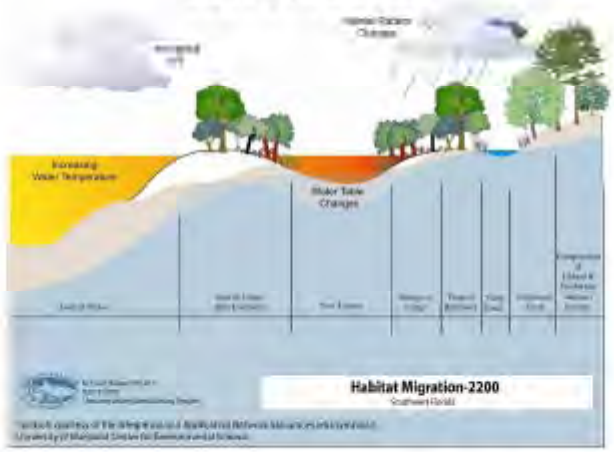
Comprehensive Southwest Florida/Charlotte Harbor Climate Change Vulnerability Assessment



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

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Dan Cobb, Jason Utley: SWFRPC
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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.

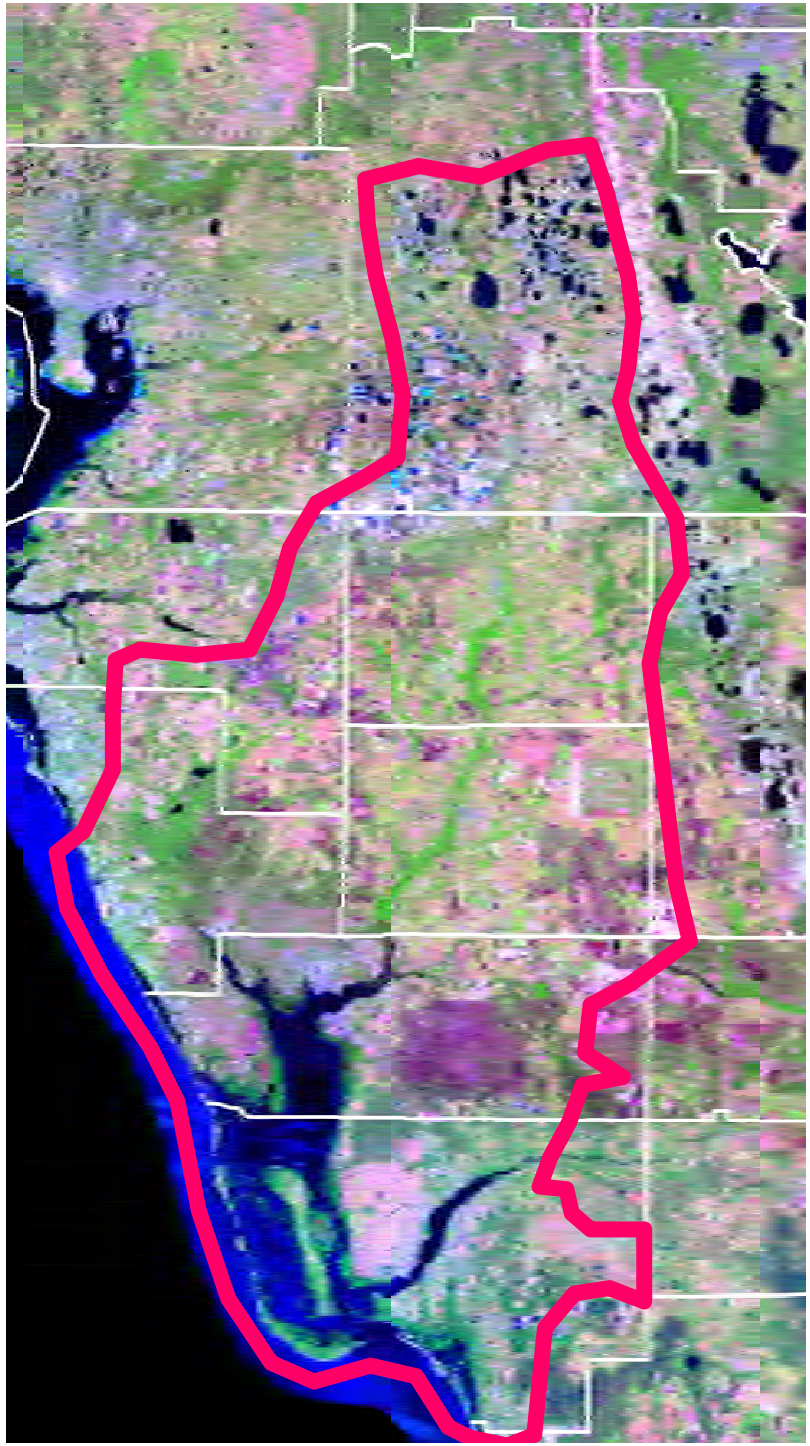
This priority action helps fulfill SG-3.

Strategy

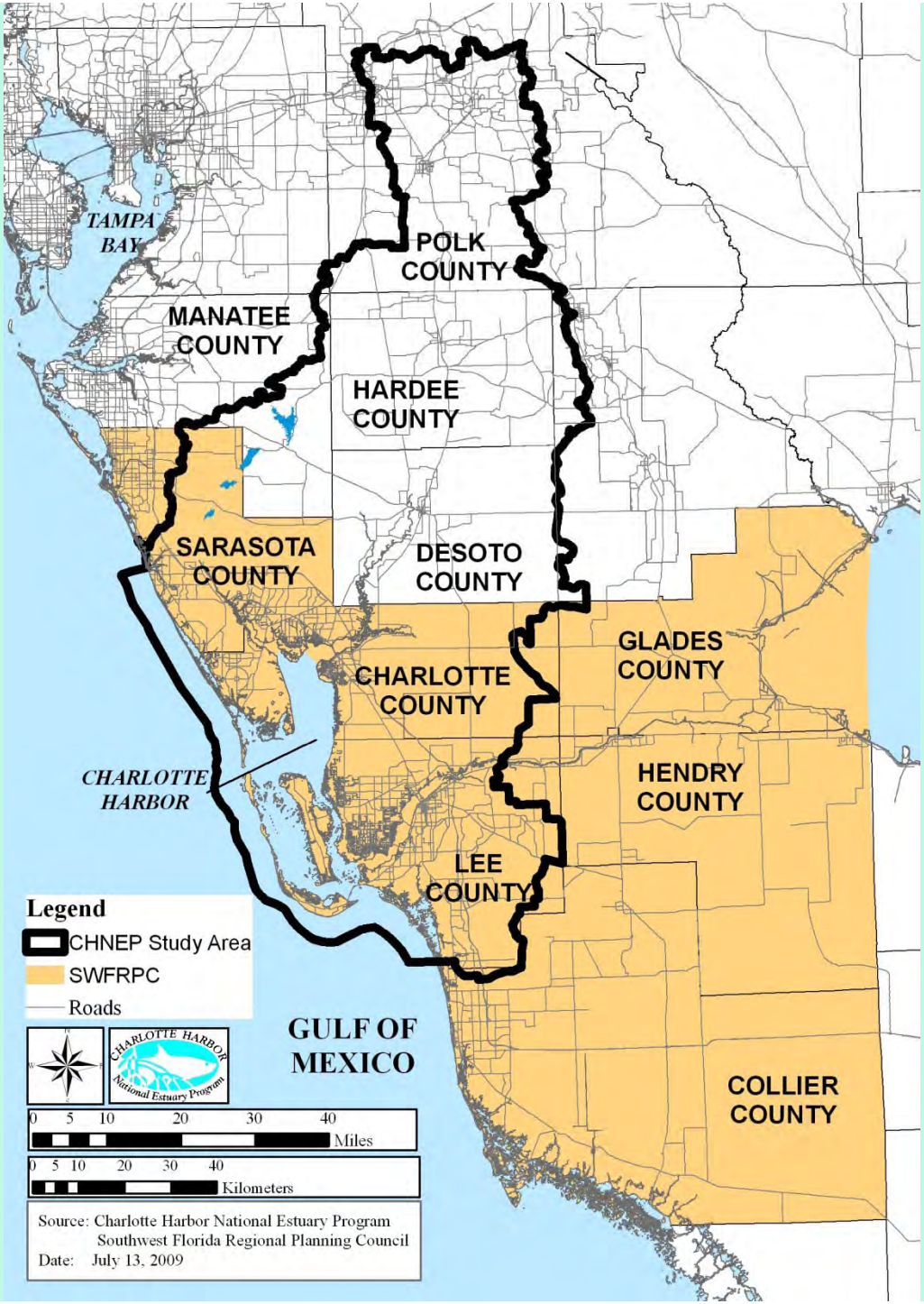
1) Conduct an initial overview of the significant potential human and ecological effects related to climate change from sea level rise, aquatic and atmospheric temperature rise, changes in rainfall patterns, increased storm intensity and ocean acidification. The goal of such an initial overview would 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

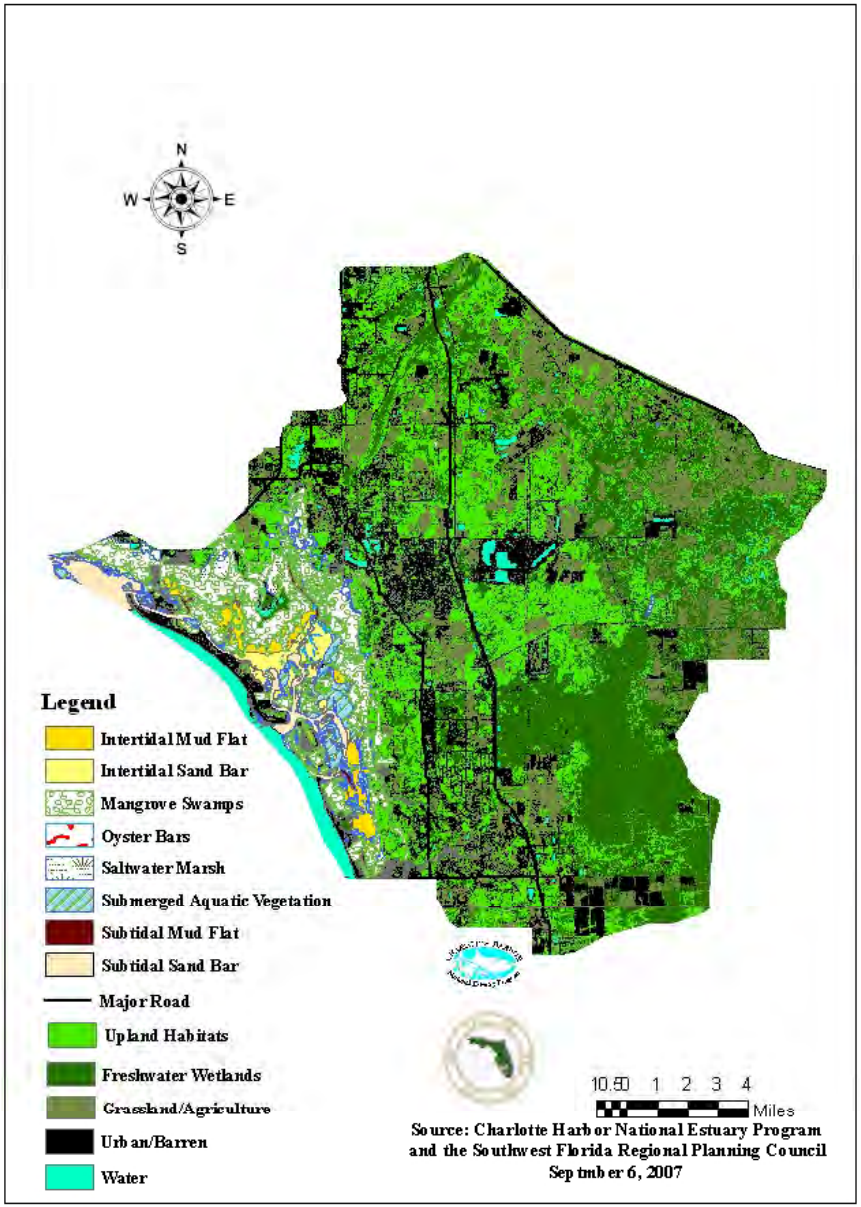
Charlotte Harbor National Estuary Program
County and municipal governments
Florida Department of Environmental Protection
Organizations: Conservation
Organizations: Nonprofit research



Study Area for the Climate Change Vulnerabilities Assessment



Year 2006 Habitats of the Estero Bay Watershed



Climate change is currently occurring and more change is to be expected.

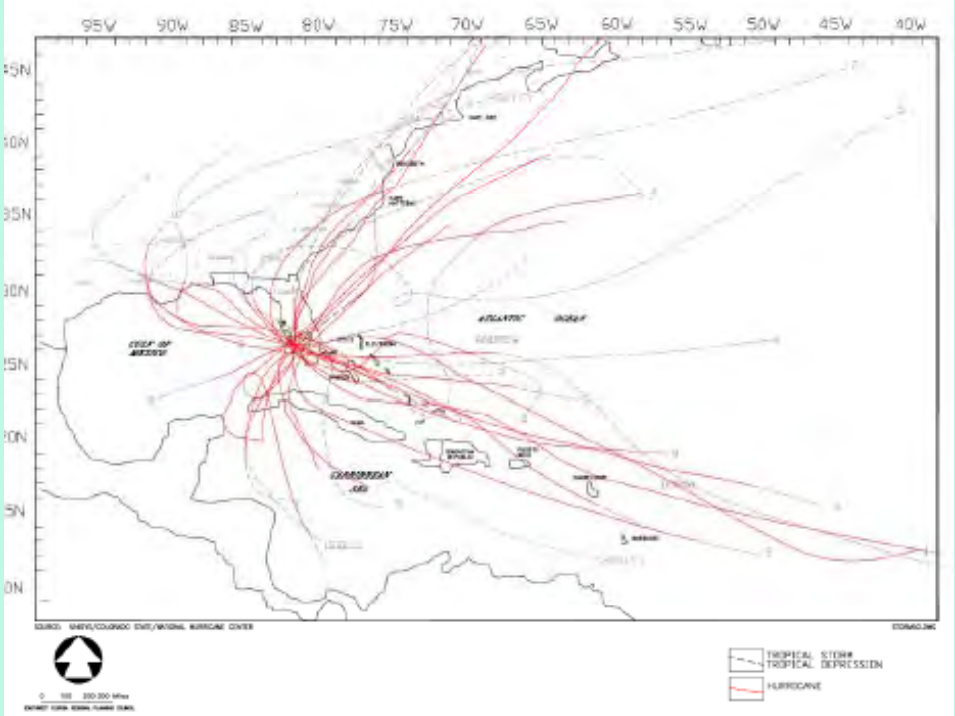
The question for Southwest Floridians is not *whether* they will be affected by climate change, but *how much* they will be affected and in what ways including the *degree* to which it will continue, *how rapidly* change will occur, *what type* of climate changes will occur, and what the *long-term effects* of these changes will be.

Vulnerable Human Economy, Human Health & Infrastructure

- **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

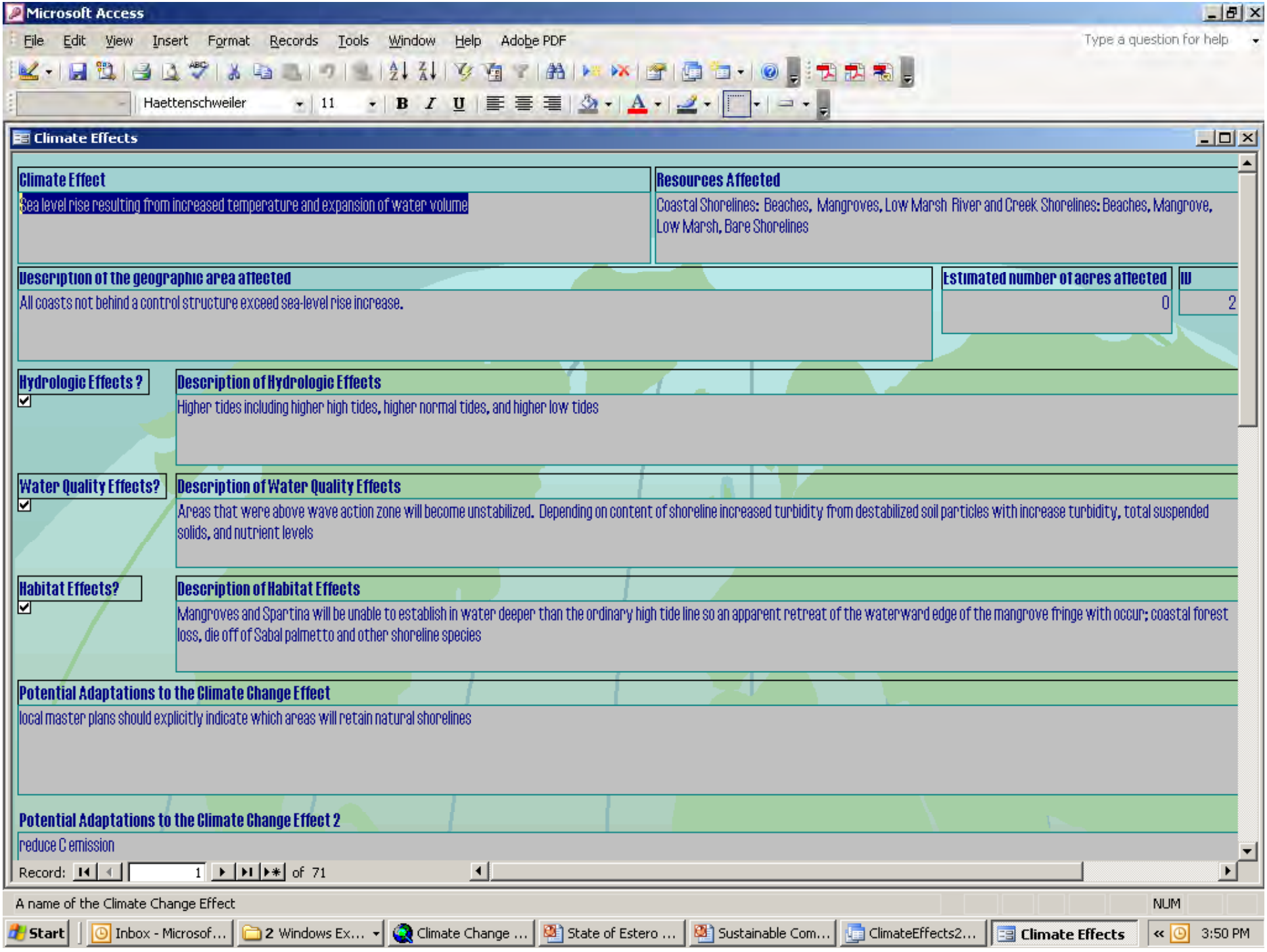
Paths of All Recorded Hurricanes



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.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11
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
Start
Inbox - Microsof...
2 Windows Ex...
Climate Change ...
State of Estero ...
Sustainable Com...
ClimateEffects2...
Climate Effects
3:50 PM

