
- Land Use Changes
- Human Economy
- Human Health
- Infrastructure
- Variable Risk

Potential Impacts of Climate Change

Infrastructure
Water
Transportation
Energy Supply & Use

Health
Weather-related Mortality
Infectious Diseases
Air Quality -Respiratory Illnesses
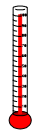
Climate Changes

Temperature

Climate Instability

Sea Level Rise

Agriculture
Crop yields
Irrigation demands

Forest
Change in forest composition
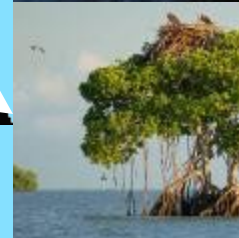Shift geographic range of forests
Forest Health and Productivity

Water Resources
Changes in water supply
Water quality
Increased competition for water

Coastal Areas
Erosion of beaches
Inundate coastal lands
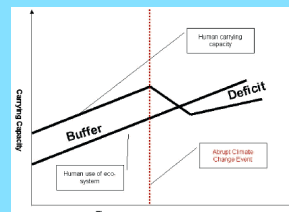Costs to defend coastal communities
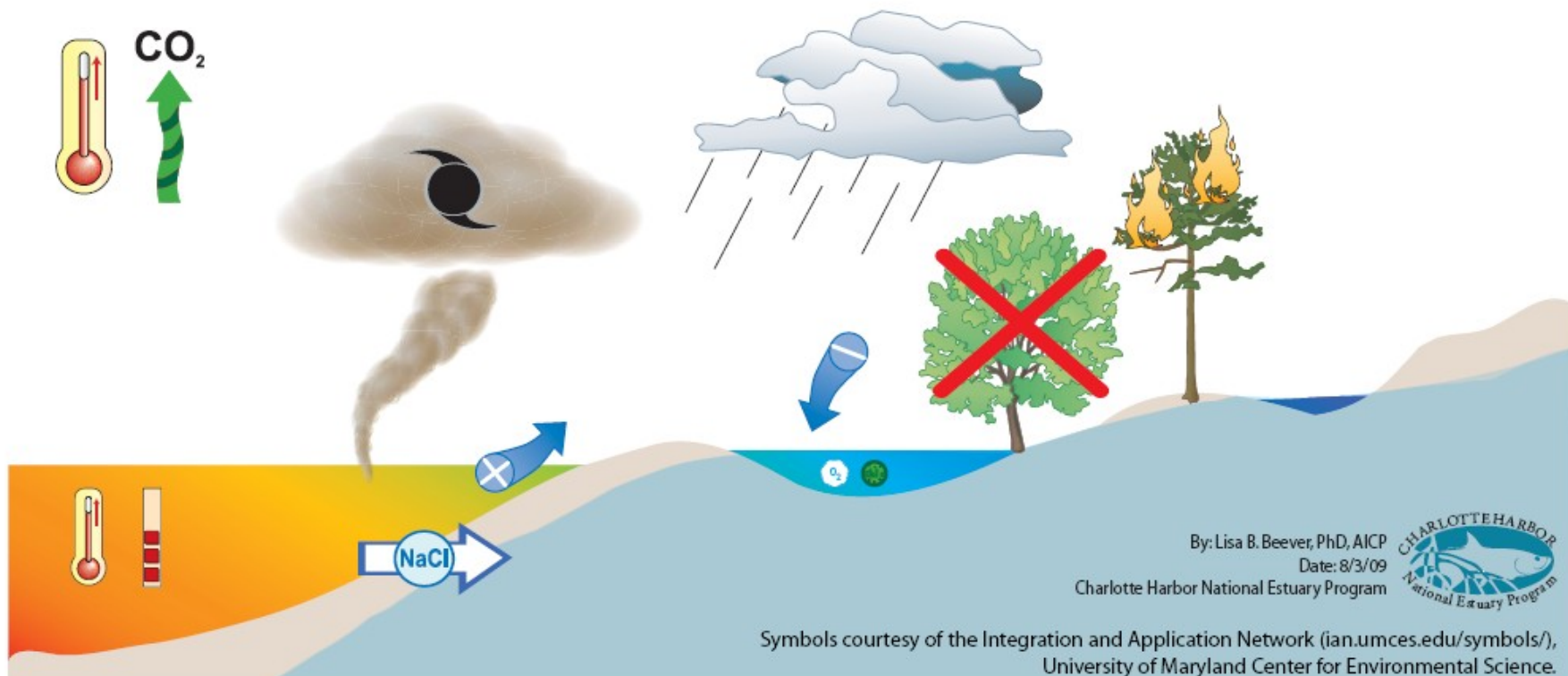
Wildlife and Ecosystems
Shift in ecological zones
Loss of habitat and species
Damage to Habitats

Cultural Resources   **Economic Disruption**

CO$_2$

By: Lisa B. Beever, PhD, AICP
Date: 8/3/09
Charlotte Harbor National Estuary Program

CHARLOTTE HARBOR National Estuary Program

Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/),
University of Maryland Center for Environmental Science.

Climate Change Drivers and Stressors
Charlotte Harbor Region

Drivers- Drivers include air temperature, air chemistry, water temperature and water chemistry. Air temperature increases as CO2 and other greenhouse gases are emitted, fuel is burned deforestation occurs, normal global warming trends, and other factors. As air temperature increases, so does water temperature. As atmospheric CO2 levels increase, ocean acidity also increases. Reduced dissolved oxygen and increased chlorophyll a in freshwater lakes and streams is also possible.

Stressors- With the drivers of air and water temperature and chemistry, stressors on natural and human systems occurs. The climate Becomes unstable with resulting changes in precipitation and increased storm frequency. Changes in rainfall patterns, results in altered hydrology (changes in stream flow) and increase chances of salt water intrusion. Water temperature and other changes increase sea level.

Southwest Florida Average Temperature

Air Temperature and Chemistry

- Elevated atmospheric carbon dioxide
- Higher temperatures increase the rate of smog formation.
- Increased air temperatures affect hydrology, water quality and habitats in wetlands.
- Increased air temperatures contribute to changes in geomorphology and habitats at coastlines.
- Increased unhealthful levels of ozone pollution
- Increases in global surface temperatures
- Timing of seasonal temperature changes is disrupted.

Temperature Predictions	Climate Scenario	Pre-development	1891-1995	2009	2025	2050	2100
Mean Annual Air Temperature	With Mitigation	73.6	73.8	74	74.6	75.1	76.2
	Least	73.6	73.8	74	75.1	74.5	77.1
	Moderate	73.6	73.8	74	75.5	77	80.4
	Worst	73.6	73.8	74	76	78.9	83.7
	"Worstest"	73.6	73.8	74	76.4	78.9	84.4

Table 11: Mean annual temperature changes for southwest Florida
Derived from Intergovernmental Panel on Climate Change (IPCC) (2007b), Florida Oceans and Coastal Council
(FOCC) 2009, Stanton, E.A., and F. Ackerman 2007

Most Severe Case
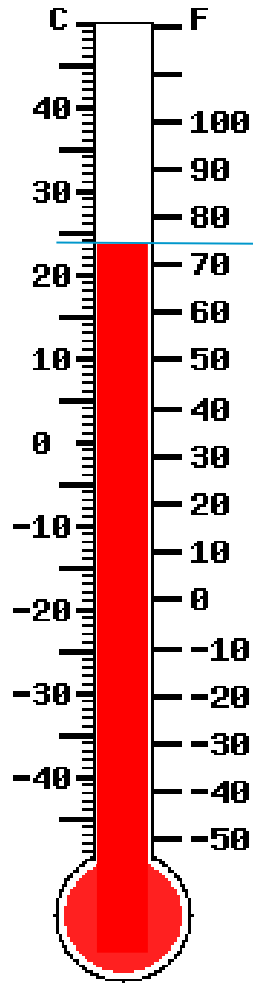
Current Temp	Current Temp	Current Temp	Current Temp	Current Temp
Pre-Development	1891-1995	2009	2025	2050
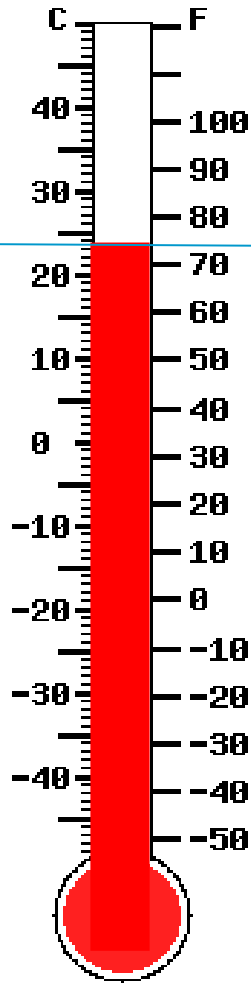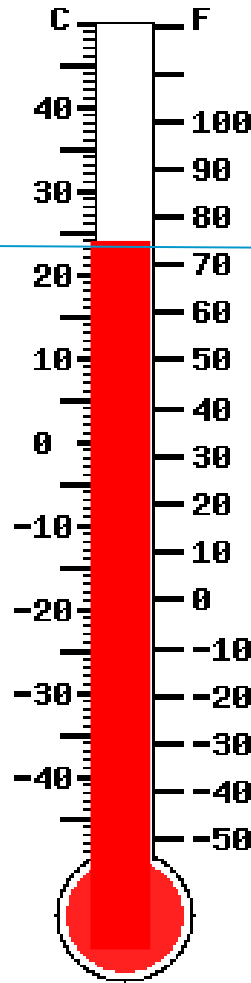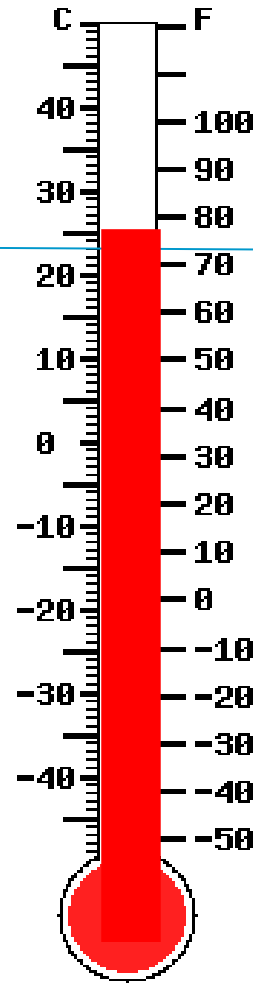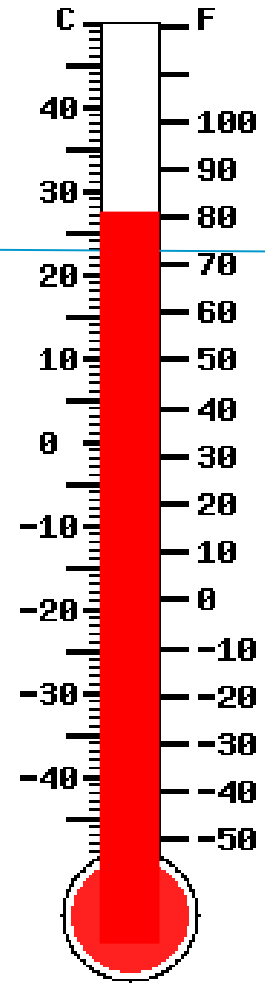
Water Temperature and Chemistry

- Acidification of marine waters
- Increase in hypoxia (low dissolved oxygen)
- Increased sea surface temperature causes geomorphic, hydrologic, and ecologic changes at the coastline.
- Marine thermal stratification
- Lake temperatures may increase.
- Changes in nutrient supply and nutrient recycling, and food webs

CO₂

By: Lisa B. Beever, PhD, AICP
Date: 8/3/09
Charlotte Harbor National Estuary Program

Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/),
University of Maryland Center for Environmental Science.

Climate Change Drivers and Stressors
Charlotte Harbor Region

Drivers- Drivers include air temperature, air chemistry, water temperature and water chemistry. Air temperature increases as CO_2 and other greenhouse gases are emitted, fuel is burned, deforestation occurs, normal global warming trends, and other factors. As air temperature increases, so does water temperature. As atmospheric CO_2 levels increase, ocean acidity also increases. Reduced dissolved oxygen and increased chlorophyll a in freshwater lakes and streams is also possible.

Stressors- With the drivers of air and water temperature and chemistry, stressors on natural and human systems occurs. The climate Becomes unstable with resulting changes in precipitation and increased storm frequency. Changes in rainfall patterns, results in altered hydrology (changes in stream flow) and increase chances of salt water intrusion. Water temperature and other changes increase sea level.

NaCl

Climate Instability

Even in the most probable, lowest impact future climate change scenario predictions, the future for southwest Florida will include increased sustained climate instability that will involve:

- Wetter wet seasons

- Drier dry seasons

- More extreme hot and cold events

- Higher wet season humidity

- Higher maximum temperatures, more hot days and heat waves over nearly all land areas
- Higher, stronger storm surges
- Increased hurricane intensity
- Increased precipitation including heavy and extreme precipitation events
- Increased regular storm frequency and intensity
- Wildfires resulting from increased atmospheric temperatures (in combination with lower dry season humidity from increased drought)
- Altered rainfall and runoff patterns

Sea Level Rise

- Florida's geologic history has consisted of cycles of sediment deposition and erosion in response to sea level changes over the last 65 million years

- The most recent geologic history (1.8 million years ago to present) has been a time of worldwide glaciations, widely fluctuating sea level and the emergence of humankind (FGHGS 1994).

- This geologic period is called the Quaternary Period and is made of two geologic epochs, the Pleistocene Epoch (1.8 million to 10,000 years ago) and the Holocene (Recent) Epoch (10,000 years ago to the present).

