Misconceptions on Sea Level Rise in South Florida

Keren Prize Bolter, PhD

BBRRCT

January 14, 2015

Florida Center for Environmental Studies

Introduction – what's changing? Why?

Current Impacts

Are people as concerned as they should be? Why/Why not?

Conclusion **What is being done? What else can we do?**

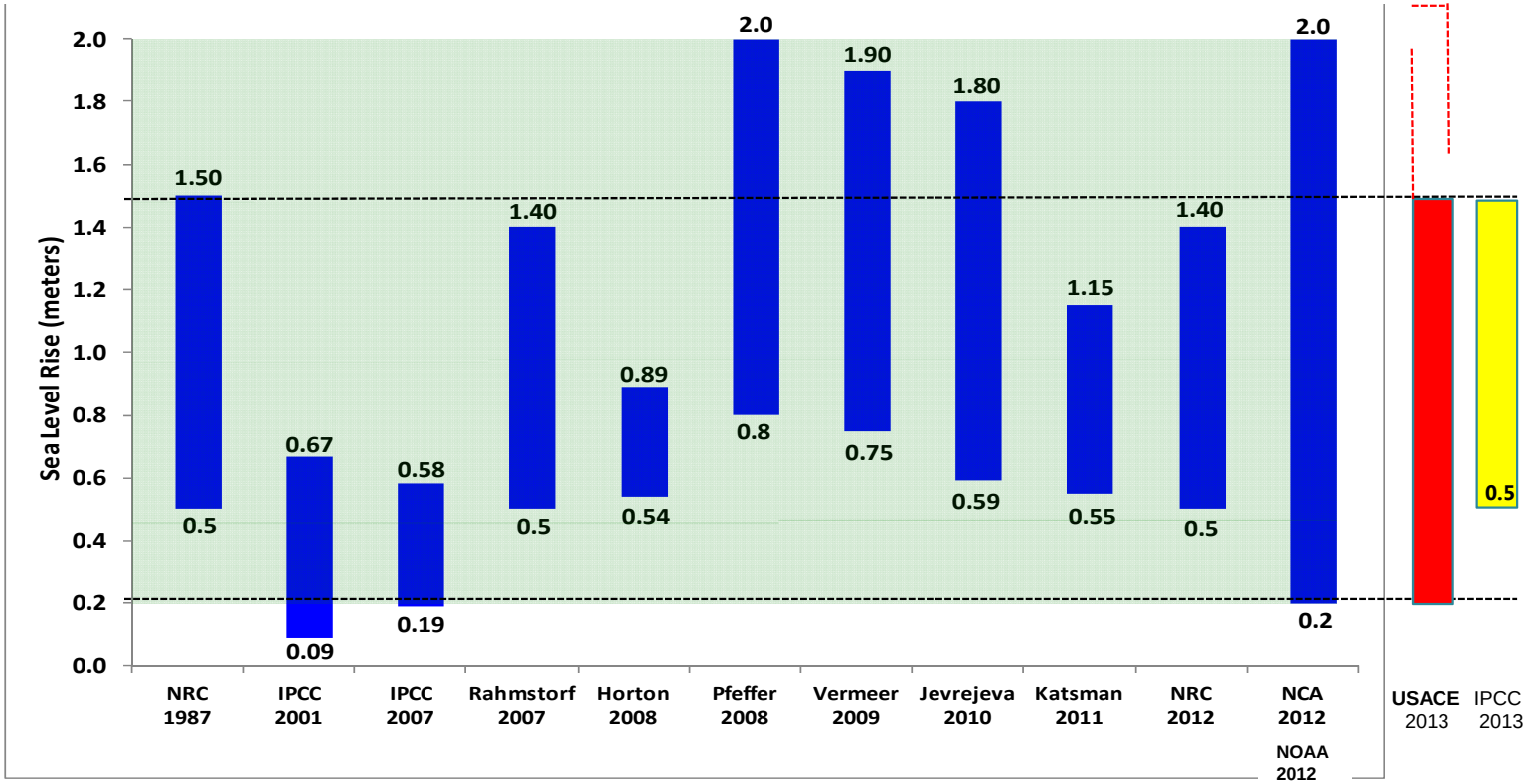
Awareness

Communication

Change in Behavior

Being Safe & Prepared

Estimates of Global Sea Level Change by 2100



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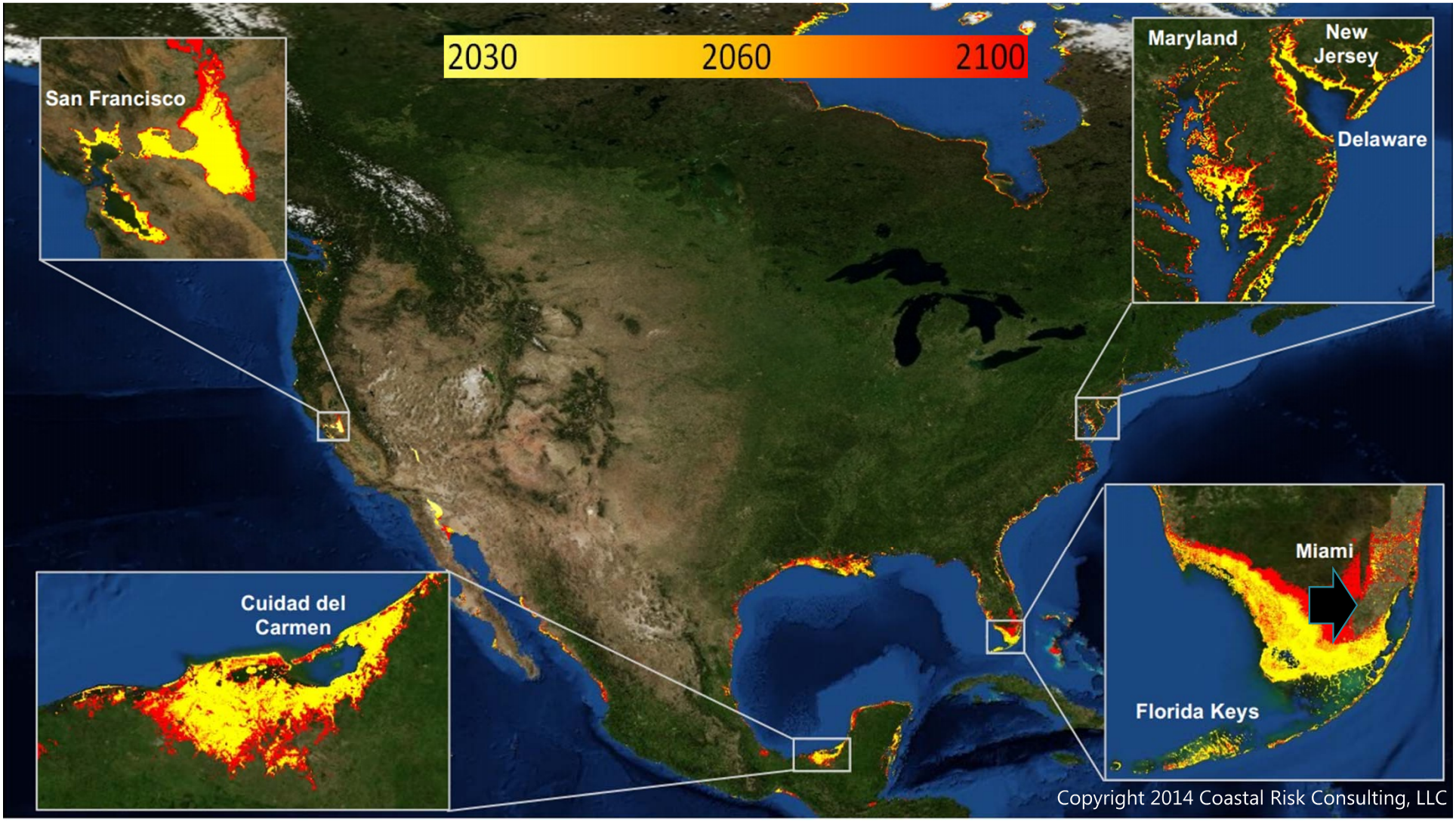
AS2


2030
2060
2100
San Francisco
Maryland
New Jersey
Delaware
Cuidad del Carmen
Miami
Florida Keys
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Slide 5

AS2 Needs a title

Albert Slap, 9/21/2014

AS3

U.S. Top 10: nuisance flooding

NOAA 2014

	"Nuisance level": Meters above MHHW	Average nuisance flood days, 1957-1963	Average nuisance flood days, 2007-2013	Percent Increase
Annapolis, Md.	0.29	3.8	39.3	925%
Baltimore, Md.	0.41	1.3	13.1	922%
Atlantic City, N.J.	0.43	3.1	24.6	682%
Philadelphia, Pa.	0.49	1.6	12.0	650%
Sandy Hook, N.J.	0.45	3.3	23.9	626%
Port Isabel, Texas	0.34	2.1	13.9	547%
Charleston, S.C.	0.38	4.6	23.3	409%
Washington, D.C.	0.31	6.3	29.7	373%
San Francisco, Calif.	0.35	2.0	9.3	364%
Norfolk, Va.	0.53	1.7	7.3	325%

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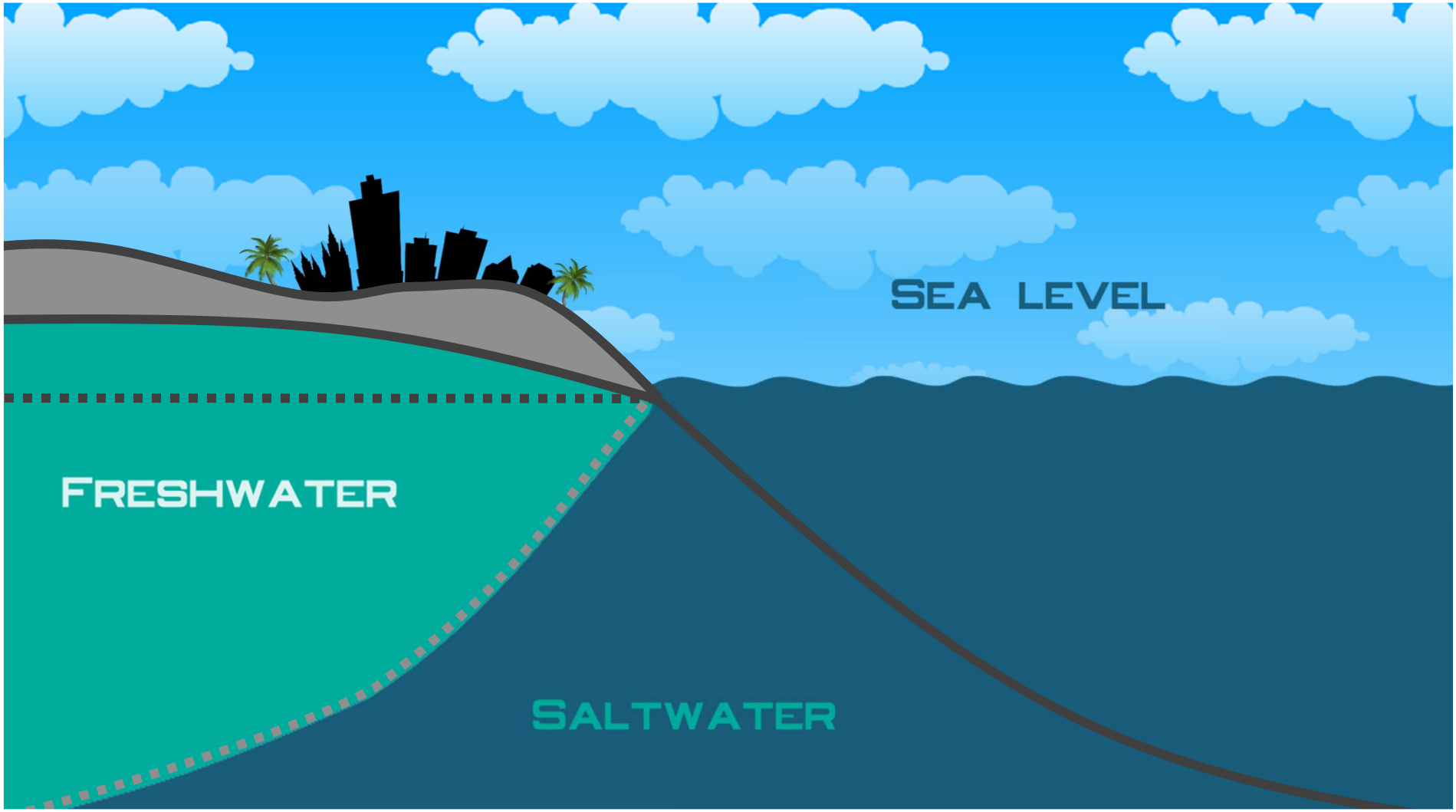
Slide 6

AS3 just one of these slides is needed
Albert Slap, 9/21/2014

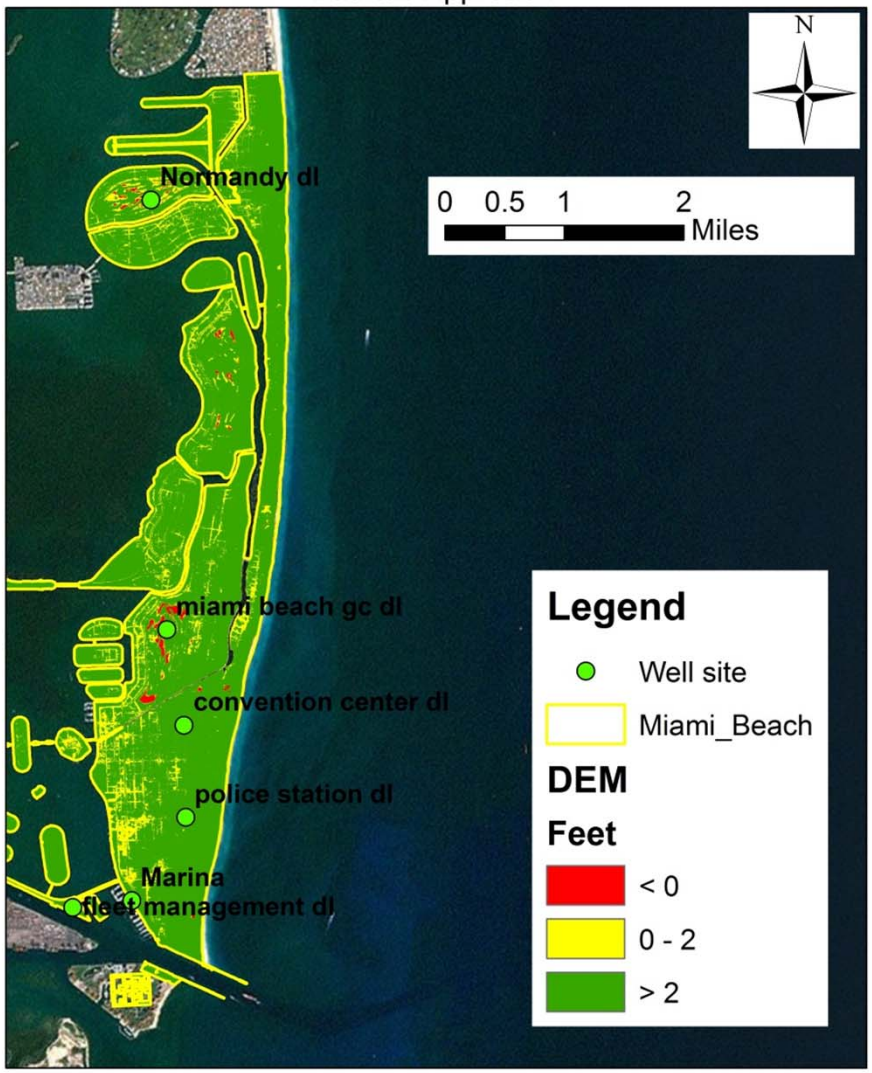
South Florida is not “just” going underwater…but

- **Tidal Flooding**
- **Saltwater Intrusion**
- **Failing Drainage**
- **Malfunctioning Canals**
- **Beach Erosion**
- **Habitat loss**

