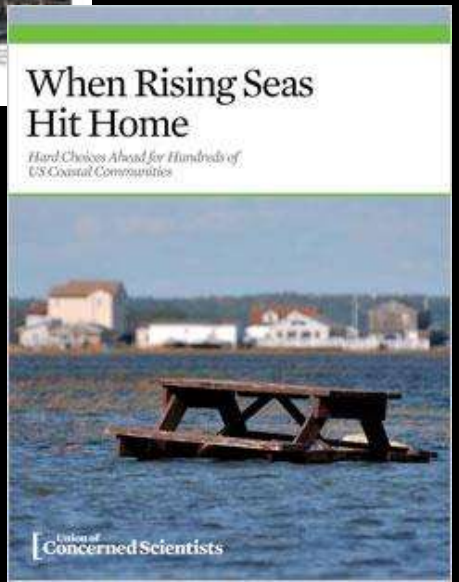
Underwater:

Rising Seas, Chronic Floods, and the Implications for U.S. Coastal Property

Shana Udvardy, Climate Resilience Analyst


Encroaching Tides
How Sea Level Rise and Tidal Flooding Threaten U.S. East and Gulf Coast Communities over the Next 30 Years
Union of Concerned Scientists


Union of Concerned Scientists
EXECUTIVE SUMMARY
The US Military on the Front Lines of Rising Seas
Growing Exposure to Coastal Flooding at East and Gulf Coast Military Bases


When Rising Seas Hit Home
Hard Choices Ahead for Hundreds of US Coastal Communities
Union of Concerned Scientists


Underwater
Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate
PRICE REDUCED
WATERFRONT
Union of Concerned Scientists