Sea level changes during the last 65 million years
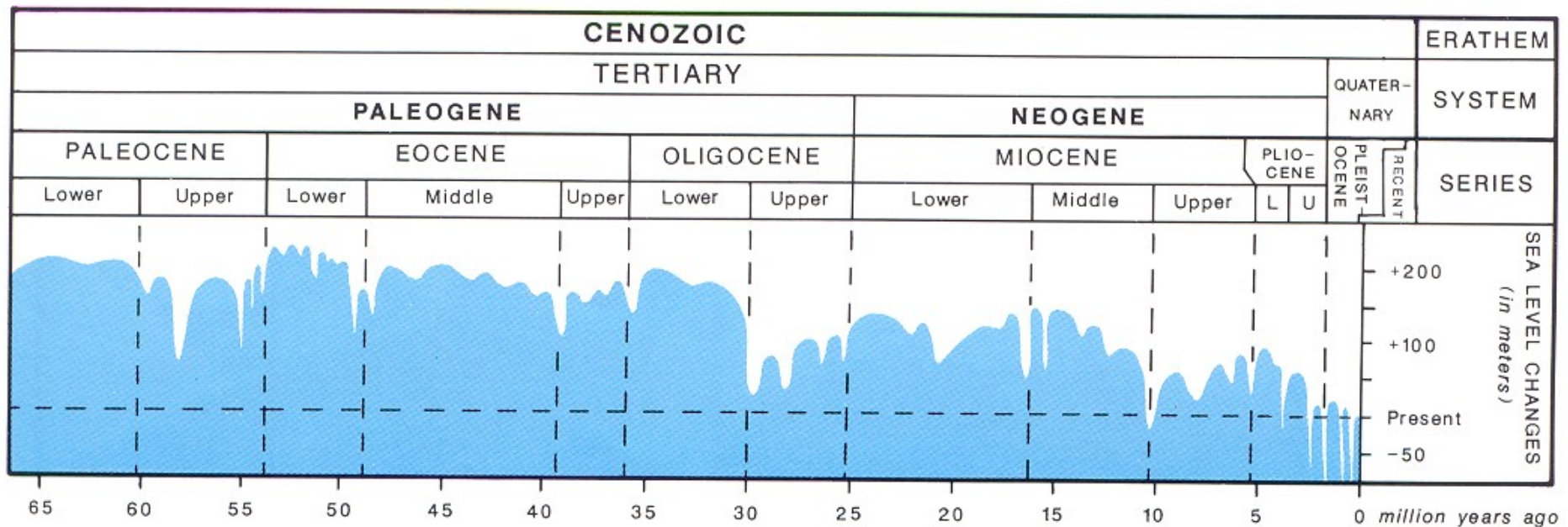
- During each period huge ice sheets covered much of the northern United States.

- Seawater was the primary water source for the expanding glaciers, causing sea level to drop as much as 300 feet below present level.

-   Between glaciations the Florida shoreline attained heights 150 feet above present sea level (Figure 3).

Interglacial Shoreline
(150 feet above
present sea level)

Glacial Shoreline
(300 feet below present sea level)

Land area above 150 feet elevation

Sea level rise rates compiled by Wanless et al. (1994)

From Stratigraphic study throughout South Florida.

Sea Level Compilation

1. 23 cm / 100 yrs
2. 4 cm / 100 yrs
3. 30 -40 cm / 100 yrs

SOUTH FLORIDA SEALEVEL HISTORY
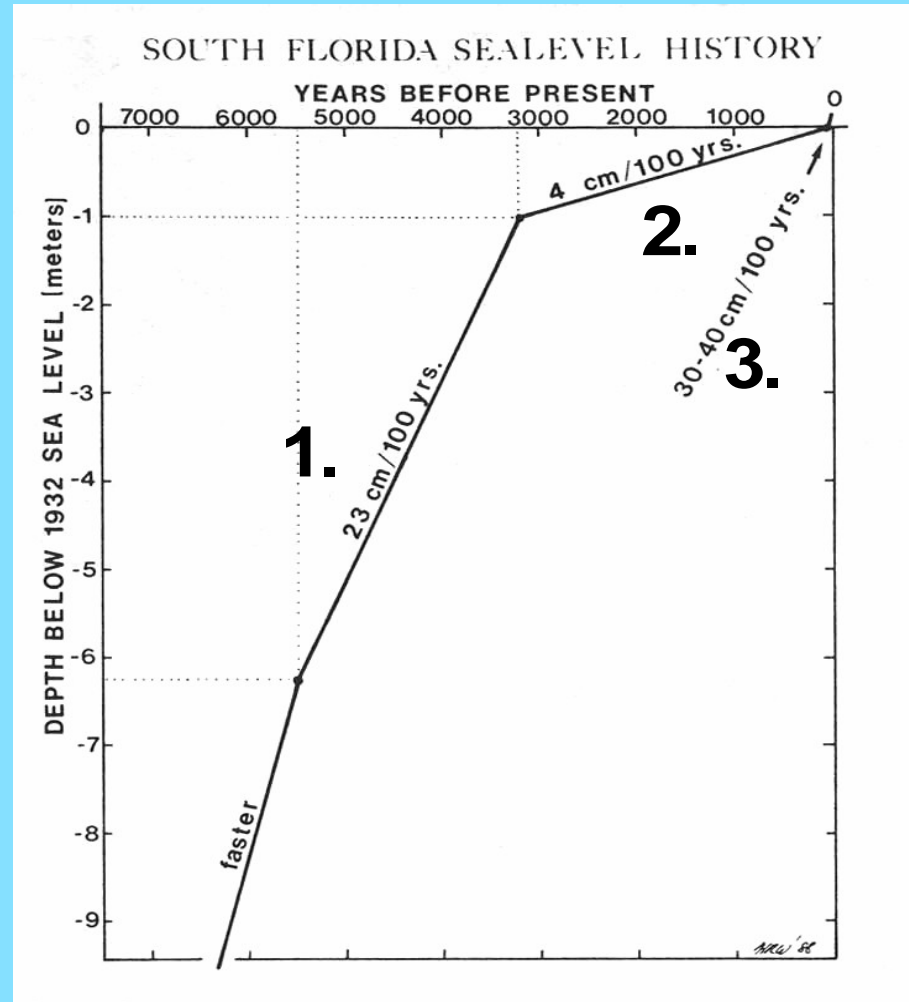
Global Sea Level Rise 1860-2009
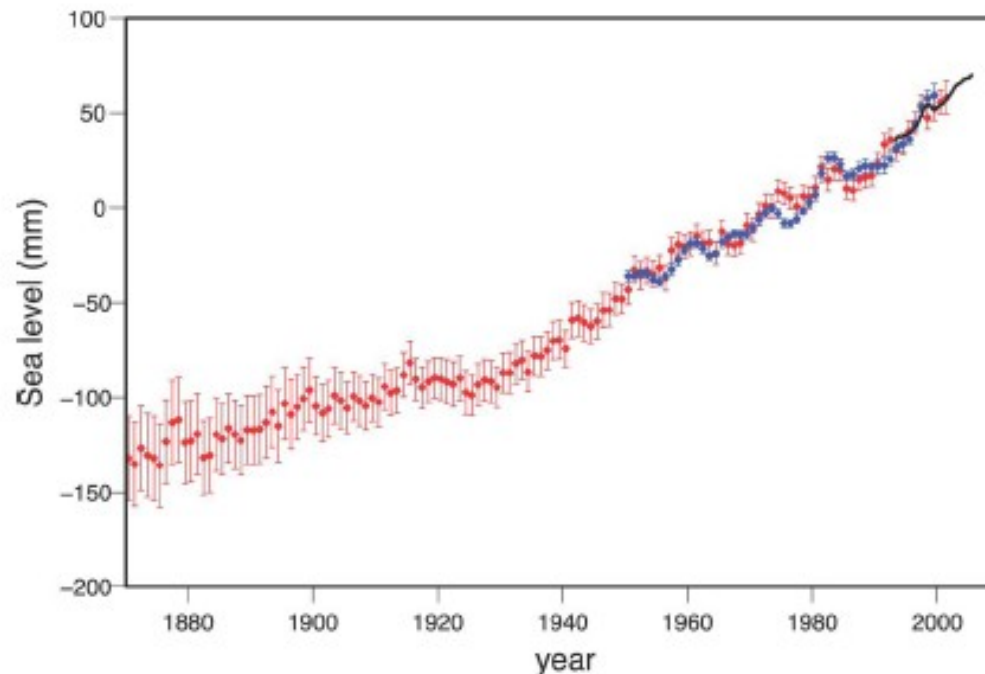
Figure 16: Annual averages of global mean sea level in millimeters

The red curve shows reconstructed sea level fields since 1870 (updated from Church and White, 2006); the blue curve shows coastal tide gauge measurements since 1950 (from Holgate and Woodworth, 2004) and the black curve is based on satellite altimetry (Leuliette et al., 2004). The red and blue curves are deviations from their averages for 1961 to 1990, and the black curve is the deviation from the average of the red curve for the period 1993 to 2001. Error bars show 90% confidence intervals.

Source: Intergovernmental Panel on Climate Change (2007) fig-5-13

Mean Annual Sea Level at Key West, Florida 1910-1990

T i d e   G a u g e   D a t a   f o r   K e

KEY WEST, FLORIDA TIDE GAUGE RECORD

~ 3 0   c m   /   1 0 0   y r s

Graphed as Mean Annual Sea Level
and as 10-Year Moving Average
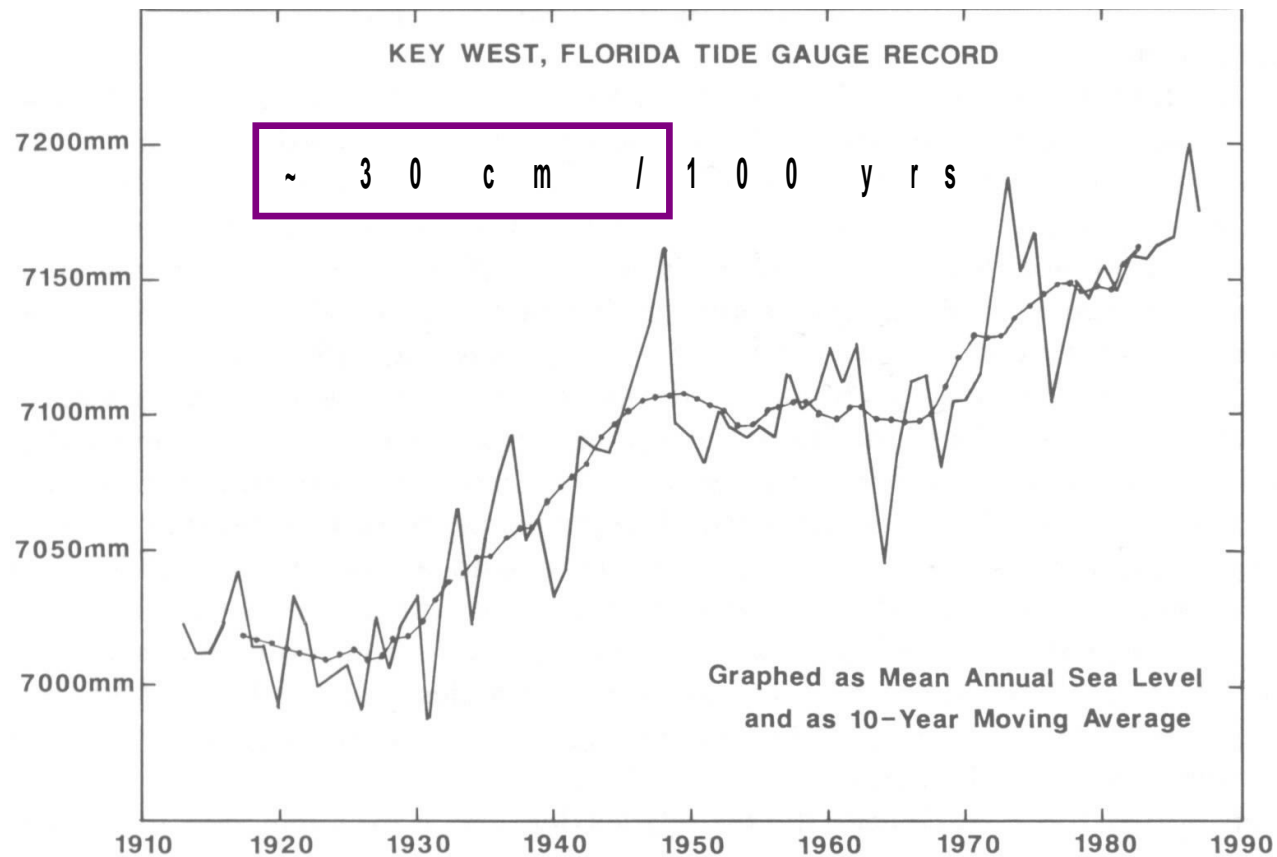
From Maul & Martin 1993

Probability of Sea Level Rise

Probability (%)	2025		2050		2075		2100		2150		2200	
	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches	cm	inches
Rapid Stabilization Case	41	1.8	9	3.5	13	5.3	18	7.1	22	8.8	27	10.5
90 (least)	7	2.8	13	5.0	20	7.7	26	10.4	40	15.7	53	21.0
80	9	3.6	17	6.6	26	10.1	35	13.9	53	20.8	71	28.1
70	11	4.4	20	7.8	30	11.6	41	16.3	63	24.7	85	33.6
60	12	4.7	22	8.6	34	13.2	45	17.8	72	28.3	99	39.1
50 (moderate)	13	5.1	24	9.4	37	14.4	50	19.8	80	31.4	112	44.2
40	14	5.5	27	10.6	41	16.0	55	21.8	90	35.4	126	49.7
30	16	6.3	29	11.3	44	17.1	61	24.1	102	40.1	146	57.6
20	17	6.7	32	12.5	49	19.1	69	27.3	117	46.0	173	68.2
10	20	7.9	37	14.5	57	22.3	80	31.6	143	56.2	222	87.5
5 (worst)	22	8.7	41	16.1	63	24.6	91	35.9	171	67.2	279	110.0
2.5	25	9.9	45	17.6	70	27.4	103	40.7	204	80.2	344	135.6
1	27	10.6	49	19.2	77	30.1	117	46.2	247	97.2	450	177.3
Business as Usual	29	11.3	57	22.6	86	34	115	45.3	247	97	450	177