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

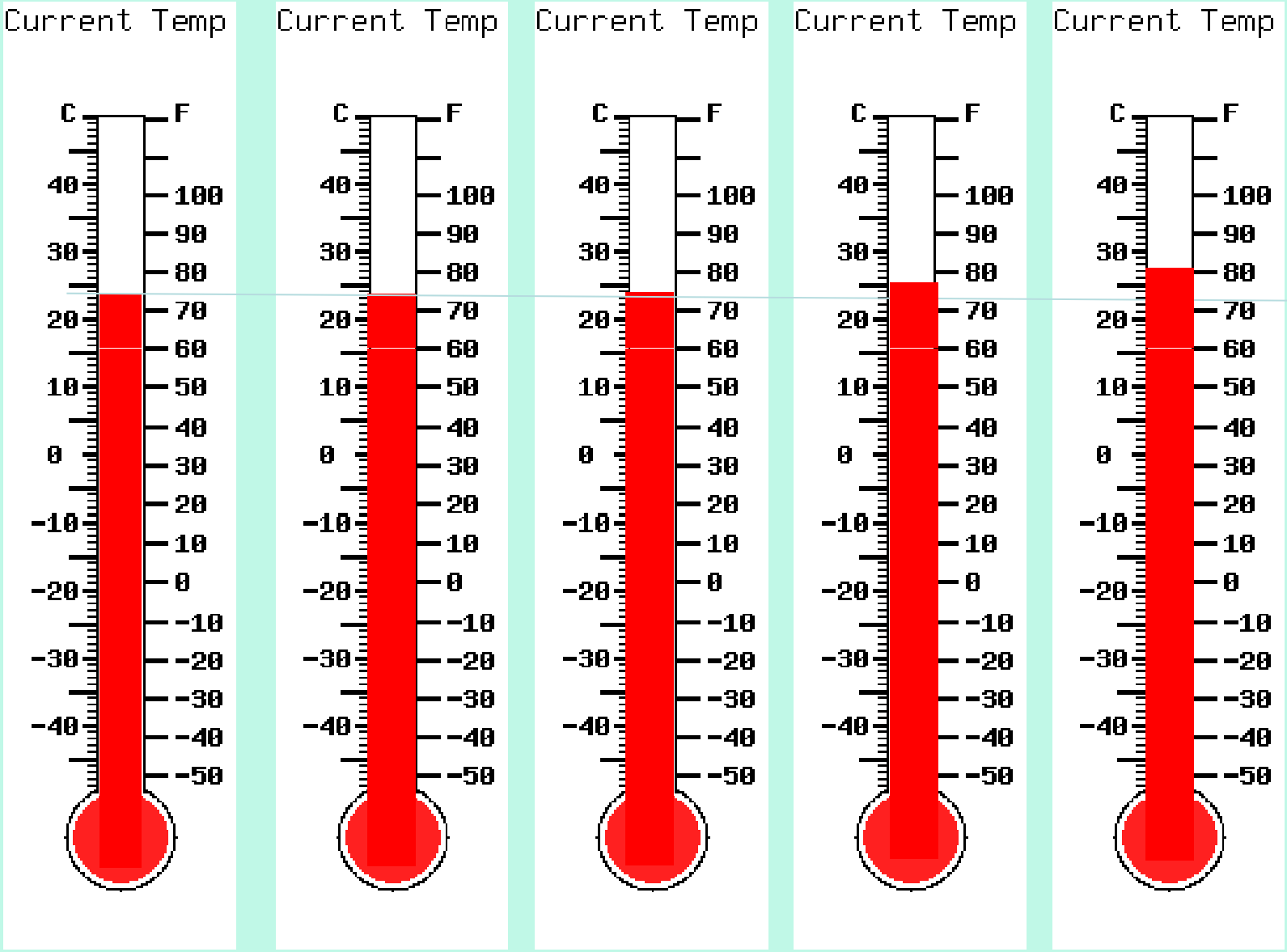
Air Temperature and Chemistry

- 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

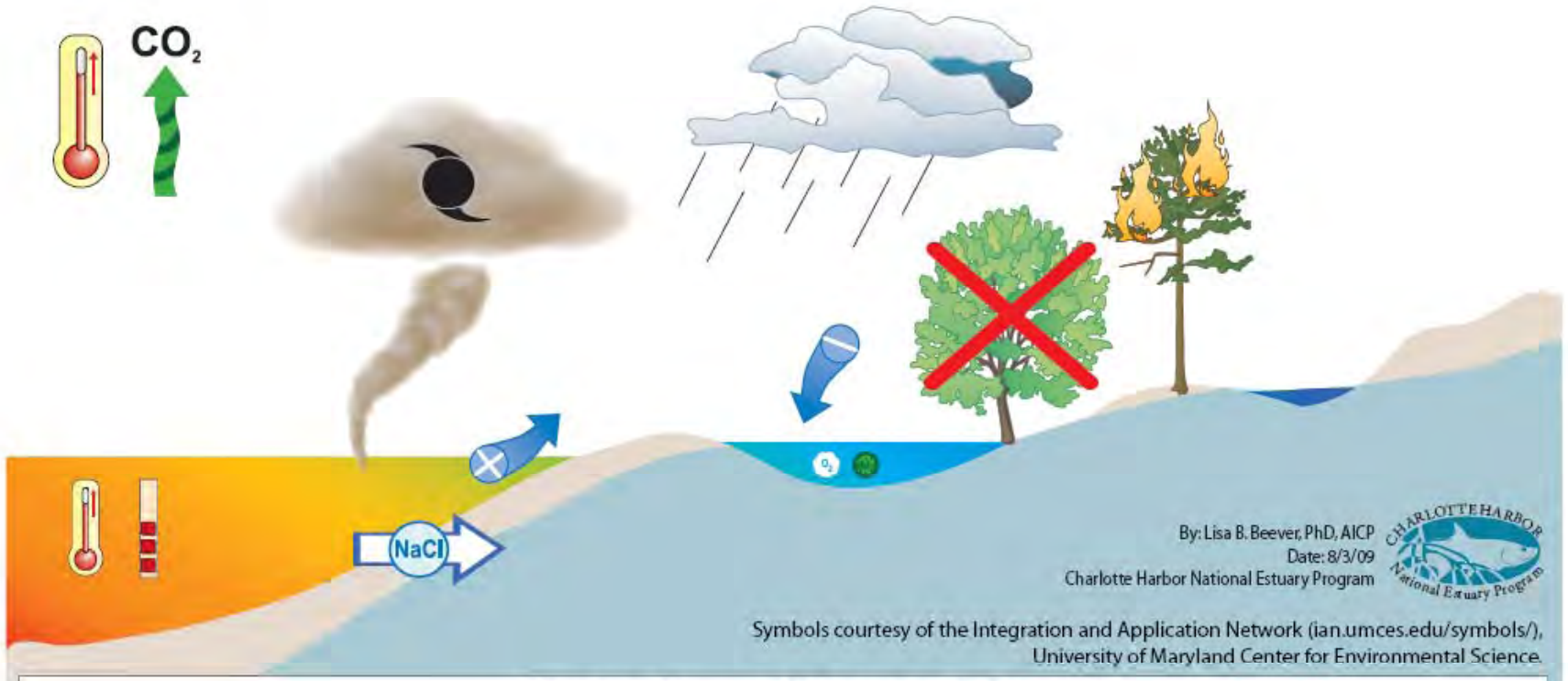
Most Severe Case



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



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 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.

Climate Instability

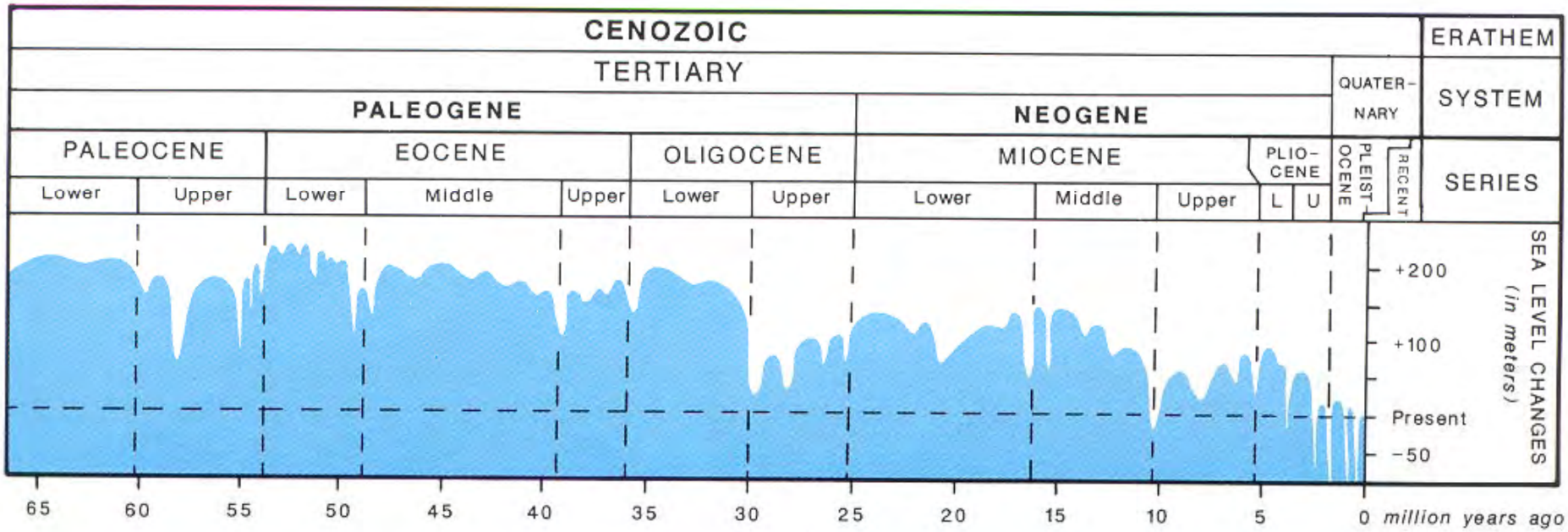
Even in the most probable, lowest impact future climate change scenario predictions, the future for southwest Florida will include increased sustained climate instability that will involve:

- 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).

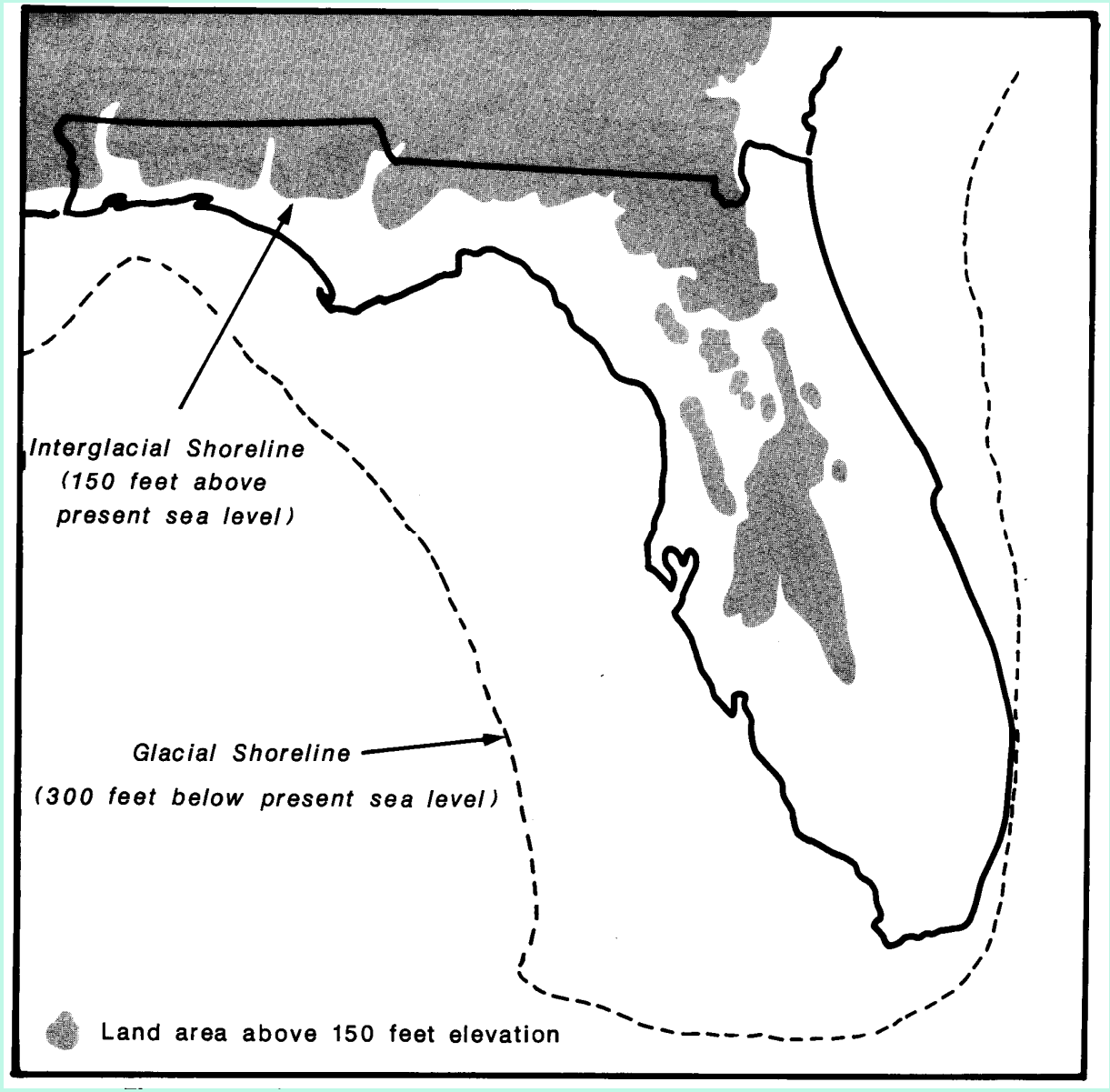
Figure 2: Sea level changes during the last 65 million years

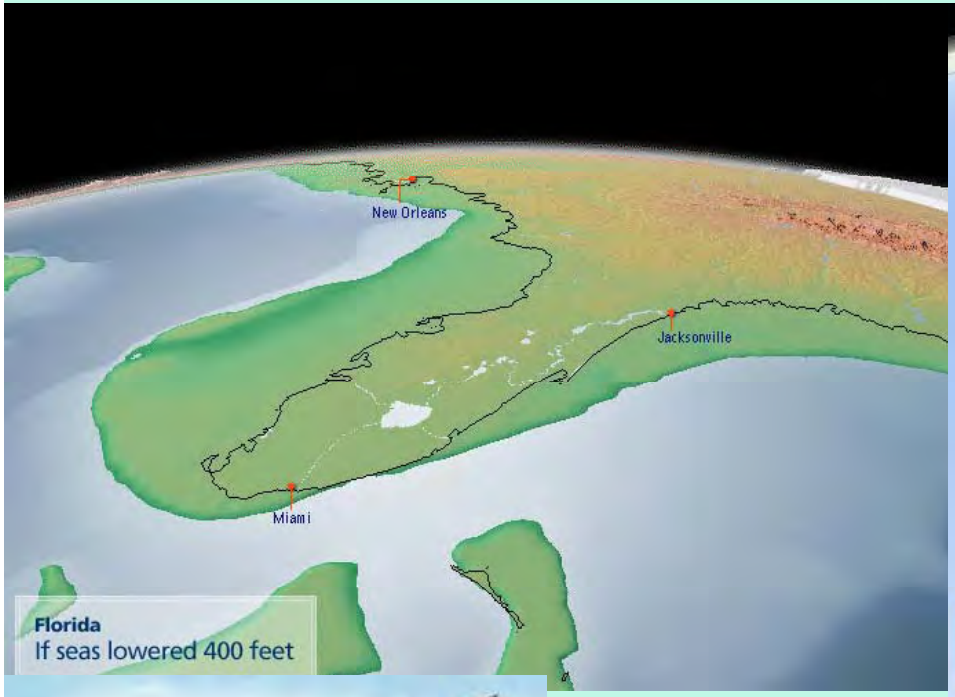


The Pleistocene Epoch is known as the “Ice Age” and includes at least four great glacial periods.

- 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).

Figure 3: Shoreline of Florida between 1.8 million to 10,000 years ago




New Orleans
Jacksonville
Miami
Florida
If seas lowered 400 feet

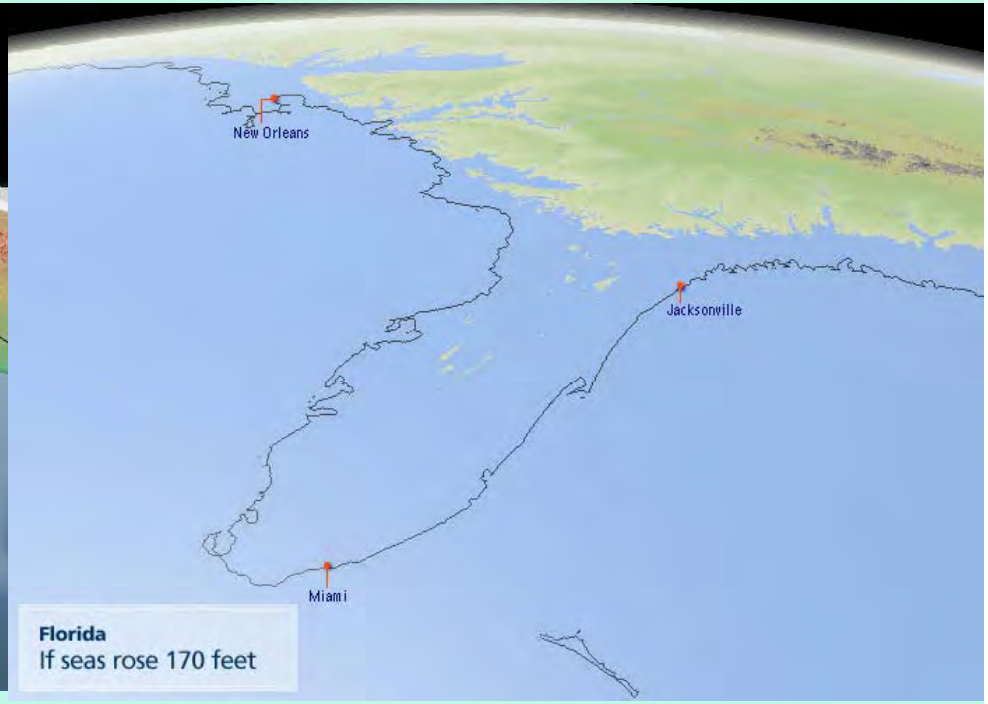
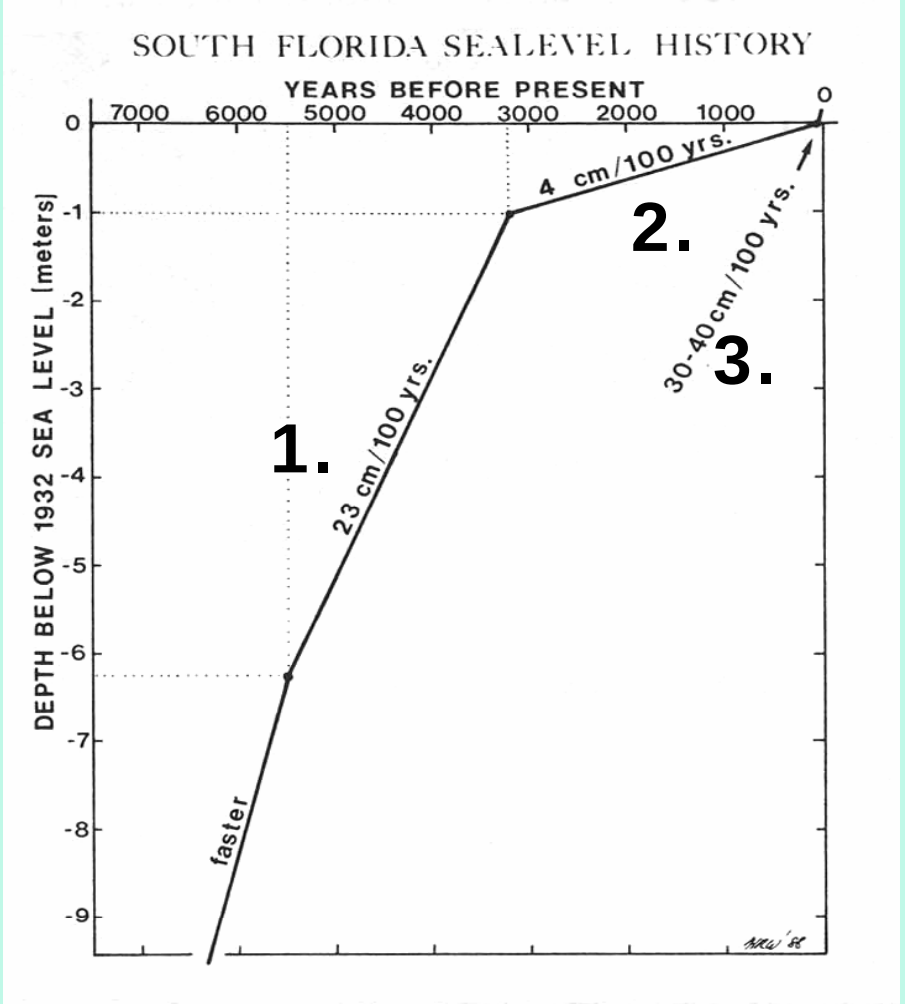