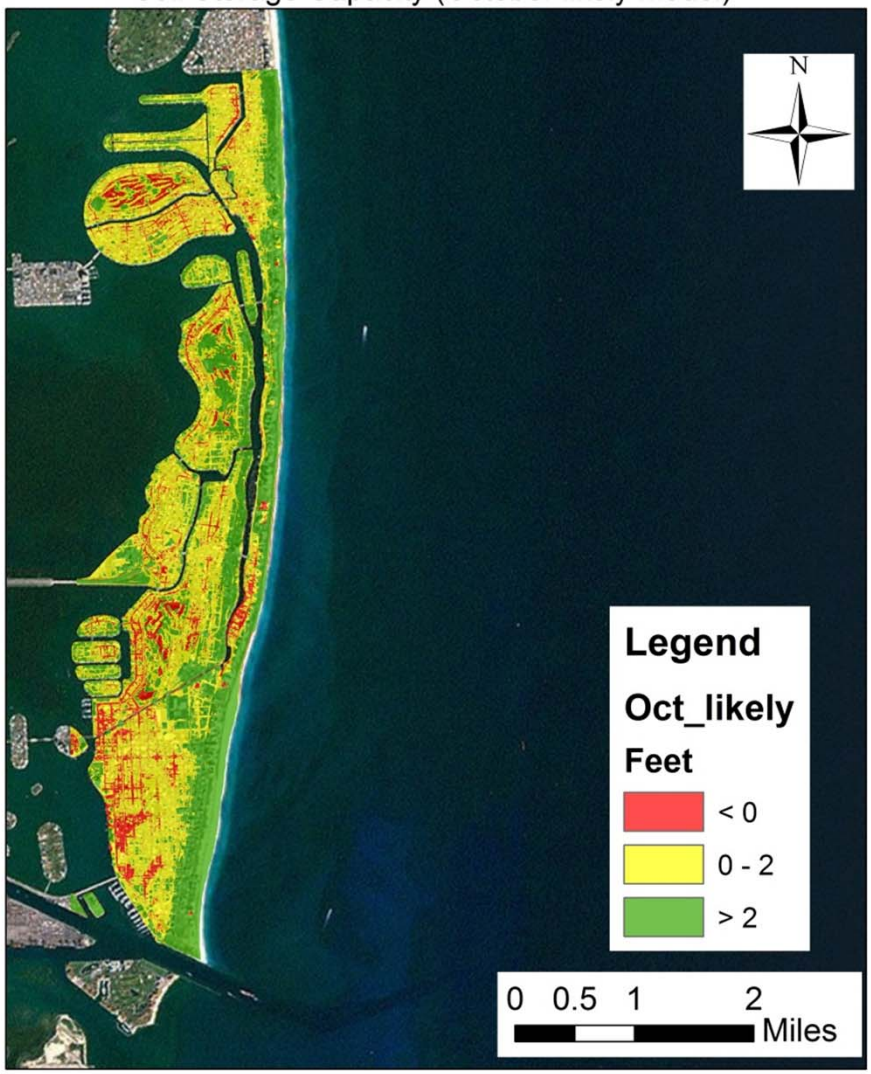

SEA LEVEL
FRESHWATER
SALTWATER

Comparing Bathtub Model vs.Soil Storage

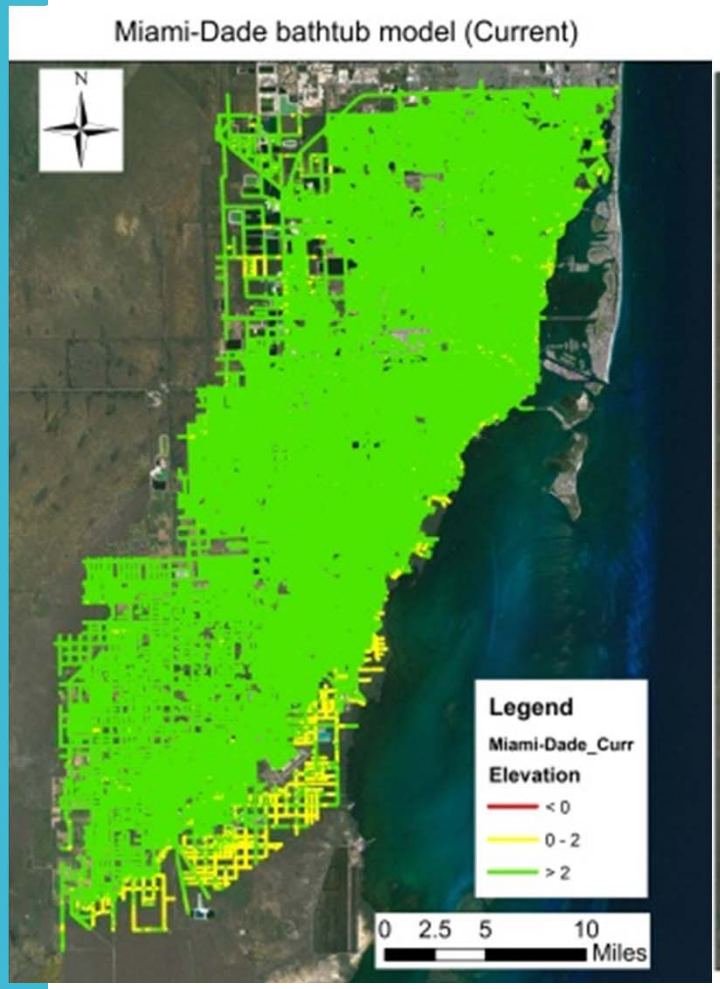
Bathtub Approach

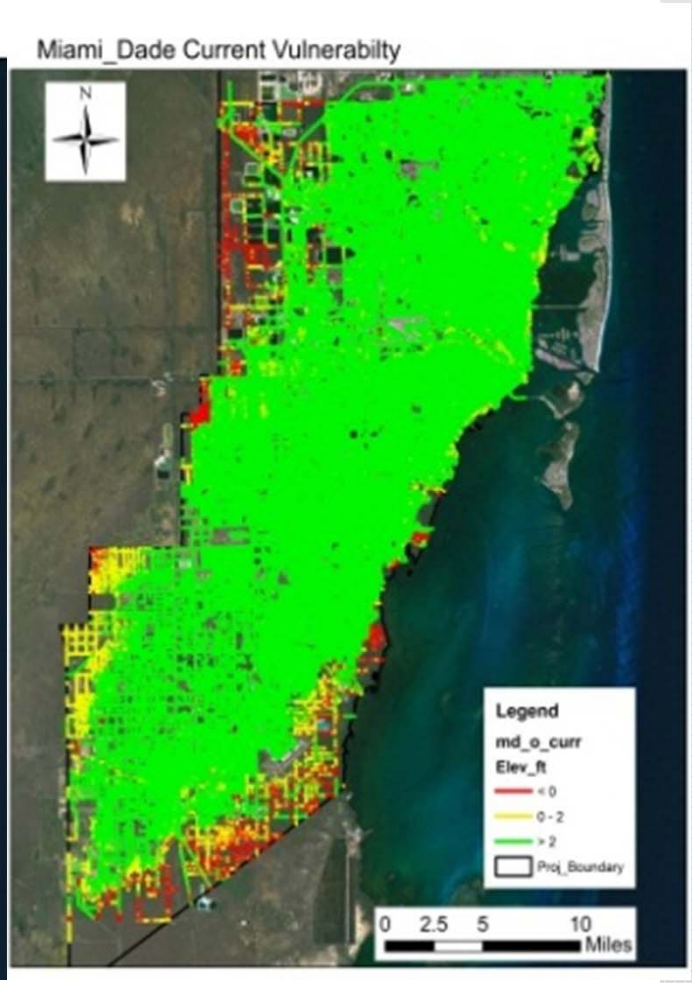


Soil Storage Capacity (October likely model)



Bathtub vs. Soil Storage Miami Dade County





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Physical Risk	Health Exposure	Vulnerable Populations

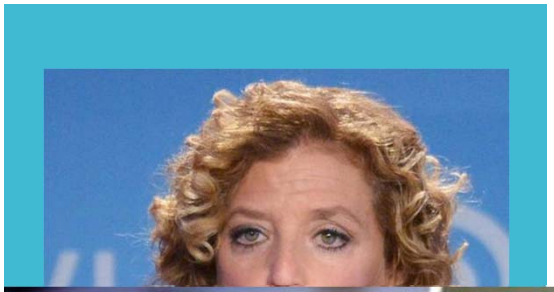
Higher Storm Surge	• **Mental health** issues from
	  • property damage
	  • displacement
	• **Injury and accidents**
		• Coastal populations
		• Elderly, handicapped, of children living in high rises
		• Remote from emergency services
		• mobile home residents

Increased Flooding	• Waterborne **disease vectors** • housing dislocation • limited **health care access** • Nutrition/ food supply • Exposure to **mold** • Drowning	• Low socioeconomic status • Handicapped, elderly, children • Residents of mobile homes • People living in areas with outdated drainage • People with respiratory illness

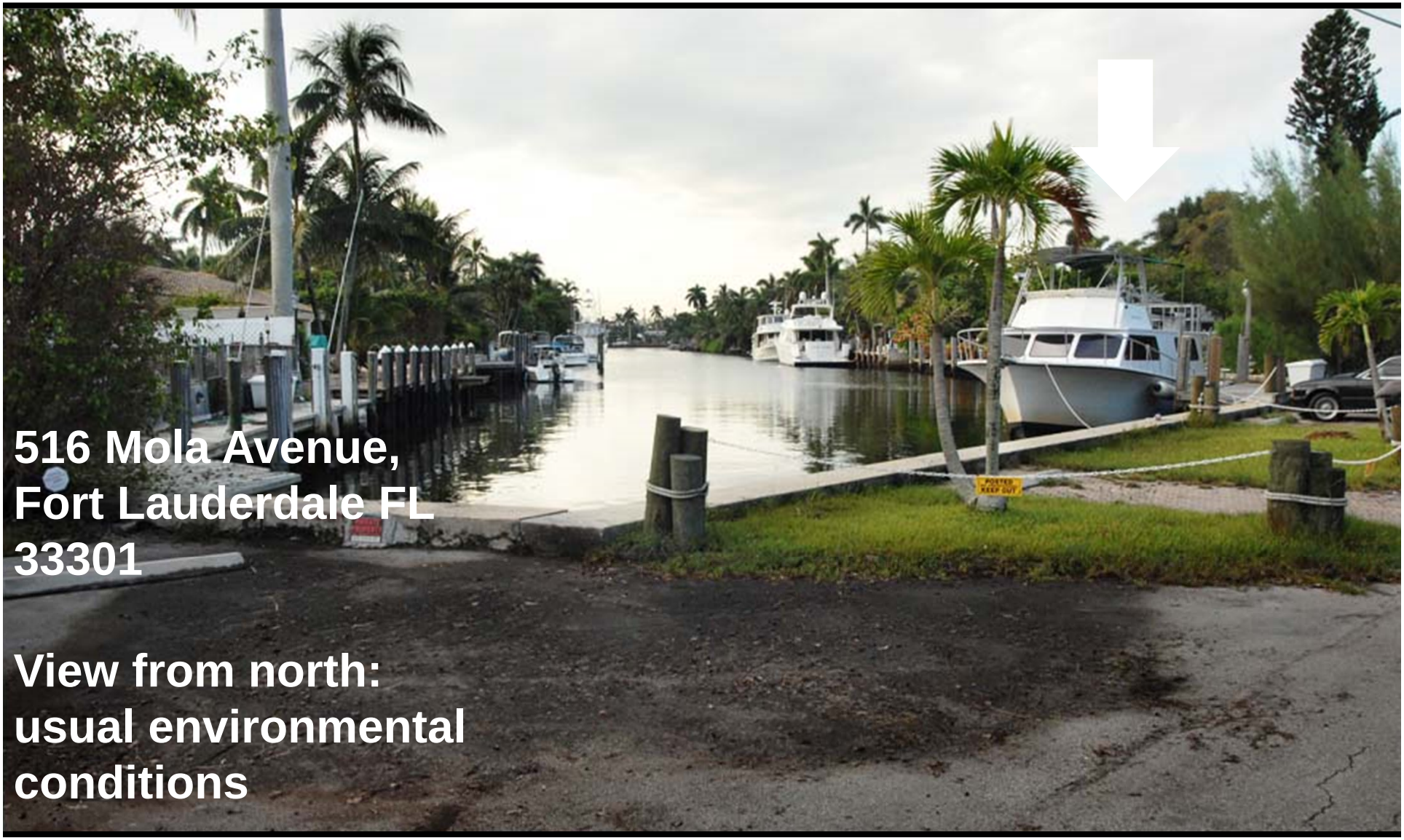
Raised Water Table	• Contaminated water supply
	  • Landfill/Brownfield seepage
	  • Sewage and toxic pollutants release
	  • **Saltwater Intrusion**
	• Unstable foundation from saturated soil
		• Low socioeconomic status
		• Handicapped, elderly, children
		• People living near impaired waters, septic tanks,
		• People who get water from wells near contaminated areas

Top 20 cities ranked in terms of assets exposed to coastal flooding in the 2070s (including both climate change and socioeconomic change) and showing present-day exposure (Source: Nicholls et al (2007), OECD, Paris)

Rank	Country	Urban Agglomeration	Exposed Assets Current ($Billion)	Exposed Assets Future ($Billion)
1	USA	Miami	416.29	3,513.04
2	CHINA	Guangzhou	84.17	3,357.72
3	USA	New York-Newark	320.20	2,147.35
4	INDIA	Kolkata (Calcutta)	31.99	1,961.44
5	CHINA	Shanghai	72.86	1,771.17
6	INDIA	Mumbai	46.20	1,598.05
7	CHINA	Tianjin	29.62	1,231.48
8	JAPAN	Tokyo	174.29	1,207.07
9	CHINA,	Hong Kong	35.94	1,163.89
10	THAILAND	Bangkok	38.72	1,117.54
11	CHINA	Ningbo	9.26	1,073.93
12	USA	New Orleans	233.69	1,013.45
13	JAPAN	Osaka-Kobe	215.62	968.96
14	NETHERLANDS	Amsterdam	128.33	843.70
15	NETHERLANDS	Rotterdam	114.89	825.68
16	VIETNAM	Ho Chi Minh City	26.86	652.82
17	JAPAN	Nagoya	109.22	623.42
18	CHINA	Qingdao	2.72	601.59
19	USA	Virginia Beach	84.64	581.69
20	EGYPT	Alexandria	28.46	563.28



13,950 peer-reviewed climate change articles Since '91, and only **24** reject global warming (Powell, 2011)


516 Mola Avenue,
Fort Lauderdale FL
33301
View from north:
usual environmental
conditions

516 Mola Avenue, Fort Lauderdale FL 33301

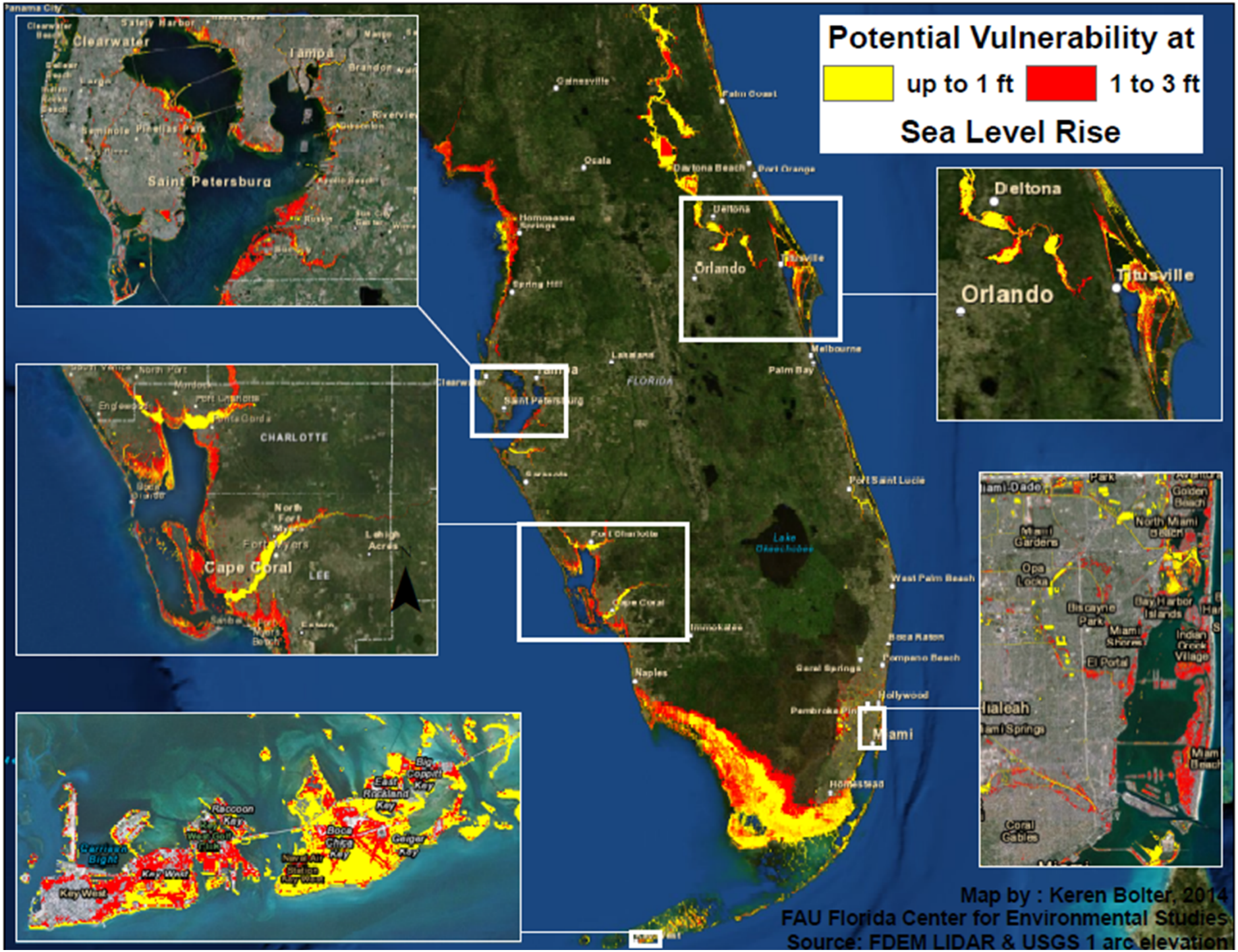
View from north: the “new normal”

SAMPLE SITE:
516 Mola Avenue,
Fort Lauderdale FL 33301

View from north:
Normal tidal conditions
2010

For Sale
Bass Realty
And Investments, Inc.
(954) 525-2069
Water Front
& pool
SAMPLE SITE:
516 Mola Avenue,
Fort Lauderdale FL
33301
View from north:
Extreme high tide 2013

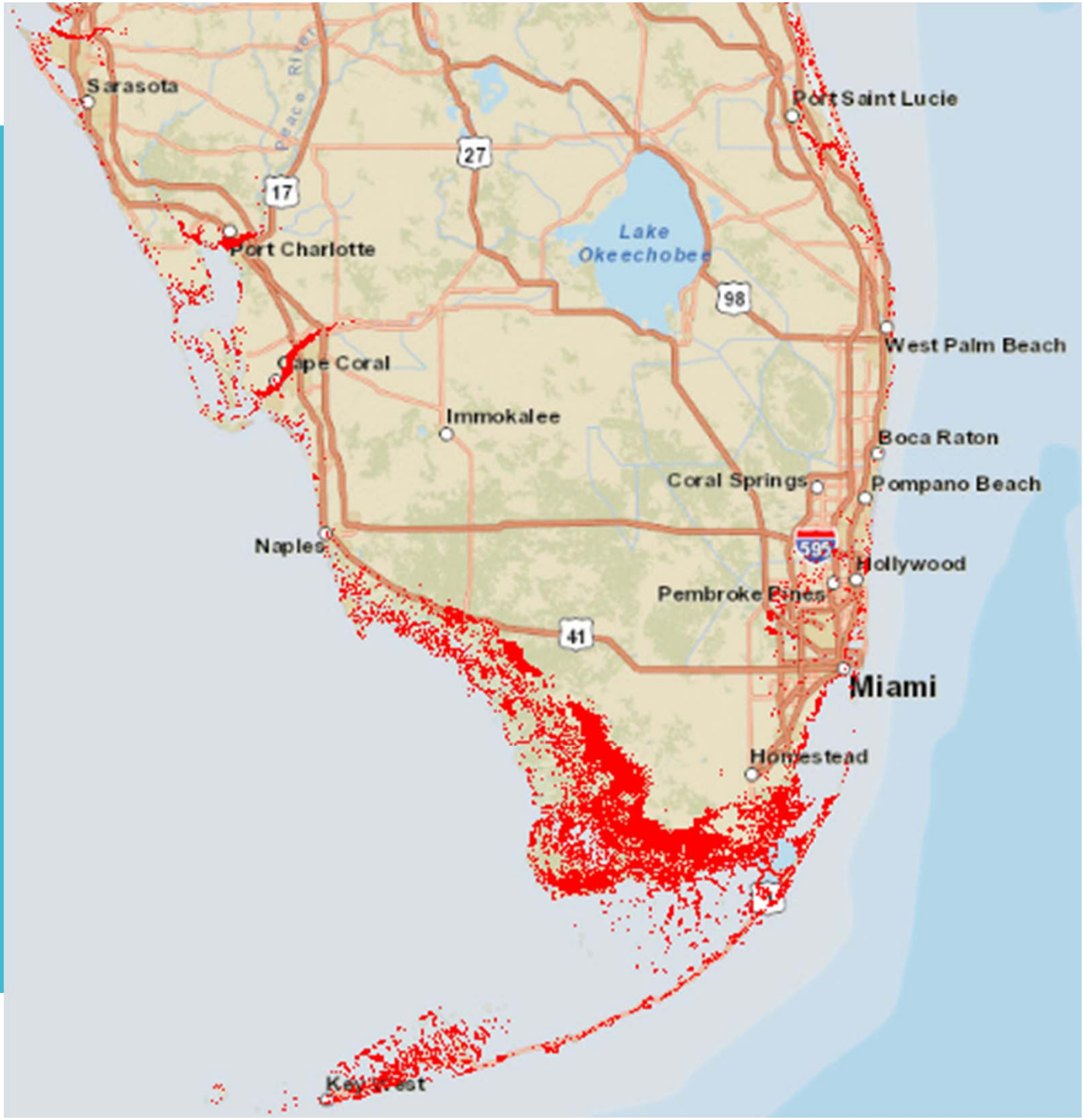
What is Florida going to look like?