*The results of this table are based on using Tables 9-1 and 9-2 of the USEPA Report "The Probability of Sea Level Rise". Basically, the formula is multiplying the historic sea level rise (2.3 mm/yr) in Southwest Florida (closest point used is St. Petersburg, Fl., Table 9-2) by the future number of years from 1990 plus the Normalized Sea Level Projections in Table 9-1 and Table ES-2. Two Future Climate Scenarios for Florida Stanton and Ackerman 2007

Table 13: Combined Sea Level Projections by Year for Southwest Florida

2000-2050 Worst Case (16 inches)
2000-2050 Moderate Case (9 inches)
2000-2050 Least Case (5 inches)
1900-2000 (8 inches)
Prior to 1900

By: Lisa B. Beever, PhD, AICP
Date: 5/15/09
From: National Resources Defence Council, 2001
www.chnep.org/projects/CRE/CRE.asp

Symbols courtesy of the Integration and Application Network
(ian.umces.edu/symbols/), University of Maryland Center for Environmental Science

Figure 23a: Sea level rise in three different probabilities in the year 2050 for Charlotte Harbor at Punta Gorda.
Least case (90% probable), moderate case (50% probable) and worst case (5% probable)
Source: IPCC 2007

Estimated Sea Level Rise 2050
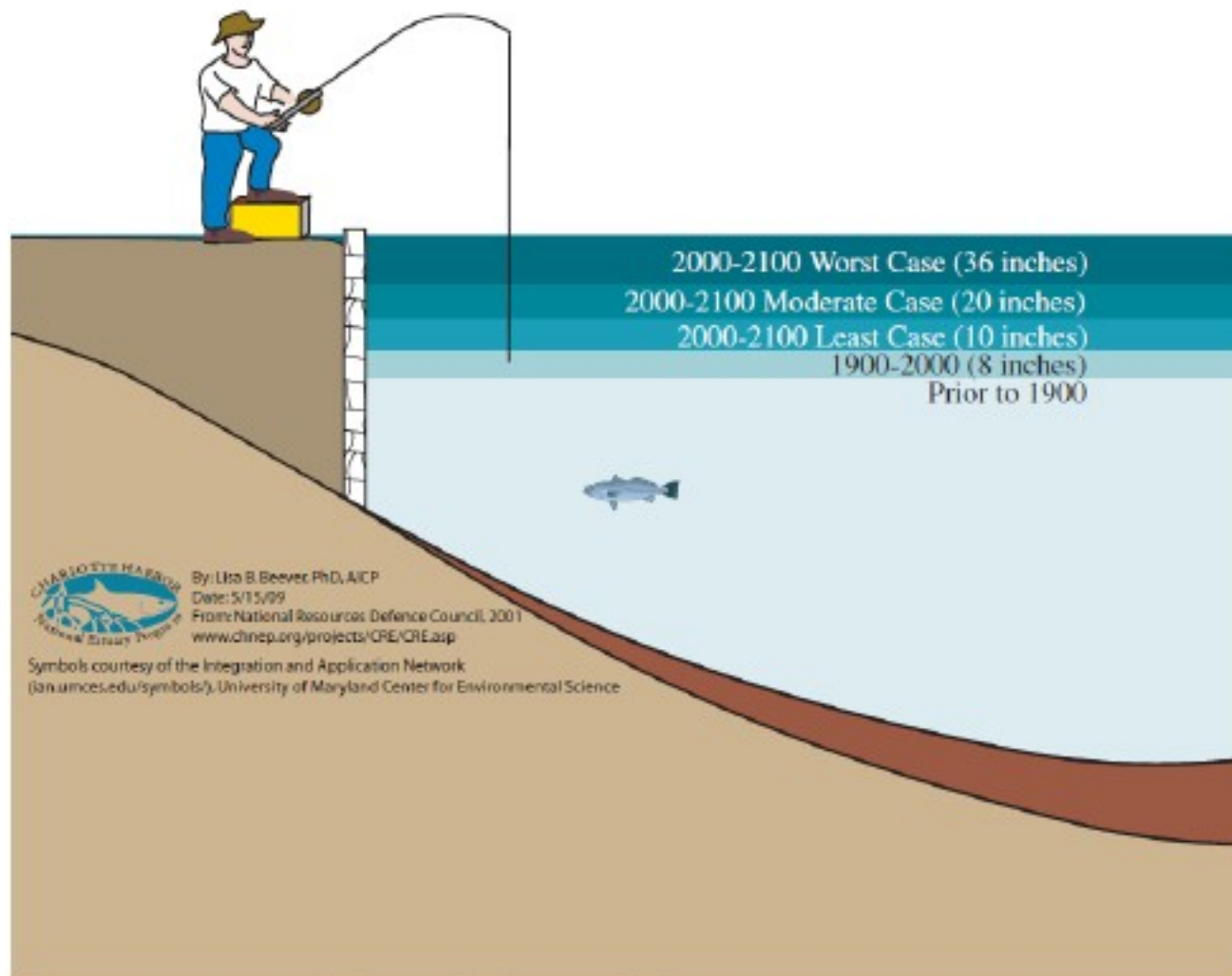
Figure 24a: Sea level rise in three different probabilities in the year 2100 for Charlotte Harbor at Punta Gorda. Least case (90% probable), moderate case (50% probable) and worst case (5% probable)
Source: IPCC 2007

Estimated Sea Level Rise 2100
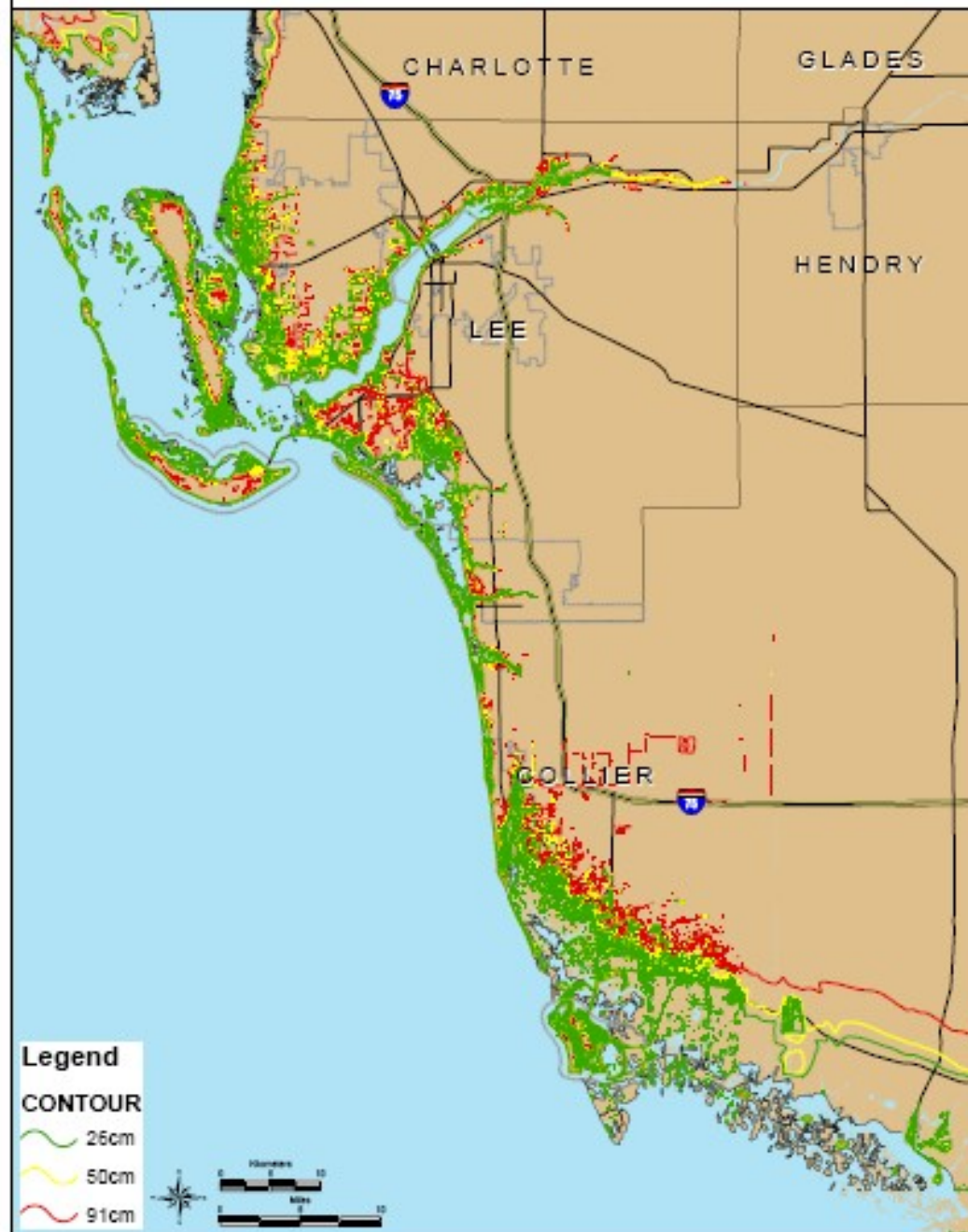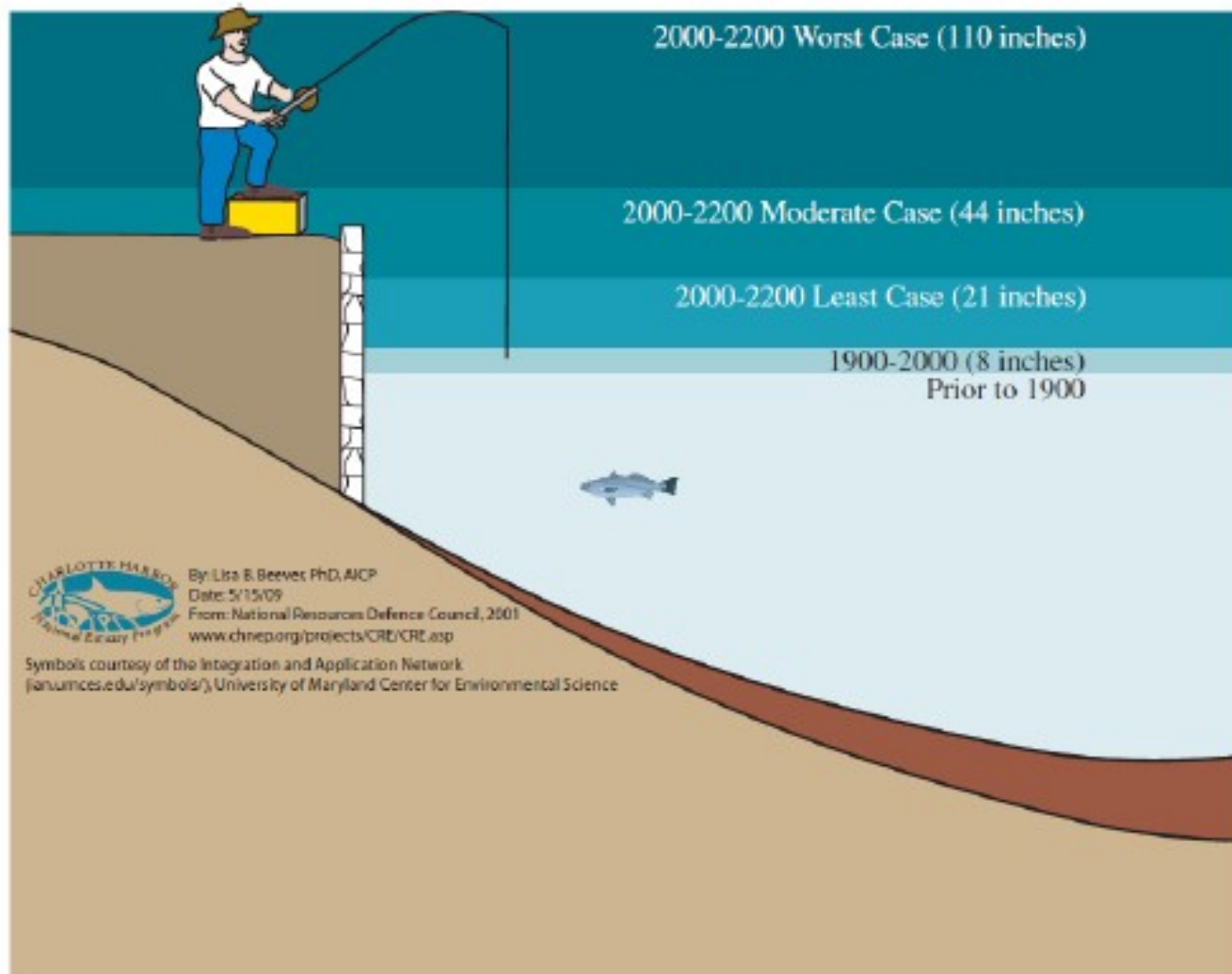
Figure 25a: Sea level rise in three different probabilities in the year 2200 for Charlotte Harbor at Punta Gorda. Least case (90% probable), moderate case (50% probable) and worst case (5% probable)