Our Coast & Why we did this work

What we did and found

Chronic inundation + Properties at risk

Mapping Chronic Inundation

1. Tide gauge records

Photo: NOAA

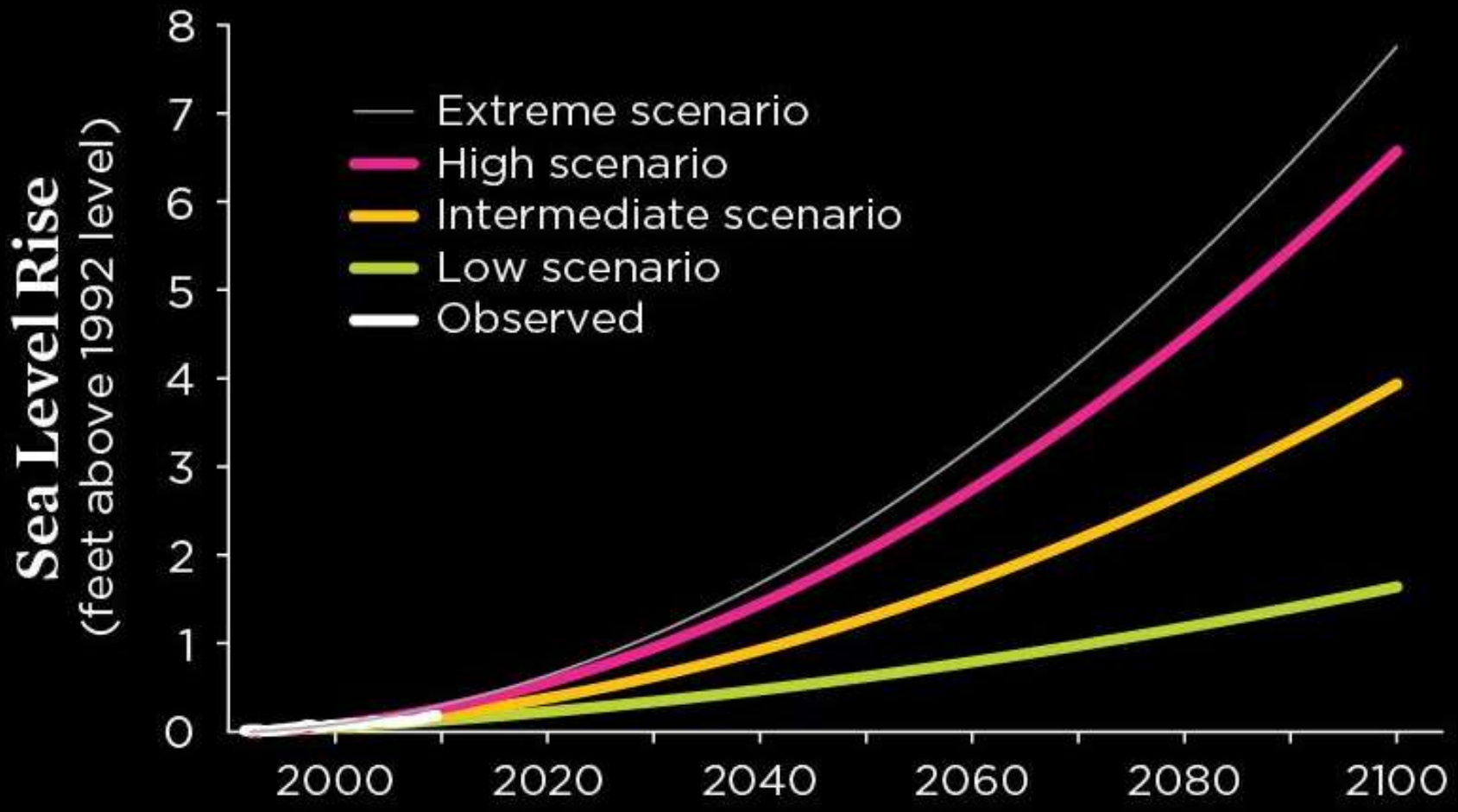
Mapping Chronic Inundation

2. Digital Elevation Models

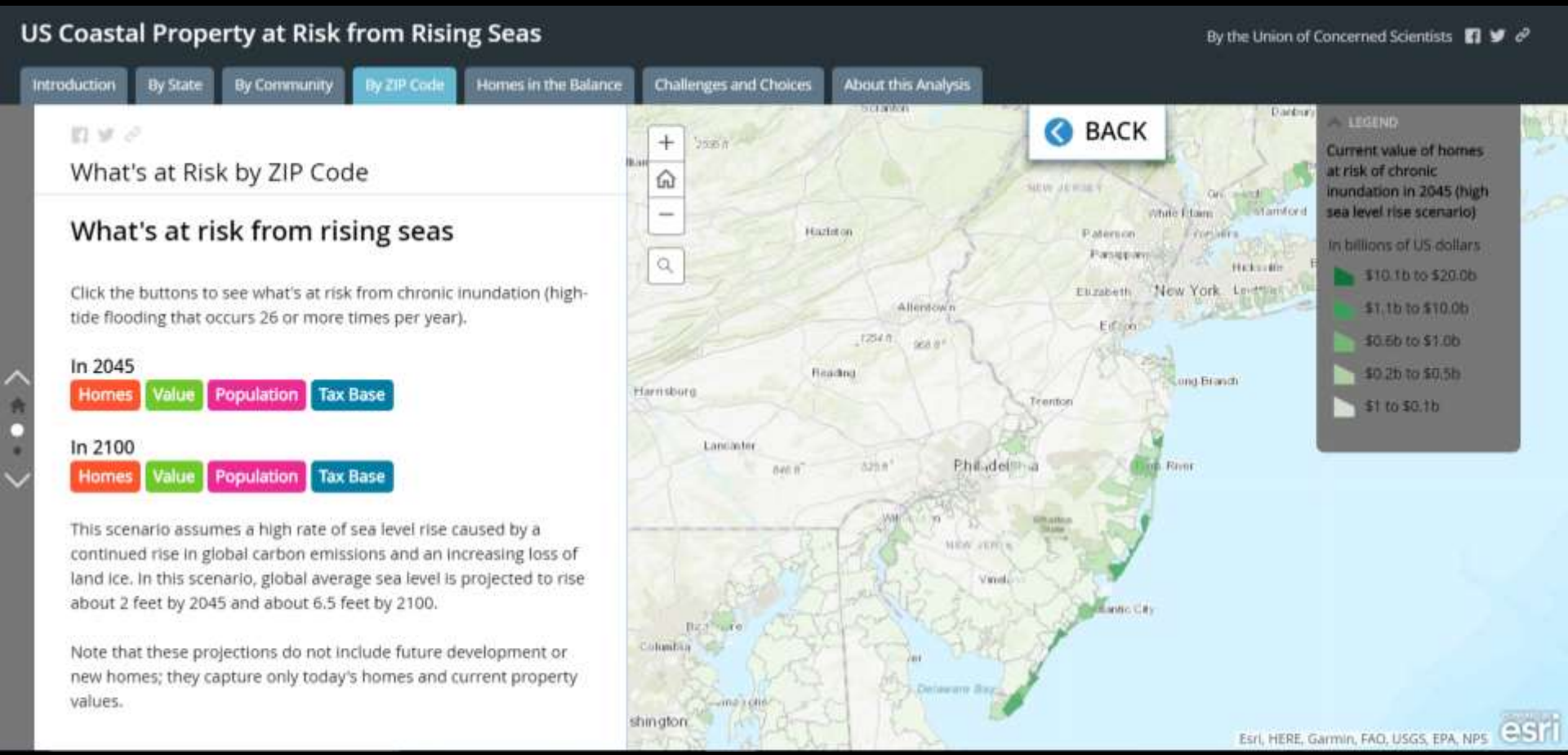
Photo: NOAA

Mapping Chronic Inundation

3. Sea level rise projections



US Coastal Property at Risk from Rising Seas



**Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX). More information on accessing the data can be found at http://www.zillow.com/ztrax. The results and opinions presented in this report are those of the author(s) and do not reflect the position of Zillow Group.*

Number of homes at risk of chronic inundation

2045:

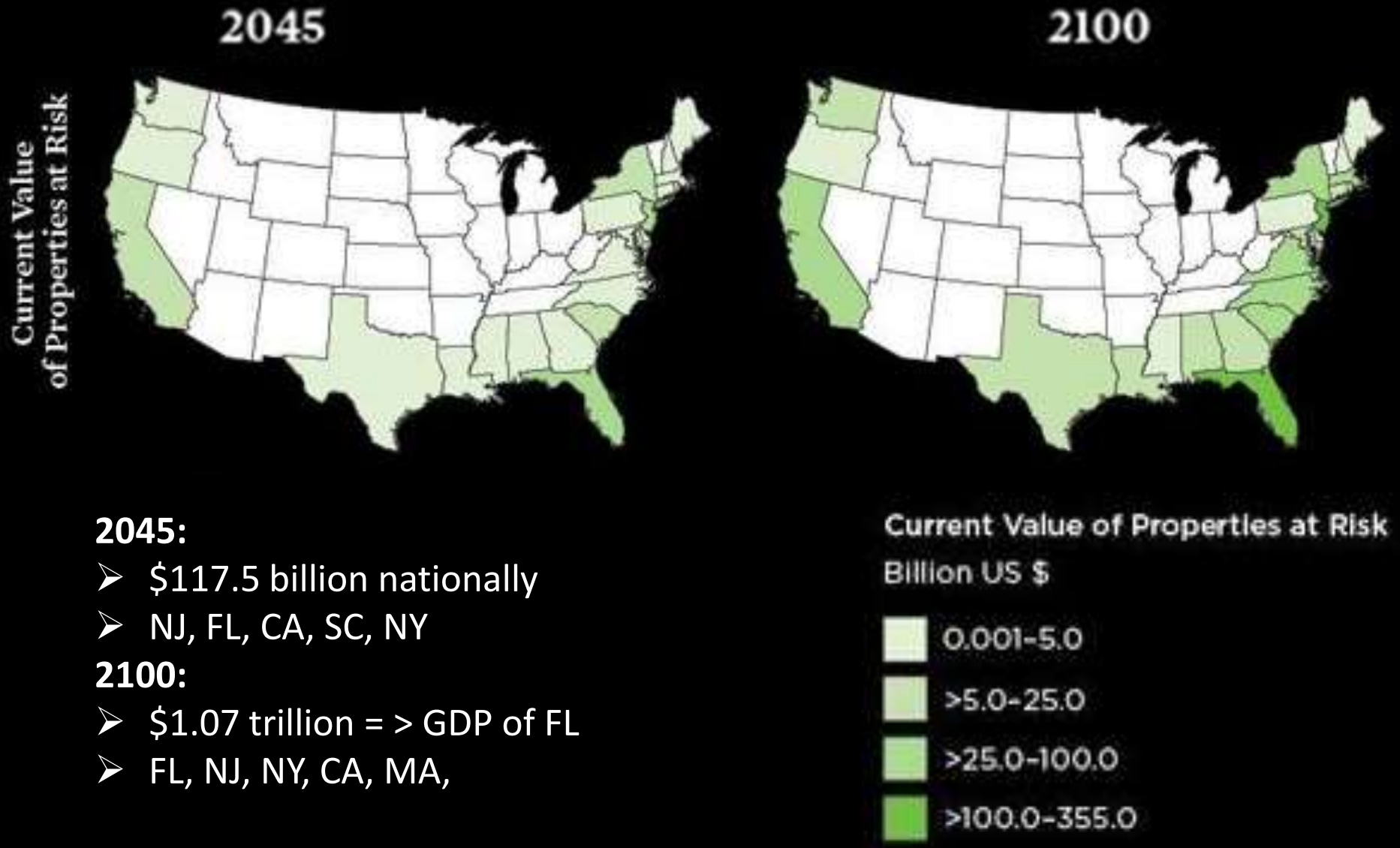
- 300,000 homes
- 4.7 million people (size of LA)
- 14,00 commercial businesses