Potential Vulnerability at
up to 1 ft
1 to 3 ft
Sea Level Rise
Clearwater
Tampa
Saint Petersburg
Gainesville
Palm Coast
Ocala
Daytona Beach
Port Orange
Deltona
Orlando
Titusville
Melbourne
Palm Bay
Lakeland
FLORIDA
Port Saint Lucie
Lake Okeechobee
West Palm Beach
Boca Raton
Pompano Beach
Hollywood
Miami
Homestead
Naples
Fort Myers
Cape Coral
CHARLOTTE
LEE
Lehigh Acres
Key West
Raccoon Key
Big Copper Key
East Rockland Key
Boca Chica Key
Geiger Key
Hialeah
Miami Springs
Coral Gables
Miami Beach
North Miami Beach
Bay Harbor Islands
Map by : Keren Bolter, 2014
FAU Florida Center for Environmental Studies
Source: FDEM LIDAR & USGS 1 arc elevation

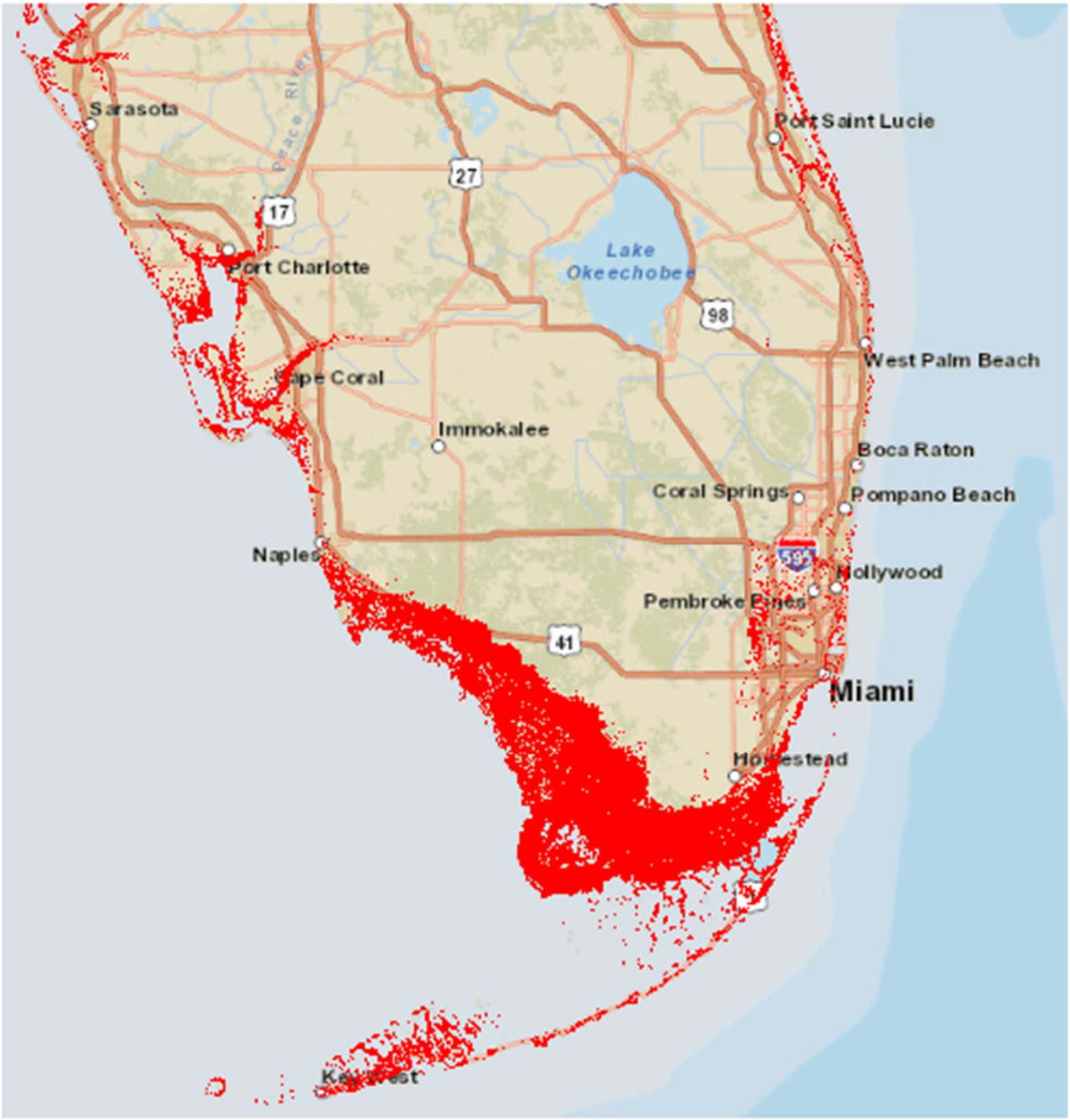
today

Sarasota
Peace River
Port Saint Lucie
27
17
Port Charlotte
Lake Okeechobee
98
West Palm Beach
Cape Coral
Immokalee
Boca Raton
Coral Springs
Pompano Beach
Naples
595
Hollywood
Pembroke Pines
41
Miami
Homestead
1
Key West

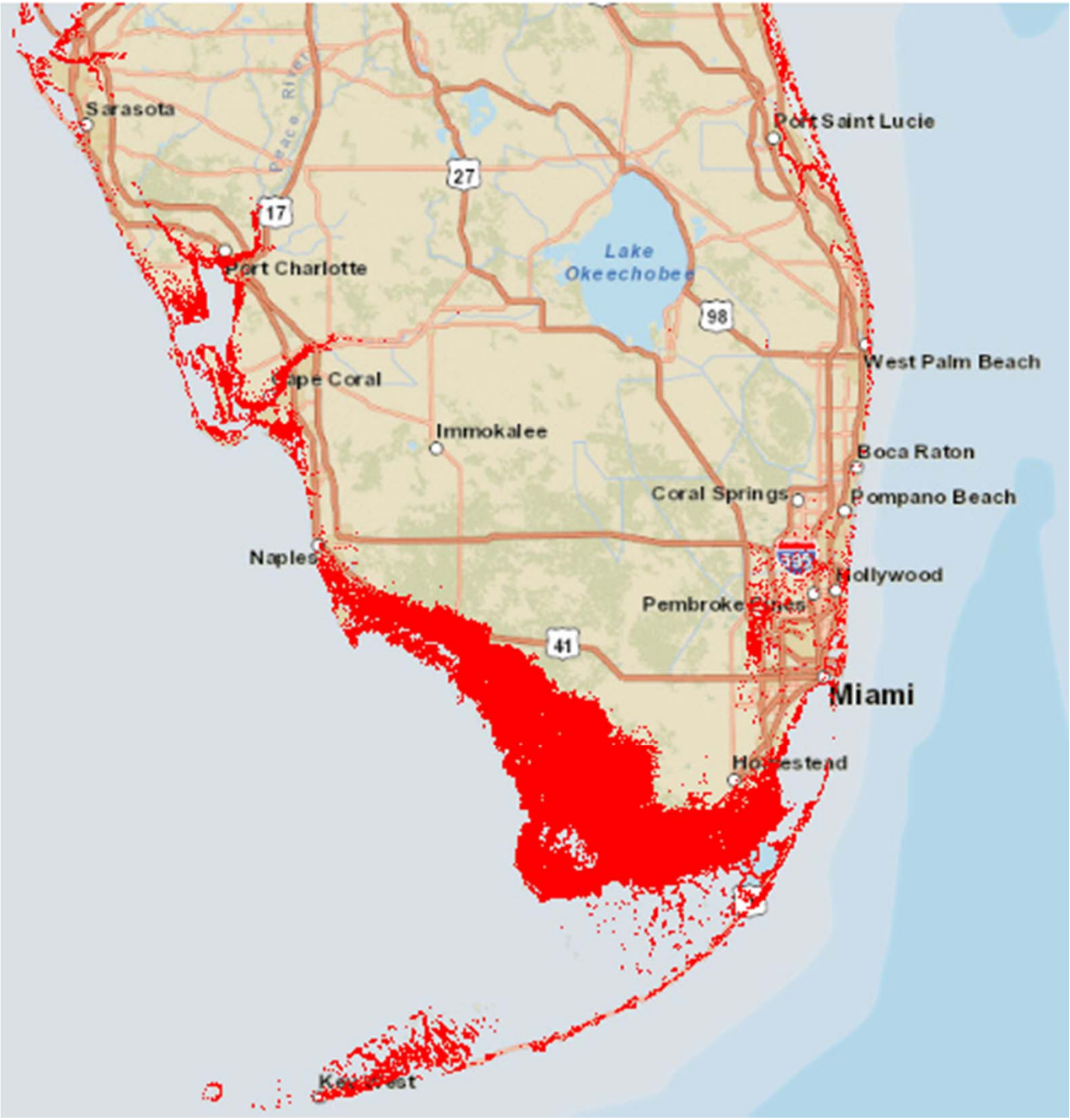
2030 – 7 inches



2060 – 2ft


Sarasota
Peace River
Port Saint Lucie
27
17
Port Charlotte
Lake Okeechobee
98
West Palm Beach
Cape Coral
Immokalee
Boca Raton
Coral Springs
Pompano Beach
Naples
595
Hollywood
Pembroke Pines
41
Miami
Homestead
Key West

2100
low
3ft


Sarasota
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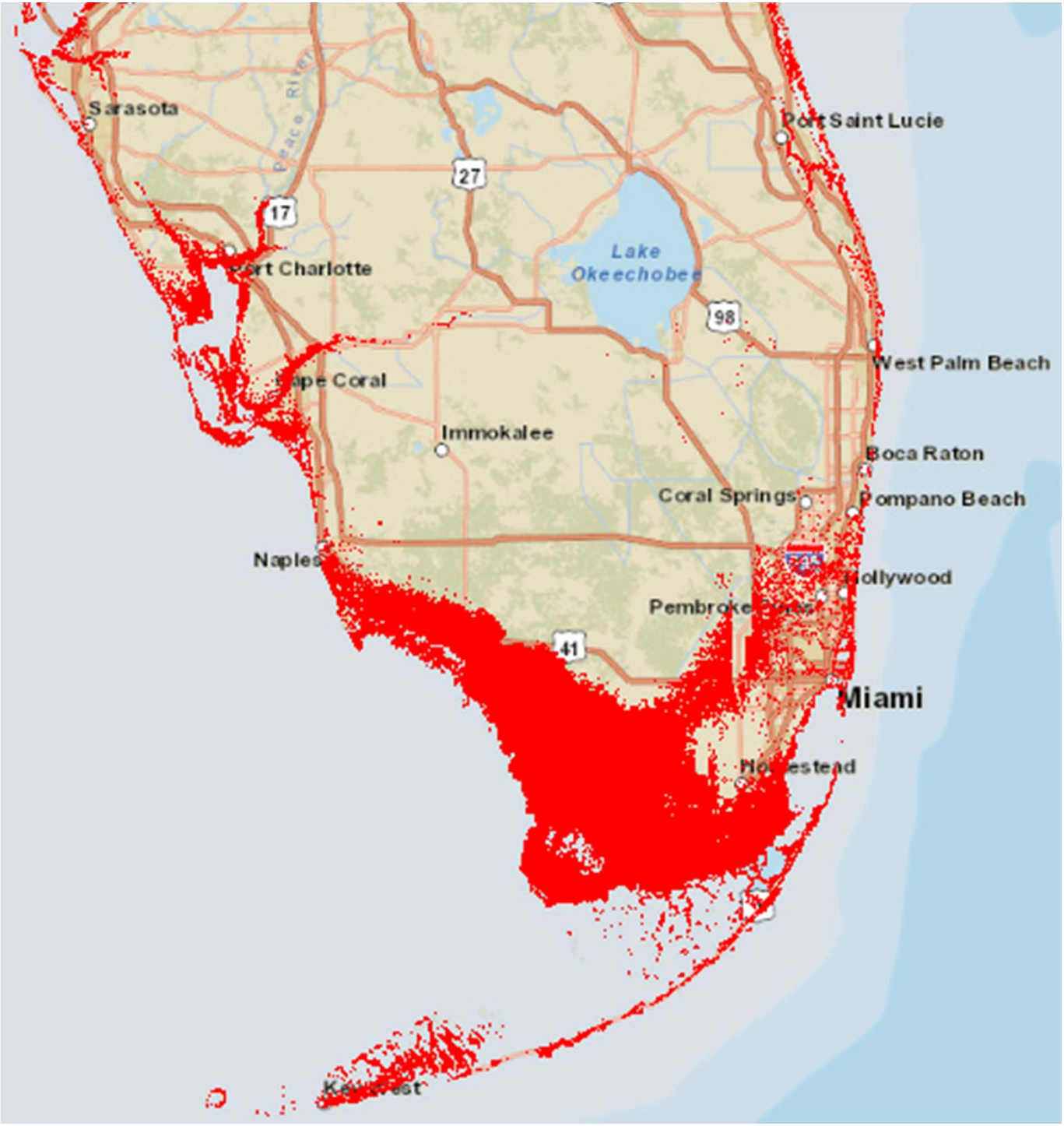
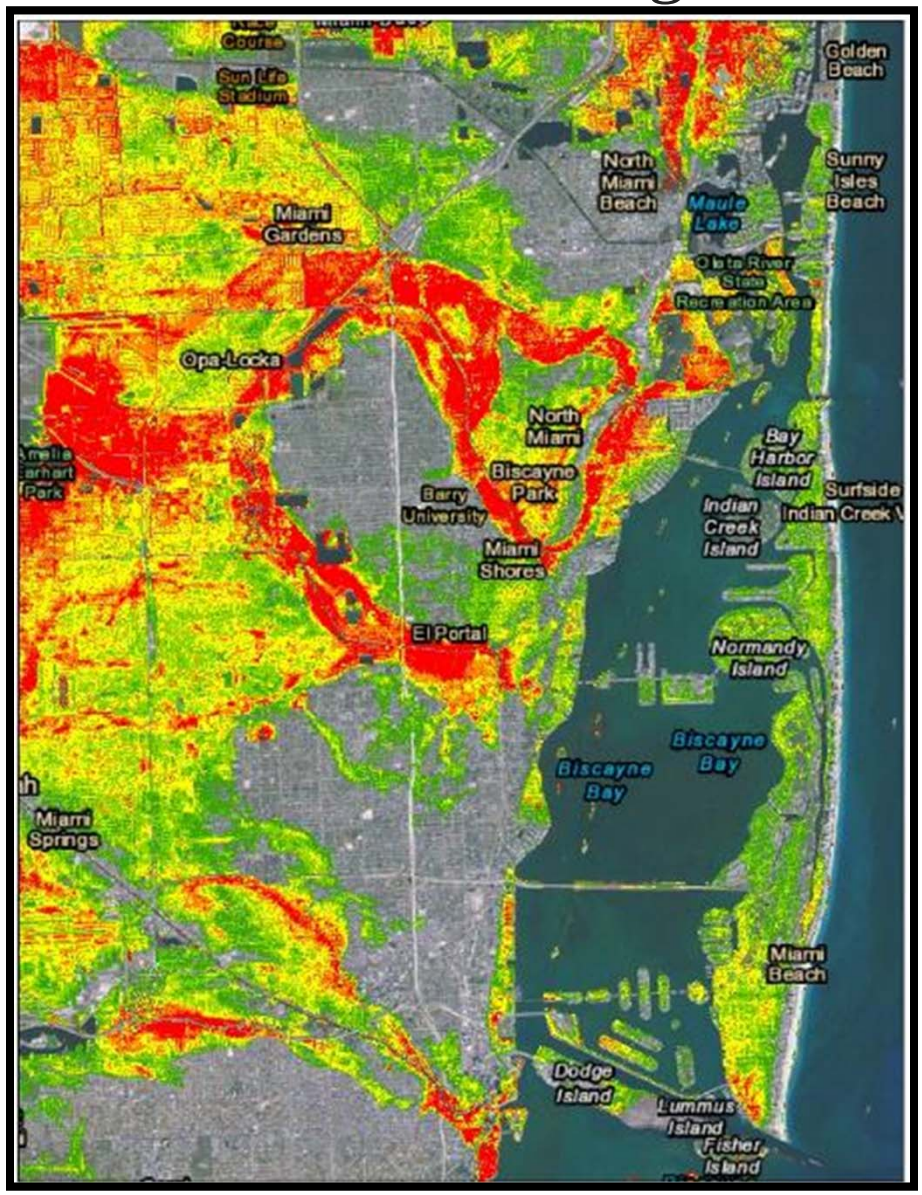
West Palm Beach
Cape Coral
Immokalee
Boca Raton
Coral Springs
Pompano Beach
Naples
Hollywood
Pembroke Pines
41
Miami
Homestead