Source: IPCC 2007

Estimated Sea Level Rise 2200
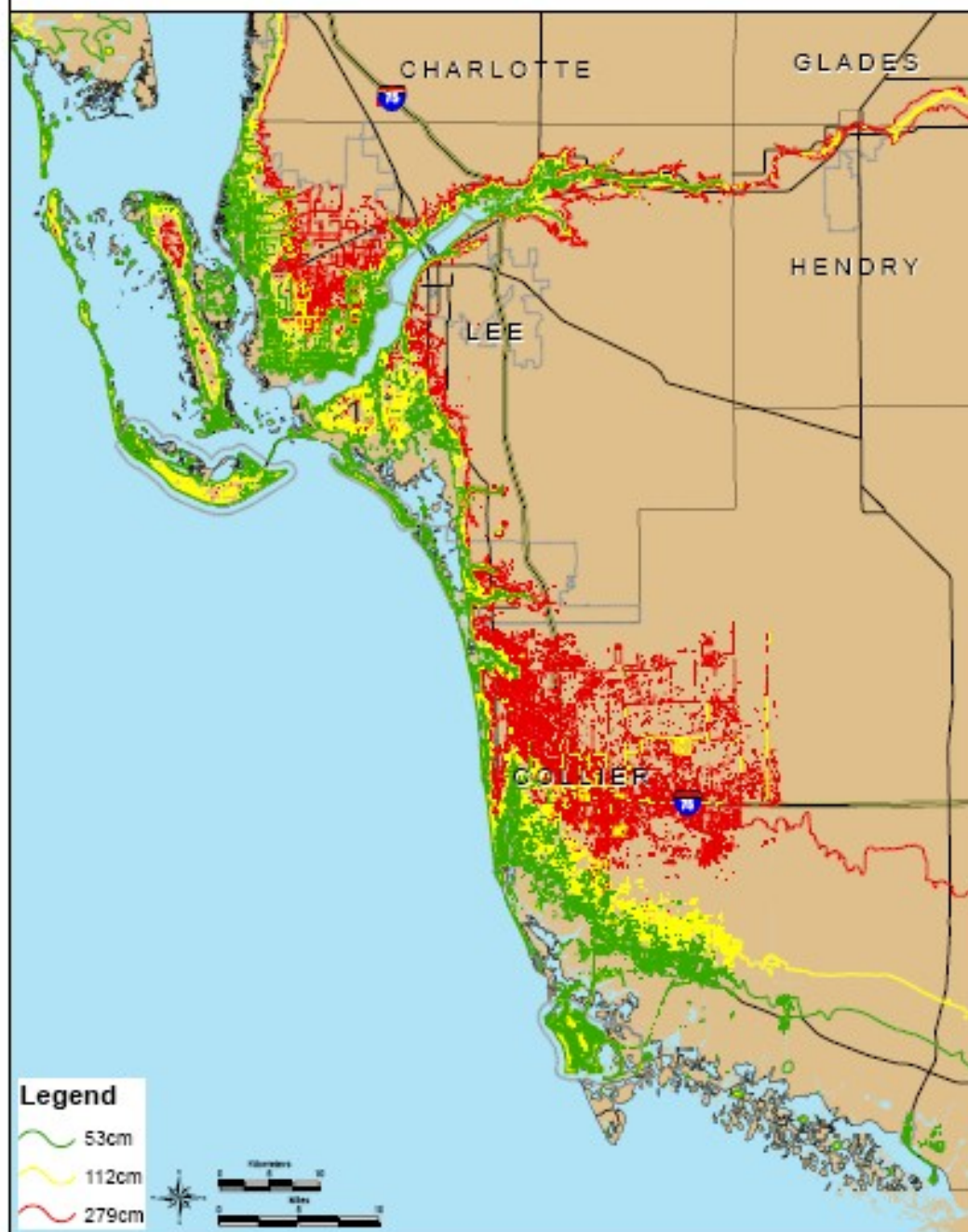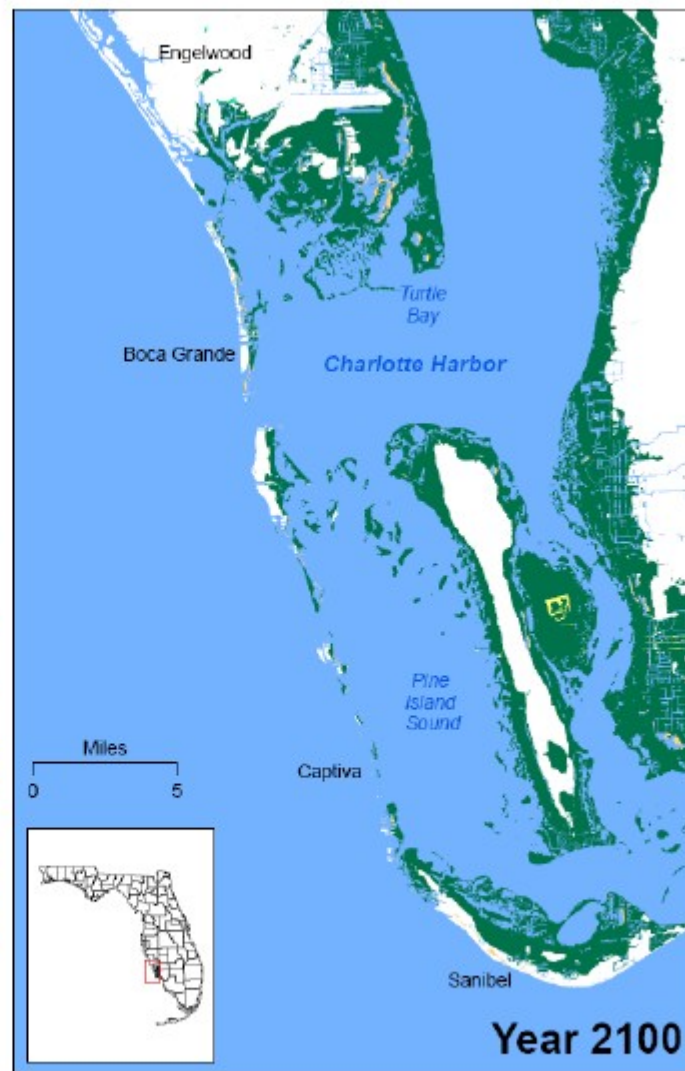
Figure 27: Three-foot contour sea level rise Sea Level Rise in Lower Charlotte Harbor Estuary Year 2100. This is the 5% probability worst case IPCC (2007) scenario.

Elevation in NGVD	Rapid Stabilization Case	90% (least)	50% (moderate)	5% (worst)	Business as Usual
Half Foot	2084	2059	2030	2014	2011
One Foot	2222	2107	2063	2036	2027
Two Feet	2398	2214	2109	2075	2053
Three Feet	2575	2270	2158	2100	2079
Four Feet	2751	2327	2208	2109	2101
Nine Feet	3633	2610	2338	2174	2153

Table 14: Predicted year of different elevation levels (NGVD) of sea level rise for different future scenarios
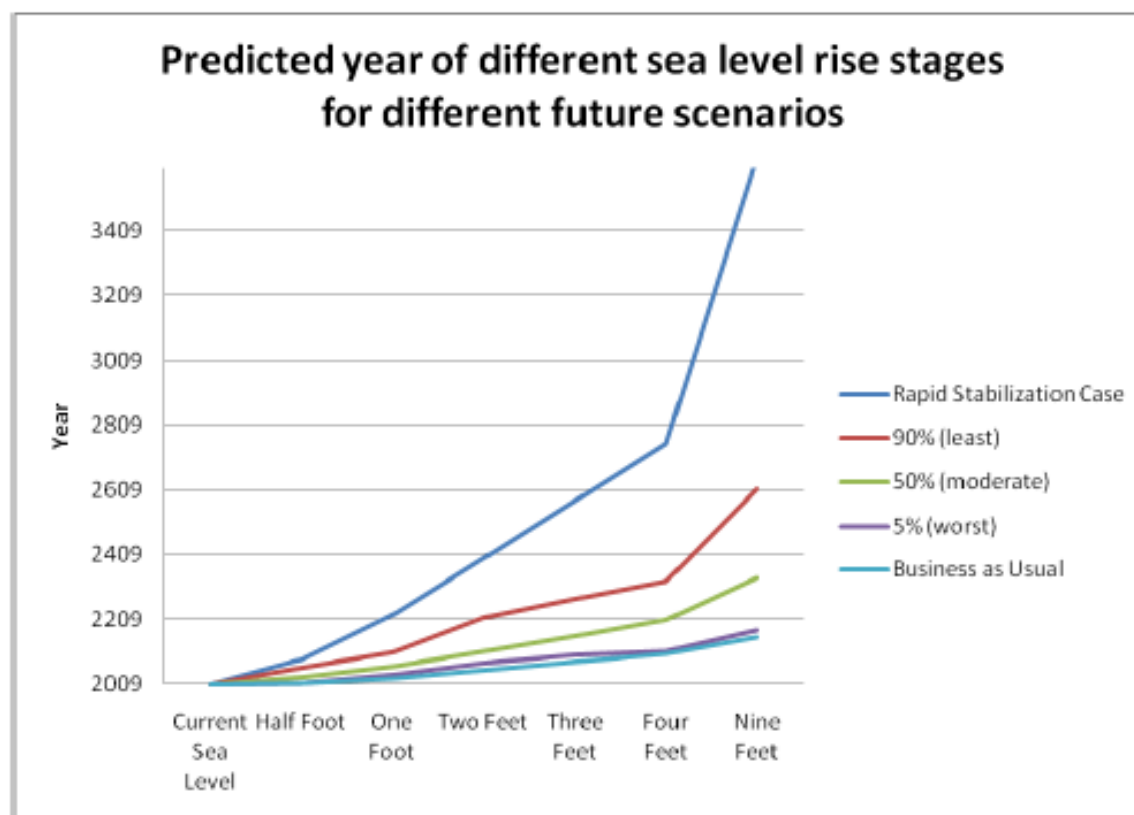
Figure 28: Approximate predicted year of different elevation levels (NGVD) of sea level rise for different future scenarios

Sarasota	Cat 1	Cat 2	Cat 3	Cat 4
	5.1' to 6.3'	8.9' to 10.1'	11.7' to 13.2'	17.5' to 27.5'
Coastal Strand	37.1	37.1	37.1	37.1
Sand/Beach	346.8	356.8	366.3	366.3
Xeric Oak Scrub	12.3	35.2	118.9	130.8
Sand Pine Scrub	6.3	10.0	17.0	26.7
Dry Prairie	308.8	2,706.1	11,135.2	20,995.3
Mixed Pine-Hardwood Forest	357.9	920.3	2,339.2	4,224.3
Hardwood Hammocks and Forest	535.6	1,381.4	3,384.6	5,809.0
Pinelands	1,397.1	3,898.7	8,803.4	16,759.2
Freshwater Marsh and Wet Prairie	159.6	1,121.9	2,870.8	7,705.7
Shrub Swamp	191.2	536.5	1,112.2	2,761.7
Bay Swamp	0.0	0.0	4.4	5.3
Cypress Swamp	153.1	274.8	536.9	1,070.5
Cypress/Pine/Cabbage Palm	0.7	0.7	0.7	0.7
Mixed Wetland Forest	285.4	453.7	780.4	1,255.1
Hardwood Swamp	454.5	1,041.4	2,368.7	4,419.5
Salt Marsh	1,198.7	1,283.3	1,300.1	1,319.9
Mangrove Swamp	665.9	695.2	699.7	701.1
Open Water	2,134.2	2,489.8	3,436.2	6,164.0
Shrub and Brushland	72.9	212.8	614.7	1,478.9
Grassland	3.4	12.1	86.3	239.4
Bare Soil/Clear-cut	100.8	143.0	352.1	685.1
Improved Pasture	6.7	186.2	1,399.9	8,614.8
Citrus	0.0	2.4	64.3	536.6
Row/Field Crops	0.0	0.0	58.4	216.4
Other Agriculture	1.2	7.2	97.8	244.0
High Impact Urban	4,649.6	8,722.6	17,695.0	41,594.7
Low Impact Urban	948.5	2,157.1	5,588.7	13,592.4
Extractive	0.0	0.0	5.9	379.7
Total	**14,028.4**	**28,686.5**	**65,275.1**	**141,334.1**

Table 17d: Acres of habitat or land use at and below different storm surge elevations in Sarasota County 2009, Note number includes the prior acreage.