2100:

- ~2.4 million homes
- 100,000 commercial properties

Florida, New Jersey, Louisiana, California

Current market value of properties at risk



2045:

- $117.5 billion nationally
- NJ, FL, CA, SC, NY

2100:

- $1.07 trillion = > GDP of FL
- FL, NJ, NY, CA, MA,

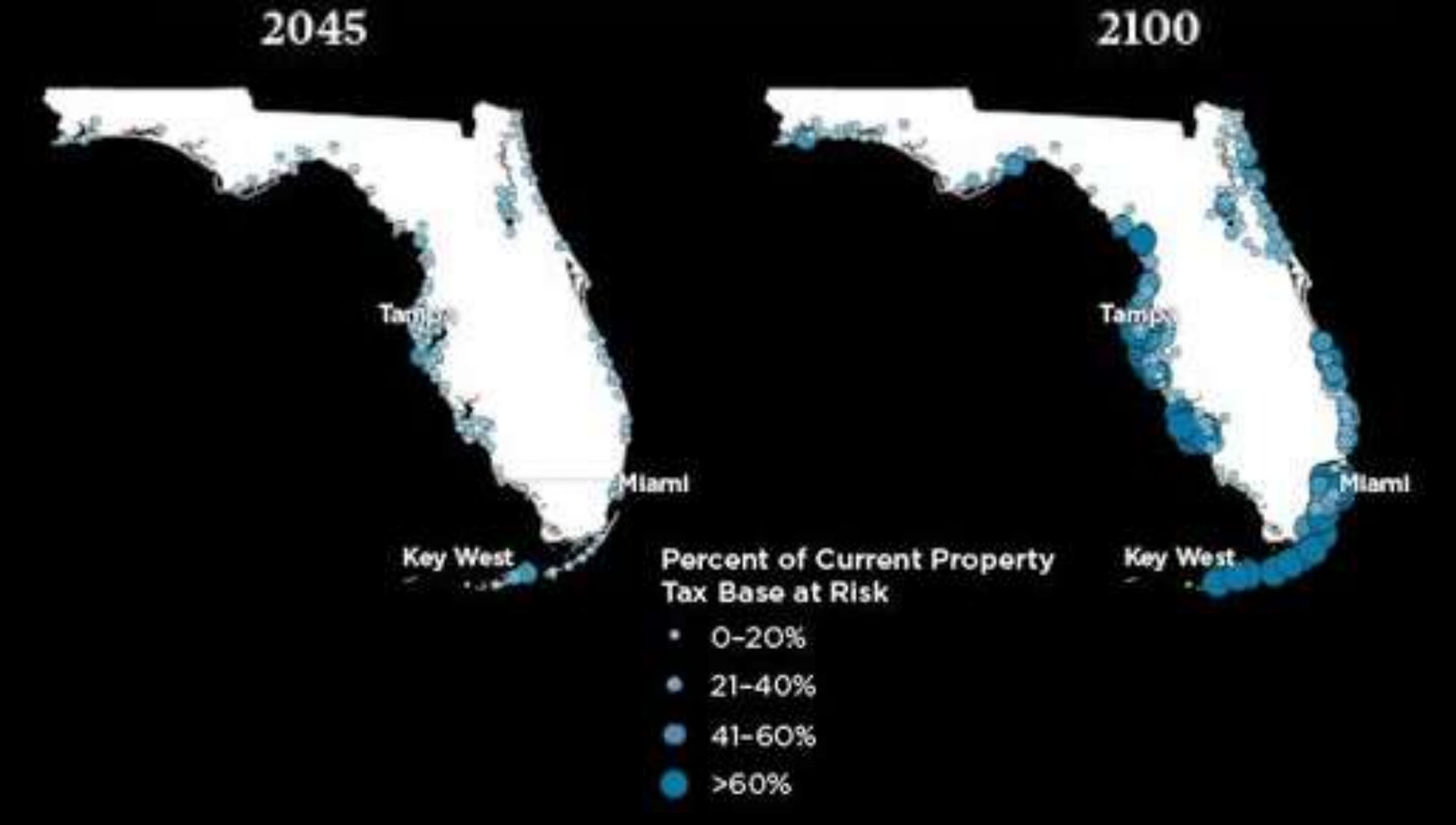
Current tax base contribution of properties at risk