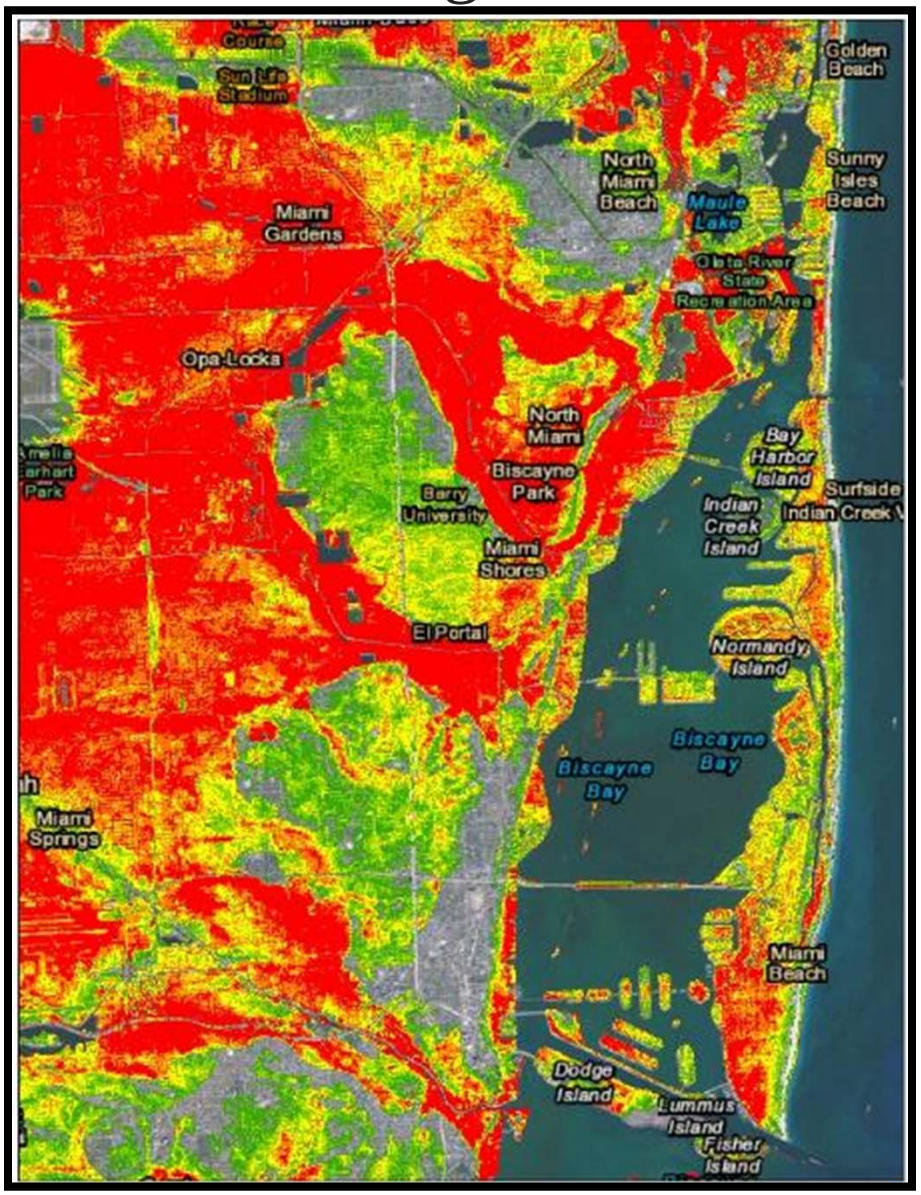
2100
high
5ft



Current Cat. 3 Surge

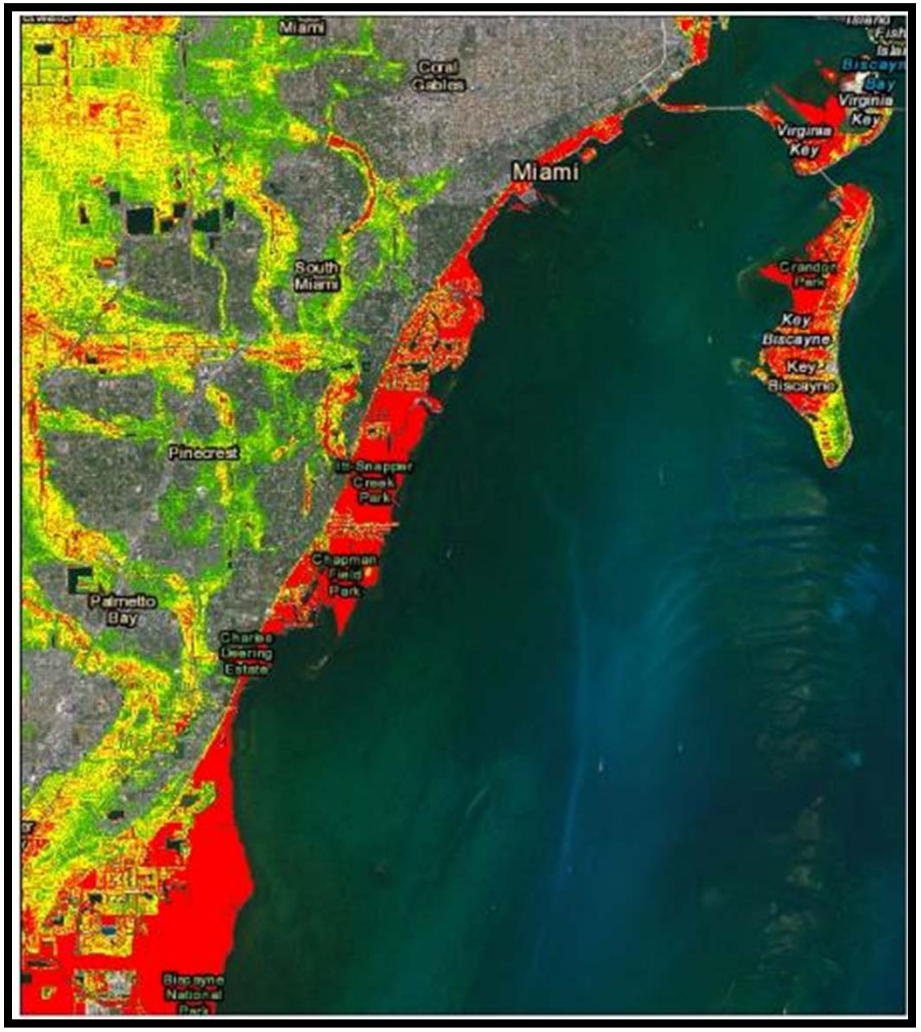


2060 Cat. 3 Surge w/2ft SLR

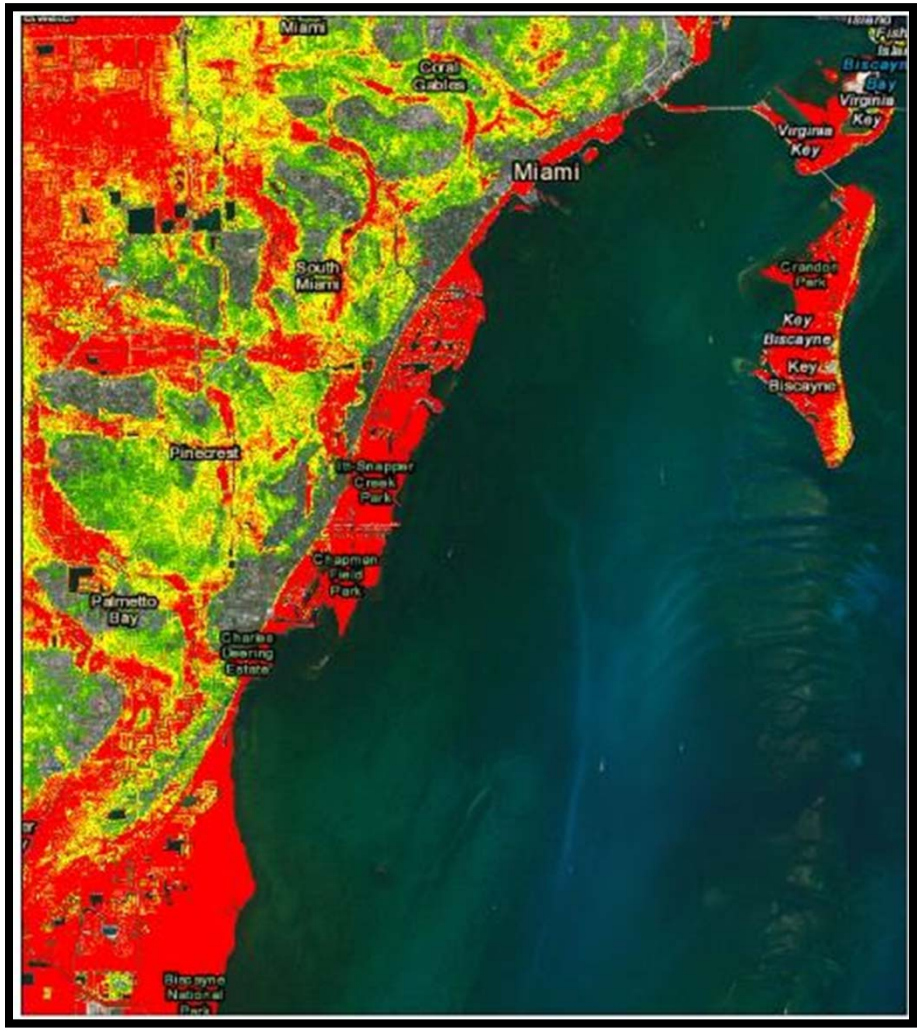


< 1 ft | 1 - 2 ft | 2 - 3 ft | 3 - 4 ft | > 4 ft

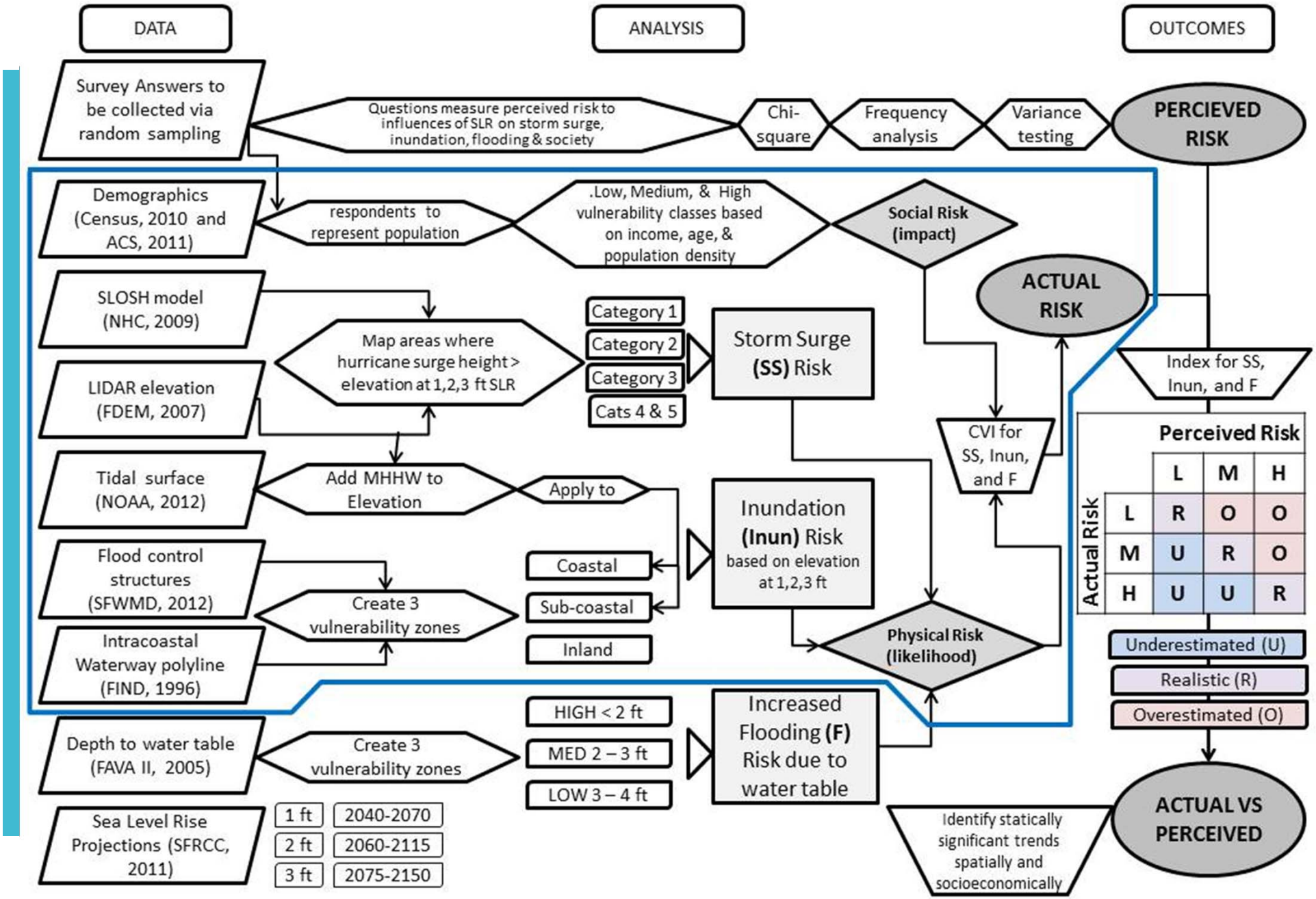
Current Cat. 3 Surge



2060 Cat. 3 Surge w/2ft SLR

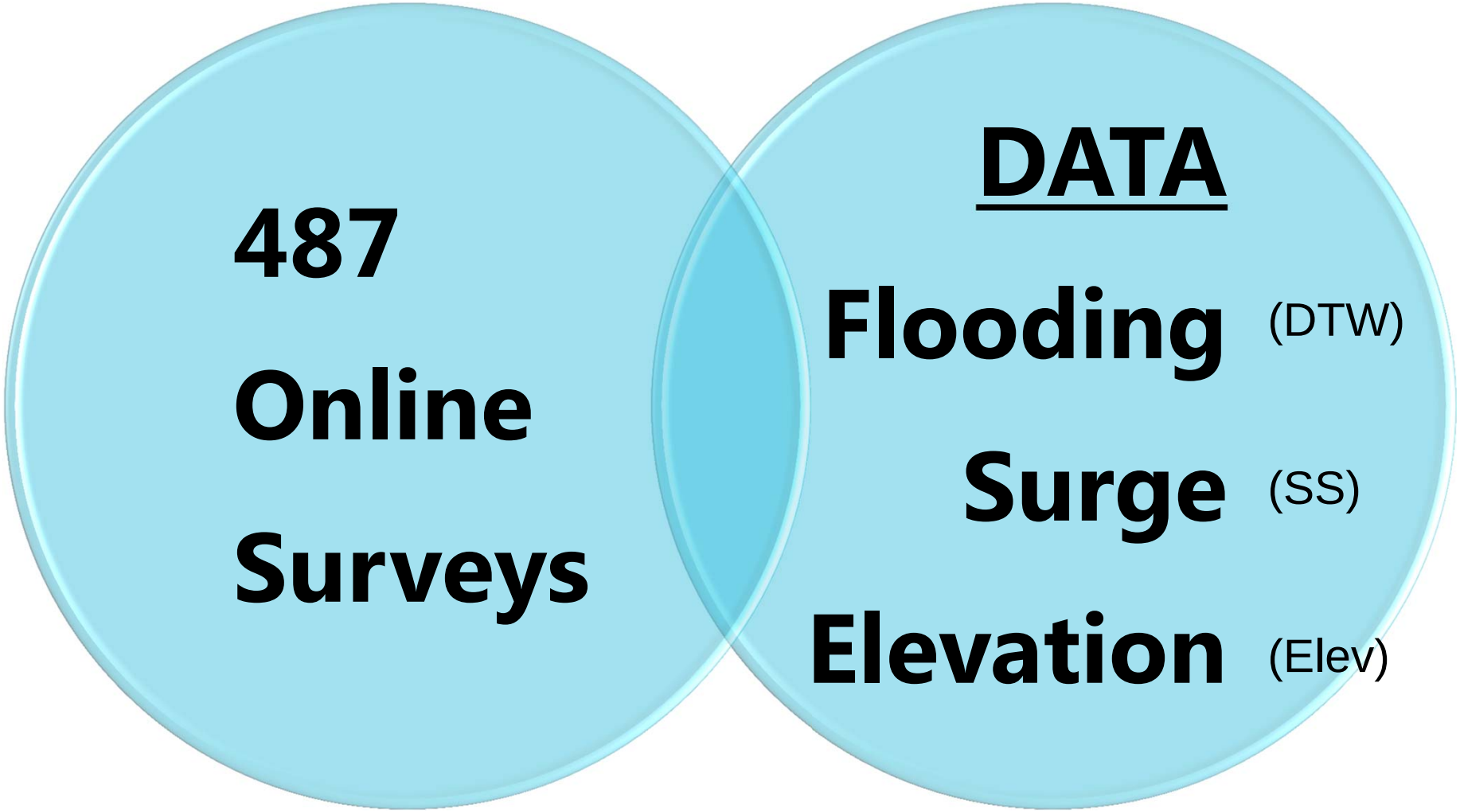


< 1 ft | 1 - 2 ft | 2 - 3 ft | 3 - 4 ft | > 4 ft


DATA
ANALYSIS
OUTCOMES
Survey Answers to be collected via random sampling
Questions measure perceived risk to influences of SLR on storm surge, inundation, flooding & society
Chi-square
Frequency analysis
Variance testing
PERCIEVED RISK
Demographics (Census, 2010 and ACS, 2011)
respondents to represent population
.Low, Medium, & High vulnerability classes based on income, age, & population density
Social Risk (impact)
ACTUAL RISK
SLOSH model (NHC, 2009)
Map areas where hurricane surge height > elevation at 1,2,3 ft SLR
Category 1
Category 2
Category 3
Cats 4 & 5
Storm Surge (SS) Risk
LIDAR elevation (FDEM, 2007)
Index for SS, Inun, and F
CVI for SS, Inun, and F
Tidal surface (NOAA, 2012)
Add MHHW to Elevation
Apply to
Inundation (Inun) Risk based on elevation at 1,2,3 ft
Flood control structures (SFWMD, 2012)
Coastal
Sub-coastal
Inland
Create 3 vulnerability zones
Intracoastal Waterway polyline (FIND, 1996)
Physical Risk (likelihood)
Perceived Risk
Actual Risk
L M H
L R O O
M U R O
H U U R
Underestimated (U)
Realistic (R)
Overestimated (O)
HIGH < 2 ft
MED 2 – 3 ft
LOW 3 – 4 ft
Depth to water table (FAVA II, 2005)
Create 3 vulnerability zones
Increased Flooding (F) Risk due to water table
Sea Level Rise Projections (SFRCC, 2011)
1 ft 2040-2070
2 ft 2060-2115
3 ft 2075-2150
Identify statically significant trends spatially and socioeconomically
ACTUAL VS PERCEIVED

P vs A

Perceived Versus Actual Risk



P vs A: Actual Risk Data Collection

Data	Source
SLR Projections	SFRCCC, 2011
Elevation	10-ft horizontal resolution LIDAR digital elevation model (FDEM,2007)
Depth to water table	FAVA II Biscayne aquifer model (Arthur et al., 2006)
Storm Surge Zones	SLOSH Model for hurricane categories 1-5 (NHC, 2009)
Water Resources	SFWMD and Broward Natural Resources
Tidal Surface	VDATUM MHHW (NOAA, 2012)
Land use	FDOT/UF GeoPlan

28 QUESTIONS
487 RESPONDENTS

Sea Level Rise Risk Perception in Broward County

coconutcreek.net/news/2013/10/28/take-sea-level-survey

Coconut Creek News

Take Sea Level Survey

by Yvonne Lopez | Oct 28, 2013

Sea Level Rise Risk Perception in Broward County

Investigator: Keren Bolter, a PhD candidate in Geosc
(This is a doctoral research project)

Thank you for your interest in taking this brief 28 que
questions below. Your participation in this survey is c

The purpose of the survey is to measure perceived ri
you may receive from participation is consideration o
Broward County educators information about demogr

Helping with student's research

STAFF PHOTO BY MARTA MIKULAN MARTIN

When Coral Springs resident Keren Bolter began researching her FAU geosciences thesis on how residents perceive the risk of climate change, she asked every mayor and city manager in Broward to post surveys on their websites. Deerfield Beach and Coconut Creek have agreed.

Deerfield, C. Creek agree to assist with sea-level survey

By Elizabeth Roberts
Staff Writer

Ever see the photograph of a polar bear clinging to a tiny piece of ice amid a great ocean and wonder what you can do to stem sea-level rise? A local Ph.D. candidate wants to give every Broward County resident that chance.

Recently, Deerfield Beach and Coconut Creek put out an online call for participation in a survey on the issue.

They agreed to assist with a survey requested by Coral Springs resident Keren Bolter, who is on the cusp of a Ph.D. in geosciences from Florida Atlantic University. The university's research department is helping with the survey.