Area of saltwater wetlands inundated at different storm surges

	Cat 1 (5.1' to 6.3')	Cat 2 (8.9' to 10.1')	Cat 3 (11.7' to 13.2')	Cat 4 (17.5' to 27.5')
■ Salt Marsh	1,198.7	1,283.3	1,300.1	1,319.9
■ Mangrove Swamp	665.9	695.2	699.7	701.1
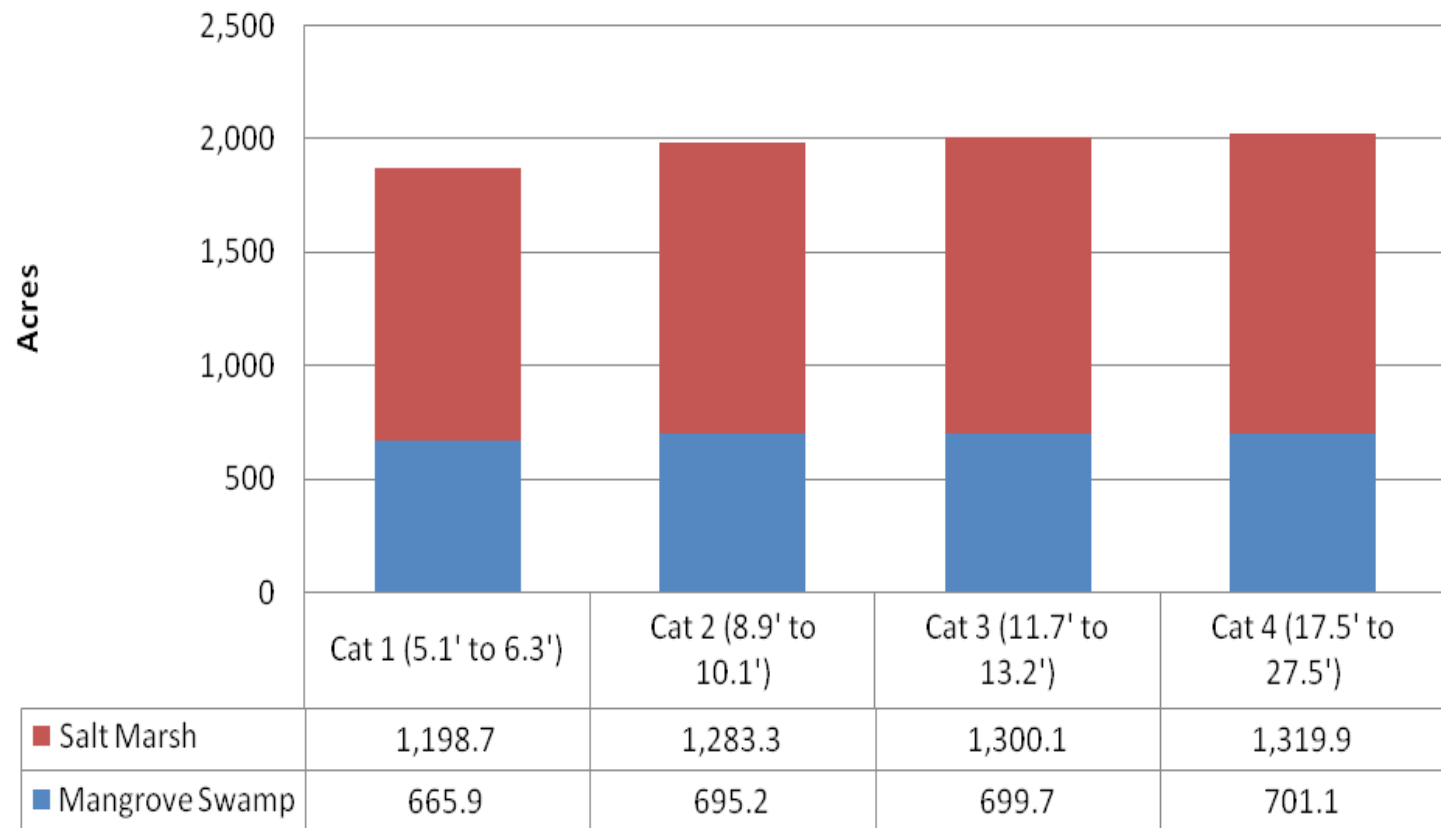
Acres of mangrove and salt marsh habitat at and below different elevations in Sarasota County 2009

Beach and Coastal Strand

	Cat 1 (5.1' to 6.3')	Cat 2 (8.9' to 10.1')	Cat 3 (11.7' to 13.2')	Cat 4 (17.5' to 27.5')
■ Sand/Beach	346.8	356.8	366.3	366.3
■ Coastal Strand	37.1	37.1	37.1	37.1
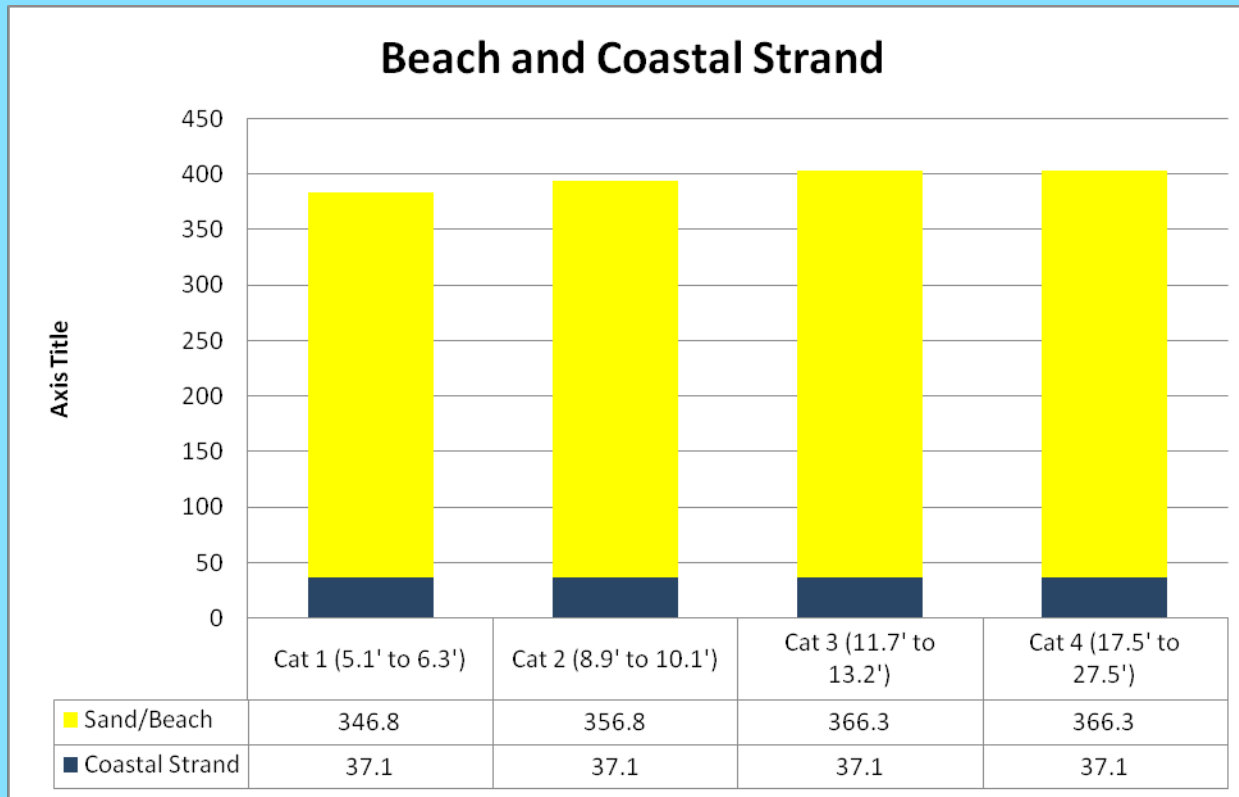
Acres of beaches and coastal strand habitat in Sarasota County at and below different storm surge elevations 2009

Freshwater Wetlands

	Cat 1 (5.1' to 6.3')	Cat 2 (8.9' to 10.1')	Cat 3 (11.7' to 13.2')	Cat 4 (17.5' to 27.5')
■ Hardwood Swamp	454.5	1,041.4	2,368.7	4,419.5
■ Mixed Wetland Forest	285.4	453.7	780.4	1,255.1
■ Cypress/Pine/Cabbage Palm	0.7	0.7	0.7	0.7
■ Cypress Swamp	153.1	274.8	536.9	1,070.5
■ Bay Swamp	0.0	0.0	4.4	5.3
■ Shrub Swamp	191.2	536.5	1,112.2	2,761.7
■ Freshwater Marsh and Wet Prairie	159.6	1,121.9	2,870.8	7,705.7
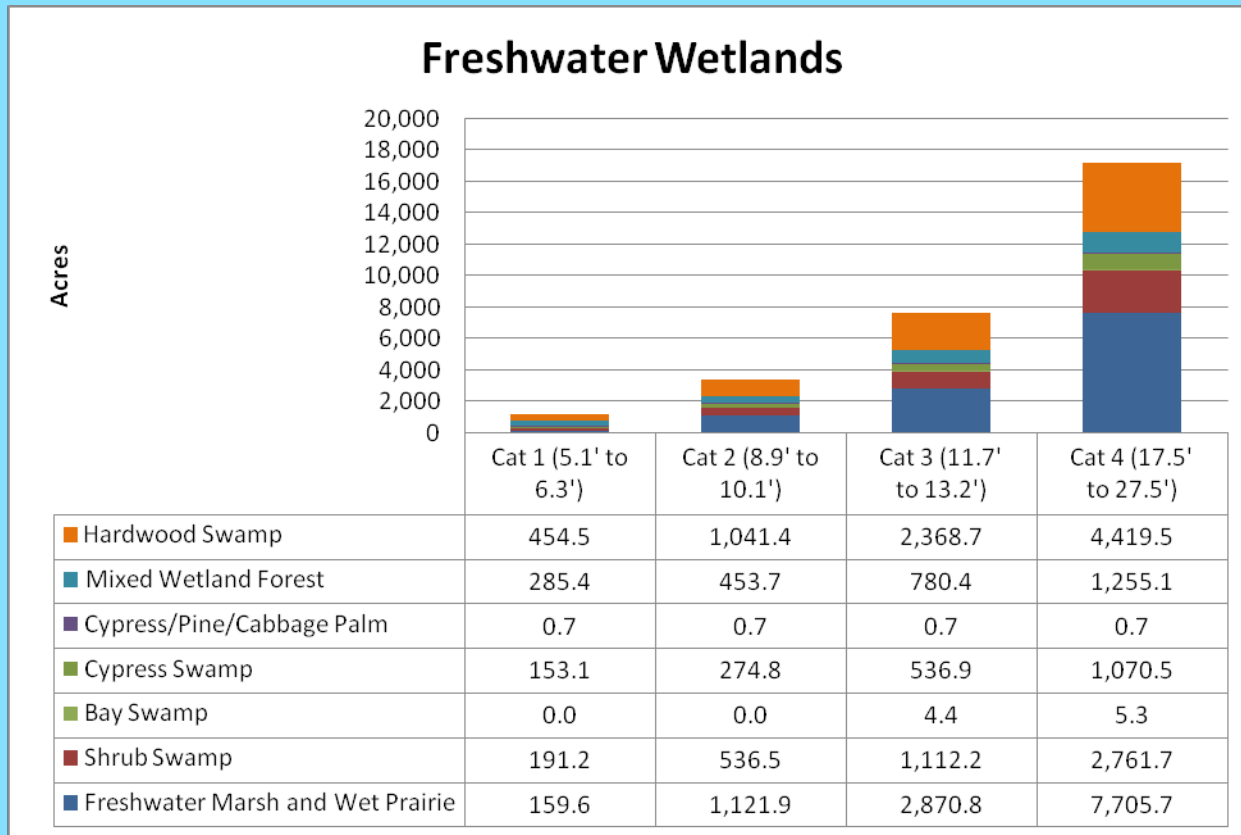
Acres of freshwater wetlands habitat in Sarasota County at and below different storm surge elevations 2009

Native Uplands

	Cat 1 (5.1' to 6.3')	Cat 2 (8.9' to 10.1')	Cat 3 (11.7' to 13.2')	Cat 4 (17.5' to 27.5')
Grassland	3.4	12.1	86.3	239.4
Shrub and Brushland	72.9	212.8	614.7	1,478.9
Pinelands	1,397.1	3,898.7	8,803.4	16,759.2
Hardwood Hammocks and Forest	535.6	1,381.4	3,384.6	5,809.0
Mixed Pine-Hardwood Forest	357.9	920.3	2,339.2	4,224.3
Dry Prairie	308.8	2,706.1	11,135.2	20,995.3
Sand Pine Scrub	6.3	10.0	17.0	26.7
Xeric Oak Scrub	12.3	35.2	118.9	130.8
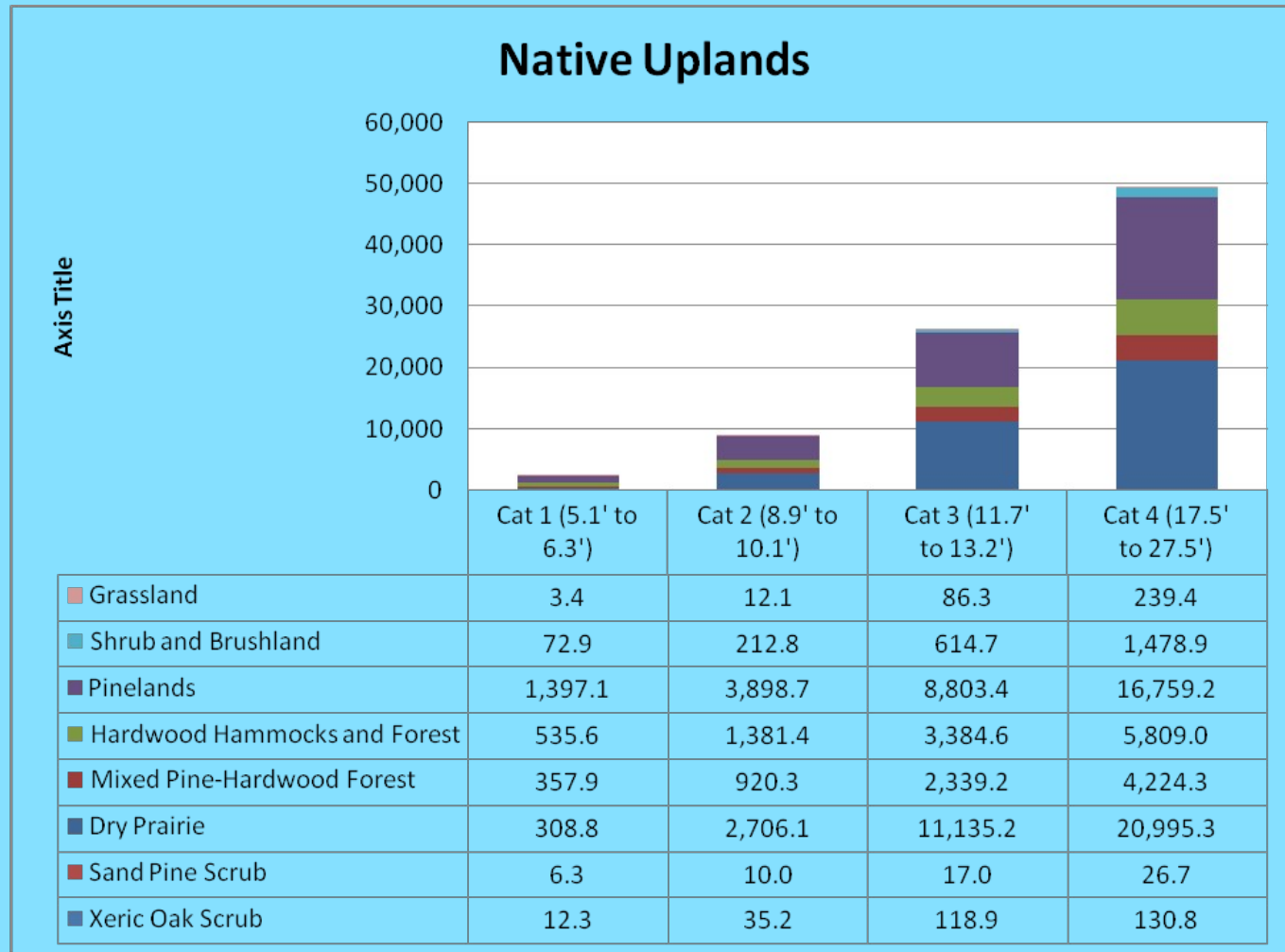
 Acres of uplands habitat in Sarasota County at and below different storm surge elevations 2009
Note; tropical storm maps were not available from Sarasota County at the time of the study

Sarasota County Florida 5' Sea Level Rise

Altered Hydrology

- Altered timing of seasonal changes
- Changes in precipitation will contribute to erosion, flooding and runoff at coastlines.
- Changes in rainfall patterns and amounts change agricultural yields.
- Drought caused by increased atmospheric temperatures
- Drought causes lower stream flows.
- Increased frequency of droughts and floods.