New Orleans
Jacksonville
Miami
Florida
If seas rose 170 feet

Figure 4: 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



Global Sea Level Rise 1860-2009

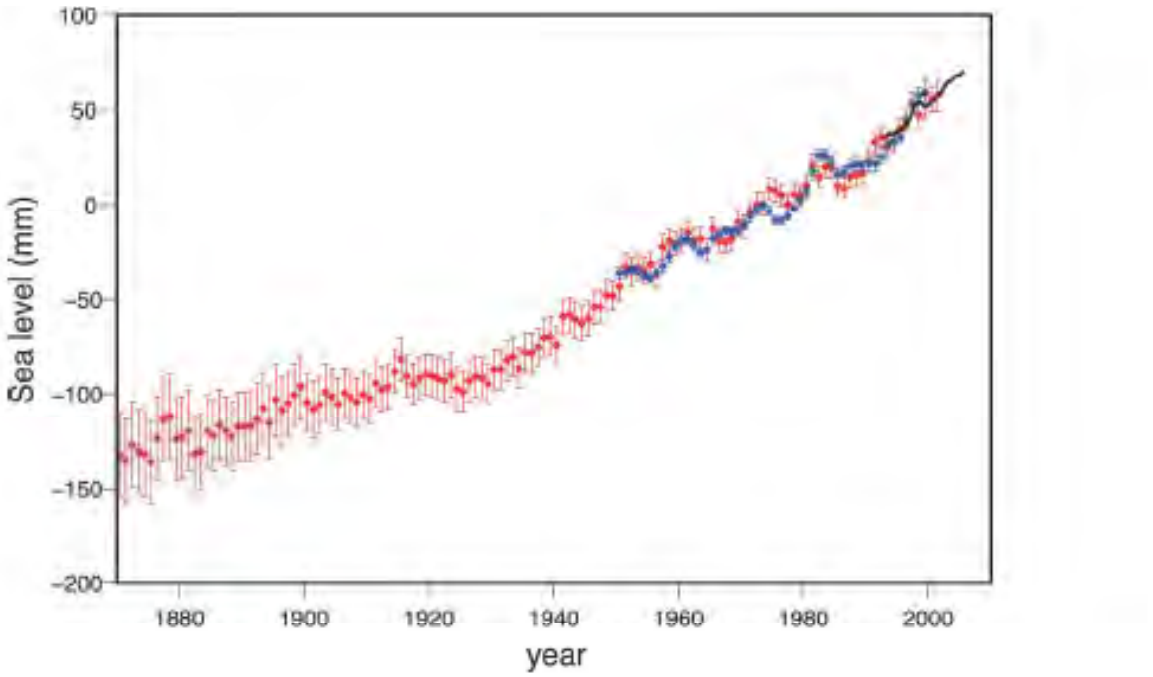


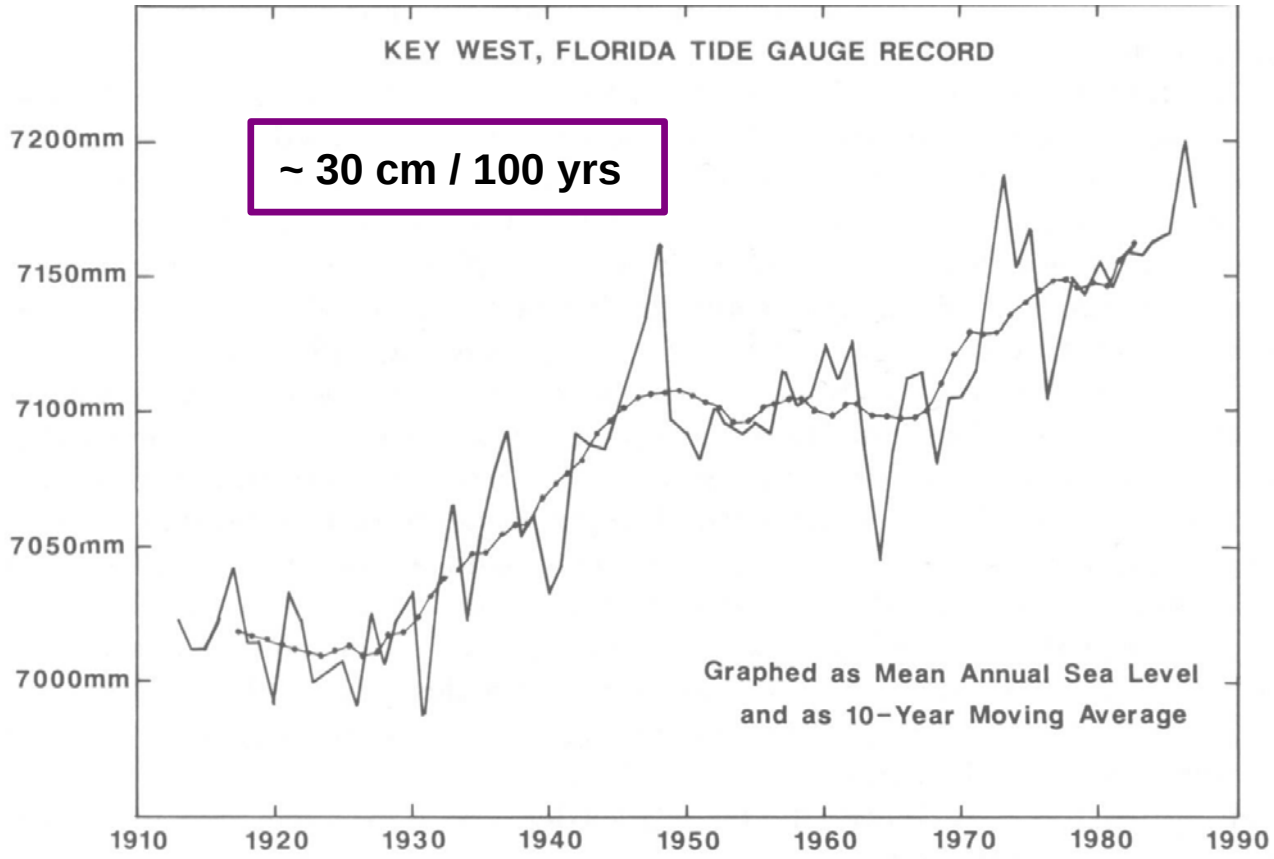
Figure 16: Annual averages of global mean sea level in millimeters

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

Figure 6: Mean Annual Sea Level at Key West, Florida 1910-1990

Tide Gauge Data for Key West



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

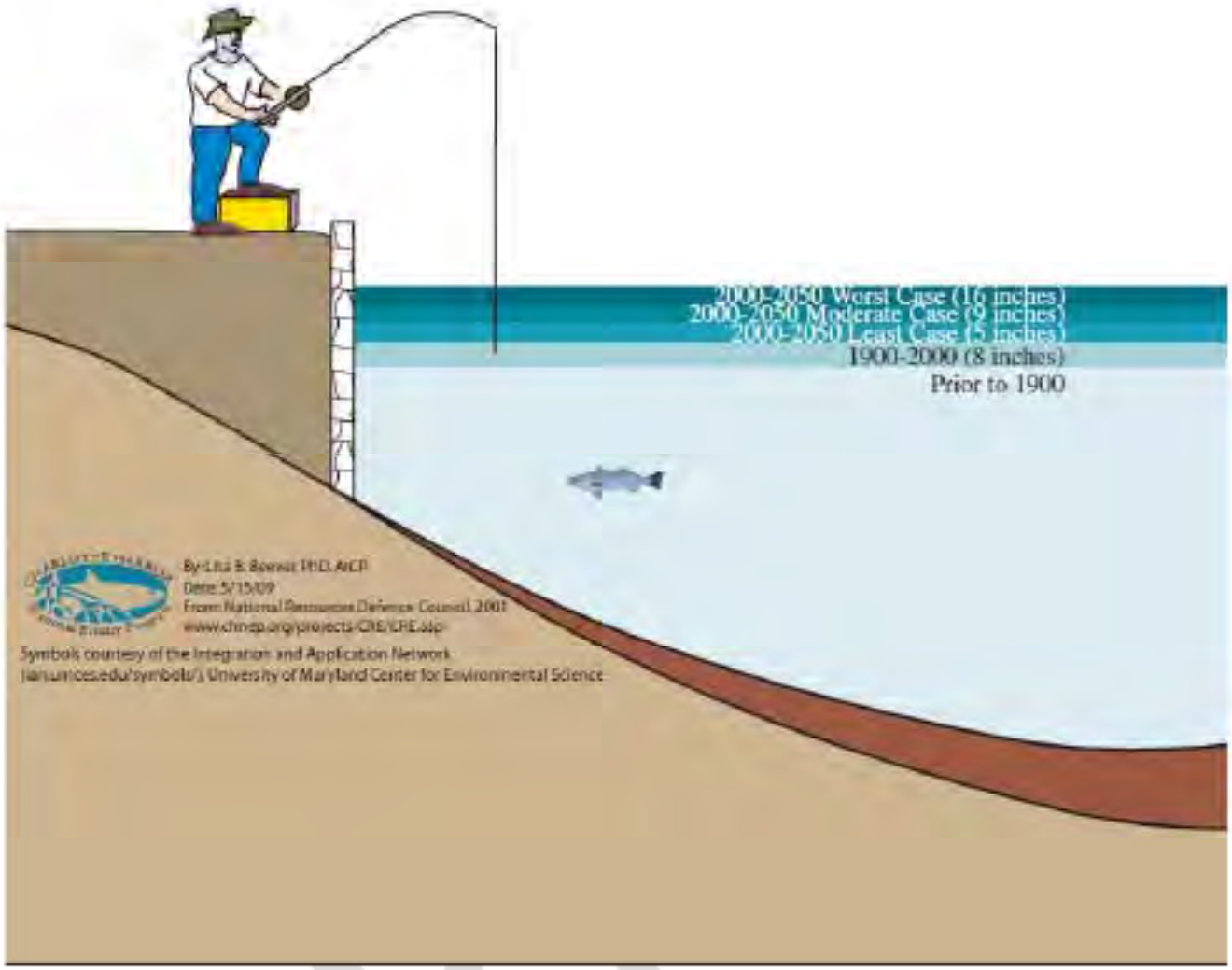


Figure 23a: Sea level rise in three different probabilities in the year 2050 for Charlotte Harbor at Punta Gorda. Least case (90% probable), moderate case (50% probable) and worst case (5% probable)

Source: IPCC 2007

Estimated Sea Level Rise 2050

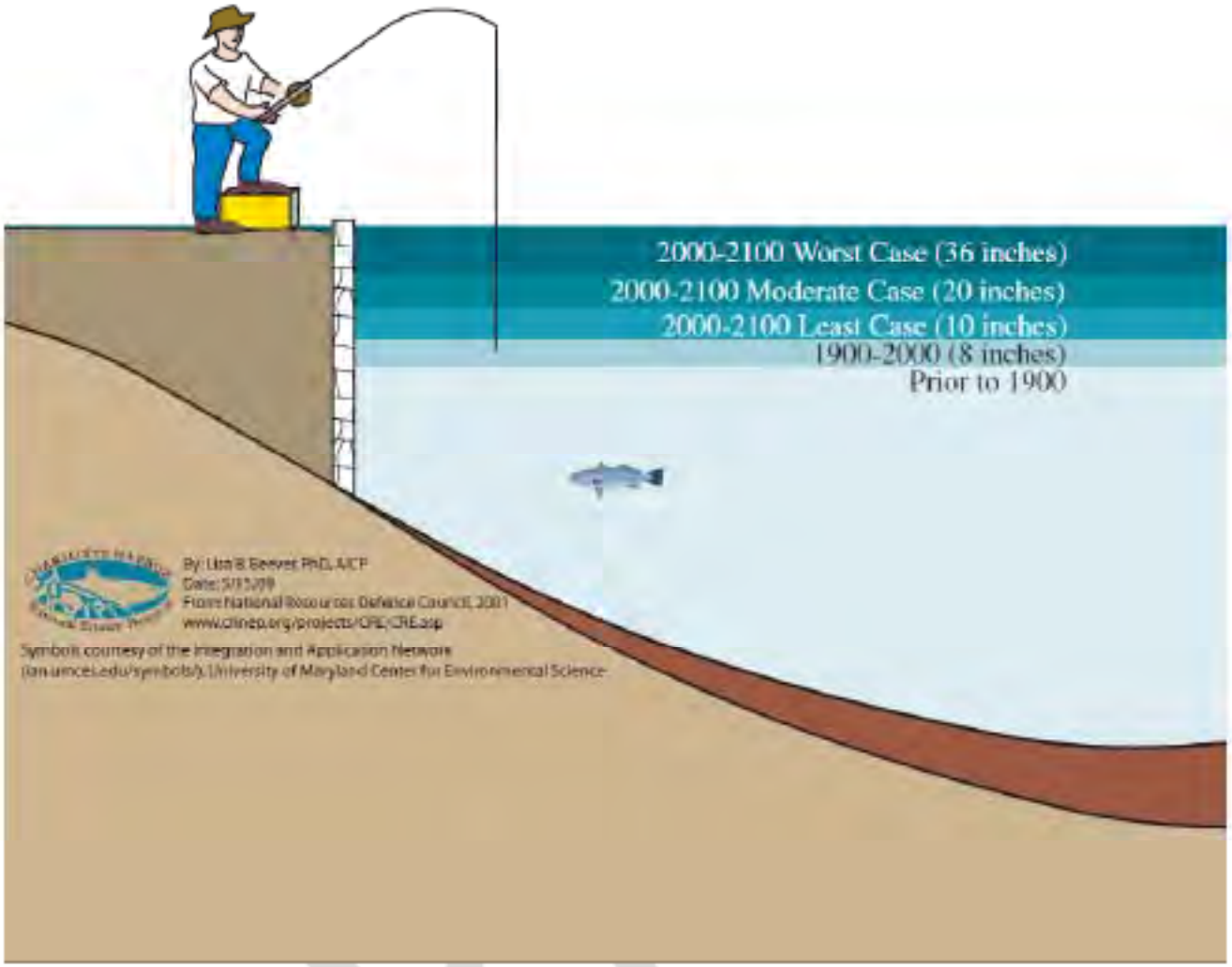
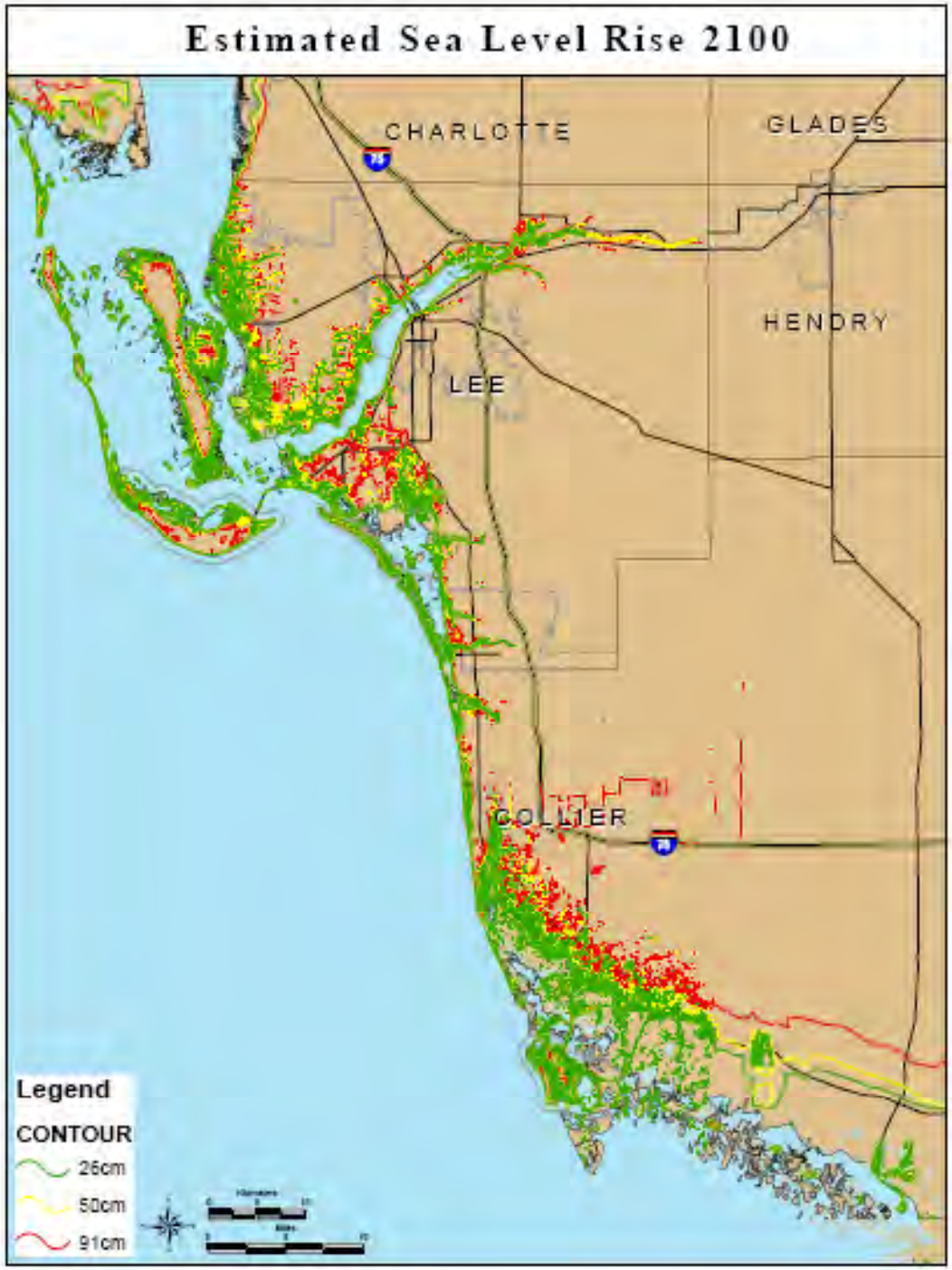


Figure 24a: Sea level rise in three different probabilities in the year 2100 for Charlotte Harbor at Punta Gorda. Least case (90% probable), moderate case (50% probable) and worst case (5% probable)
***Source:** IPCC 2007*


Estimated Sea Level Rise 2100
CHARLOTTE
GLADES
HENDRY
LEE
COLLIER
Legend
CONTOUR
26cm
50cm
91cm