Bolter will use the data for a doctoral thesis comparing the perceived risk of sea-level rise with real data. Her goal is to find out if people are concerned — and whether they should be.

"Why are people buying property at 2 feet above sea level when the sea level is projected to rise up to 2 feet by the year 2060?" she said. "Inland areas think they are safe, but they don't realize the water comes up through the porous ground."

Bolter knows of what she speaks. She recently gave a talk for TEDxMiami about the misconceptions related to sea-level rise that was later broadcast on a National Public Radio affiliate. The information, Bolter said, is vital to helping planners and emergency personnel identify where people are at greatest risk.

But of 30 Broward cities she contacted, only Deerfield Beach and Coconut Creek have agreed to help. Ironically, she said, those are among the Broward communities with perhaps the least to worry about.

"In general, the elevations in Broward County go from north to south, from high to low. Deerfield Beach, in terms of elevation, is close to 10 feet higher than Fort Lauderdale," Bolter said.

Bolter said she is hoping to get about 1,000 survey respondents.

The survey is available at www.kbolter.com through Dec. 31.

Elizabeth Roberts can be reached at eroberts@tribune.com.

urbanhs.com/blog/

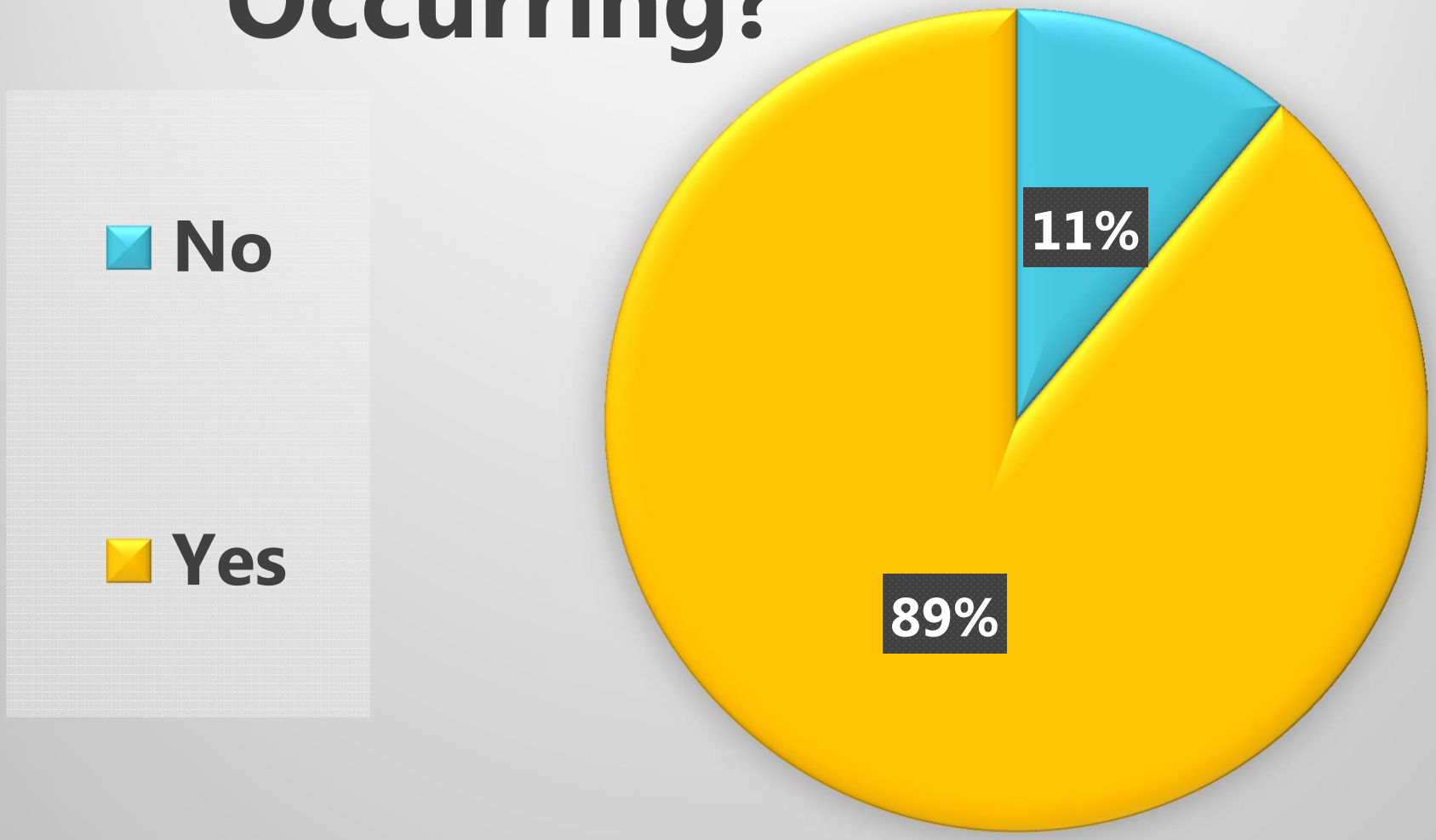
Live in Broward County and Interested in Sea Level Rise? Take This Survey Today!

October 24th, 2013 | Posted by UrbanHS in Sea Level Rise - (0 Comments)

Keren Bolter (954-881-1409, www.kbolter.com), a PhD candidate in Geosciences at FAU, has developed a short survey comparing perceived risk versus actual risk to sea level rise in Broward County. Her goal is to have 1,000 Broward County residents respond. Would you (1) take a few minutes to take the survey and (2) to send it along to other Broward residents?

To take the survey today, click here. (https://docs.google.com/forms/d/1X1d2PNCiw02gEnaz8aCnSWVgTfWI451bNydrGwsFgMQ/viewform)

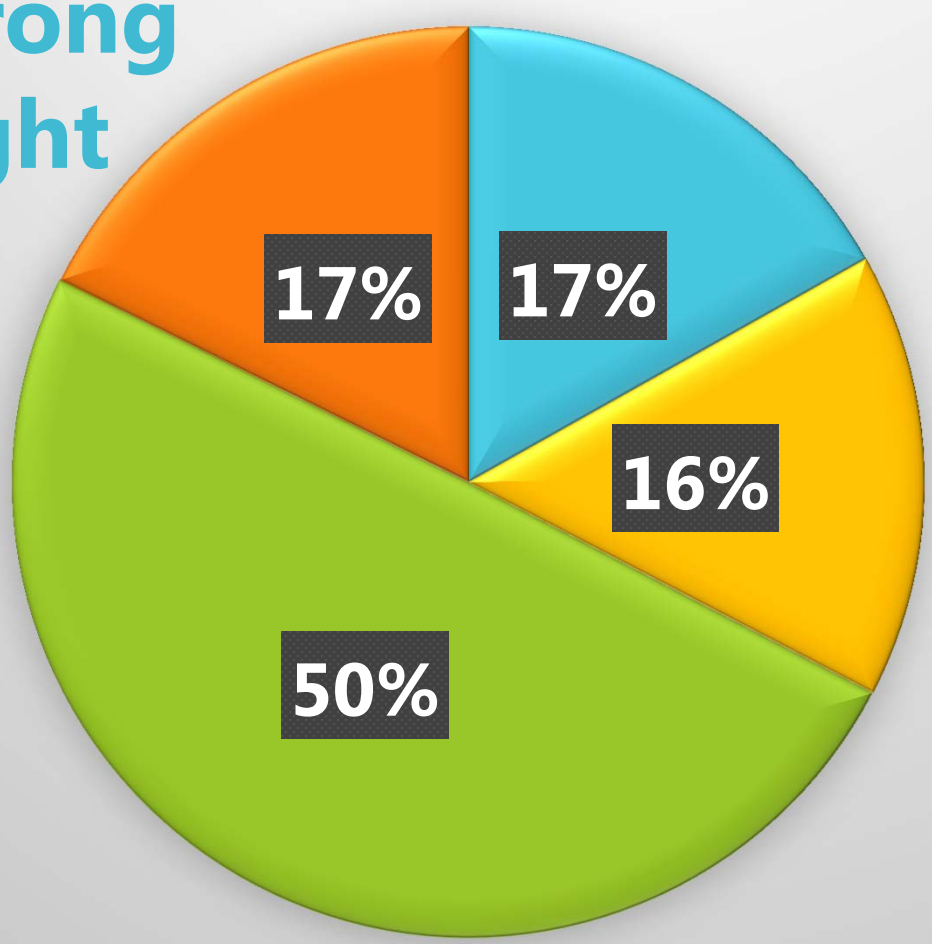
Is Sea Level Rise Occurring?



Which Evacuation Zone?

From Survey

122 wrong
276 right



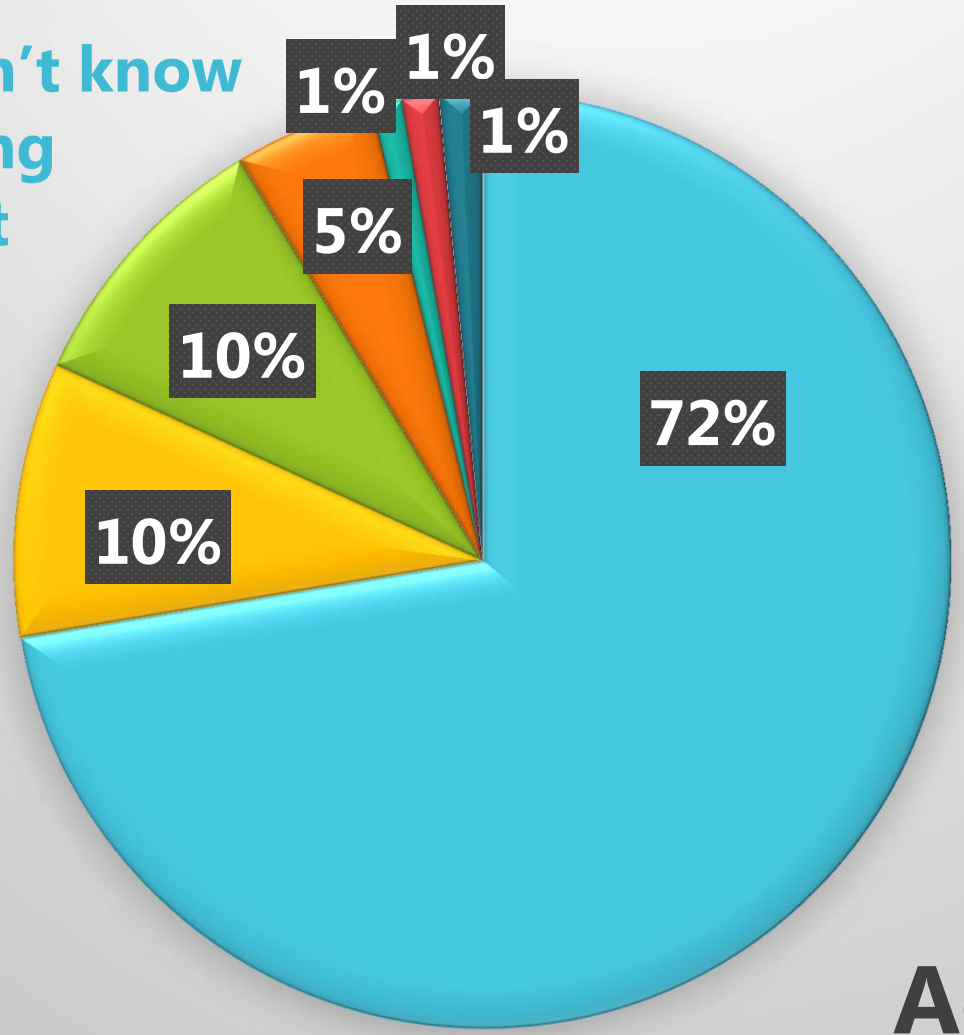
- Yes, Zone A
- Yes, Zone B
- No
- I don't know

Actual

Zone A	6%
Zone B	12%
No	82%

Which Flood Zone?
Survey answers

351 don’t know
73 wrong
63 right



I don't know
X
AH
AE
VE
other

Actual

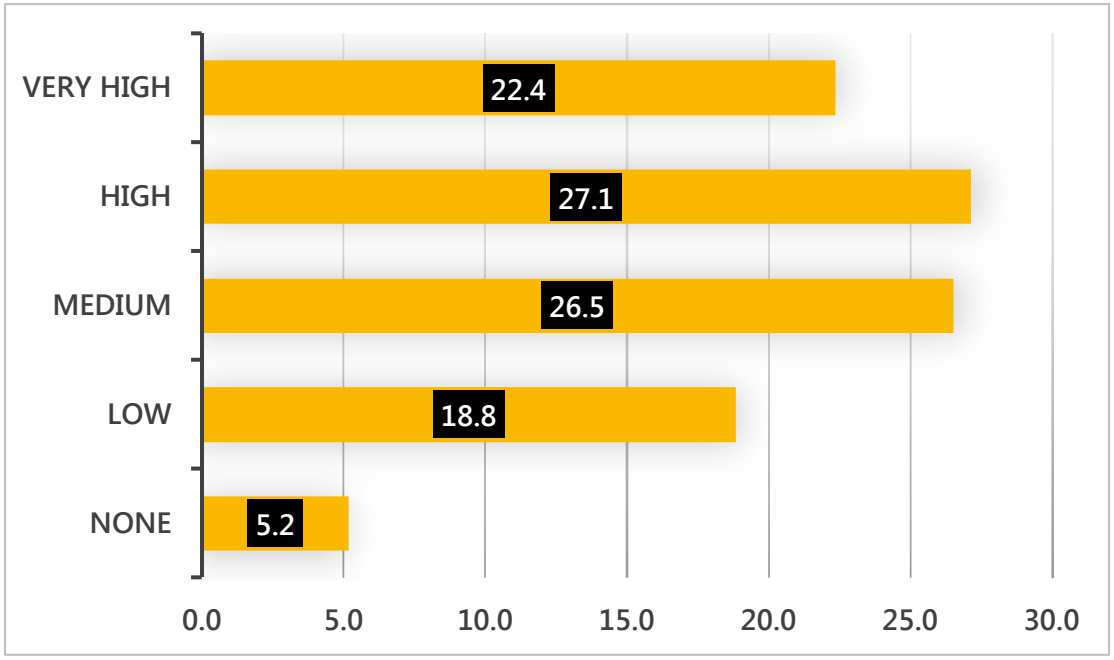
X	5%
AH	24%
AE	45%
VE	26%

QCA

Overall Concerns

Qualitative content analysis (QCA)

complex classification of large amounts of diverse information into categories with similar meanings



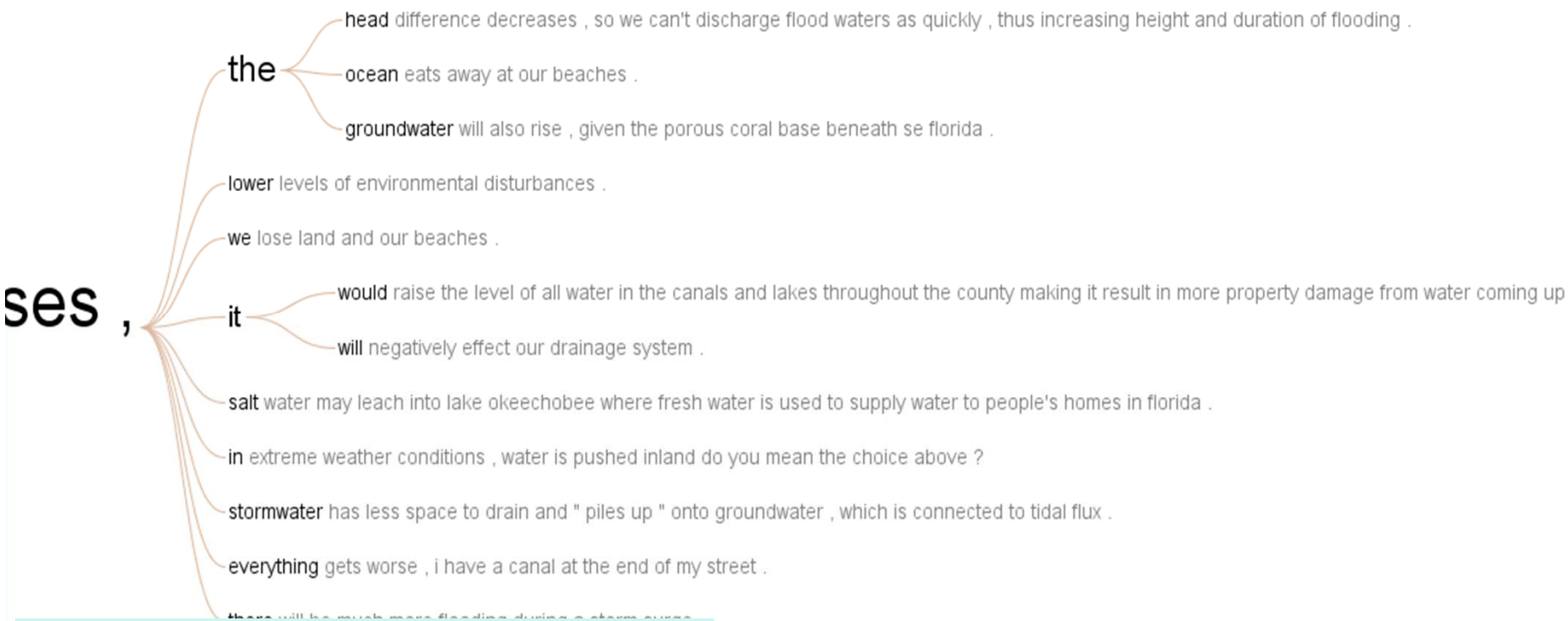
QCA

Q7) brief your for c and/ conc

Q8) sea-level affect flooding, storm surge, and extreme tides?