Geomorphic Changes

- Landform migration to maintain relative position within the coastal energy gradient (Pethick 2001)
- Mangrove ability to accrete sediment (in absence of killing storms or human impacts)
- "Mangroves cannot persist with relative sea level rise above 12 cm/100 years" (Singh 2003)
- Habitat migration with landform changes

August 15, 2004

North Captiva
Island breach

USGS photo

Mote Marine Laboratory
Brad Robbins, Michelle Gitfler, Anamari Boyes
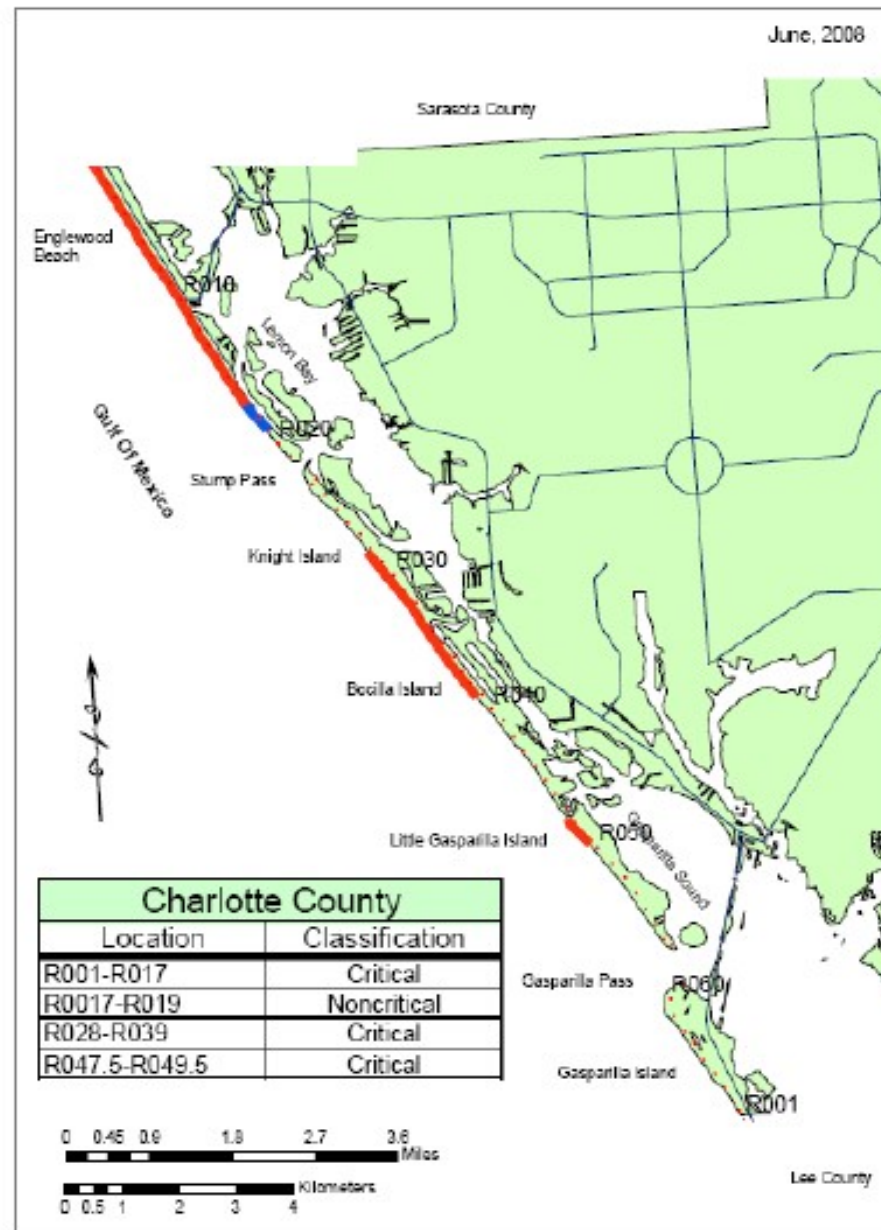
Figure 39: Identified areas of coastal erosion Charlotte County

Habitat and Species Changes

| Estuary | Seagrass | Mangrove Fringe | Tropical Hammock | Tidal Creek | Freshwater Creek | Pine Flatwoods (Hydric, Mesic, Xeric) | Oak Scrub |

Habitat Structure-2000
Southwest Florida

By: Lisa B. Beever, PhD, AICP
Date: 4/16/08
Charlotte Harbor National Estuary Program

Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/),
University of Maryland Center for Environmental Science.

Rainfall Pattern Changes

Increasing E/T

Increasing Water Temperature

Water Table Changes

Gulf of Mexico

Barrier Island Shift Landward

New Lagoon

Mangrove Fringe

Tropical Hammock

Tidal Creek

Freshwater Creek

Compression of Upland & Freshwater Wetland Systems
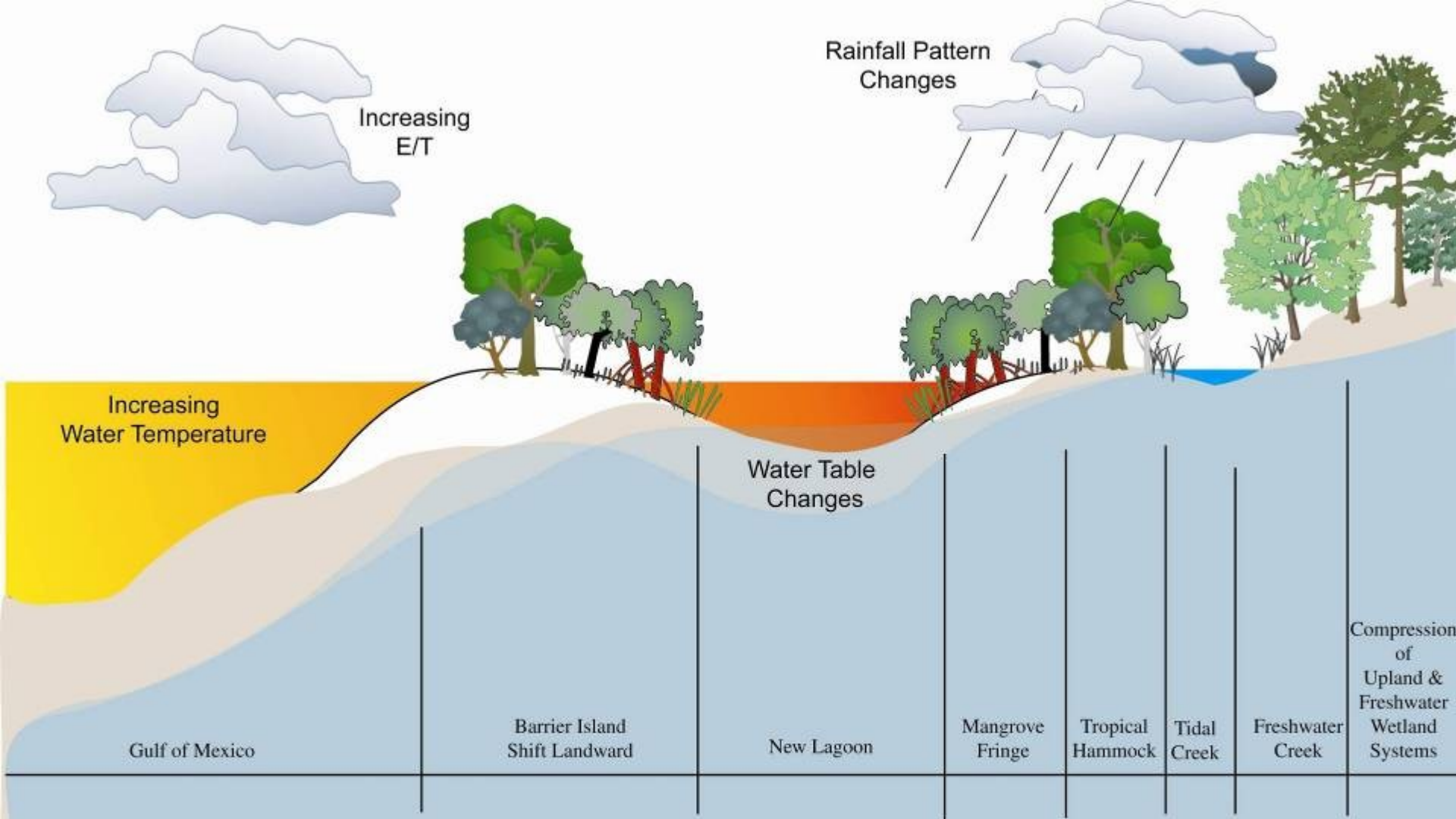
By: Lisa B. Beever, PhD, AICP
Date: 4/16/08
Charlotte Harbor National Estuary Program

Habitat Migration-2200
Southwest Florida

CHARLOTTE HARBOR National Estuary Program

SLAMM Predictions of Habitat Fate under Scenario A1B, Mean for Charlotte Harbor, FL

Initial Condition — Year 2100
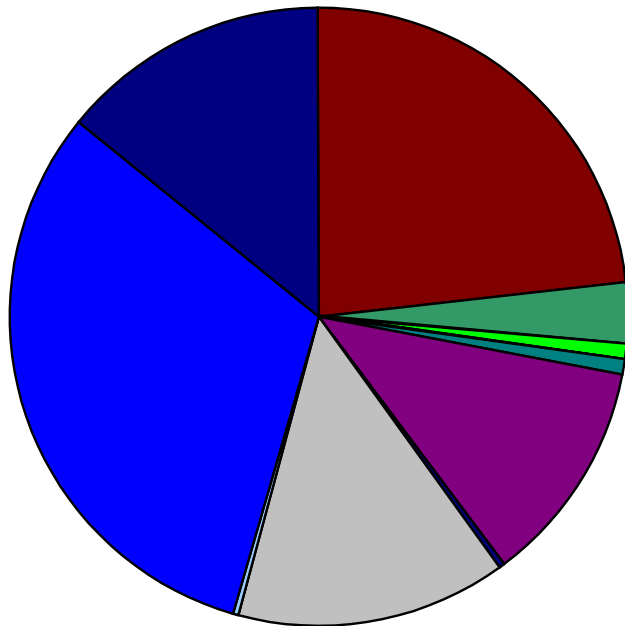
Legend:
- Dry Land
- Hardwood Swamp
- Cypress Swamp
- Inland Fresh Marsh
- Tidal Fresh Marsh
- Transitional Salt Marsh
- Saltmarsh
- Mangrove
- Estuarine Beach
- Tidal Flat
- Ocean Beach
- Rocky Intertidal
- Inland Open Water
- Riverine Tidal
- Estuarine Open Water
- Open Ocean

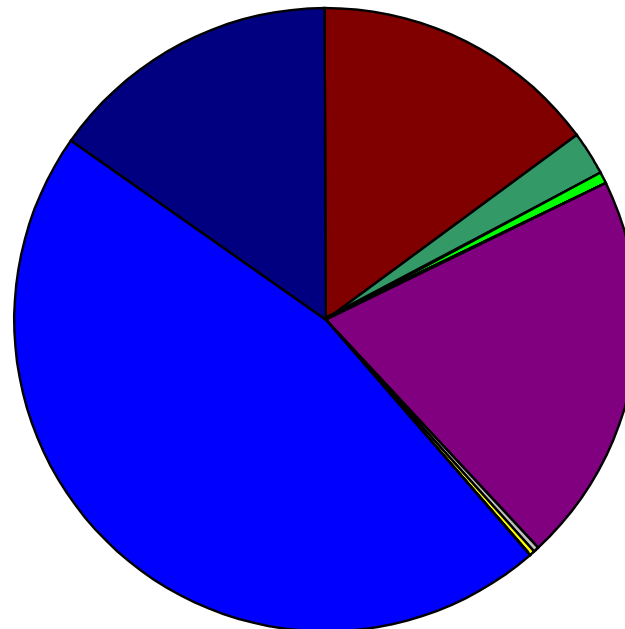## State Endangered Species

Florida panther, Everglades mink, West Indian manatee, Atlantic right whale, finback whale, humpback whale, sei whale, sperm whale, bonneted bat, wood stork, snail kite, peregrine falcon, Florida grasshopper sparrow, American crocodile, Atlantic green turtle, leatherback turtle, Atlantic ridley turtle, Atlantic hawksbill turtle, small-toothed sawfish