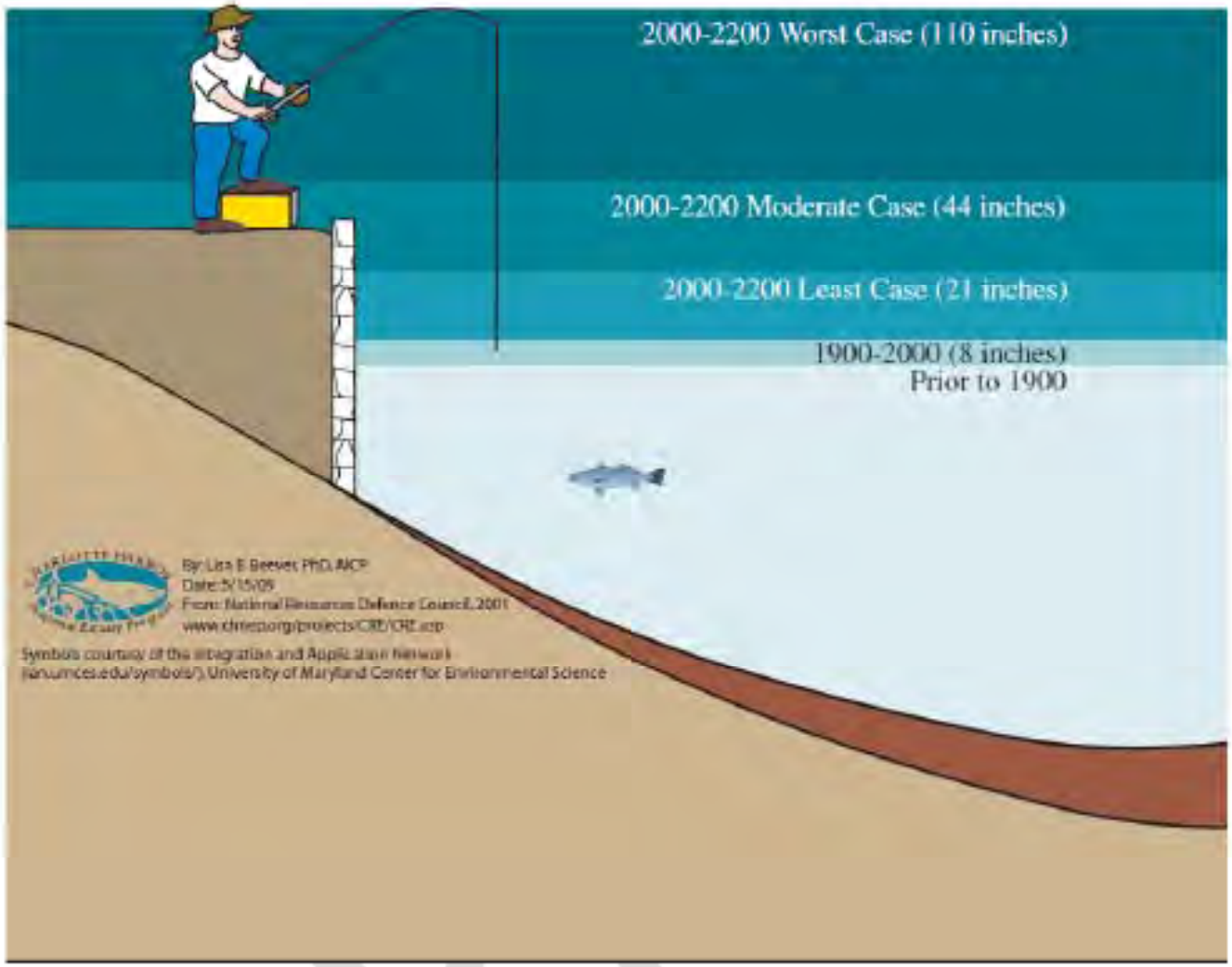
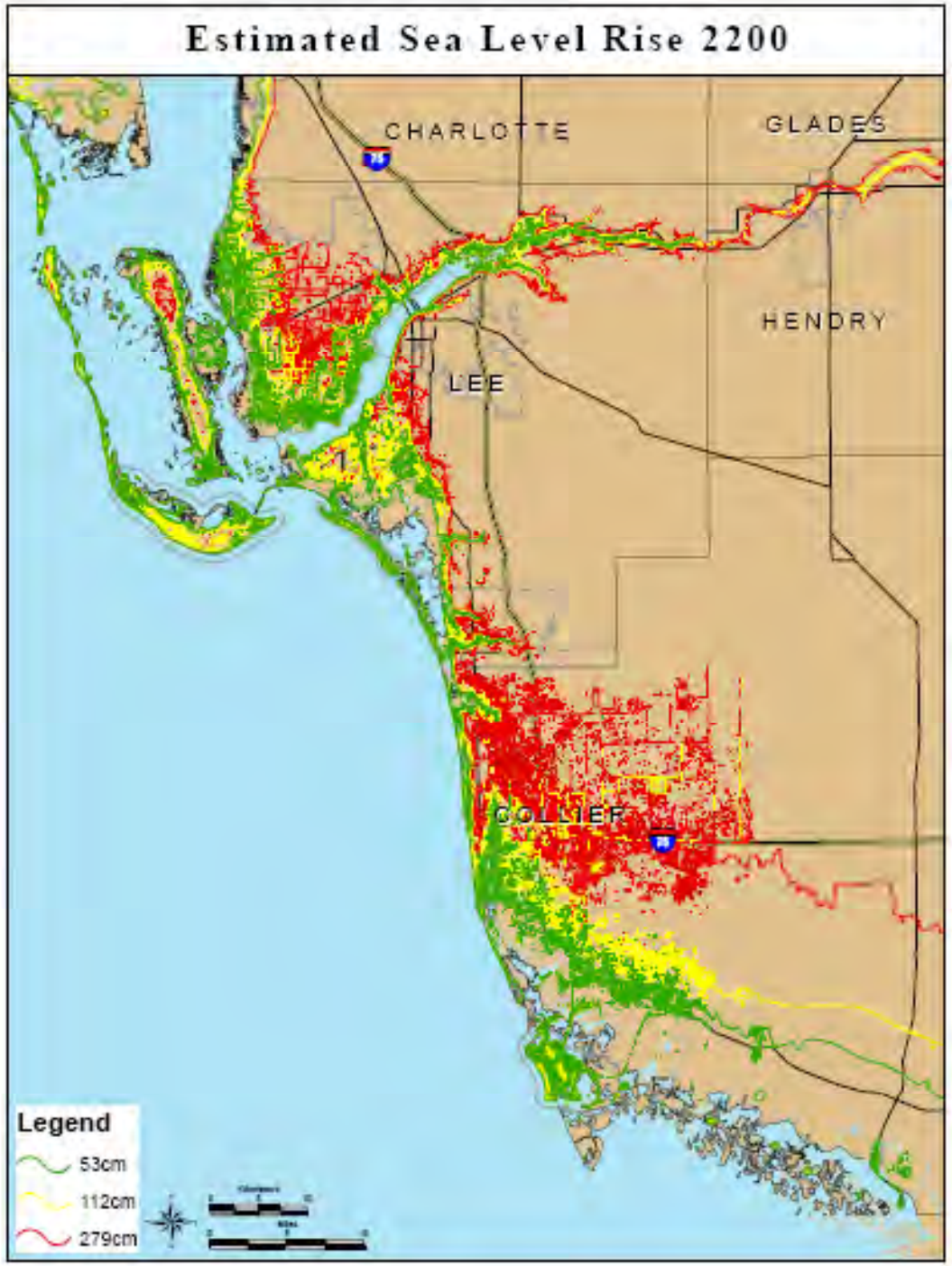


Figure 25a: Sea level rise in three different probabilities in the year 2200 for Charlotte Harbor at Punta Gorda. Least case (90% probable), moderate case (50% probable) and worst case (5% probable)

Source: IPCC 2007


Estimated Sea Level Rise 2200
CHARLOTTE
GLADES
HENDRY
LEE
COLLIER
Legend
53cm
112cm
279cm

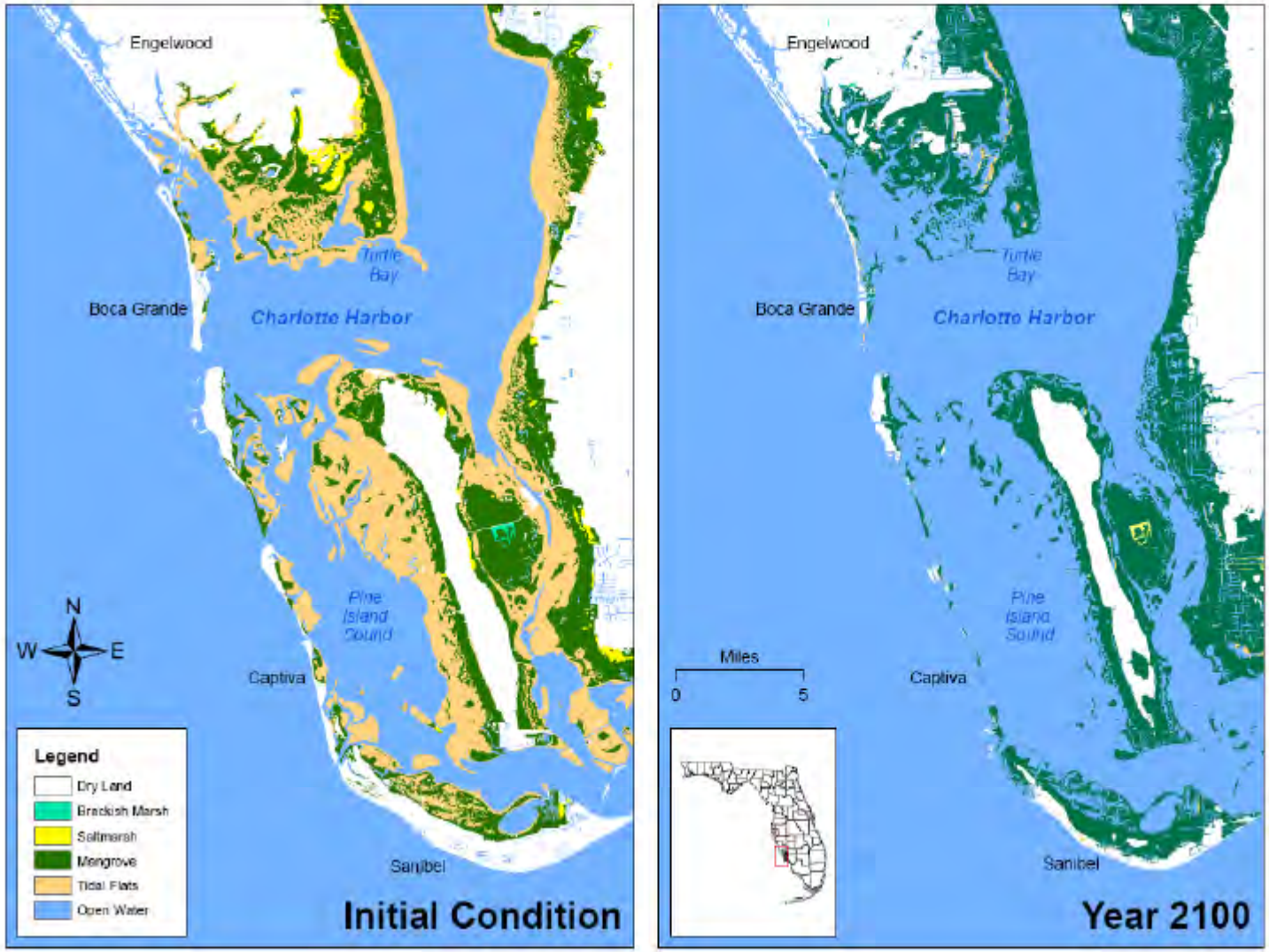


Figure 27: Three-foot contour sea level rise Sea Level Rise in Lower Charlotte Harbor Estuary Year 2100. This is the 5% probability worst case IPCC (2007) scenario.

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

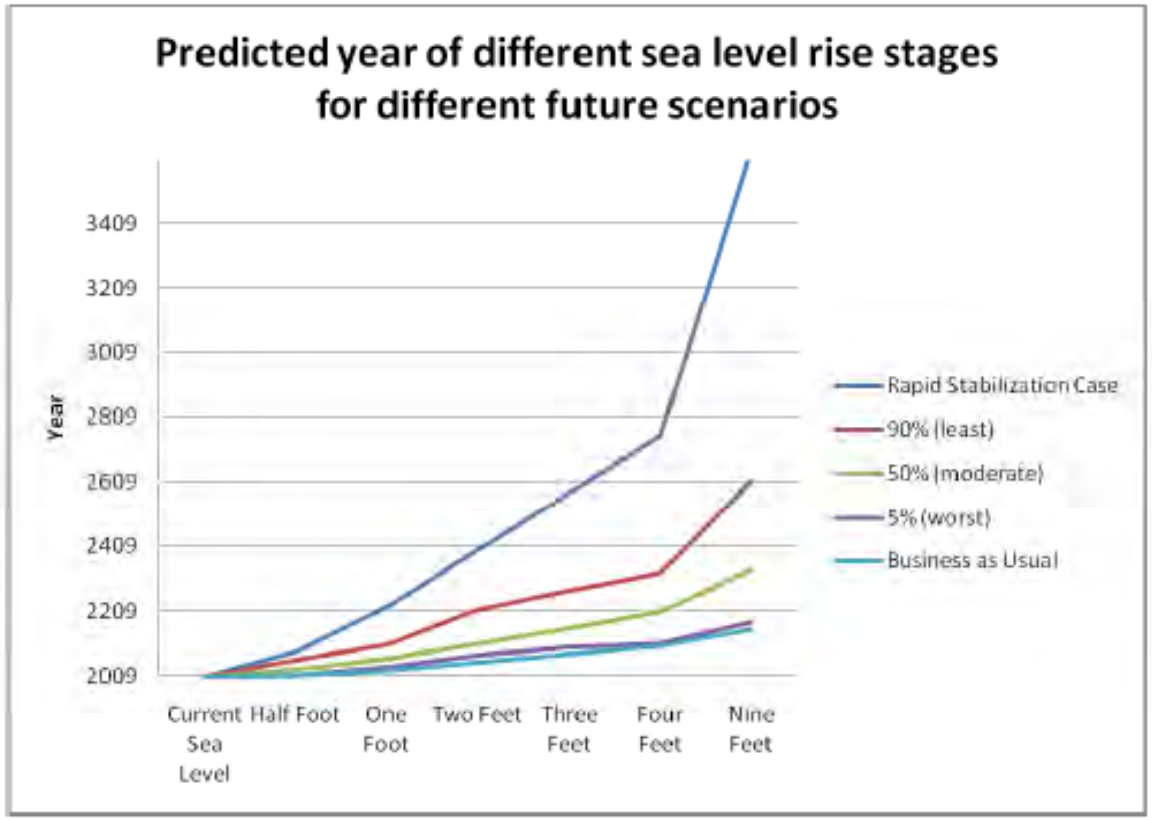
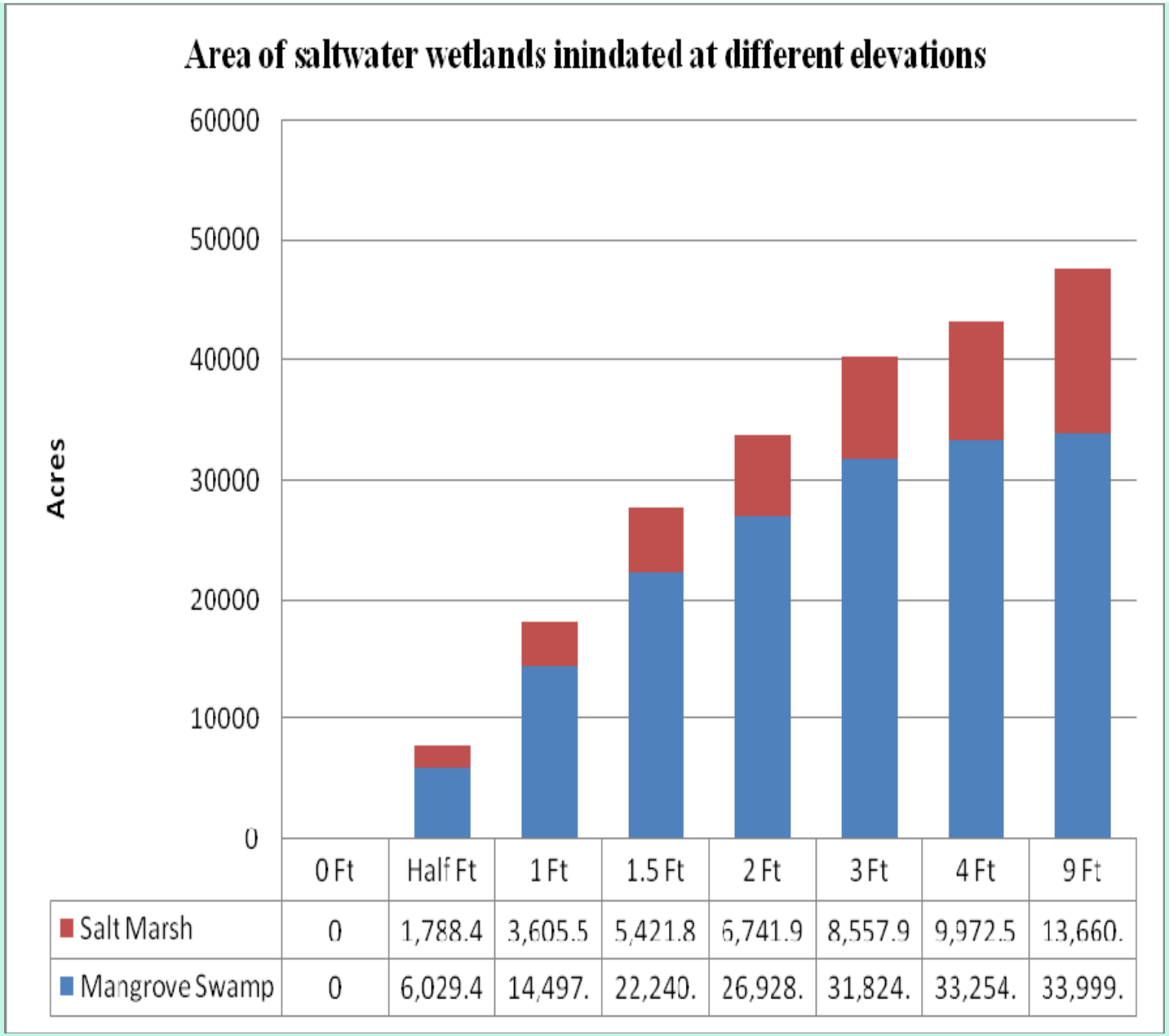


Figure 28: Approximate predicted year of different elevation levels (NGVD) of sea level rise for different future scenarios