	Q7	Q8	total
flood	138	90	228
storm	94	89	183
storm surge	64	76	140
tide	21	83	104
high	46	55	101
sea-level rise	43	54	97
Home (house)	75	14	89
property	76	12	88
rain	54	21	75
coast	38	18	56
season	40	16	56
road/street	34	16	50
drain/drainage	32	17	49
ocean	31	18	49
hurricane	36	6	42
beach	29	13	42
inland	22	18	40
risk	29	10	39
canal	27	11	38
damage	24	12	36
low	24	9	33
impact	19	13	32
west	23	6	29
believe	21	6	27
weather	14	7	21

	Q7	Q8	total
elevation	11	7	18
ice	14	3	17
east	14	3	17
climate/change	10	7	17
worry	14	2	16
global warming	14	0	14
infrastructure	9	5	14
erosion/erode	7	7	14
intercoastal	10	3	13
rising sea-level	8	5	13
A1A	6	6	12
insurance	9	1	10
Sandy	6	4	10
Everglades	8	0	8
value	6	1	7
intrusion	3	4	7
evacuate	5	1	6
fear	4	1	5
flood control	4	1	5
pump	2	3	5
tax	3	1	4
Andrew	3	0	3
Wilma	3	0	3
seawall	2	1	3
water supply	1	2	3



"Concerns? None, the rise of sea levels hasn't been an inch in 10 years, and until the dire predictions show some substance, I am not concerned, except for the scare campaigns like this that could raise insurance rates pre-maturely, and devalue my property"

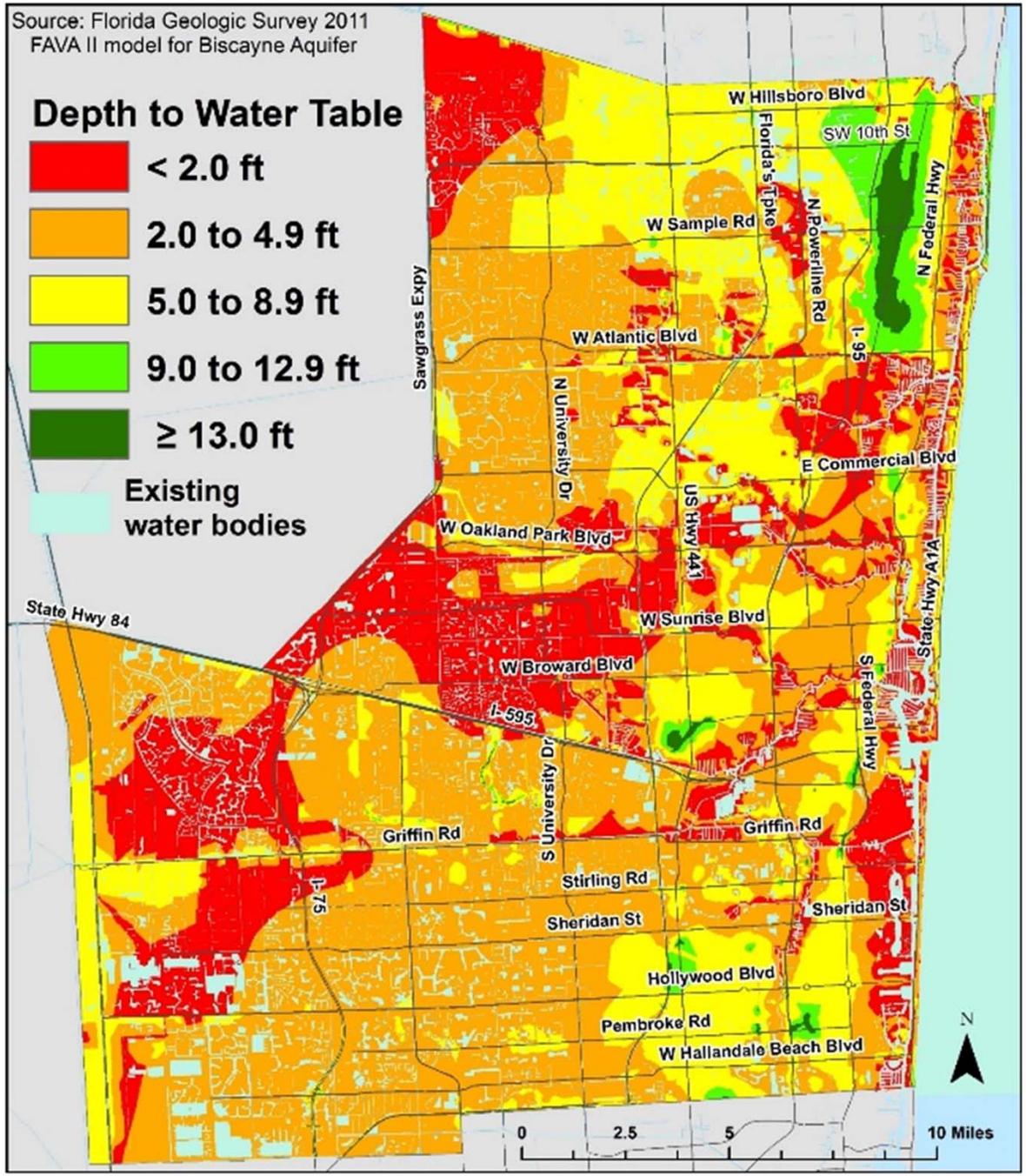
- ***Solutions/Change in Behavior***
  - NO "adapt", "adaptation", "resilient", and "resilience" (1 mitigation…)
  - 16 more specific suggestions
  - Considerations for where to live/buy home
- ***Economic Considerations***
  - Problems with development,
  - taxes, insurance, home value

ttp://www-
58.ibm.com/software/analytics/manyeyes/
isualizations/new/word-tree/slr/1

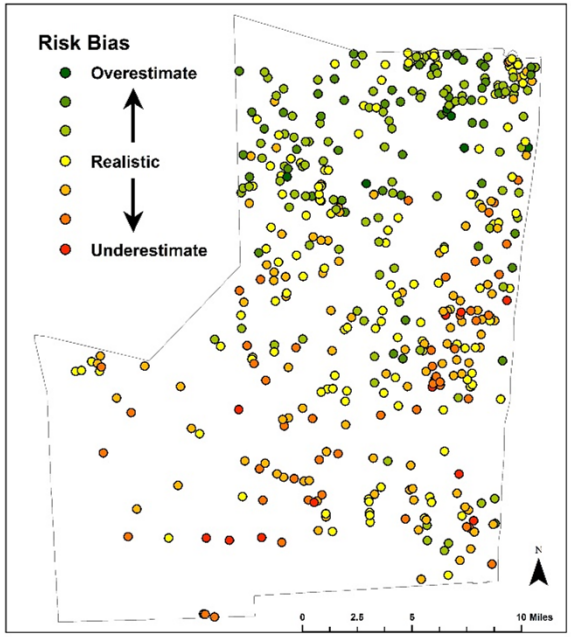
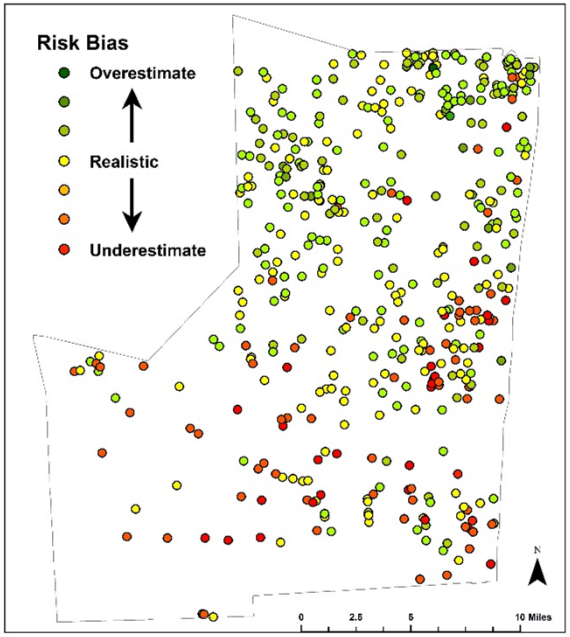
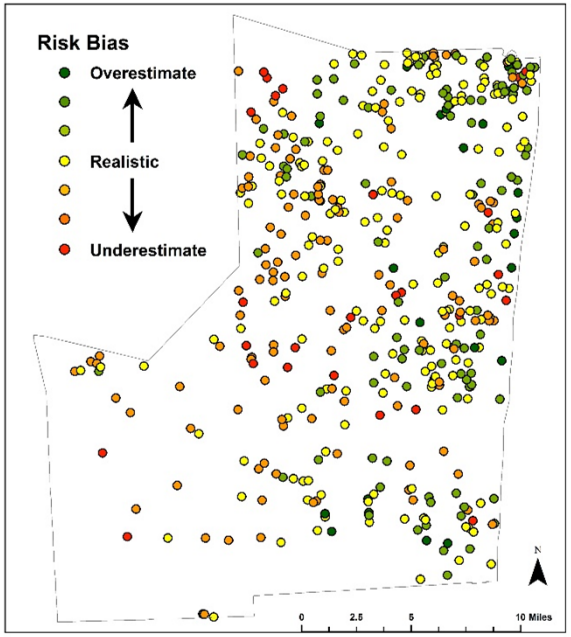
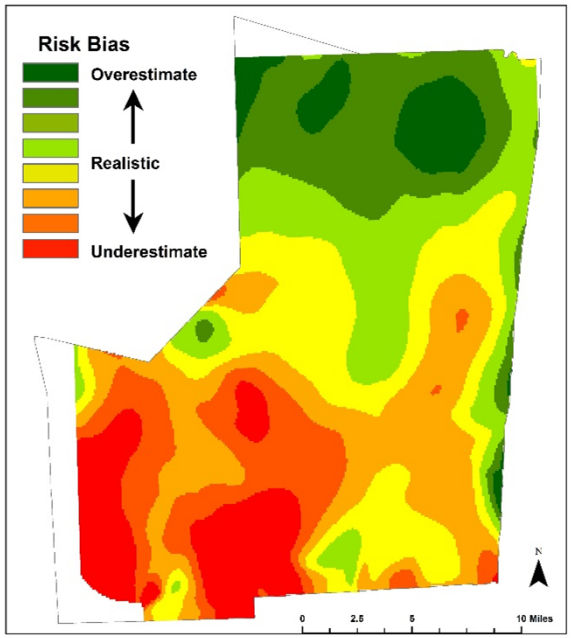
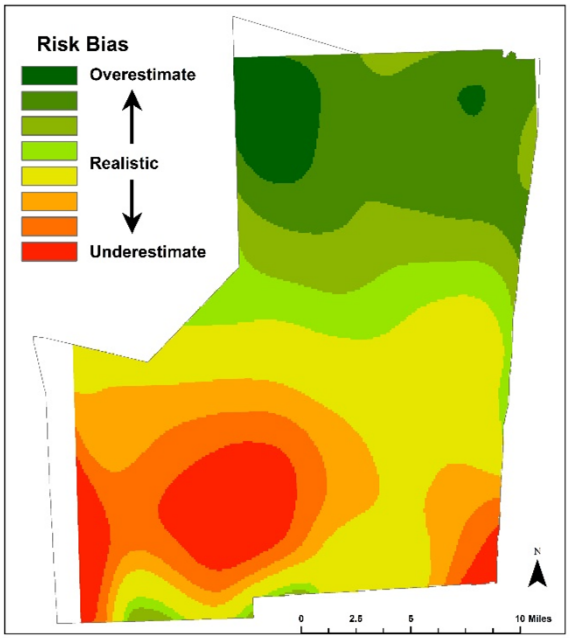
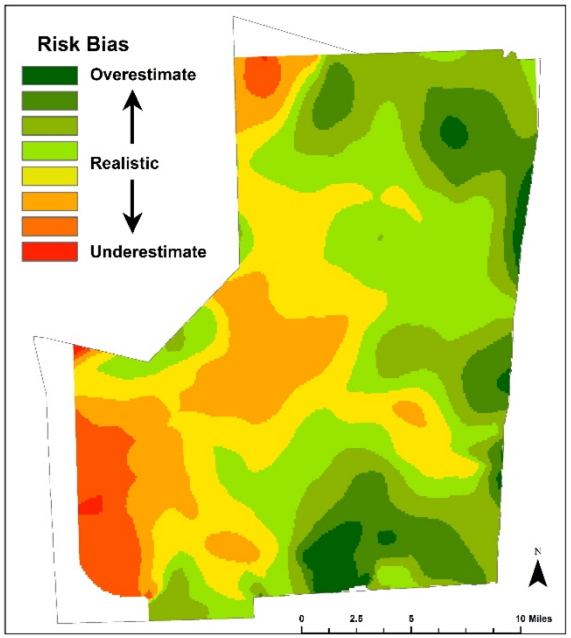
P vs A

ACTUAL Risk

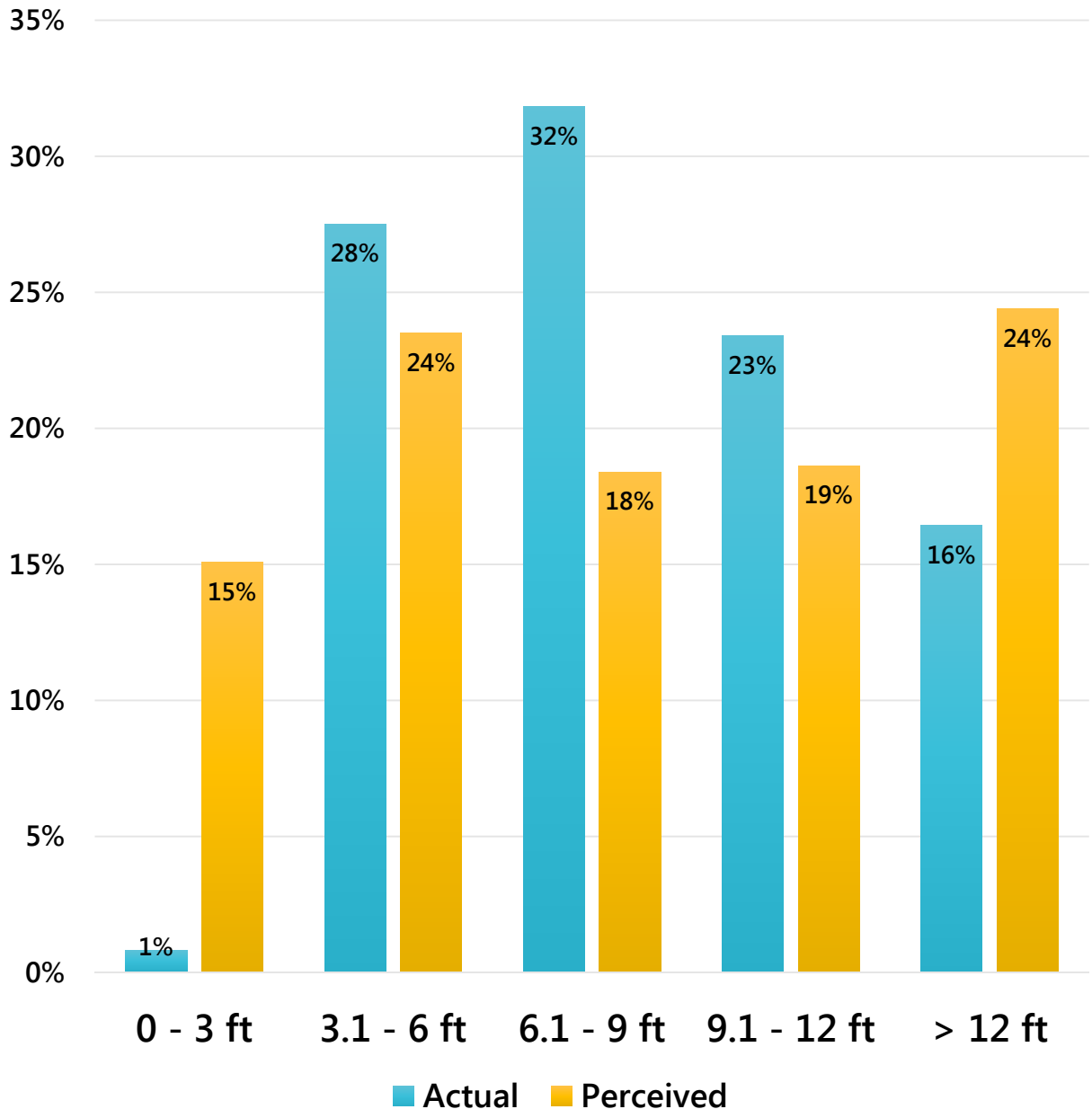
Relative Indices



P vs A

	Elevation	Storm Surge	Flooding
Respondents			
Trend Analysis			

P vs A



Elevation Accurate within	Percent
1 ft	14.6%
2 ft	34.1%
5 ft	64.8%
10 ft	85.0%
15 ft	92.0%
Off by over 15 ft	8%

Conclusion

- This risk to land loss (elevation) and storm surge and was underestimated in coastal, low-lying areas towards the south
- The risk to flooding was underestimated mainly by respondents in inland areas

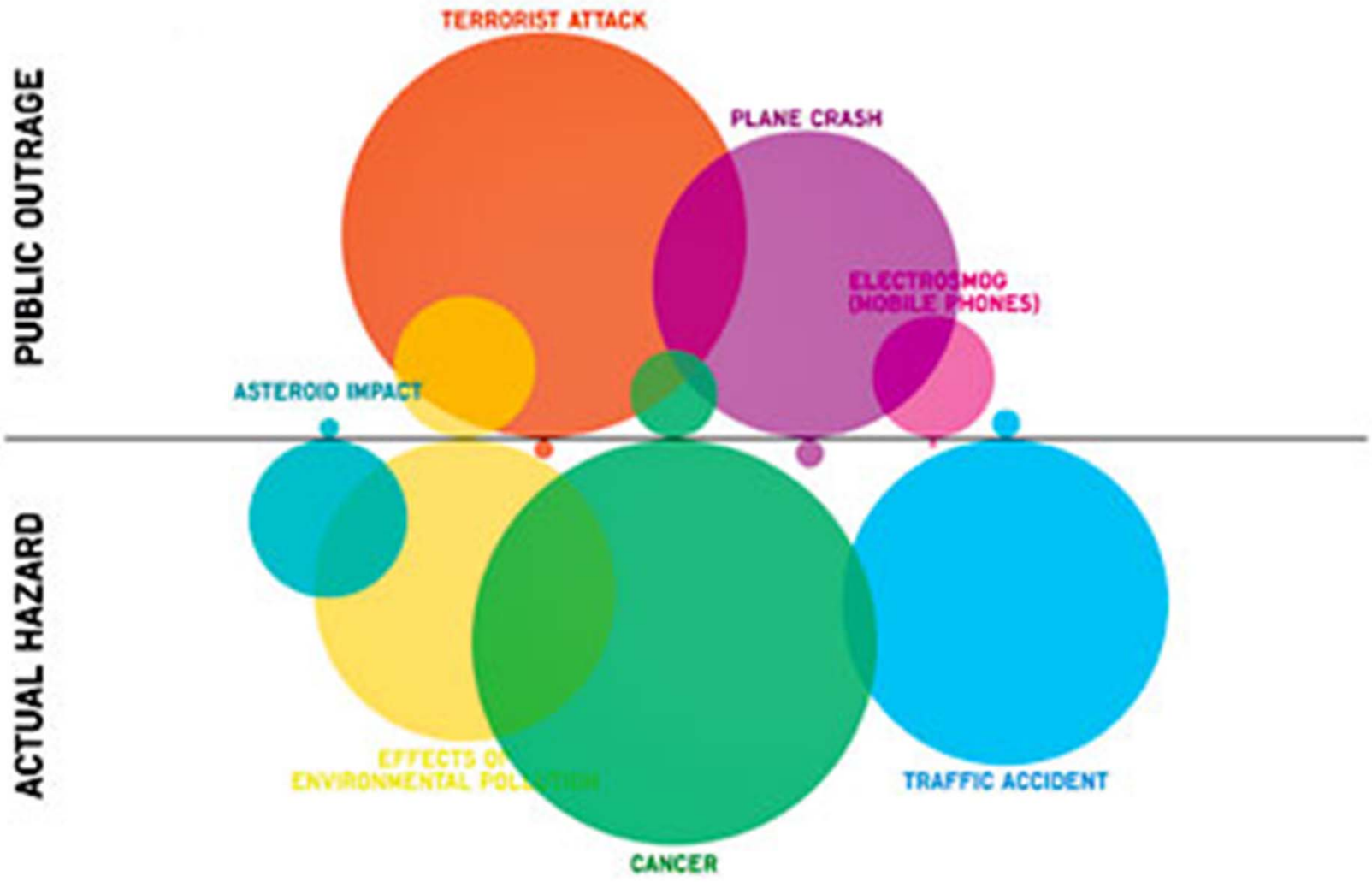
Risk Communication

- Instils a sense of urgency &
- A call to action
- But still a sense of hope

Why aren't people concerned?