State Threatened Species

Florida black bear, Big Cypress fox squirrel, Florida sandhill crane, southeastern American kestrel, least tern, roseate tern, piping plover, southeastern snowy plover, Florida scrub jay, crested caracara, white-crowned pigeon, eastern indigo snake, Atlantic loggerhead turtle, gopher tortoise

State Species of Special Concern

Florida mouse, Sherman's fox squirrel, Sanibel Island rice rat, Sherman's short-tailed shrew, red-cockaded woodpecker, roseate spoonbill, little blue heron, reddish egret, snowy egret, tricolored heron, white ibis, limpkin, brown pelican, American oystercatcher, black skimmer, burrowing owl, Florida pine snake, American alligator, gopher frog, mangrove rivulus, Florida tree snail

55 State Listed Species with 20 of these Federally Listed

Marine and Estuarine Waters

Bill Keogh

1   **Listed Animal Species in the Marine and Estuarine Ecosystems**

23 Listed Animal Species

Loggerhead sea turtle

Least tern. *Original photograph by Barry Mansell.*

© Joanne Williams

© Dean Jue

Problems for Shore-nesting Species:Birds and Reptiles

- **Increased Sea-Level**
- **Increased Storm Frequency and Severity**
- **Higher-High Tides**
- **Increased erosion and narrowing of shorefront (beach)**
- **Increased Harmful Algae Blooms including Macroalgal Drifts**
- **Shifts in location of food resources to deeper waters**
- **Changes in beach particle size and compaction if renourishment is employed to detain erosion**
- **Increased shore-armoring to protect human financial investments in place**

Photo Credit: D. Scott Taylor
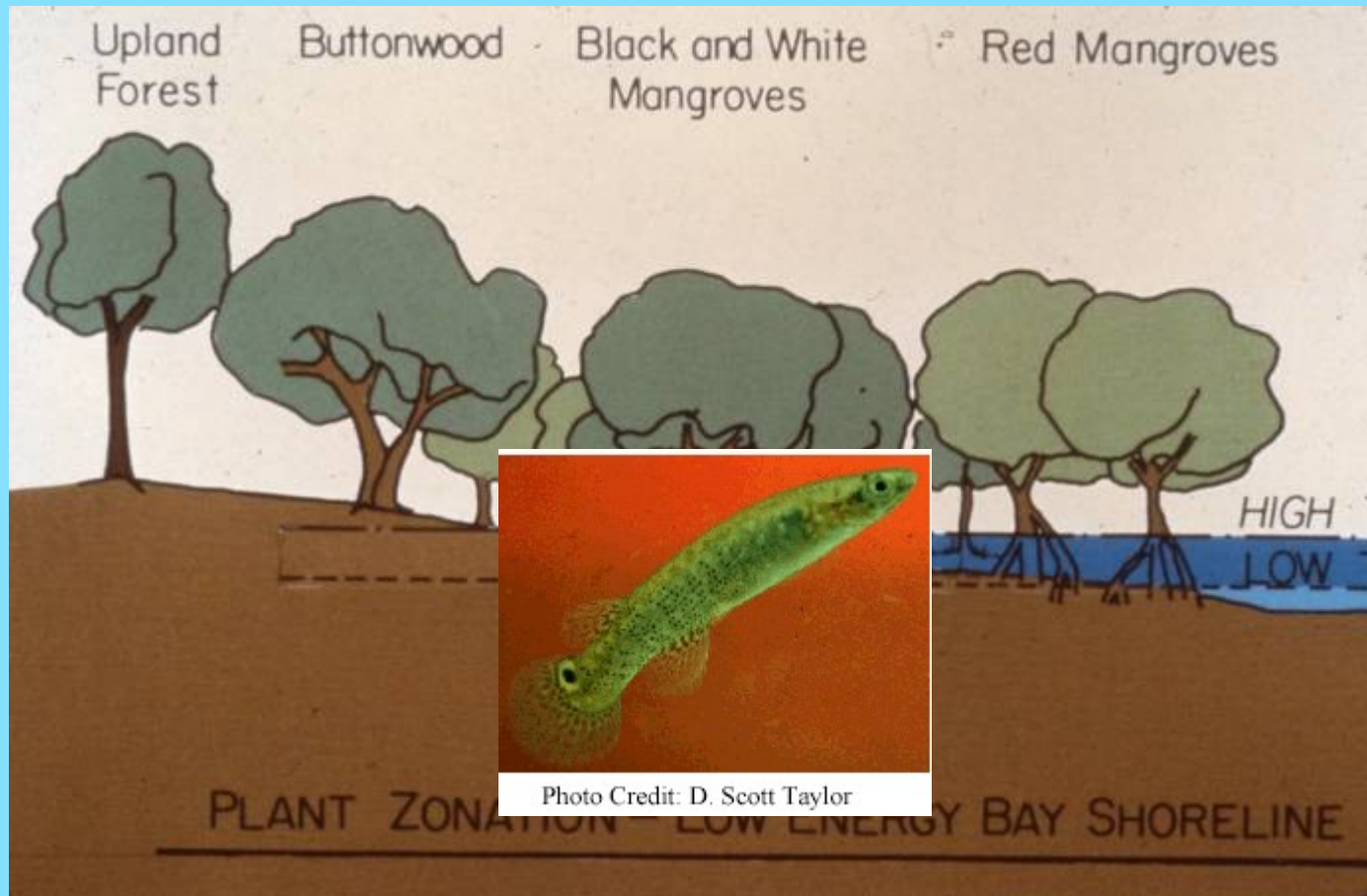
Mangrove Rivulus

American crocodile: Charlotte, Collier, Lee Counties

Increased Sea-Level

Increased Storm Frequency

Increased Storm Severity

Increased Water Temperature

Increased Harmful Algae Blooms

Increased Nutrient Run-off from Watershed from Increased Precipitation

Increased Summer Range

Increased Predation on Chicks

Increased Food Stealing

Overwash Mangrove Island Rookery

Increases in Water Temperature Move Forage Fish Schools into Gulf of Mexico away from Rookeries and Passes

Major Freshwater Releases from Watershed

Increased Storm Frequency

Increased Storm Severity

Increased Water Temperature

Increased Harmful Algae Blooms

Increased Nutrient Run-off from Watershed from Increased Precipitation

Small-toothed Sawfish

Decreased Dissolved Oxygen

Decreased in-river Submerged Aquatic Vegetation

Decreased forage fish
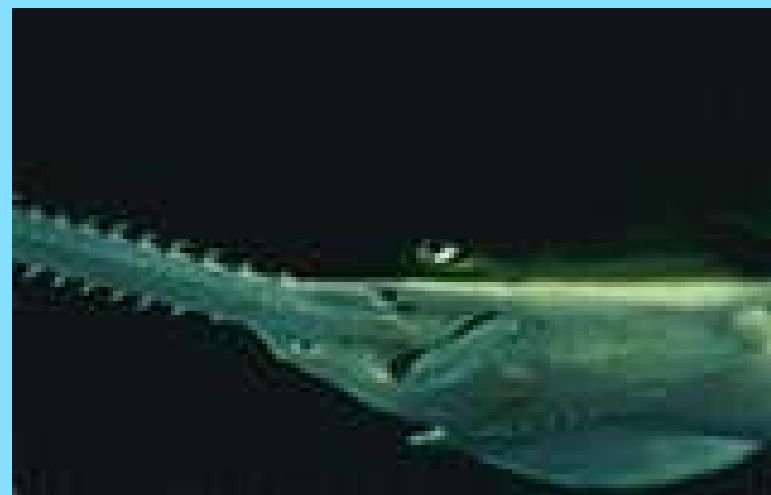
Marshes

23 Listed Animal Species in the
Marsh
isted Animal Species in the
shwater Marsh
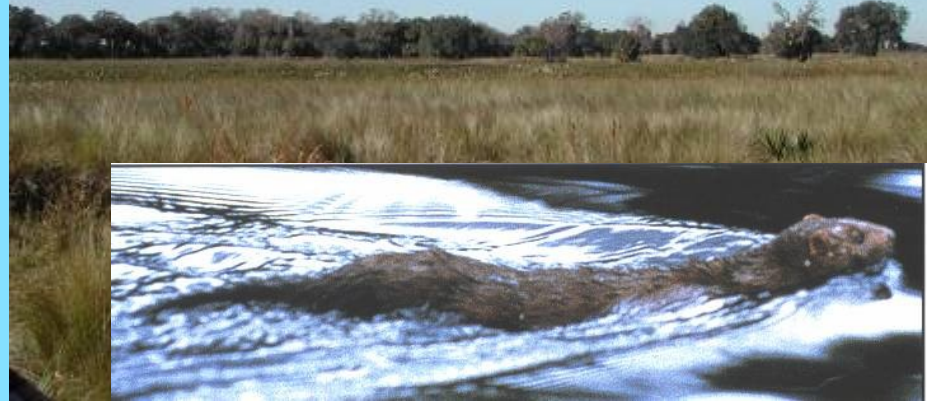
Quercus inopina
Photo by Shirley Denton

Most Southwest Florida Xeric Oak Scrub is Coastal or along Rivers and Streams. Inland Retreat will eliminate the rarest of the upland habitats with endemic animals such as the Florida scrub jay and endemic plants.

Quercus geminata
Photo by Shirley Denton

Interior pinelands and other uplands of Southwest Florida are the last refuge of the Florida Panther, Florida Black Bear, Big Cypress Fox Squirrel and Red-Cockaded Woodpecker.

County	Dengue and dengue hemorrhagic fever	Malaria	West Nile Virus	Yellow Fever	Encephalitis including St. Louis, California	Equine Encephalitis (Eastern & Western)	Lyme Disease (Borrelia burgdorferi)	Rocky Mountain Spotted Fever	Ehrlichiosis	Typhus Fevers
Charlotte	1	4	0	0	7	0	14	0	1	0
Collier	3	44	3	0	11	0	3	0	1	0
DeSoto	0	0	1	0	0	0	0	0	0	0
Glades	0	0	0	0	0	0	2	0	0	0
Hardee	0	1	0	0	3	0	0	1	0	0
Hendry	0	1	0	0	0	1	0	0	1	0
Lee	5	31	5	0	17	0	37	6	2	2
Manatee	2	8	1	0	3	0	19	0	2	0
Polk	4	21	1	0	4	2	9	2	1	0
Sarasota	0	13	6	0	28	0	55	5	3	0
Totals	15	123	17	0	73	3	139	14	11	2

County	Plague (Yersinia pestis)	Chagas (Trypanosoma cruzi)	Rabies (possible exposures)	Hantavirus	Tularemia (Francisella tularensis)
Charlotte	0	X	0 (298)	0	0
Collier	5	X	1 (382)	0	0
DeSoto	1	X	0 (4)	0	0
Glades	0	X	0 (1)	0	0
Hardee	0	X	0 (35)	0	0
Hendry	1	X	0 (44)	0	0
Lee	2	X	0 (624)	0	0
Manatee	0	X	0 (225)	0	0
Polk	2	X	0 (21)	0	0
Sarasota	0	X	0 (189)	0	0
Totals	11		1 (1823)	0	0

mosquito-borne
tick-borne
flea-borne
other insect-borne
mammal-borne

Human Health

Table 25: Tropical diseases occurrence in southwest Florida
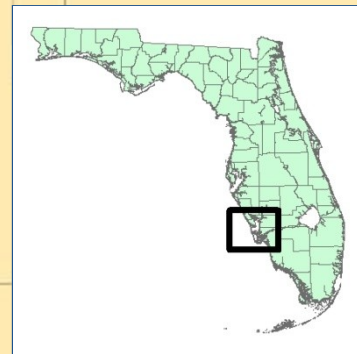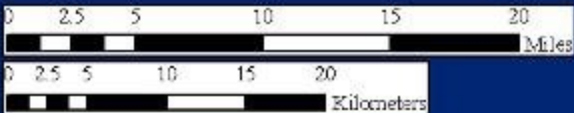
Land Use and Human Infrastructure

Legend
Potential Sea Level Rise
Underlying Land Uses

- Tidal Wetlands
- Non-Tidal Wetlands
- Upland Conservation
- Urban
- Roads
- Existing Open Water
- Land Above 10'