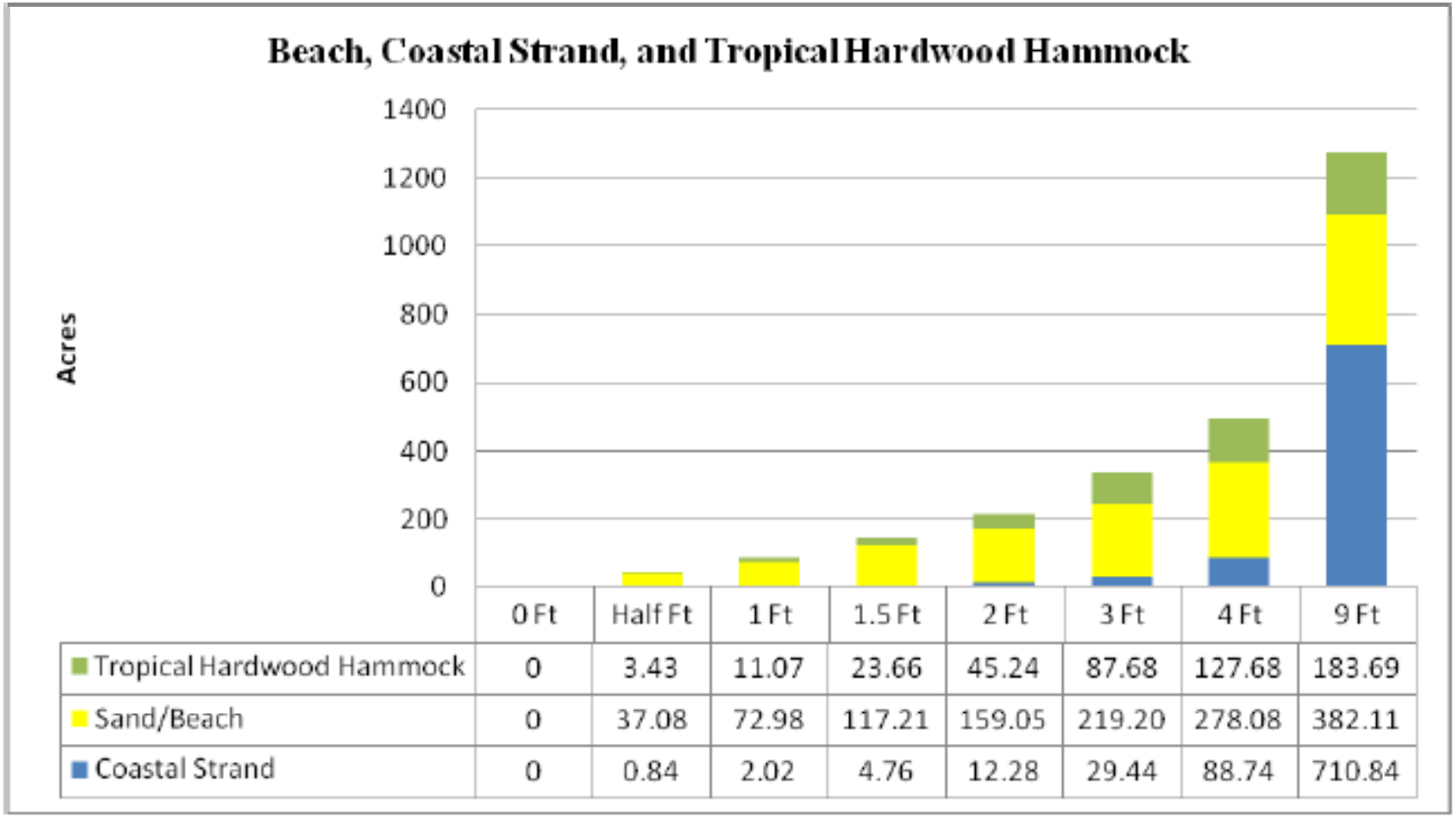
Lee County	0 Ft	Half Ft	1 Ft	1.5 Ft	2 Ft	3 Ft	4 Ft	9 Ft
	Acres	Acres	Acres	Acres	Acres	Acres	Acres	Acres
Coastal Strand	0	7.4	11.1	12.9	21.2	24.9	45.1	219.2
Sand/Beach	0	306.7	551.6	759.8	926.4	1,141.0	1,324.3	1,689.0
Dry Prairie	0	395.1	826.1	1,328.9	1,817.0	2,985.6	4,396.4	12,174.4
Mixed Pine-Hardwood Forest	0	227.5	389.5	659.4	905.3	1,793.0	2,356.6	3,831.0
Hardwood Hammocks and Forest	0	186.0	651.1	1,125.4	1,731.3	2,841.9	4,021.6	9,141.0
Pinelands	0	433.7	1,129.0	1,968.0	2,801.4	4,337.5	5,930.7	12,111.8
Tropical Hardwood Hammock	0	24.9	58.0	93.9	117.9	152.0	193.4	212.7
Freshwater Marsh and Wet Prairie	0	112.4	169.4	312.2	502.8	1,309.5	1,774.6	4,216.9
Shrub Swamp	0	96.7	228.4	376.7	482.6	692.5	885.9	1,760.8
Cypress Swamp	0	147.3	349.0	672.3	928.3	1,579.4	1,948.6	2,876.0
Cypress/Pine/Cabbage Palm	0	97.6	311.3	560.8	687.9	961.4	1,087.6	1,742.4
Mixed Wetland Forest	0	233.0	630.8	1,078.4	1,495.6	2,148.5	2,600.7	4,537.3
Hardwood Swamp	0	271.7	708.2	1,247.8	1,688.0	2,283.9	2,860.4	3,757.3
Salt Marsh	0	1,560.0	3,166.1	4,948.1	5,768.6	6,692.3	7,182.2	7,951.1
Mangrove Swamp	0	2,302.3	4,586.1	6,200.5	7,167.5	8,332.4	8,718.3	9,041.5
Open Water	0	5,095.4	9,543.4	12,919.5	15,319.4	18,638.3	21,058.5	27,232.3
Shrub and Brushland	0	13.8	85.6	117.9	140.0	220.1	364.7	1,351.9
Bare Soil/Clear-cut	0	74.6	172.2	289.2	462.3	763.4	1,089.4	2,688.1
Improved Pasture	0	73.7	152.0	243.1	261.5	302.1	373.0	1,122.6
Unimproved Pasture	0	1.8	1.8	1.8	3.7	8.3	27.6	116.0
Citrus	0	0.0	1.8	6.4	11.1	19.3	24.9	265.2
Row/Field Crops	0	0.0	5.5	10.1	10.1	55.3	201.7	396.0
Other Agriculture	0	0.0	0.0	0.0	2.8	27.6	150.1	447.6
Exotic Plants	0	0.0	0.0	0.0	0.0	0.0	0	0.9
High Impact Urban	0	442.0	1,044.3	1,852.9	2,832.7	5,345.9	8,695.2	31,870.0
Low Impact Urban	0	229.3	668.6	1,279.1	1,810.5	3,102.5	5,068.7	18,553.6
Total	**0.0**	**12,332.8**	**25,441.1**	**38,064.9**	**47,895.7**	**65,758.6**	**82,380.1**	**159,306.6**

Table 15a: Acres of habitat or land use at and below different elevations in Lee County 2009. Note: number includes the prior acreage.



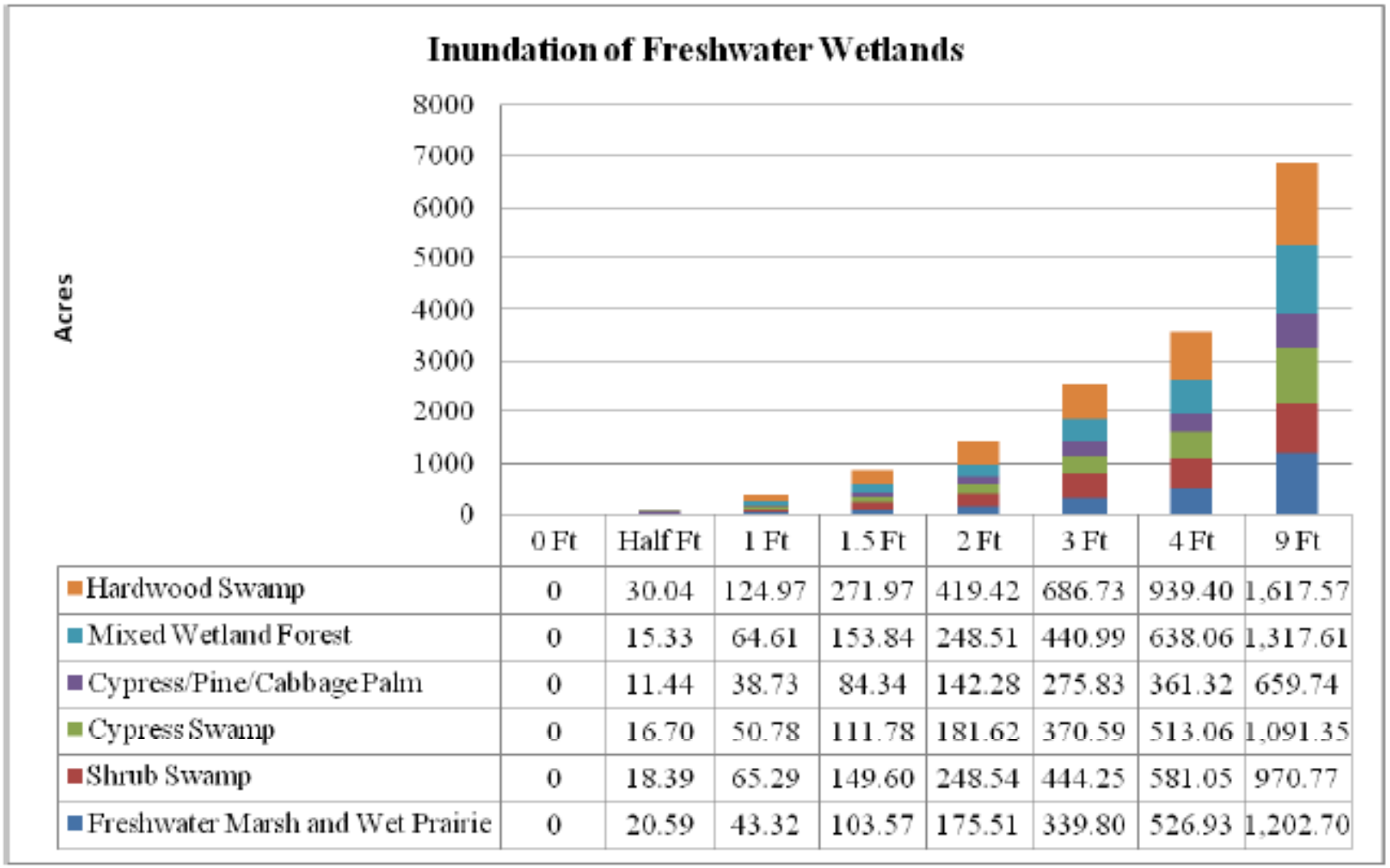
	0 Ft	Half Ft	1 Ft	1.5 Ft	2 Ft	3 Ft	4 Ft	9 Ft
Salt Marsh	0	1,788.4	3,605.5	5,421.8	6,741.9	8,557.9	9,972.5	13,660.
Mangrove Swamp	0	6,029.4	14,497.	22,240.	26,928.	31,824.	33,254.	33,999.

Figure 30a: Acres of mangrove and salt marsh habitat at and below different elevations in Lee County 2009



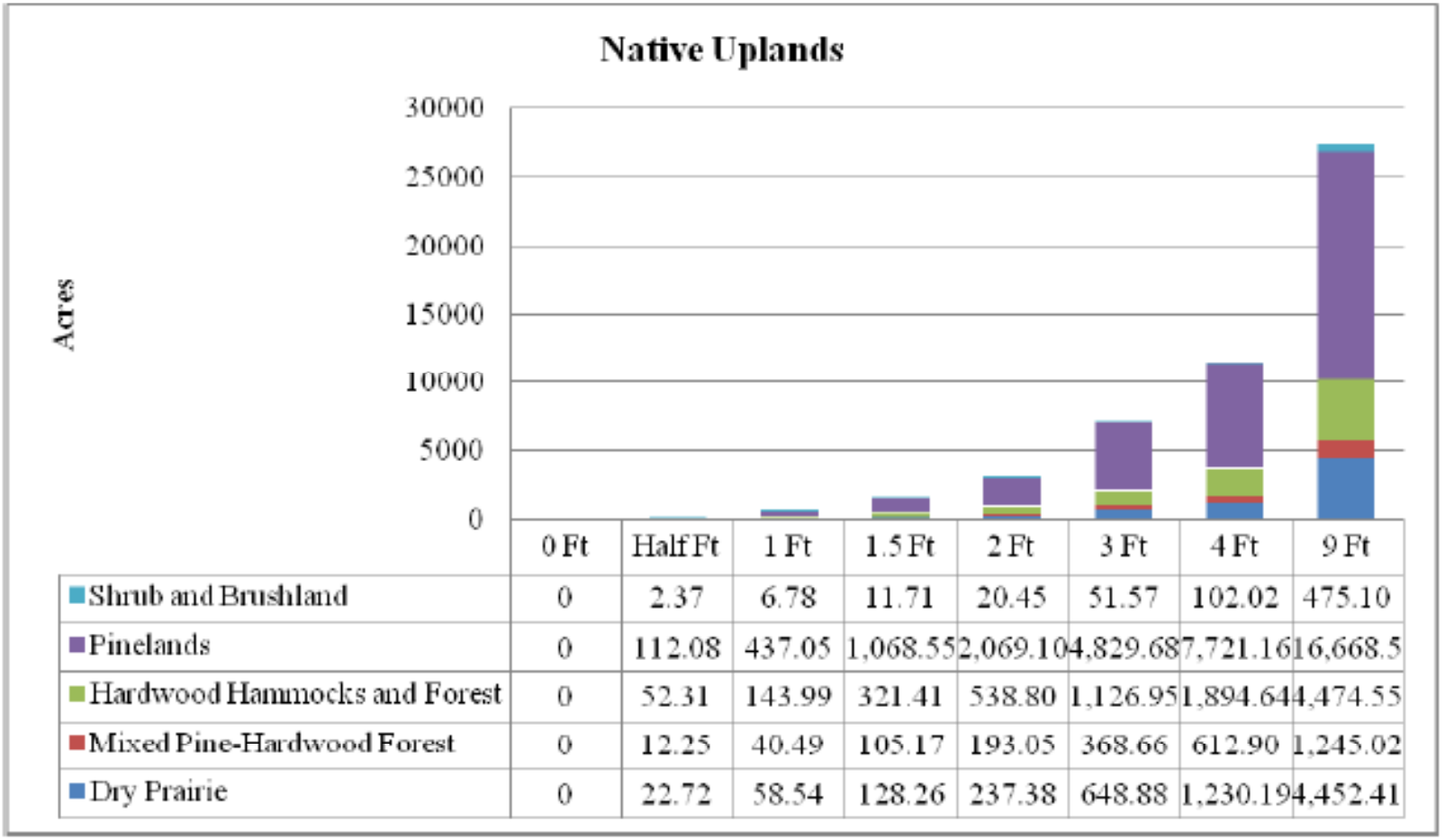
	0 Ft	Half Ft	1 Ft	1.5 Ft	2 Ft	3 Ft	4 Ft	9 Ft
Tropical Hardwood Hammock	0	3.43	11.07	23.66	45.24	87.68	127.68	183.69
Sand/Beach	0	37.08	72.98	117.21	159.05	219.20	278.08	382.11
Coastal Strand	0	0.84	2.02	4.76	12.28	29.44	88.74	710.84

Figure 31a: Acres of beaches and coastal strand habitat in Lee County at and below different elevations 2009



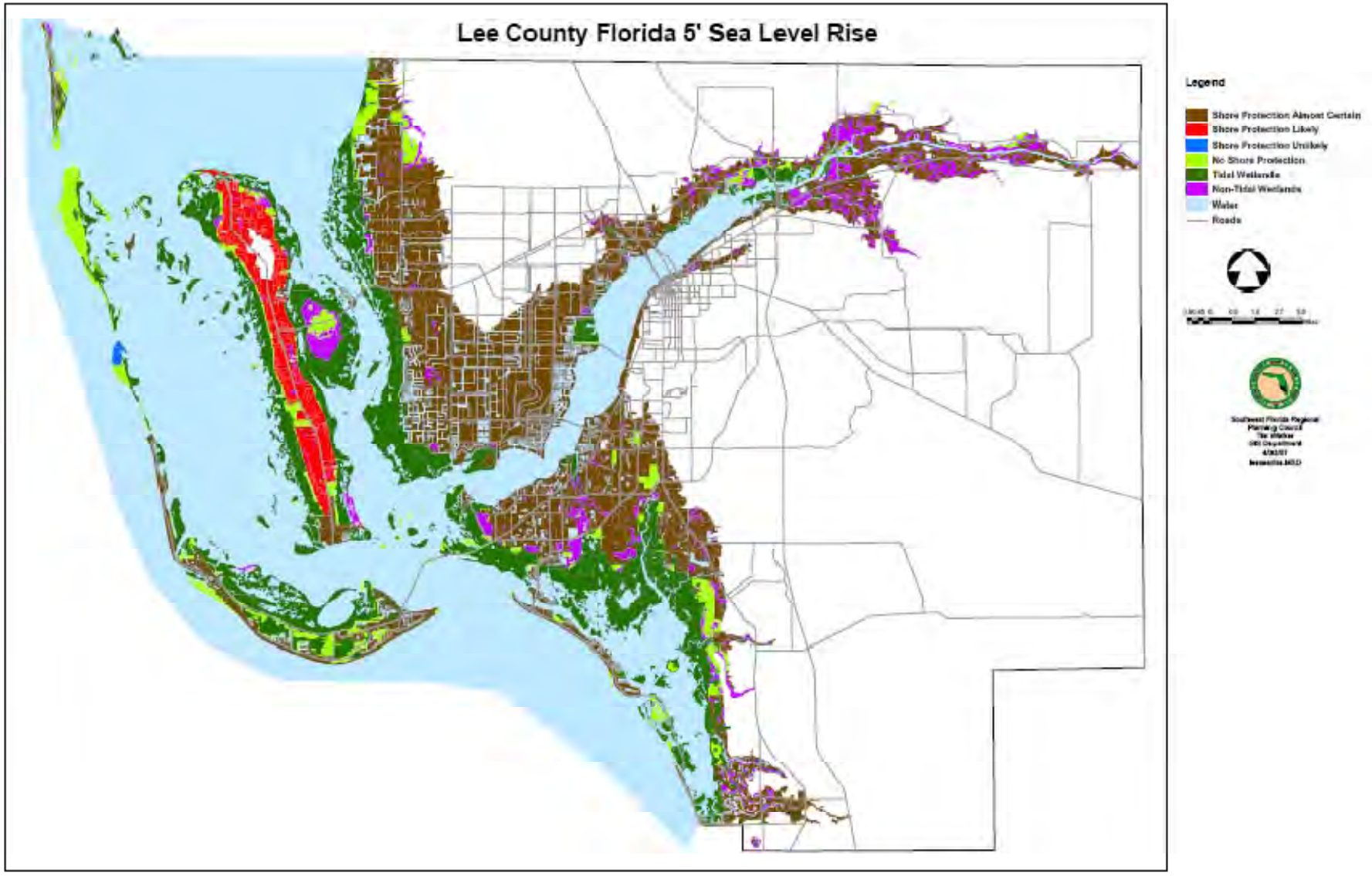
	0 Ft	Half Ft	1 Ft	1.5 Ft	2 Ft	3 Ft	4 Ft	9 Ft
Hardwood Swamp	0	30.04	124.97	271.97	419.42	686.73	939.40	1,617.57
Mixed Wetland Forest	0	15.33	64.61	153.84	248.51	440.99	638.06	1,317.61
Cypress/Pine/Cabbage Palm	0	11.44	38.73	84.34	142.28	275.83	361.32	659.74
Cypress Swamp	0	16.70	50.78	111.78	181.62	370.59	513.06	1,091.35
Shrub Swamp	0	18.39	65.29	149.60	248.54	444.25	581.05	970.77
Freshwater Marsh and Wet Prairie	0	20.59	43.32	103.57	175.51	339.80	526.93	1,202.70

Figure 32a: Acres of freshwater wetlands habitat in Lee County at and below different elevations 2009



	0 Ft	Half Ft	1 Ft	1.5 Ft	2 Ft	3 Ft	4 Ft	9 Ft
Shrub and Brushland	0	2.37	6.78	11.71	20.45	51.57	102.02	475.10
Pinelands	0	112.08	437.05	1,068.55	2,069.10	4,829.68	7,721.16	16,668.5
Hardwood Hammocks and Forest	0	52.31	143.99	321.41	538.80	1,126.95	1,894.64	4,474.55
Mixed Pine-Hardwood Forest	0	12.25	40.49	105.17	193.05	368.66	612.90	1,245.02
Dry Prairie	0	22.72	58.54	128.26	237.38	648.88	1,230.19	4,452.41

Figure 33a: Acres of uplands habitat in Lee County at and below different elevations 2009


Lee County Florida 5' Sea Level Rise
Legend
Shore Protection Almost Certain
Shore Protection Likely
Shore Protection Unlikely
No Shore Protection
Tidal Wetlands
Non-Tidal Wetlands
Water
Roads

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
15 19 05
USGS photo
Mote Marine Laboratory
Brad Robbins, Michelle Gitfler, Anamari Boyes