-
- 2100? I'll be dead by then
- Organized effort at disinformation
- Insurance - NFIP
- Policy - CCCL
- Media
- Risk Perception characteristics

RISK PERCEPTION AND ACTUAL HAZARDS



www.susannahertrich.com

DEO

South Florida Regional Planning Council

USGS
science for a changing world

South Florida Water Management District
Protector of the Everglades Since 1949

US Army Corps of Engineers®

SOUTHEAST FLORIDA
REGIONAL COMPACT
CLIMATE CHANGE

Florida Climate Institute

seven counties 50 years
SE Florida Prosperity Plan

FAU
Florida Atlantic University

Florida State University 1851

University of Central Florida

UF
University of Florida

University of Miami

USF
University of South Florida

A lot is being done!

- **Miami-Dade County Sea Level Rise Task Force – Recommendations Report**
  - www.miamidade.gov/planning/library/reports/sea-level-rise-report-recommendations.pdf
  - **2 Resolutions already!**
- **Miami-Dade Mayor Carlos A. Gimenez at 6th Annual Southeast Florida Climate Leadership Summit**
- **Comprehensive Development Master Plan's (CDMP) Evaluation and Appraisal Report**, identifies climate change as a top priority and includes language on **Adaptation Action Areas**
- **Urban Miami-Dade County Surface-Water/Groundwater Model**

Section 163.3164(1), Florida Statutes **Adaptation Action Area** or "adaptation area" means a designation in the **coastal management element** of a local government's **comprehensive plan** which identifies one or more areas that experience **coastal flooding** due to **extreme high tides** and **storm surge**, and that are vulnerable to the related impacts of **rising sea levels** for the purpose of **prioritizing funding** for **infrastructure needs** and **adaptation planning**.

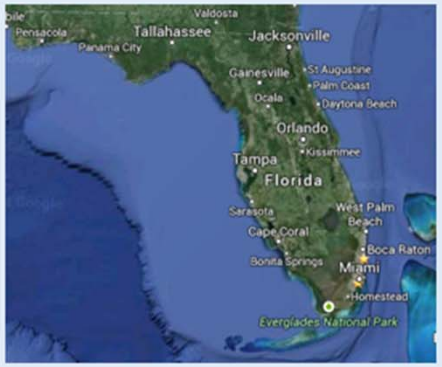
Criteria for the adaptation action area may include, but need not be limited to:

- areas for which the land elevations are below, at, or near **mean high water**;
- which have **hydrologic connection** to coastal waters; and/or
- which are designated as **evacuation zones** for **storm surge**.

flash floods

high-tide events

storm surge



Adaptation Action Areas

stormwater runoff

related impacts of sea-level rise

Strategies for Adaptation Action Areas may include

- **Protection**
- **Accommodation**
- **Managed retreat**
- **Avoidance**
- **Other options**

Protection

Strategies that involve “hard” and “soft” structurally defensive measures to mitigate impacts of rising seas in order to decrease vulnerability to coastal hazards while allowing structures and infrastructure to remain largely unaltered.

Accommodation

Strategies that do not act as a barrier, but rather alter the design through measures such as vertical elevation of structures or stormwater system improvements.

Managed Retreat/Relocation

Strategies that involve the possible relocation of existing development to other areas, and/or the prevention of future development in high-risk areas.

Avoidance

Involves guiding development away from areas subject to coastal hazards associated with sea level rise or where the risk of coastal flooding inundation is moderate at present but the risk may increase over time.

What more needs to be done?

We need a powerful message

Framing sea level rise messages

- **Health Impacts**
- **Financial Impacts**
- **Cultural Preservation**
- **Habitat Loss**
- **Environmental Justice**
- **Sustainability for future generations**

Learn More – Map your risk

- http://sealevel.climatecentral.org/
- csc.**noaa**.gov/slr/**viewer**

- **Or contact me –**
  - **Keren143@gmail.com**
  - **www.Kbolter.com**
  - **twitter: SLRBrowardFL**

Thank you!

BBRRCT

SFRPC - Jim Murley

CES – Colin Polsky

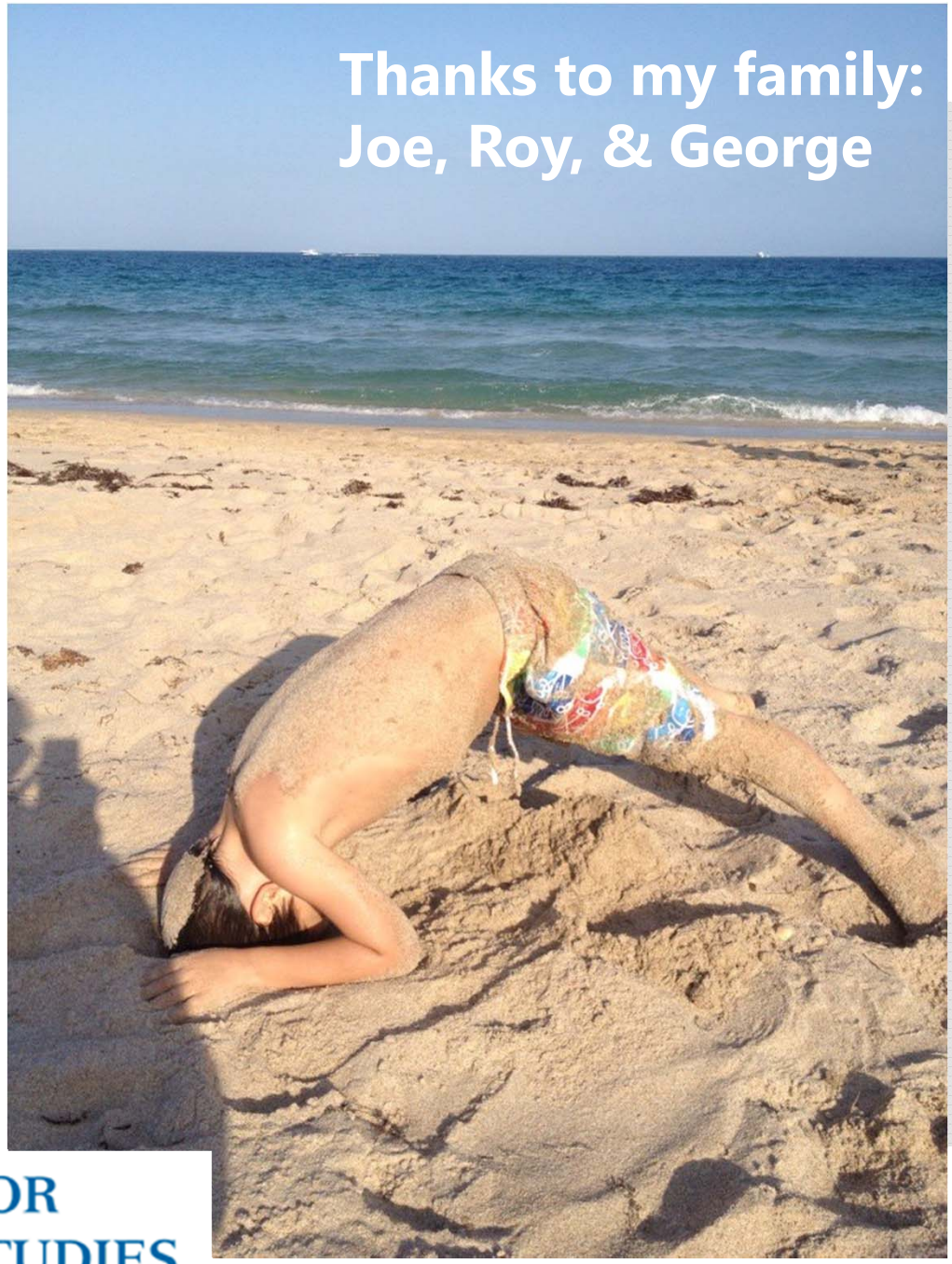
and my committee:

Tobin Hindle

Tara Root

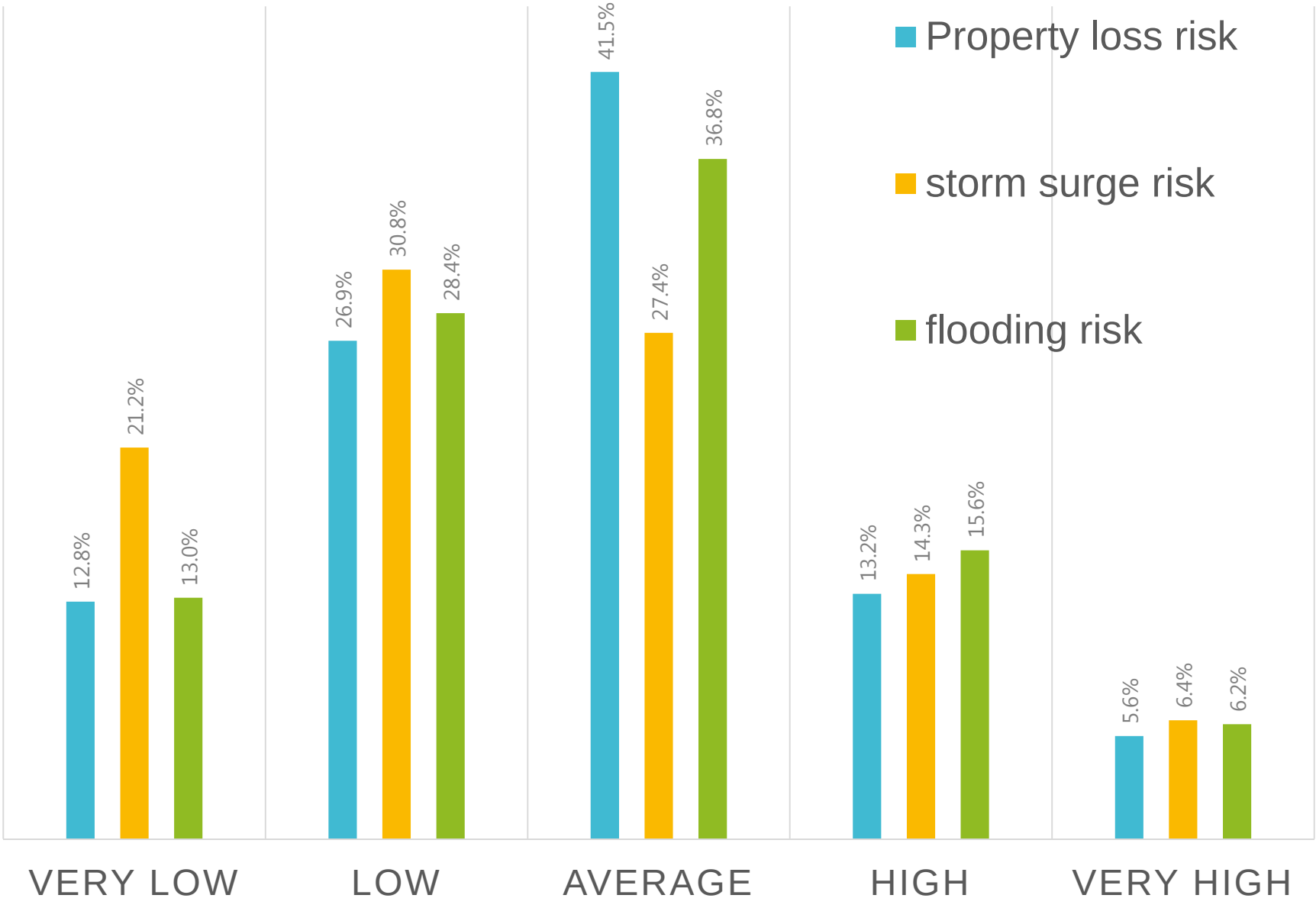
Jayantha Obeysekera

Diana Mitsova



FLORIDA CENTER FOR ENVIRONMENTAL STUDIES

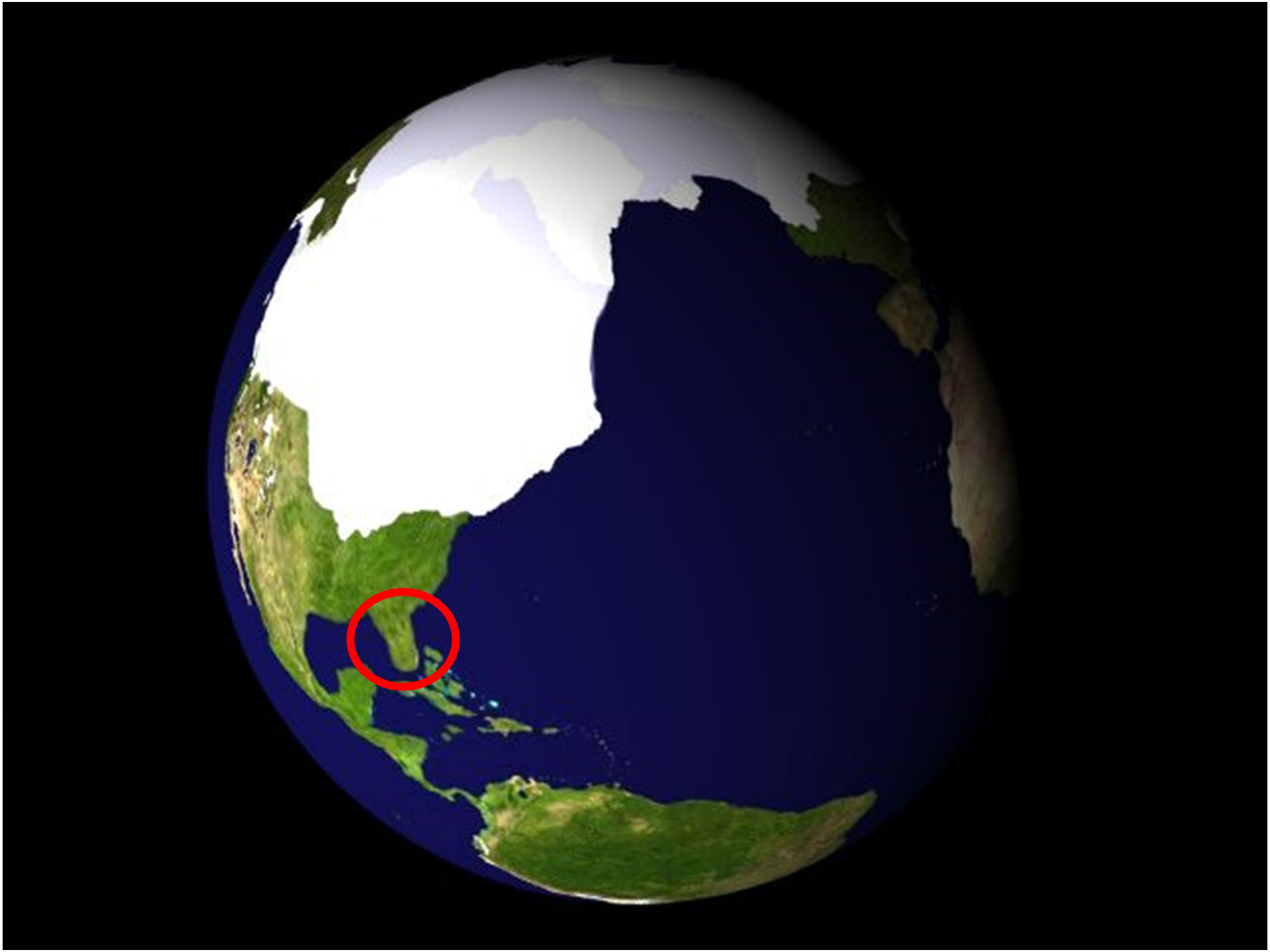
P vs A


Property loss risk
storm surge risk
flooding risk
12.8%
21.2%
13.0%
26.9%
30.8%
28.4%
41.5%
27.4%
36.8%
13.2%
14.3%
15.6%
5.6%
6.4%
6.2%
VERY LOW
LOW
AVERAGE
HIGH
VERY HIGH

QCA

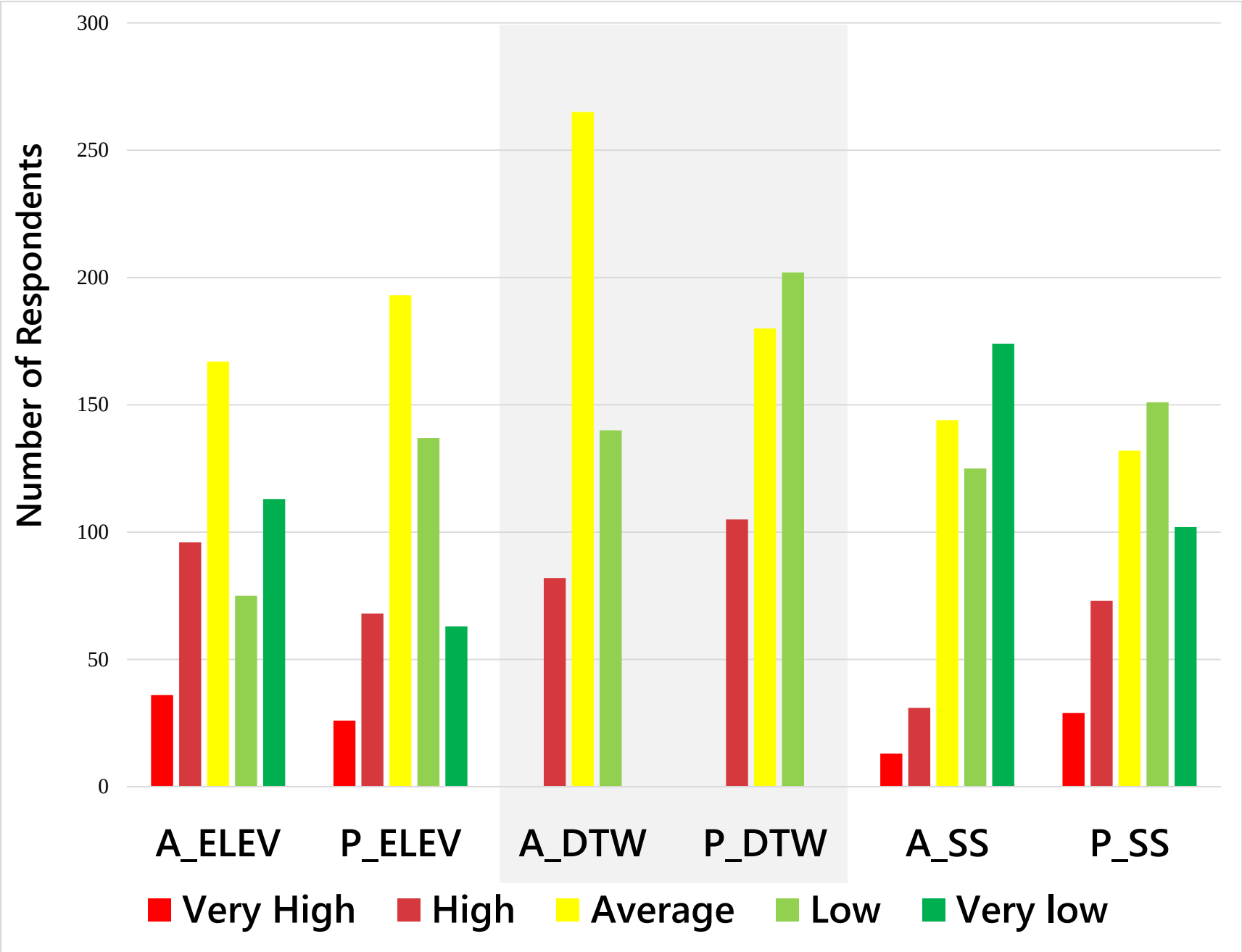
"Which sources of information, if any, do you feel have informed you the most about sea-level rise?"