2045:

- **80 communities =** 25% or > of the local property tax base
- **30 communities** = > ½ local property tax base at risk

Acute Exposure in Florida:

Percent of Current Property Tax Base at Risk



Housing Risk Hotspots

Bay Area:

- ~13,000 homes
- 33,000 people

Current Population Living in At-Risk Properties

- 1-500
- 501-1,000
- 1,001-2,500
- 2,501-5,000
- 5,001-11,000

Long Island:

- 15,000 homes
- ~40,000 people

Poverty, race, & tides create hotspots of risk

Nationwide, in 2045, approx. 175 communities could see 10% or > of housing stock at risk & ~40% are low-income communities w/ poverty levels above the national average.

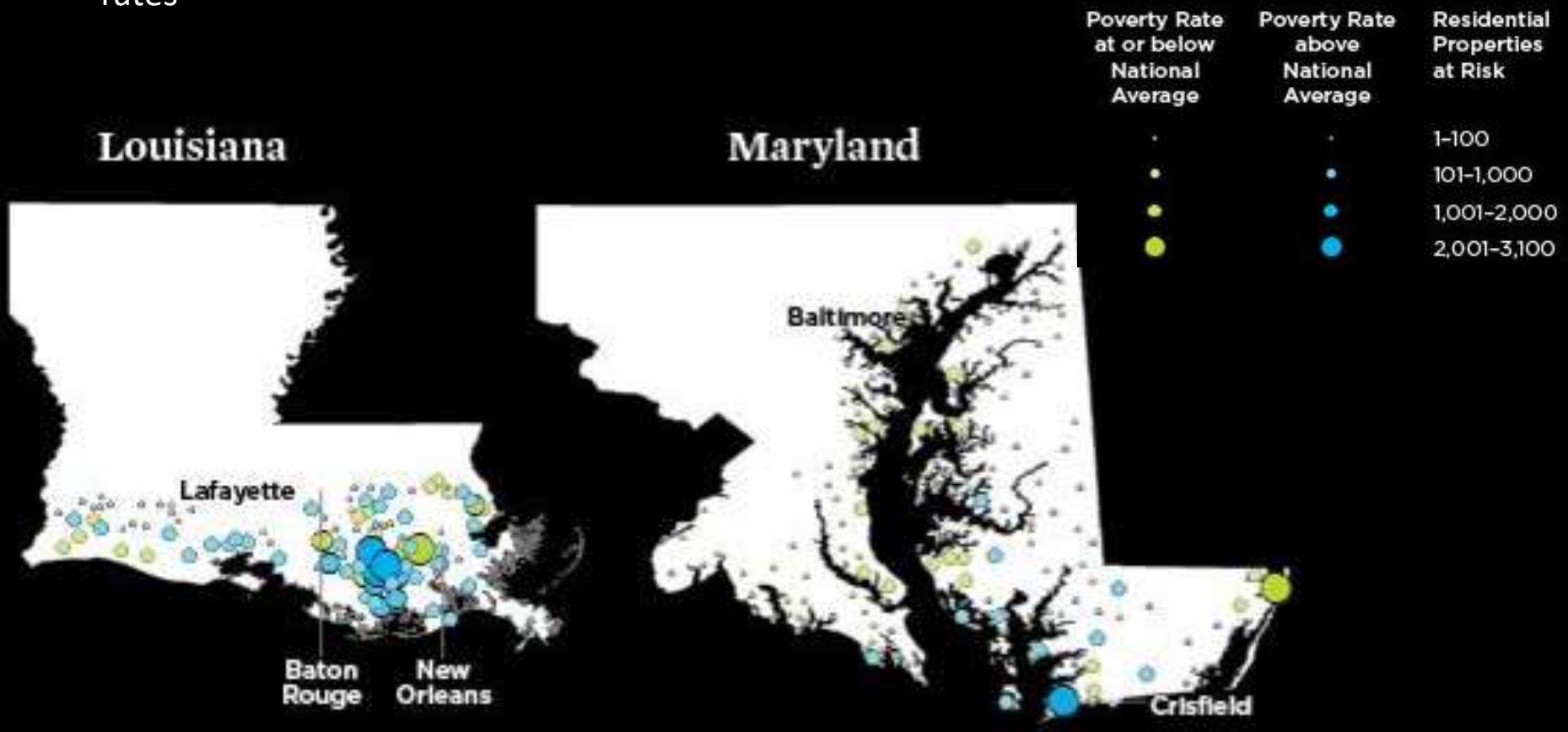
Poverty, race, & tides create hotspots of risk