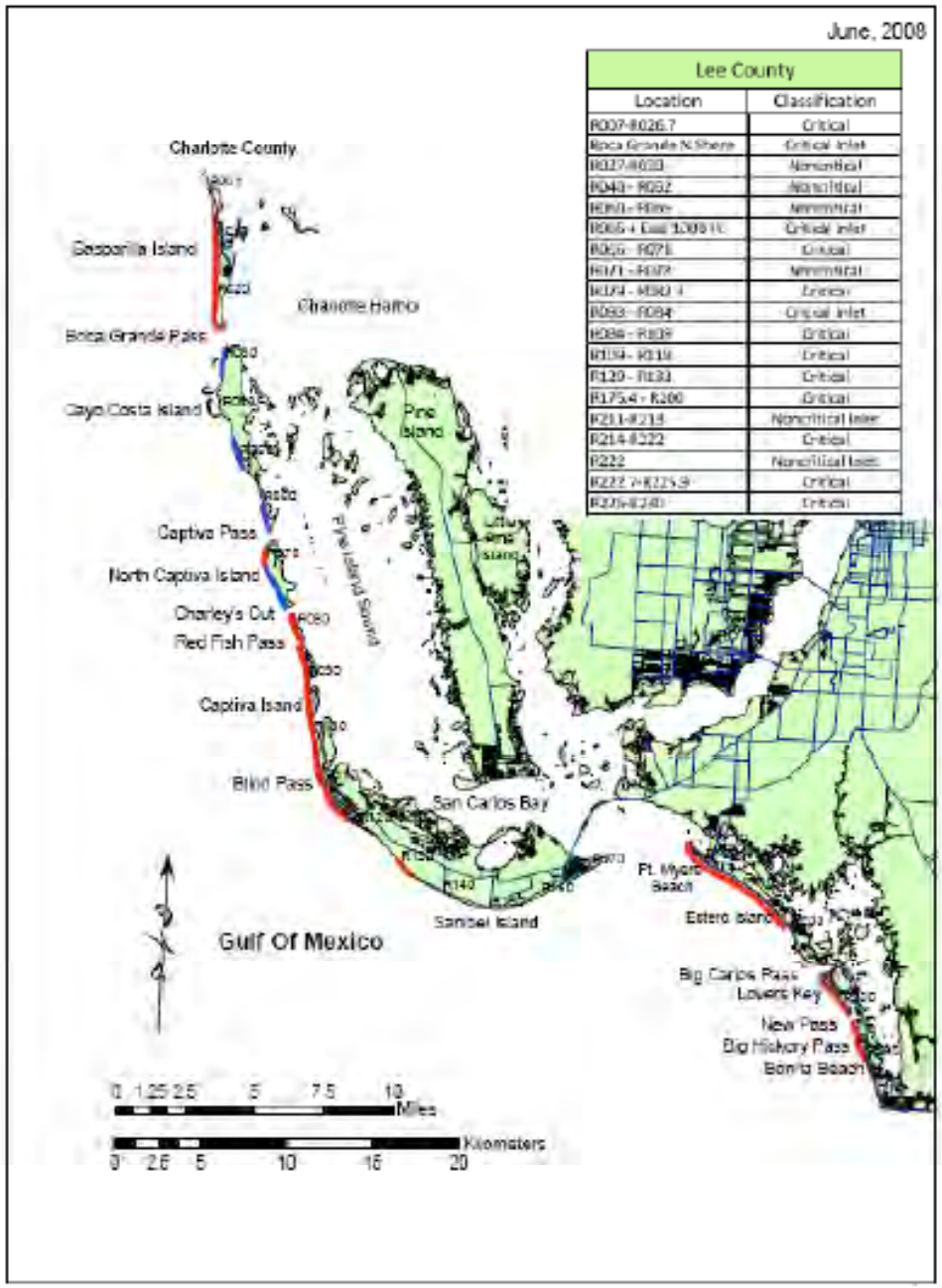
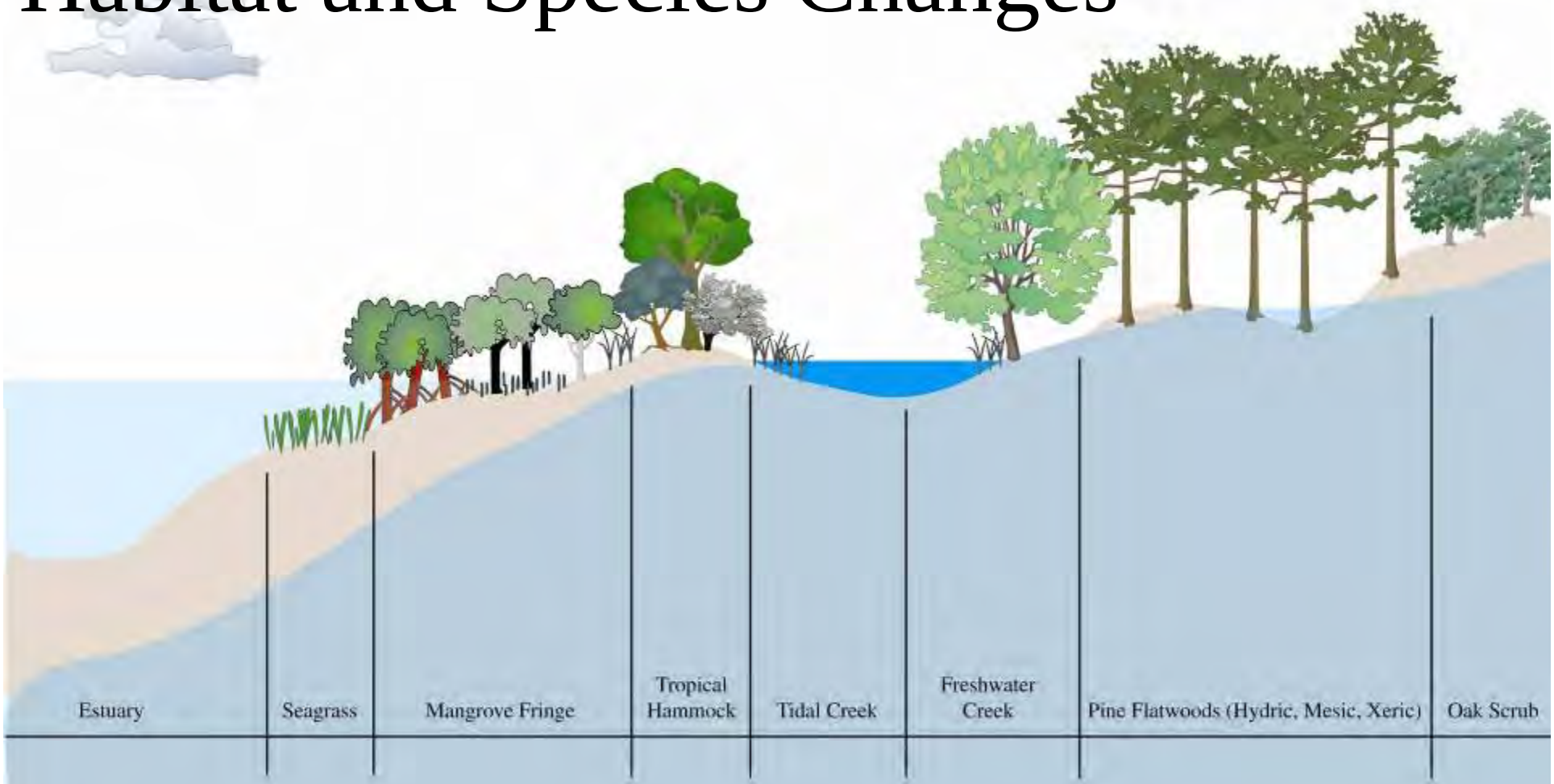


Figure 40: Identified areas of coastal erosion Lee County

Habitat and Species Changes



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

Habitat Structure-2000
Southwest Florida

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

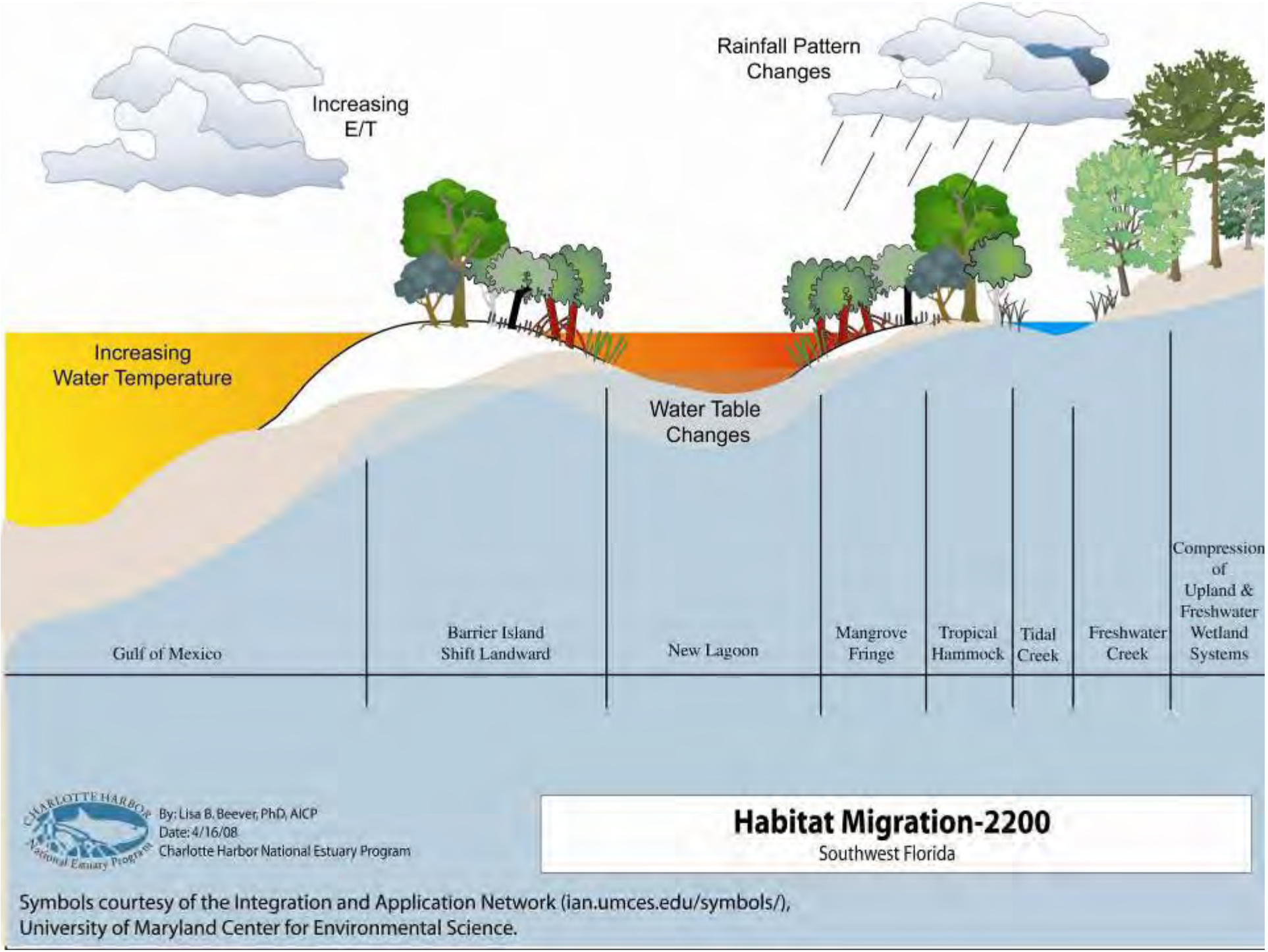
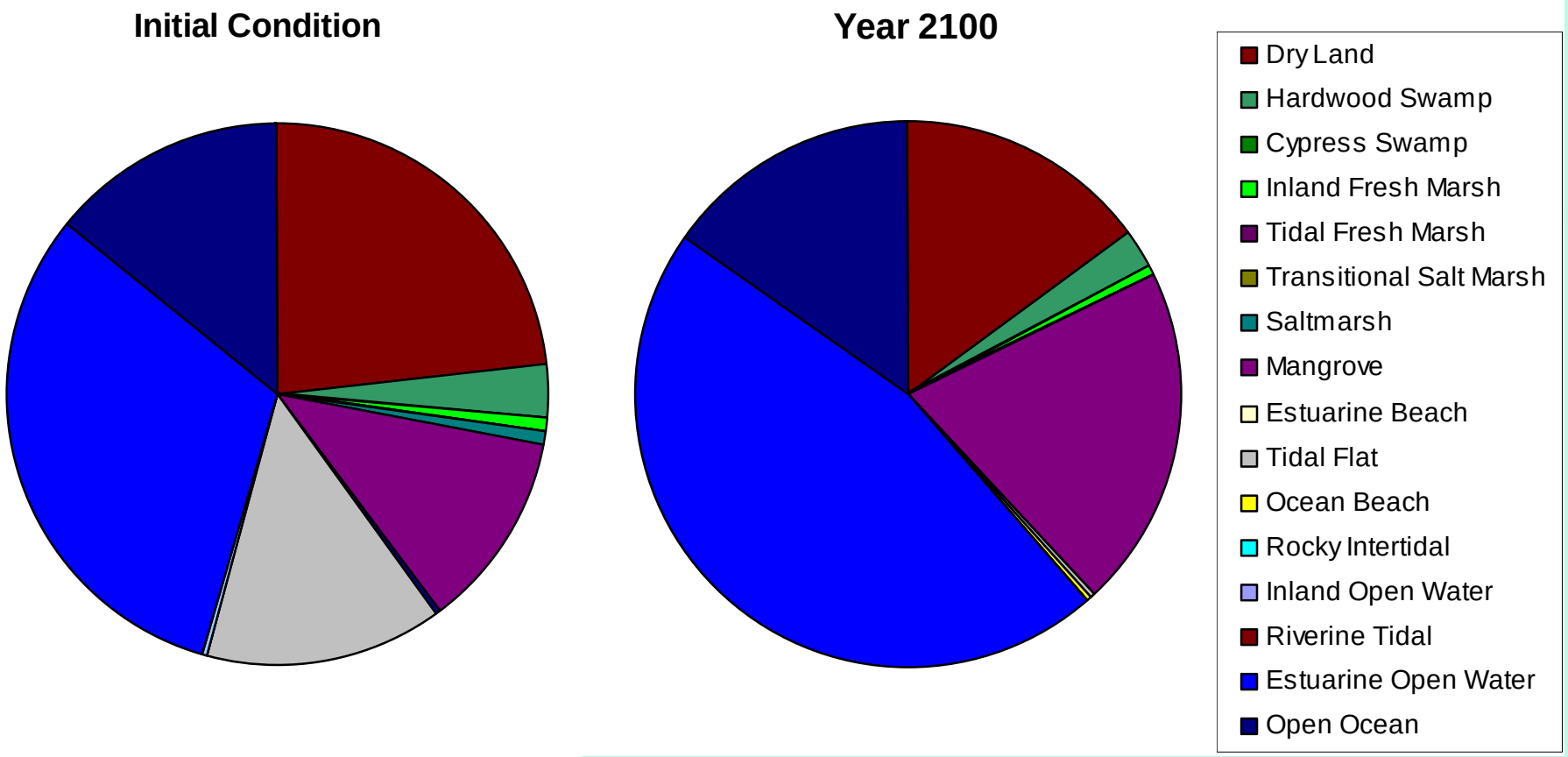

Rainfall Pattern Changes
Increasing E/T
Increasing Water Temperature
Water Table Changes
Gulf of Mexico
Barrier Island Shift Landward
New Lagoon
Mangrove Fringe
Tropical Hammock
Tidal Creek
Freshwater Creek
Compression of Upland & Freshwater Wetland Systems
By: Lisa B. Beever, PhD, AICP
Date: 4/16/08
Charlotte Harbor National Estuary Program
Habitat Migration-2200
Southwest Florida
Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/),
University of Maryland Center for Environmental Science.

Figure 24: SLAMM Predictions of Habitat Fate under Scenario A1B, Mean for Charlotte Harbor, FL



State of Florida Listed Animal Species of Southwest Florida in the Order of Endangerment, as of 21 October 2008

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

11 Listed Animal Species in the Marine and Estuarine Ecosystems

23 Listed Animal Species

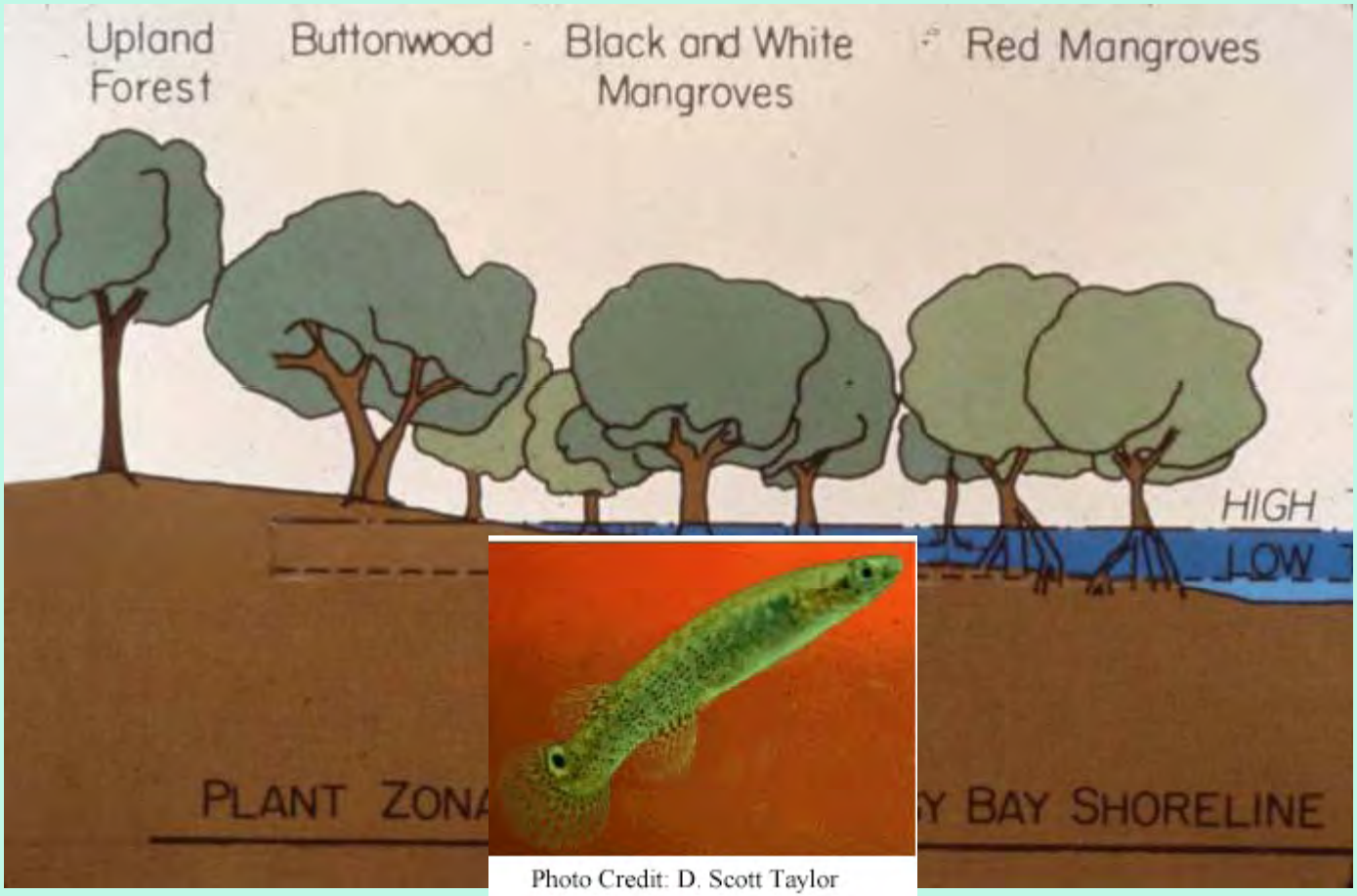
Least tern. *Original photograph by Barry Mansell.*

Loggerhead sea turtle

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**

32 Listed Animal Species in the Mangrove Swamp



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

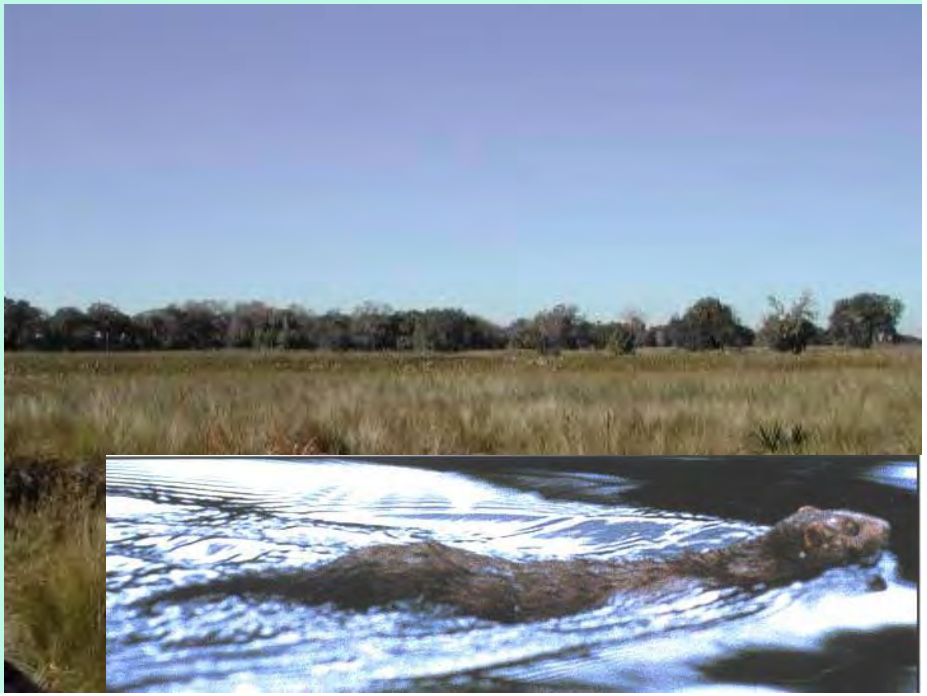
Decreased forage fish

9 Listed Animal Species in the Tropical Hardwood Hammocks

Marshes

23 Listed Animal Species in the Salt Marsh

19 Listed Animal Species in the Freshwater Marsh



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.