Potential sea level rise to the year 2200 based on 95% cumulative probability (Titus and Narayanan 1995)
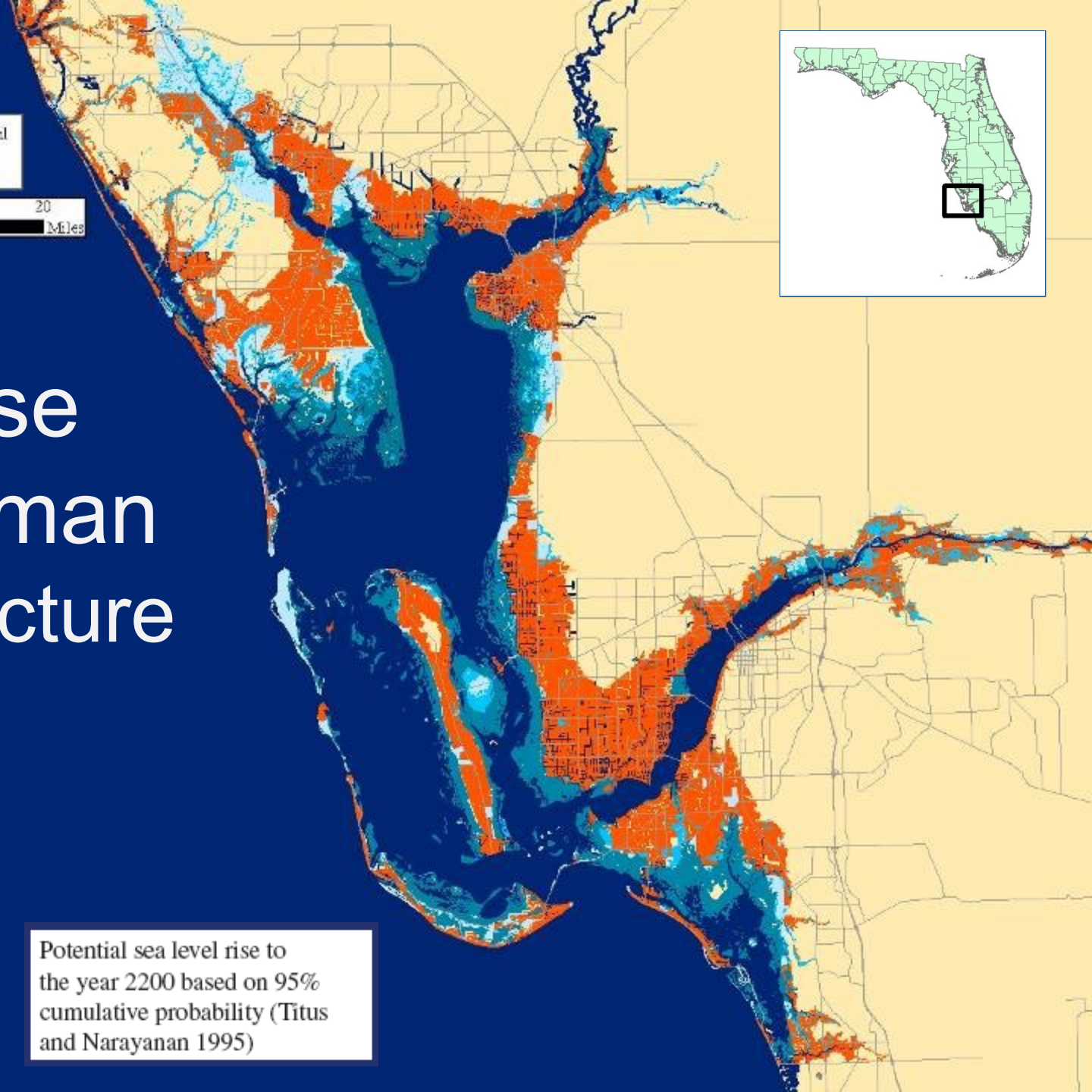
Visual Imaging from "A Nation Under Siege," The 2030 Research Center
www.architecture2030.org/current_situation/coastal_impact.html

Visual Imaging from "A Nation Under Siege," The 2030 Research Center
www.architecture2030.org/current_situation/coastal_impact.html

Source: Southwest Florida Regional Planning Council
        Charlotte Harbor National Estuary Program
        South Florida Water Management District
        Florida Natural Areas Inventory
Date: June 18, 2008

0 2.5 5   10   15   20
                                      Miles

0 2.5 5   10   15   20
                              Kilometers

CHARLOTTE HARBOR
National Estuary Program
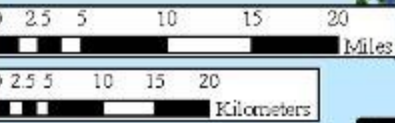
Lake Okeechobee

Gulf of Mexico

Legend

Storm Surge

- ▇ Tropical Storm
- ▇ Category 1
- ▇ Category 2
- ▇ Category 3
- ▇ Category 4/5
- ▬ SWFFS Boundary
- □ County Boundaries
- — Roads
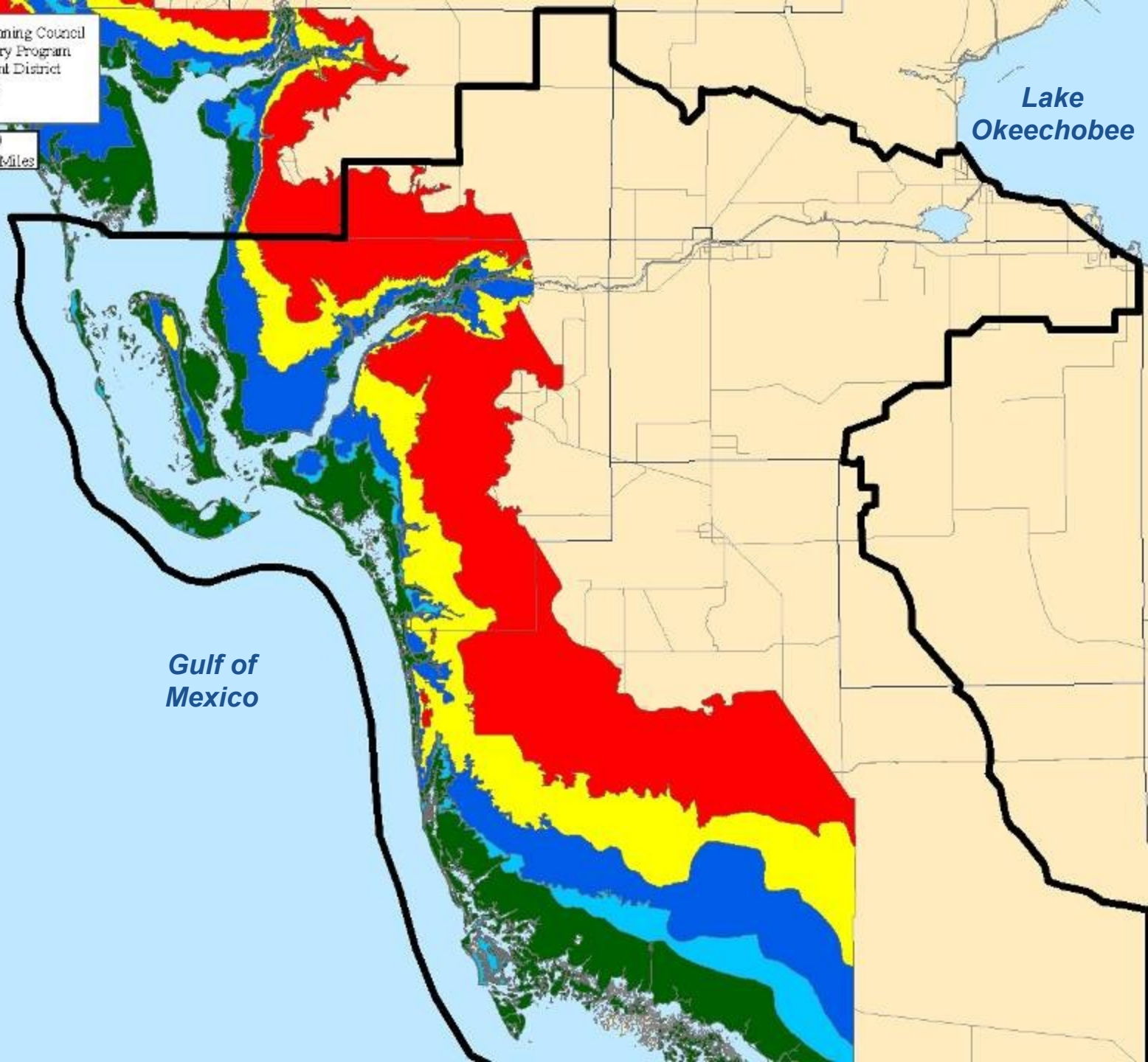
Figure 9: Number of buildings located in each tropical storm and hurricane storm surge zone in coastal CHNEP/SWFRPC study area

Figure 10: Proportion of buildings located in each tropical storm and hurricane storm surge zone in coastal CHNEP/SWFRPC study area

Percentage of monetary value in 2005 dollars of properties in each storm surge zone in Coastal CHNEP/SWFRPC

■ Tropical Storm ■ Category 1 ■ Category 2 ■ Category 3 ■ Category 4 / 5 ■ Not in Any Zone
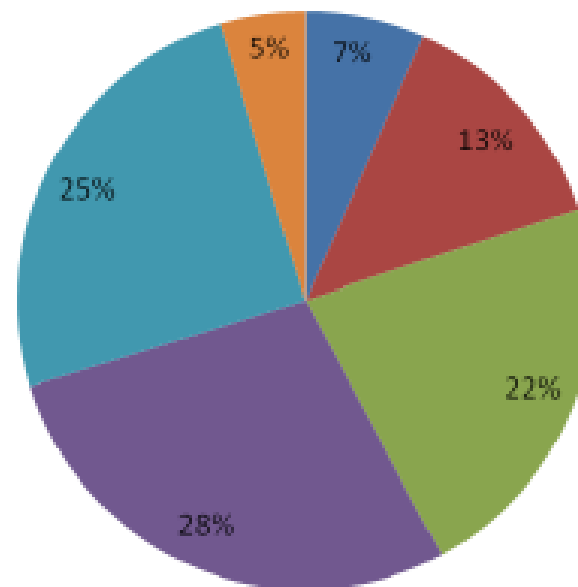
Figure 12: Percentage in monetary value in 2005 dollars of properties in each storm surge zone in coastal CHNEP/SWFPC study area

Figure 55: Major Florida roads vulnerable to projected worst case sea level rise

Transportation Infrastructure Impacts

	Limited Access Highways (miles)	Other Highways (miles)	Major Roads (miles)	Railroads (miles)
Florida Total	75.5	390.8	1972.4	181.3
Charlotte	1.9	6.1	51.4	3.5
Collier	46.4	101.4	2.3	
Lee	1.4	3.5	97.5	1.5
Manatee	8.8	3.3	40.6	2.8
Sarasota	0.1	12	44.2	
Region	12.2	71.3	186.3	10.1

County	Charlotte	Collier	Lee	Sarasota	Total
Facility					
Airport	1	3	3	0	7
Boat Locks	3	0	2	0	5
Clinic	2	8	2		12
Communication Tower	19	8	9	5	41
Community Centers	14	0	0	0	14
Community College	1	1	1	2	5
Drinking Water Facilities	0	9	13	25	47
Electrical Facilities	15	6	14	0	35
Elementary Schools	6	8	11	0	25
Emergency Medical Services	10	2	3	1	16
Fire Stations	0	12	19	14	45
Government Facilities	18	33	27	14	92
High School	3	2	2	0	7
Hospital	1	0	1	1	3
Hurricane Shelters	0	17	12	0	29
Landfills	0	2	2	1	5
Middle School	1	3	3	0	7
Nursing & Convalescent Facilities	0	0	26	1	27
Police-sheriff Facilities	4	9	3	6	22
Port	0	0	1	0	1
Private College	0	0	1	1	2
Private School	2	3	1	0	6
Sewage Treatment Facilities	0	6	43	21	70
Telephone Remote Building	1	0	0	0	1
Telephone Switching Stations	12	0	0	0	12
U.S. Post Office	0	1	0	0	1
Total	113	133	199	92	537

Combining the ranking provides the following priority for climate change vulnerabilities:

Prioritization	CHNEP CCMP Goal Implementation	Proximity in Time	Habitat Loss in the Estuary	Habitat Loss in the Watersheds	Sum of Scores	Average Rank
Air Temperature and Chemistry	7	7	8	8	30	7.5
Altered Hydrology	1	1	1	1	4	1.0
Climate Instability	2	2	3	2	9	2.3
Geomorphic Changes	6	5	7	5	23	5.8
Habitat and Species Changes	4	4	5	4	17	4.3
Sea Level Rise	5	11	2	12	30	7.5
Water Temperature and Chemistry	3	12	6	3	24	6.0
Human Economy	9	9	10	10	38	9.5
Human Health	10	6	11	7	34	8.5
Infrastructure	8	8	9	9	34	8.5
Land Use Changes	11	10	4	6	31	7.8
Variable Risk	12	3	12	11	38	9.5

Table 30: Prioritization of climate change effects in southwest Florida

Prioritized Climate Change Vulnerabilities

1) Altered Hydrology

2) Climate Instability/ Storm Severity

3) Habitat and Species Changes

4) Geomorphic (Landform) Changes

5) Water Temperature & Chemistry Changes

6) Air Temperature & Chemistry Changes and Sea Level Rise

7) Land Use Changes

8) Human Health and Infrastructure Impacts

9) Human Economy and Variable Risk

Models of sustainability and management that were developed in an era of stable climate will not be sufficient.

CONCLUSIONS

- SWF currently experiencing climate change.
- Natural setting + overinvestment near coast = Among first to suffer
- Changes will continue even with GHG reduction
- Impacts are inevitable
- We have already experienced:
  - More severe storms
  - Loss of mature mangrove, water quality, island area
  - Longer, more severe dry seasons
  - Shorter wet seasons of higher precipitation

Even the least impact future climate change scenario:

- increased climate instability

- wetter wet seasons

- drier dry seasons

- more extreme hot and cold events

- increased coastal erosion

- continuous sea-level rise

- shifts in fauna and flora

- increased tropical diseases in plants, wildlife & humans

- destabilized aquatic food webs including increased HAB

- increasing strains upon and costs in infrastructure

- increased uncertainty concerning variable risk assessment with uncertain actuarial futures.

Committing to Our Future

A Comprehensive Conservation and Management Plan

for the Greater Charlotte Harbor Watershed

from Venice to Bonita Springs to Winter Haven

Update 2008

CHARLOTTE HARBOR National Estuary Program

In the absence of effective avoidance, mitigation, minimization & adaptation, climate-related failures will result in greater difficulty in addressing the priority problems identified in the CCMP and the Myakka River Plan.

Presenter Contact: James (Jim) W. Beever III

1926 Victoria Ave, Fort Myers FL 33901-3414

239/338-2550 ext 224, Toll free 866/835-5785
Fax 239/338-2560,
jbeever@swfrpc.org   www.SWFRPC.org