Louisiana

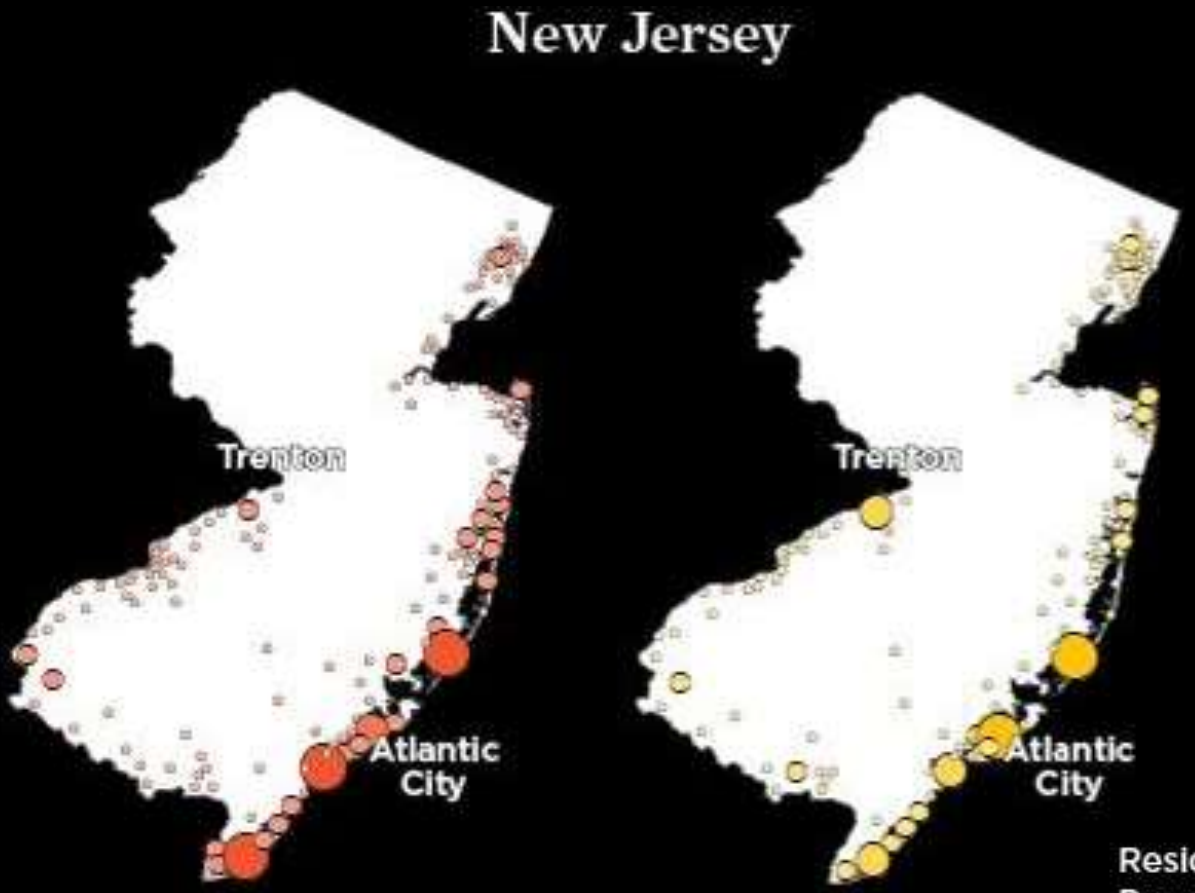
- By 2045, 60% of 120 communities have at least 1 home w/at risk property are above national poverty average (12.7%)

Maryland

- By 2045, 30 of the 105 communities w/at risk properties have above average national poverty rates



Business as usual?