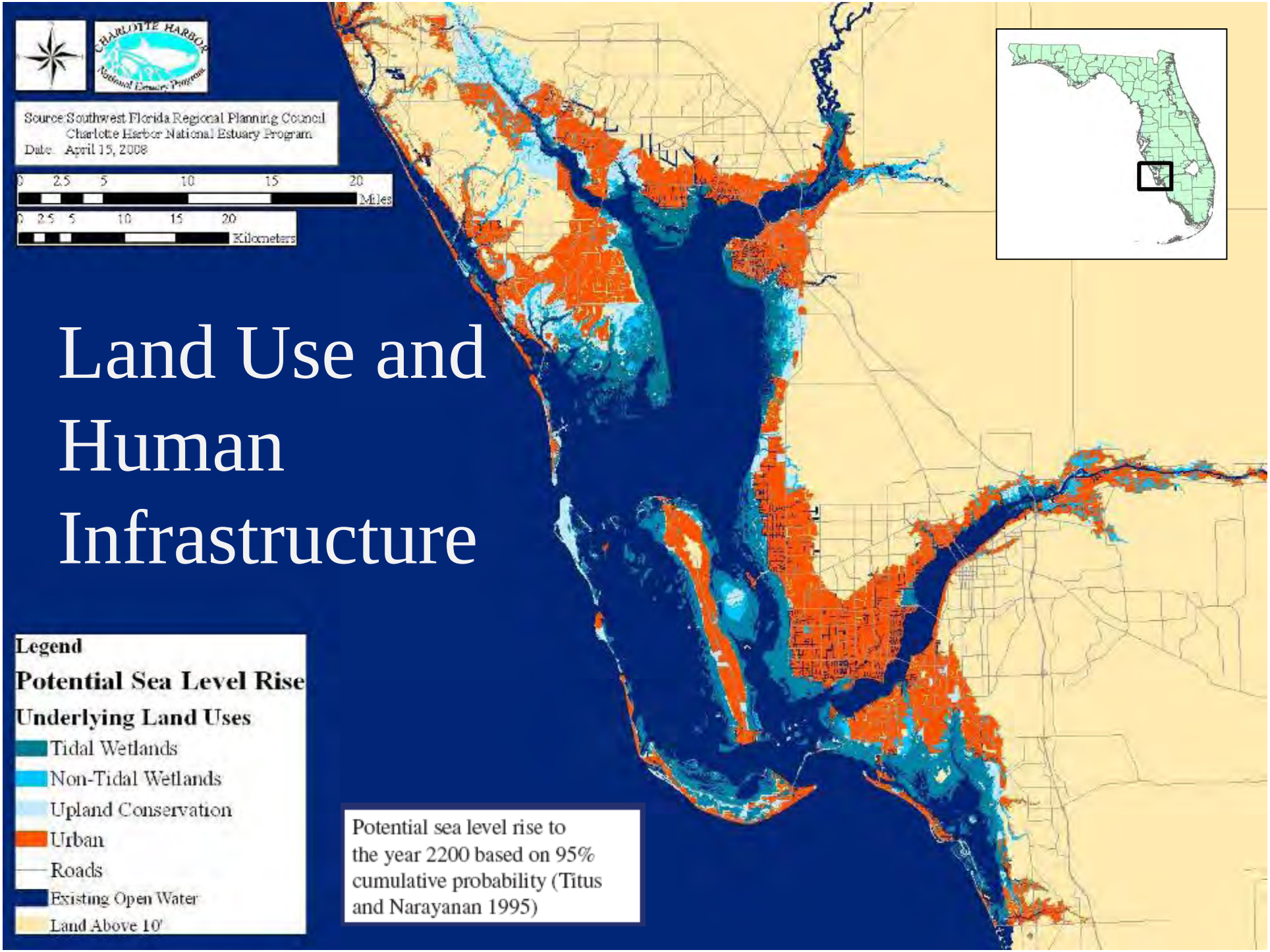
Interior pinelands and other uplands of Southwest Florida are the last refuge of the Florida Panther, Florida Black Bear, Big Cypress Fox Squirrel and Red-Cockaded Woodpecker.

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	mosquito-borne
Glades	0	X	0 (1)	0	0	tick-borne
Hardee	0	X	0 (35)	0	0	flea-borne
Hendry	1	X	0 (44)	0	0	other insect-borne
Lee	2	X	0 (624)	0	0	mammal-borne
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	

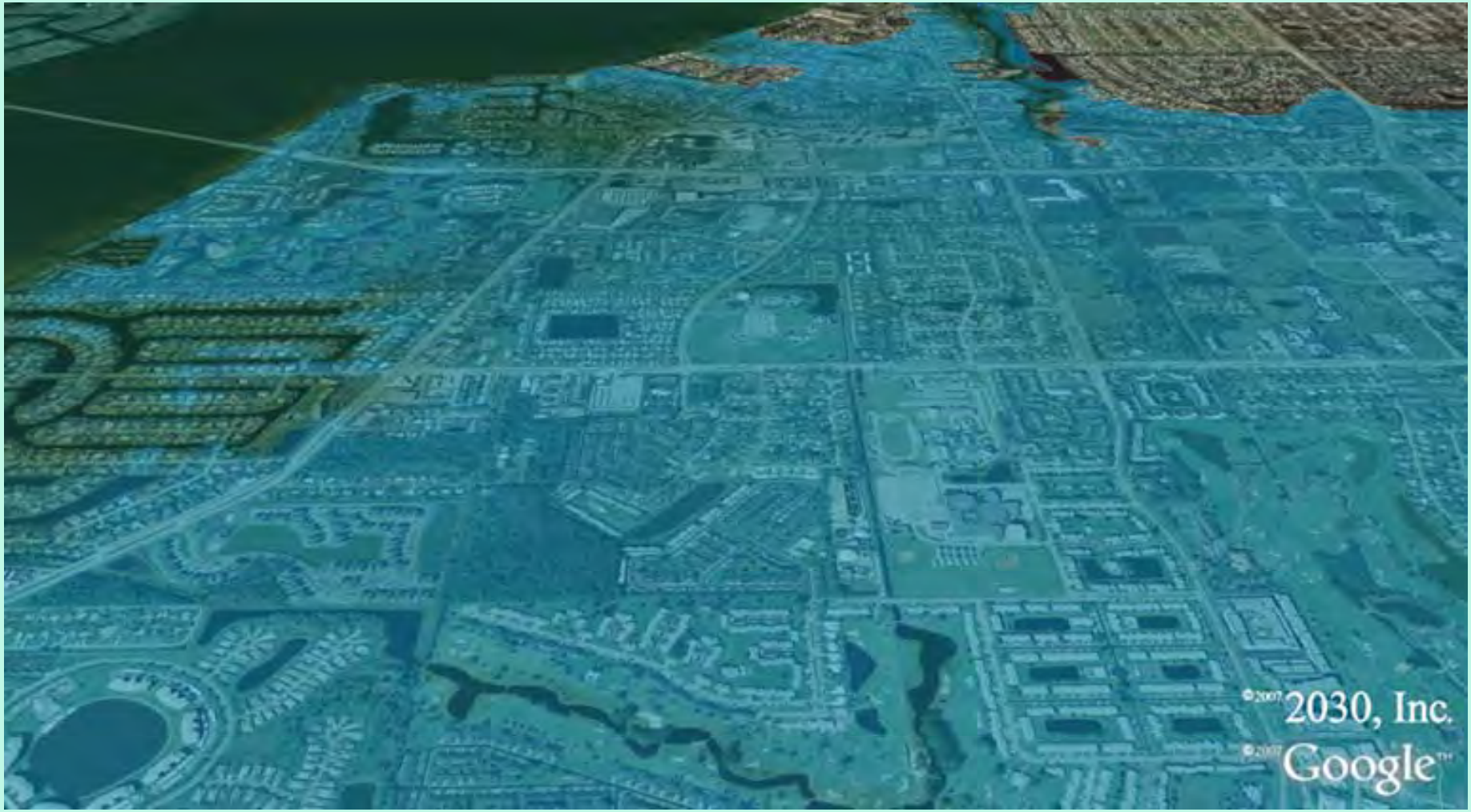
Table 25: Tropical diseases occurrence in southwest Florida

Human Health


Source: Southwest Florida Regional Planning Council
Charlotte Harbor National Estuary Program
Date: April 15, 2008
0 2.5 5 10 15 20
Miles
0 2.5 5 10 15 20
Kilometers
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

Cape Coral 1.25 meters (4 feet) sea level rise (or storm surge) Moderate Case Scenario
Visual Imaging from "A Nation Under Siege," The 2030 Research Center
www.architecture2030.org/current_situation/coastal_impact.html



Cypress Lakes 1.25 meters (4 feet) sea level rise (or storm surge) Moderate Case Scenario

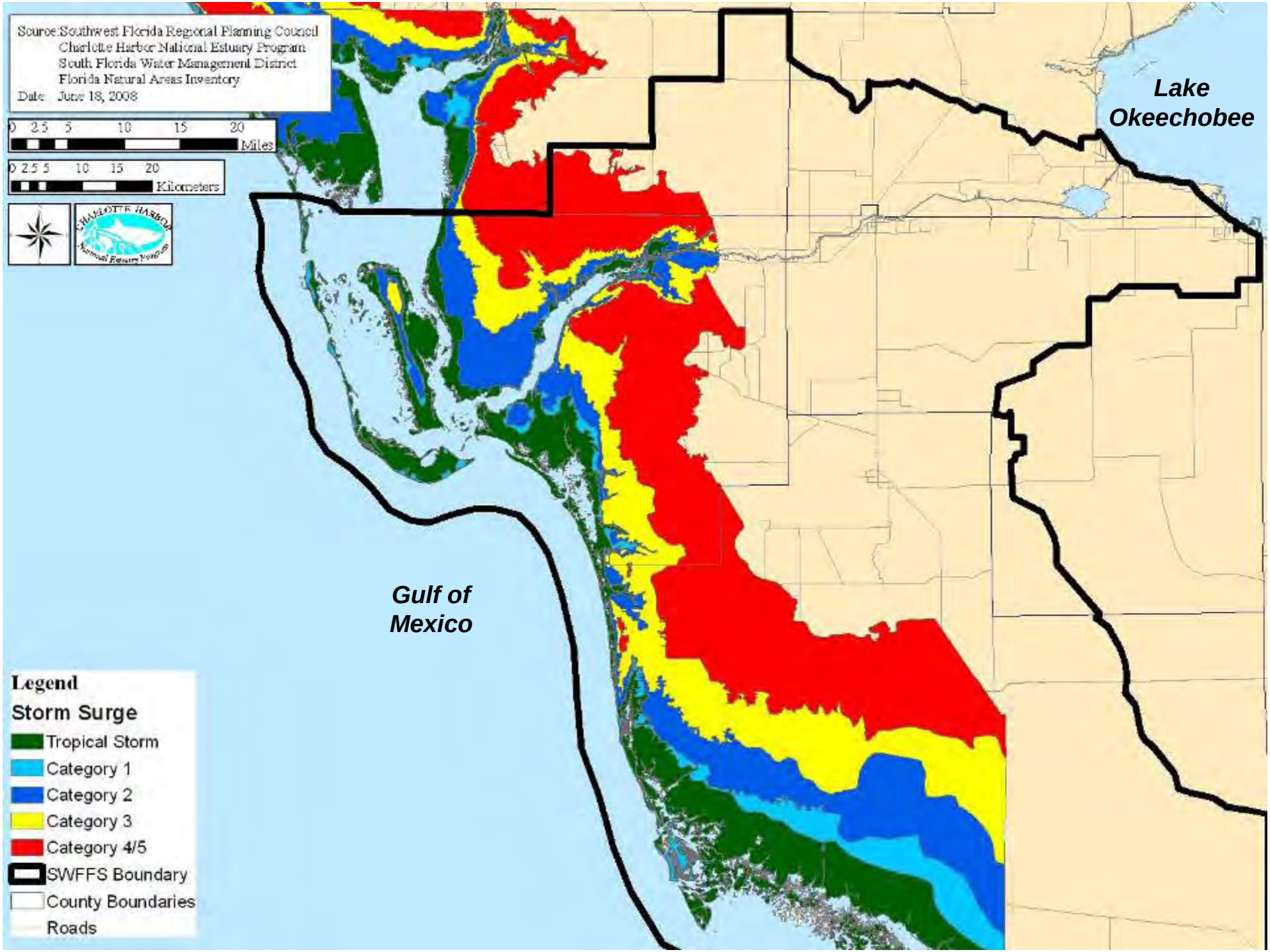
Visual Imaging from "A Nation Under Siege," The 2030 Research Center

www.architecture2030.org/current_situation/coastal_impact.html

City of Naples 1.25 meters (4 feet) sea level rise (or storm surge) Moderate Case Scenario

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
Lake Okeechobee
Gulf of Mexico
Legend
Storm Surge
Tropical Storm
Category 1
Category 2
Category 3
Category 4/5
SWFFS Boundary
County Boundaries
Roads

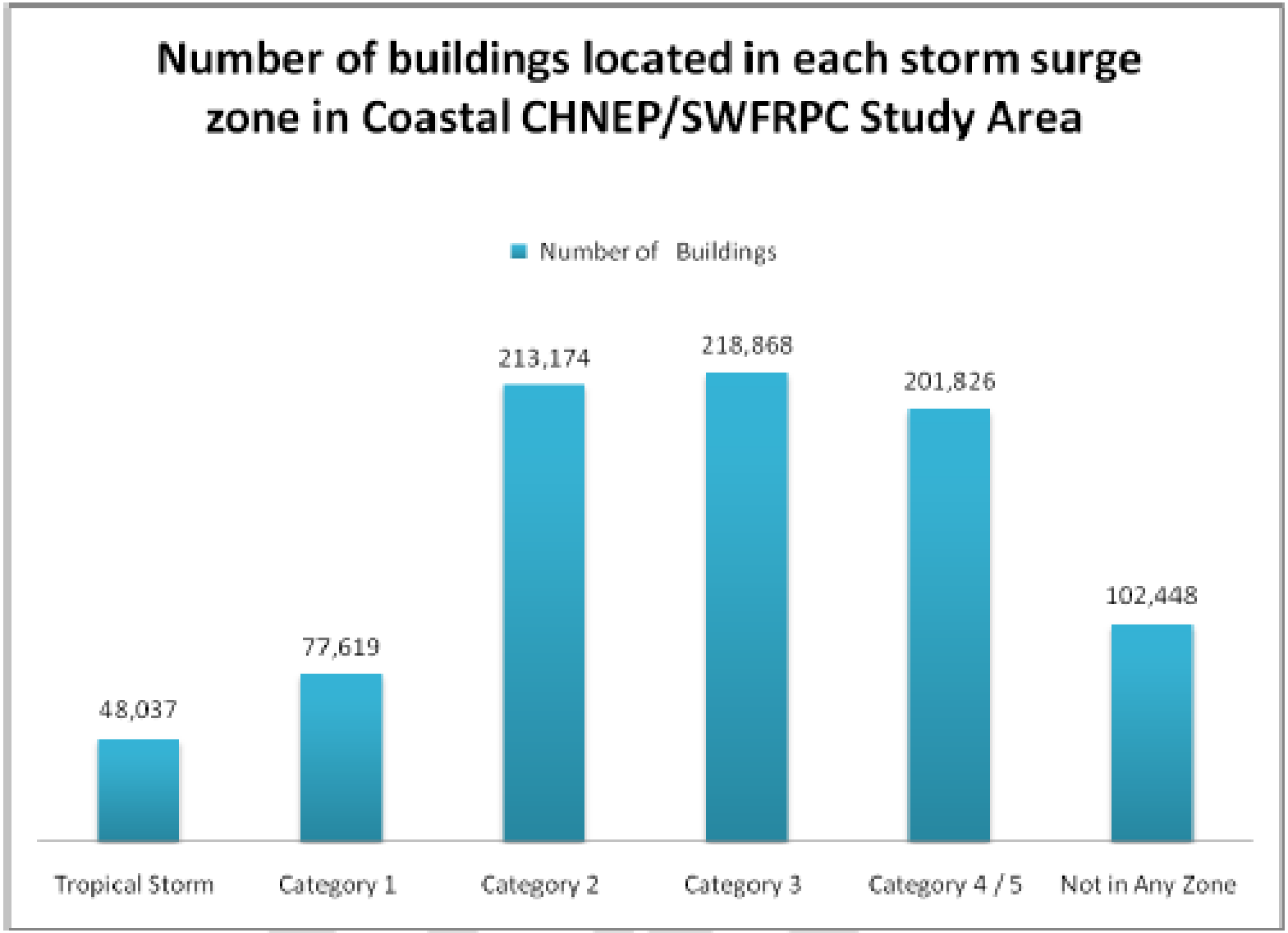


Figure 9: Number of buildings located in each tropical storm and hurricane storm surge zone in coastal CHNEP/SWFRPC study area

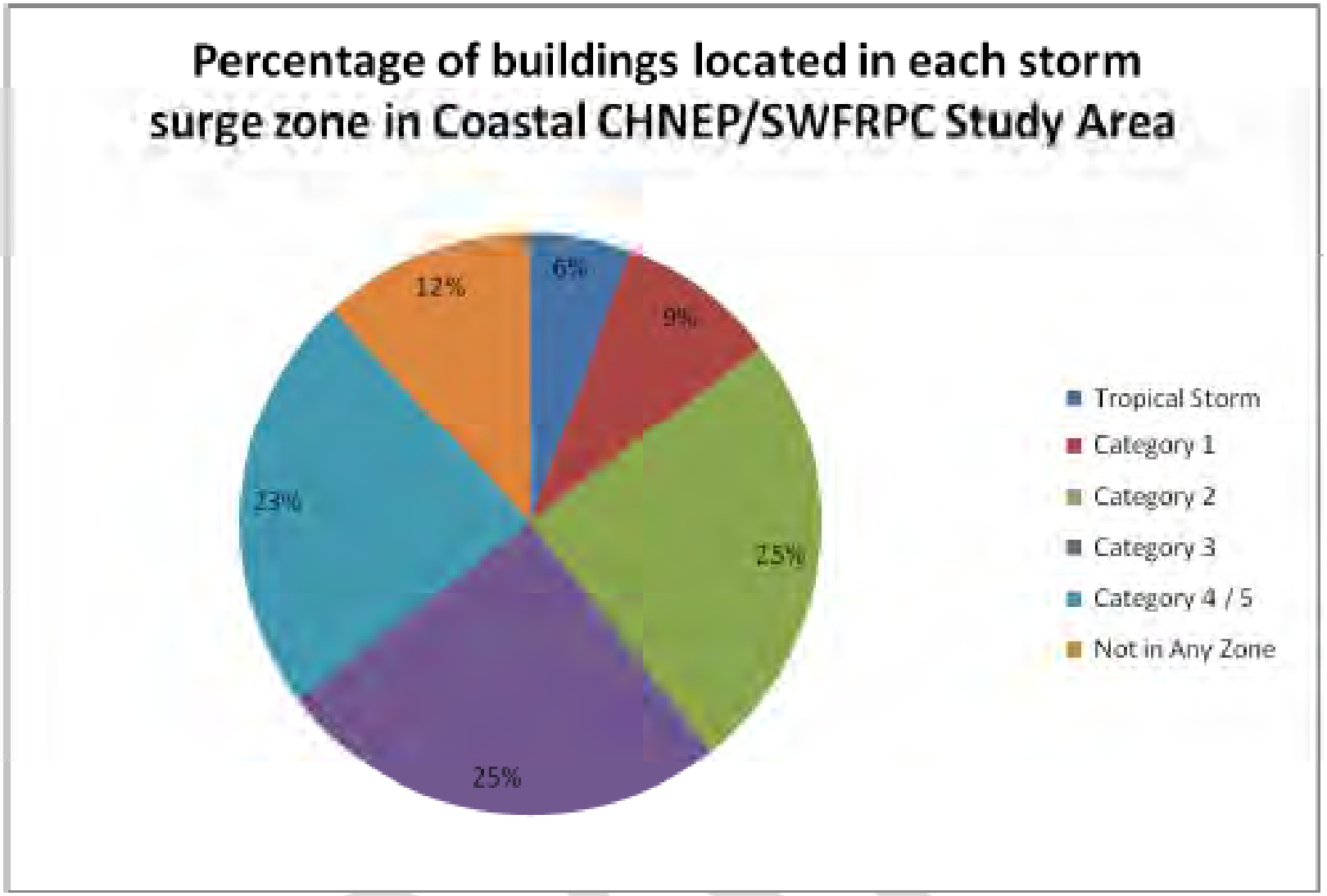


Figure 10: Proportion of buildings located in each tropical storm and hurricane storm surge zone in coastal CHNEP/SWFRPC study area