- Of 401 responses, most popular
  - **Internet**/web/online (78)
  - **TV** network (71)
    - Discovery Channel (20). National Geographic (16)
  - **News** network (61)
    - CNN (17), NBC (16), Weather Channel (12),
  - **Magazine** (43)
    - National Geographic(16), TIME (13)
  - **Newspaper** (42)
    - Sun Sentinel (32), Miami Herald (11)
  - **Radio** – NPR/WLRN (29)
  - Also sources from **groups** (NOAA, 9) (SFRCC, 7)
  - Other:
    - Education/Academic (66)
    - Personal Communication/Experience (50)
    - Event (29)
  - **climate change (9) vs global warming (4)**

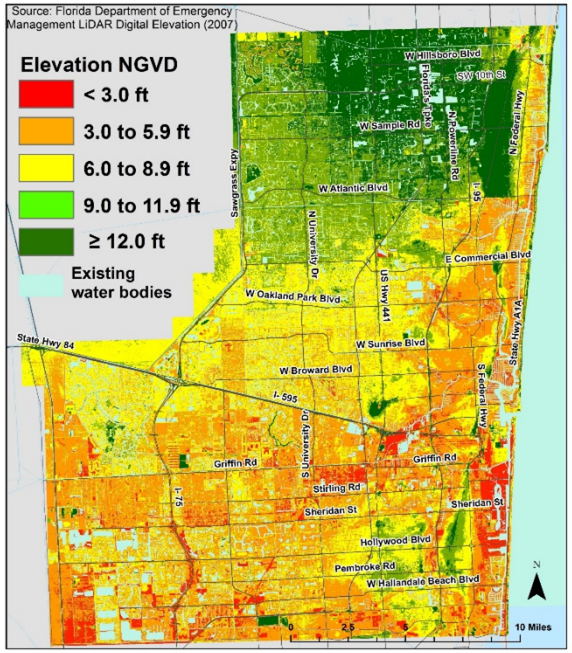


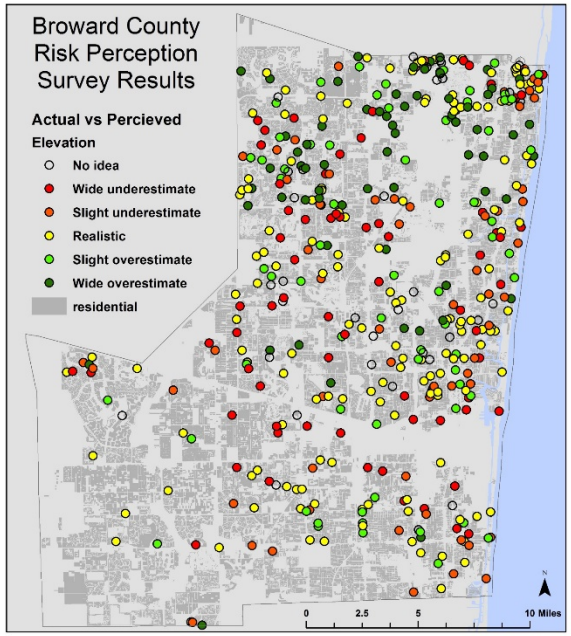
200 MILES
0 100 200 300
KILOMETERS

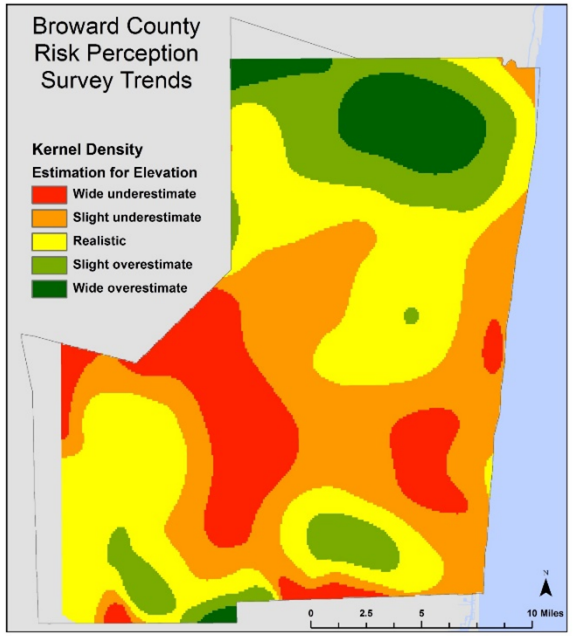
P vs A


Number of Respondents
300
250
200
150
100
50
0
A_ELEV
P_ELEV
A_DTW
P_DTW
A_SS
P_SS
Very High
High
Average
Low
Very low

P vs A

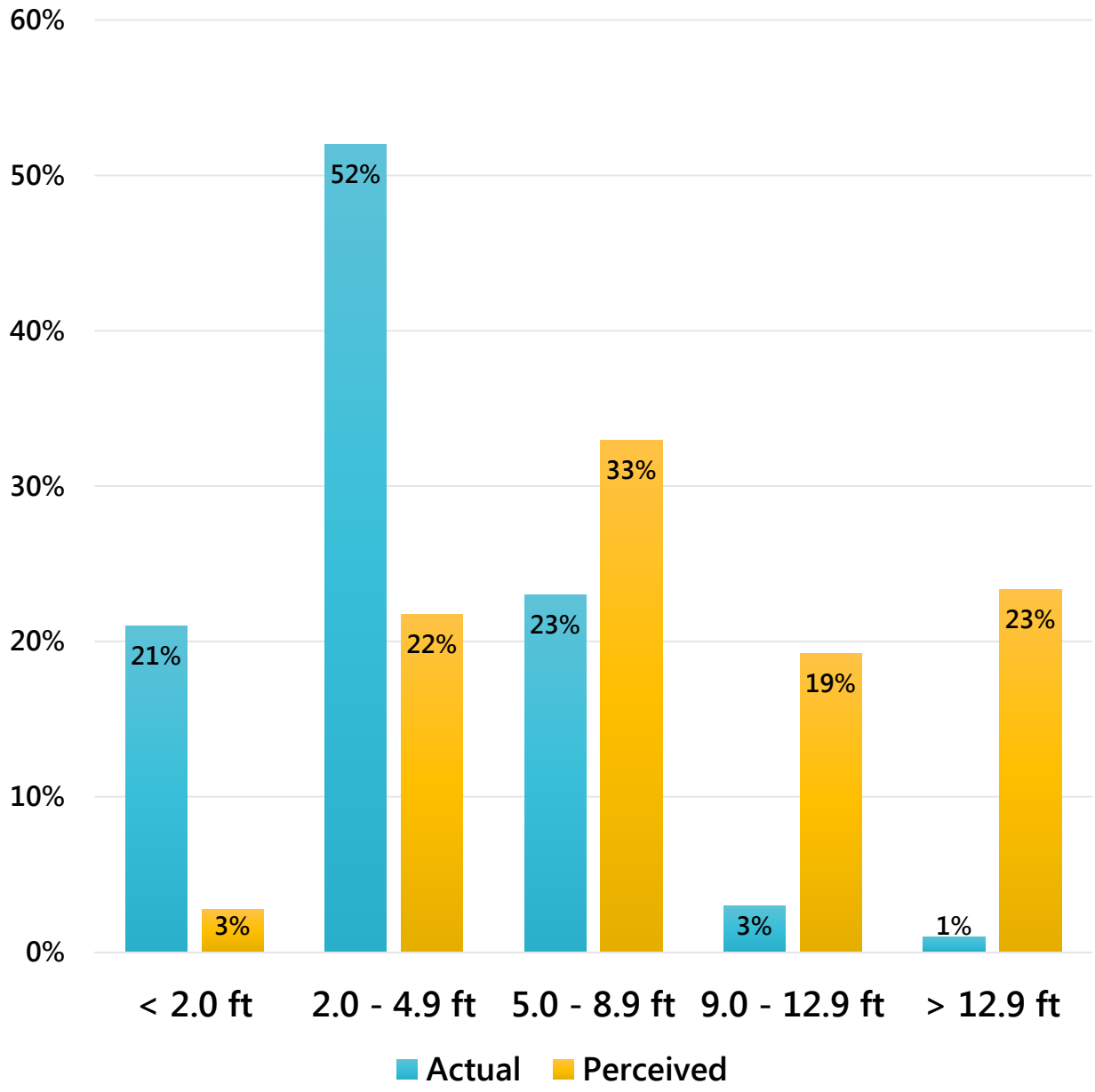






Class	Difference in Elevation	Respondent count
Wide underestimate (WUE)	> 6.20	72
Underestimate (UE)	2.40 < UE < 6.20	68
Realistic (R)	-2.20 < R < 2.40	172
Overestimate (OE)	-5.05 < OE < -2.20	68
Wide overestimate (WOE)	< -5.05	72

P vs A



59% underestimated DTW

2/3 of people did not comprehend that elevations were higher than the DTW

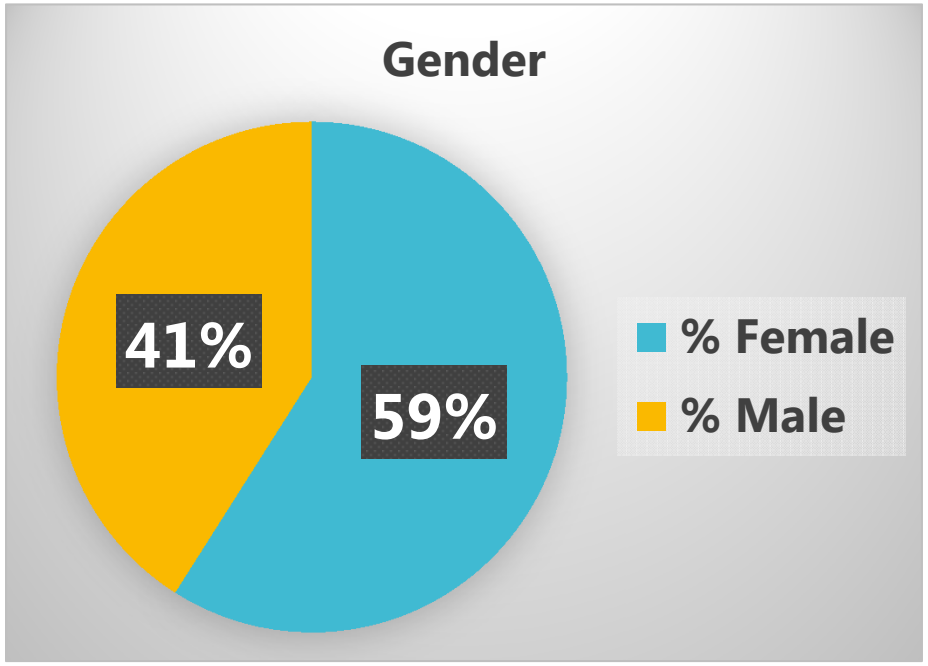
P vs A

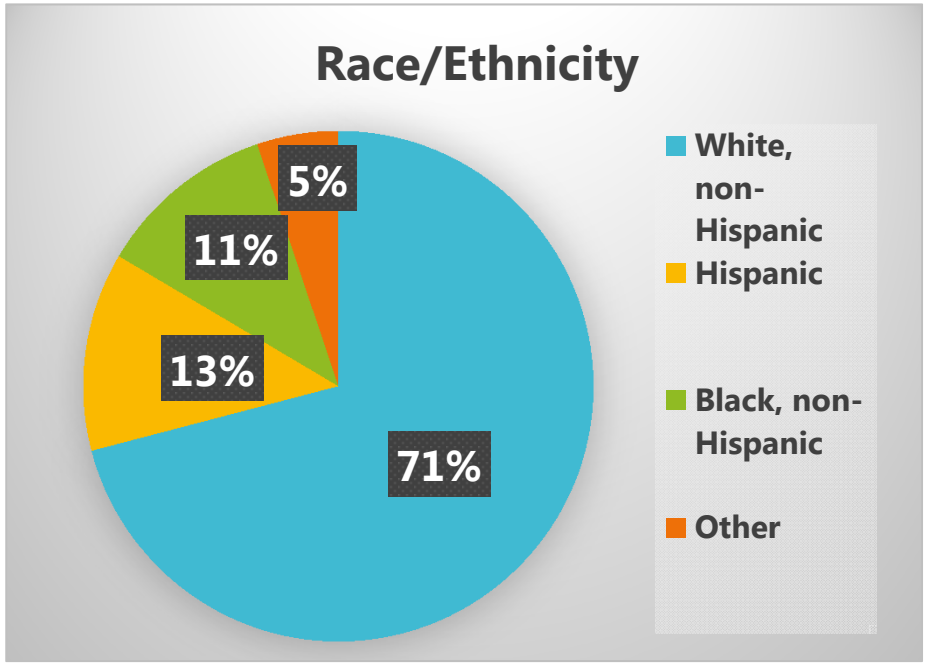
Relative Risk Bias Indices

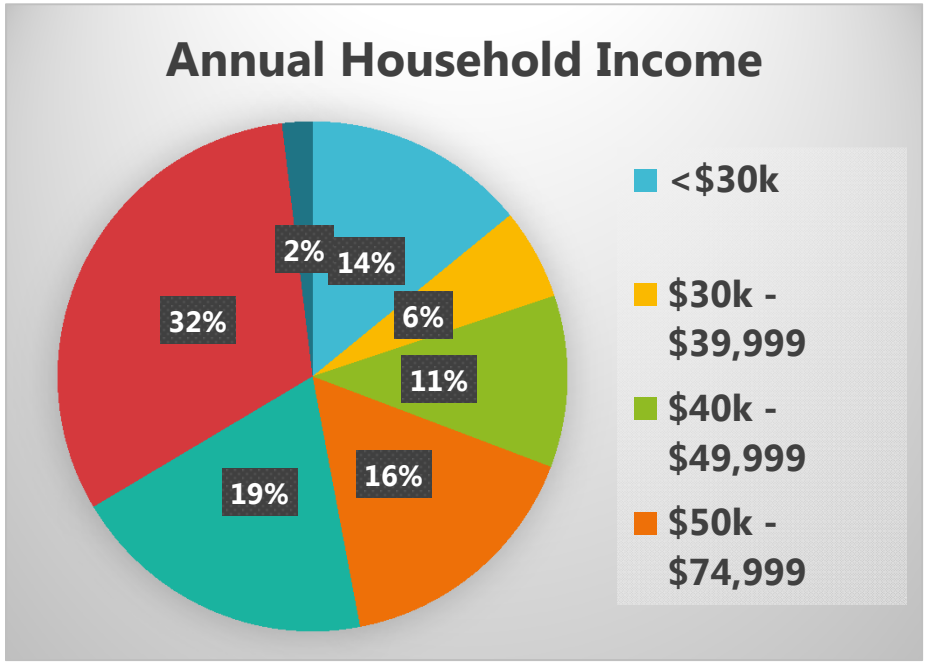
Actual Risk Index					
VH	WUE	WUE	UE	UE	R
H	WUE	UE	UE	R	OE
A	UE	UE	R	OE	OE
L	UE	R	OE	OE	WOE
VL	R	OE	OE	WOE	WOE
	VL	L	A	H	VH
	Respondent Likert Response				

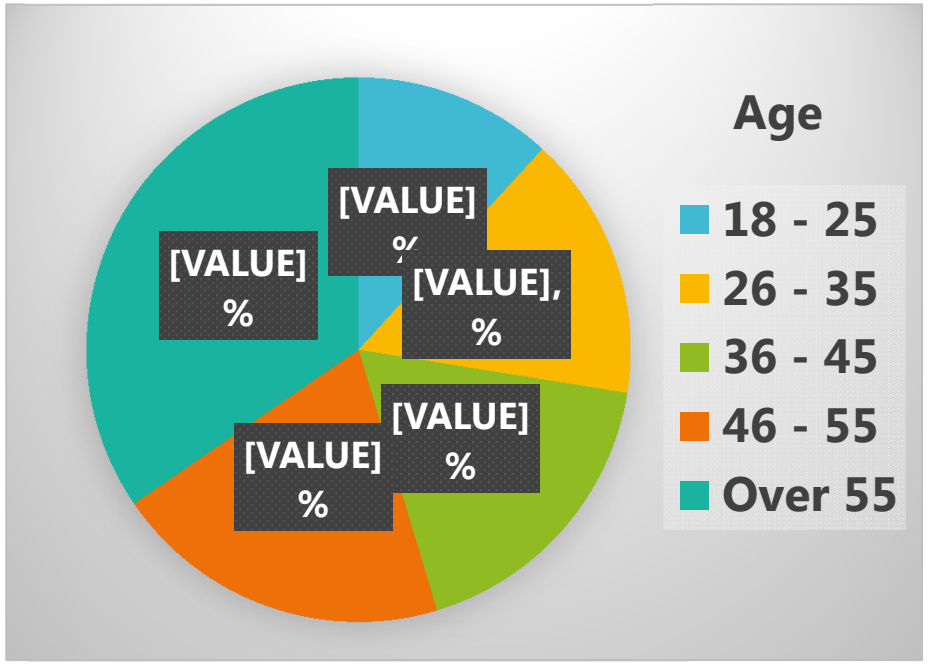
Scale (decreasing exposure)	Storm Surge depth (ft)	Elevation (ft)	DTW (ft)
1 - Very High	> 5.5	< 4.2	
2 - High	3.7 - 5.5	4.2 - 5.9	< 2.0
3 - Average	1.9 - 3.7	5.9 - 9.3	2.0 - 4.9
4 - Low	0.1 - 1.9	9.3 – 11.0	> 4.9
5 - Very Low	0 (dry)	>11.0	

Actual Risk Index			
H	WUE	UE	R
A	UE	R	OE
L	R	OE	WOE
	L	A	H
	Respondent Likert Response		


Gender
41%
59%
% Female
% Male


Race/Ethnicity
5%
11%
13%
71%
White, non-Hispanic
Hispanic
Black, non-Hispanic
Other


Annual Household Income
2%
14%
6%
11%
16%
19%
32%
<$30k
$30k - $39,999
$40k - $49,999
$50k - $74,999


Age
[VALUE] %
[VALUE] %
[VALUE], %
[VALUE] %
[VALUE] %
18 - 25
26 - 35
36 - 45
46 - 55
Over 55