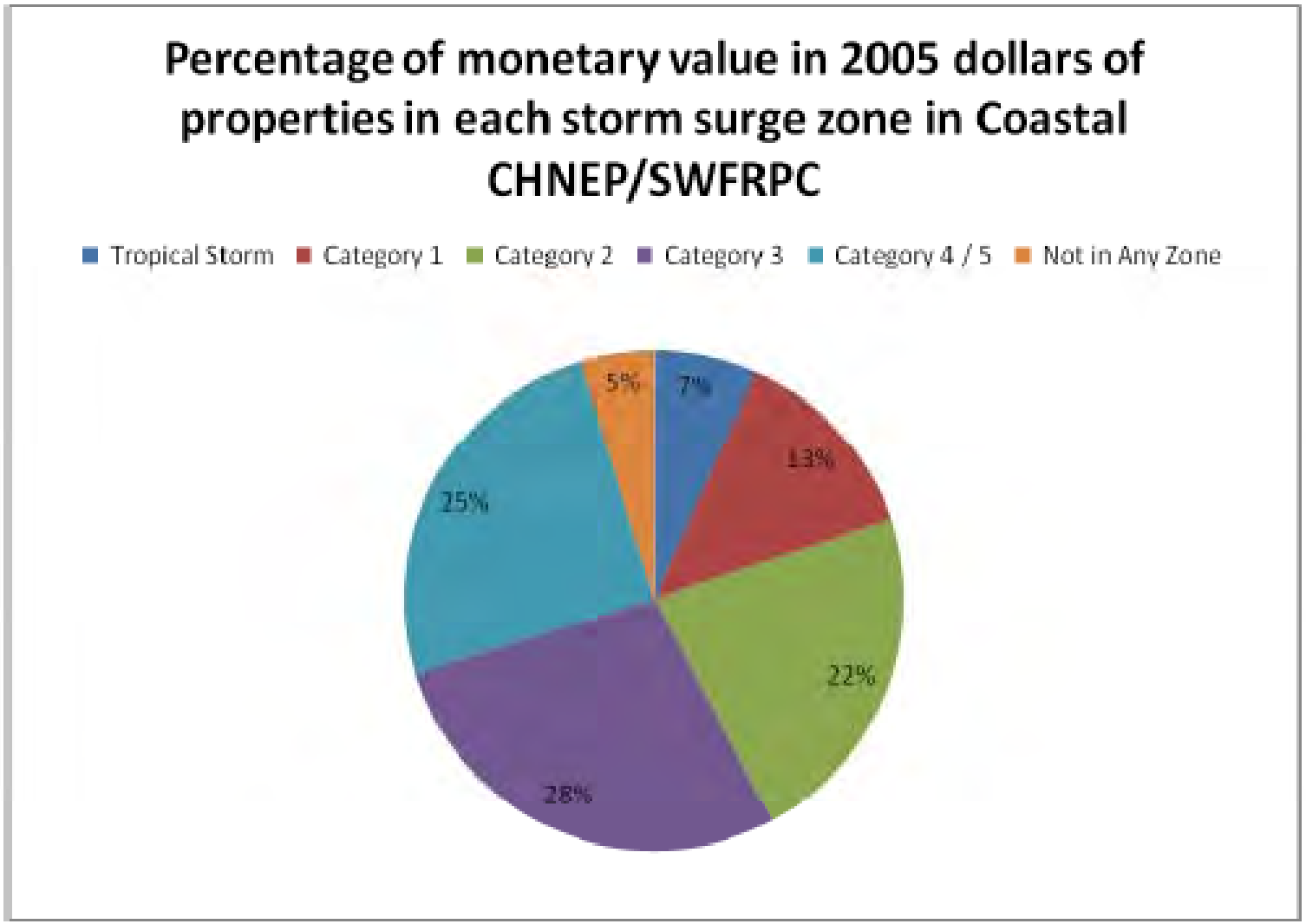


Figure 12: Percentage in monetary value in 2005 dollars of properties in each storm surge zone in coastal CHNEP/SWFPC study area

Transportation Infrastructure Impacts

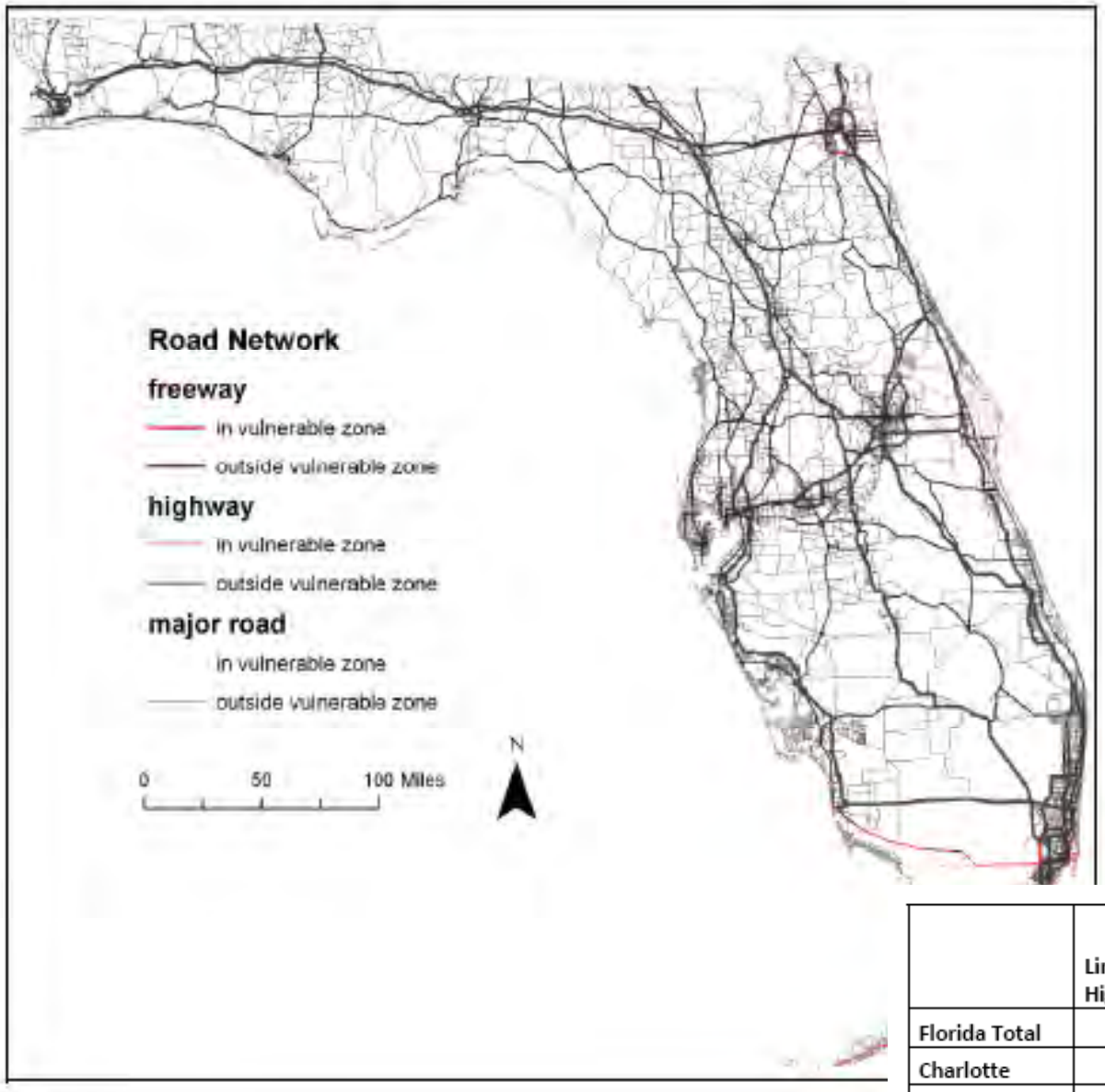


Figure 55: Major Florida roads vulnerable to projected worst case sea level rise

	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:

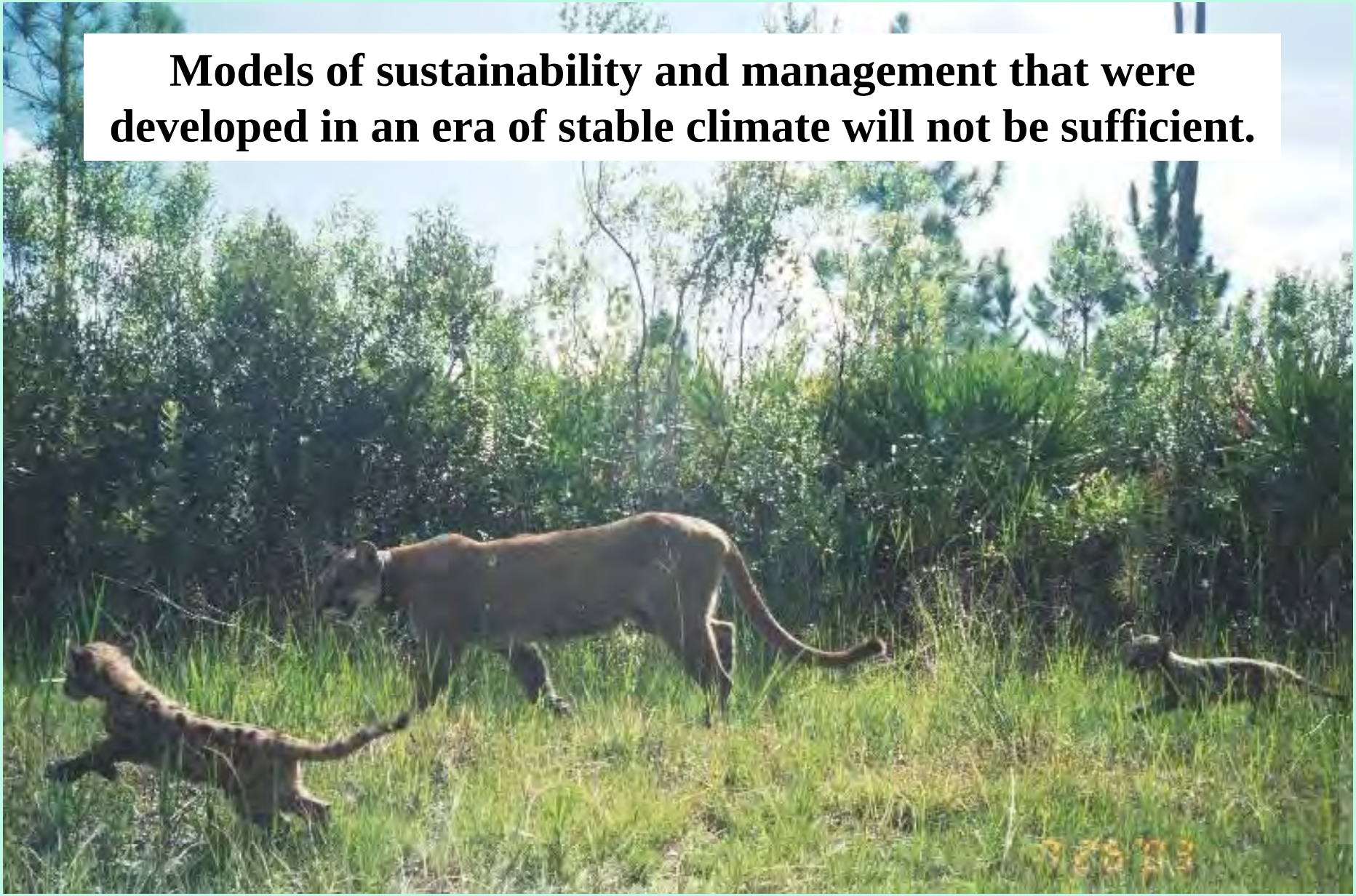
Prioritization	CHNEP CCMP Goal Implementation	Proximity in Time	Habitat Loss in the Estuary	Habitat Loss in the Watersheds	Sum of Scores	Average Rank
Air Temperature and Chemistry	7	7	8	8	30	7.5
Altered Hydrology	1	1	1	1	4	1.0
Climate Instability	2	2	3	2	9	2.3
Geomorphic Changes	6	5	7	5	23	5.8
Habitat 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

CHNEP Grouped Vulnerabilities

1. Altered Hydrology
2. Storm Severity/Climate Instability
3. Water Temperature & Chemistry
4. Habitat and Species Changes
5. Sea Level Rise
6. Geomorphic (Landform) Changes
7. Air Temperature & Chemistry
8. Infrastructure
9. Human Economy
10. Human Health
11. Land Use Changes
12. Variable Risk

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

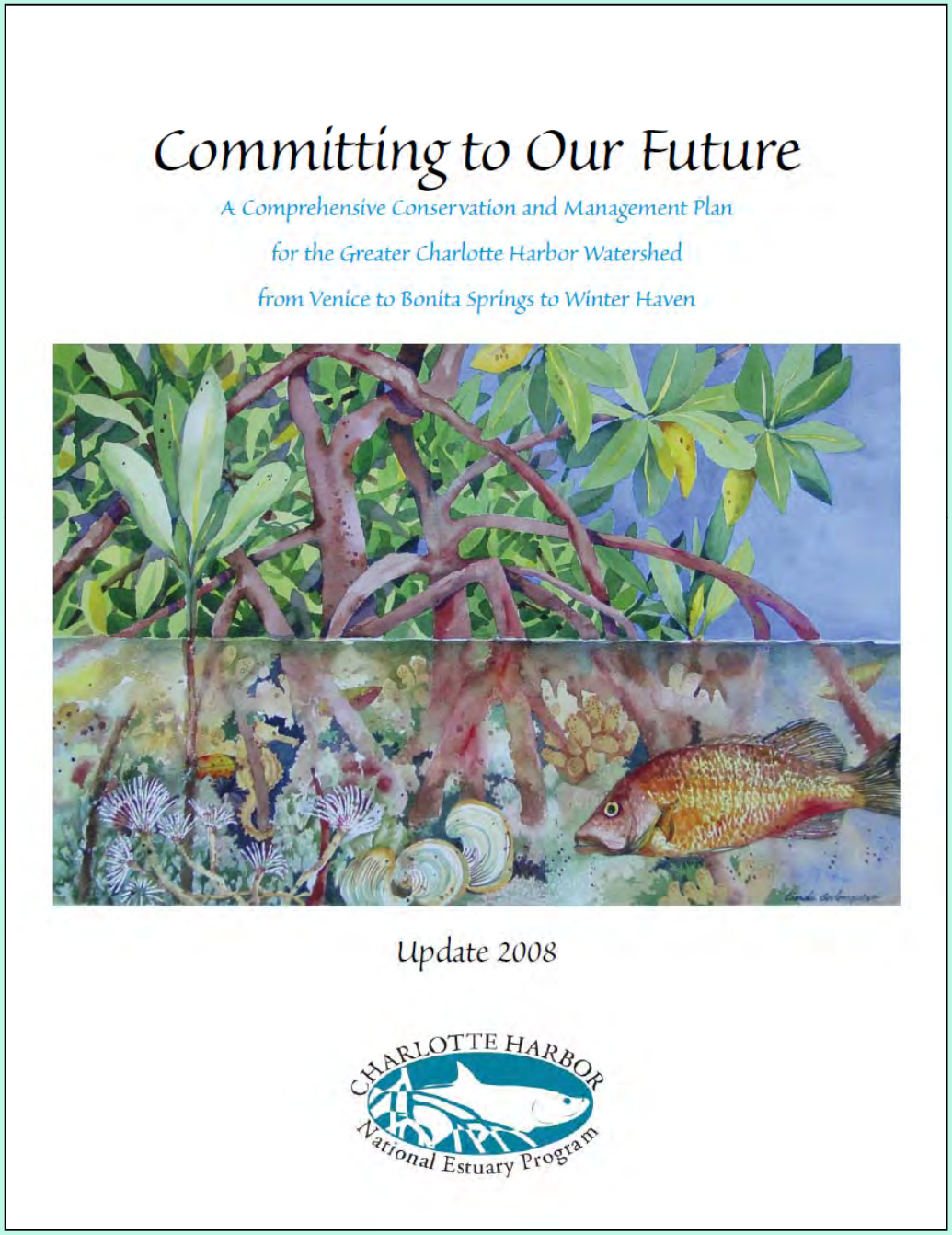


CONCLUSIONS

- 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.



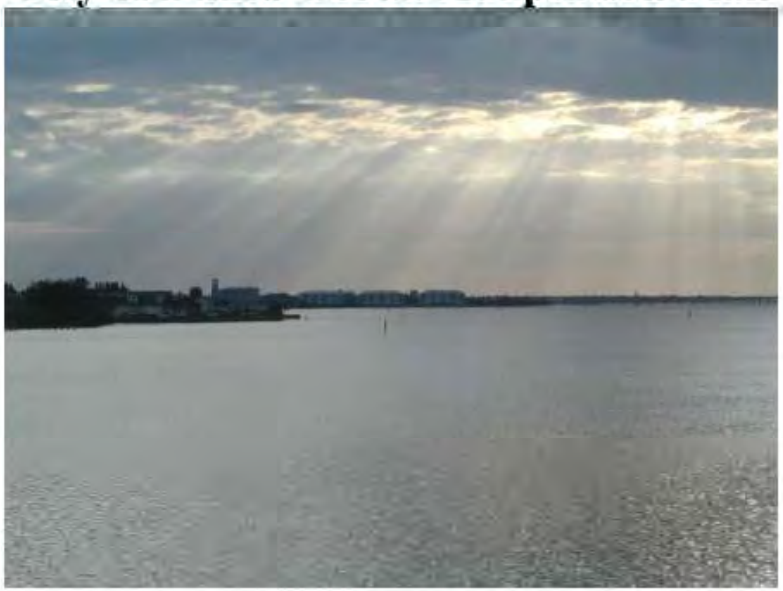
In the absence of effective avoidance, mitigation, minimization & adaptation, climate-related failures will result in greater difficulty in addressing the priority problems identified in the CCMP.

In order to be prepared for the anticipated effects of climate change Adaptation Plans should be developed for each community

The Adaption Plans should include:

- An assessment of climate vulnerabilities for that particular Community;
- A summary of the considerations and public participation processes used to set priorities and select vulnerabilities and implementation actions
- Communication with stakeholders and decision makers.
- How the plan affects existing goals of the Community as expressed in the existing 2025Comprehensive Plan;
- Additional climate change-induced goals and objectives beyond the existing management goals tithe period of the year 2200;
- Adaptation management actions associated with achieving those goals and objectives;
- Description of specific implementation actions for the priority adaptations with the highest level of consensus (including some of the associated tools and resources that can be employed to implement the priority adaptations).
- Plans for monitoring and evaluation of results if the adaptations are implemented

City of Punta Gorda Adaptation Plan



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