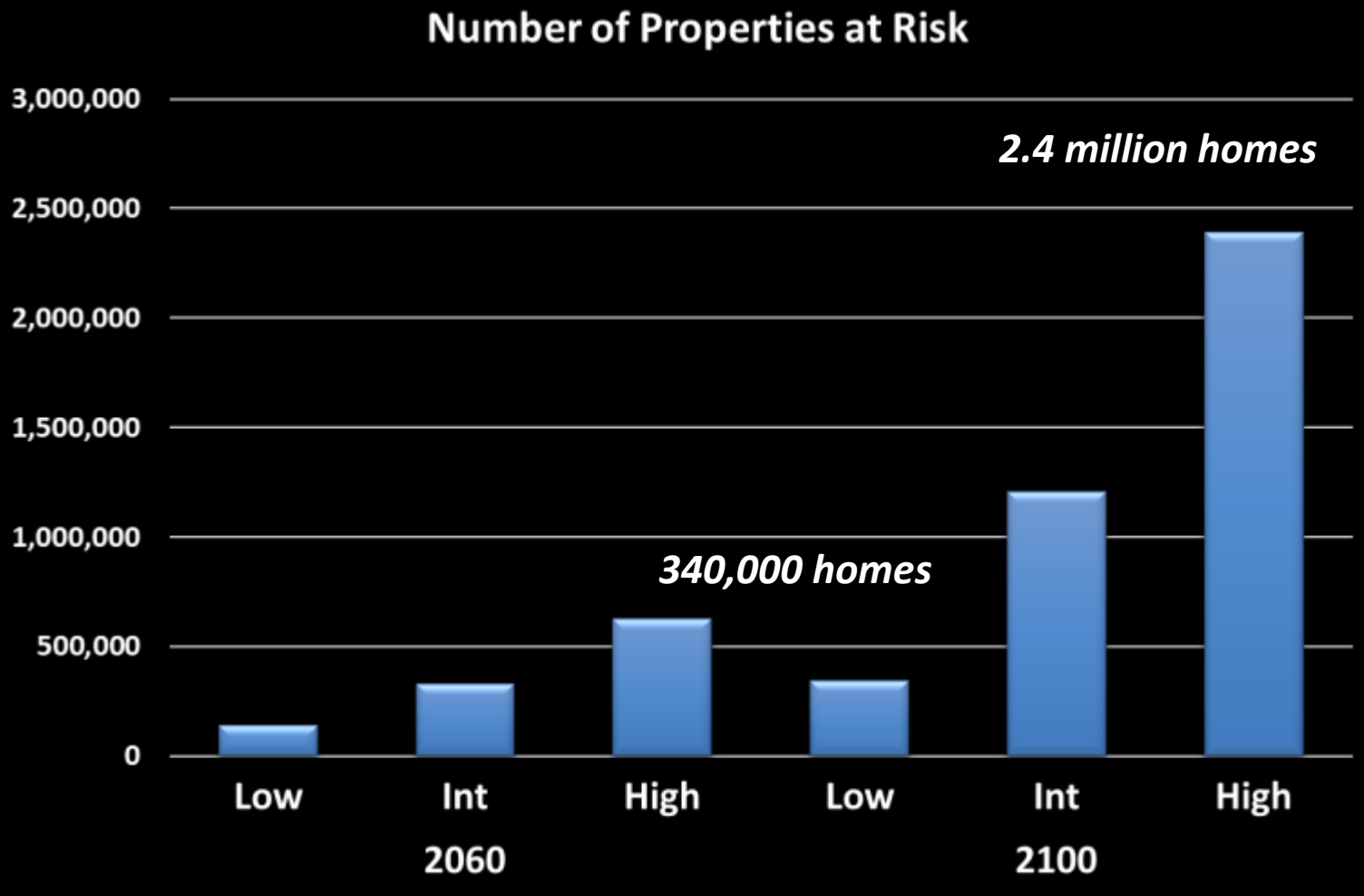
In 2045, 96% of ~2,600 commercial properties would be at risk (shops, hotels, & restaurants).

Additional state stories…

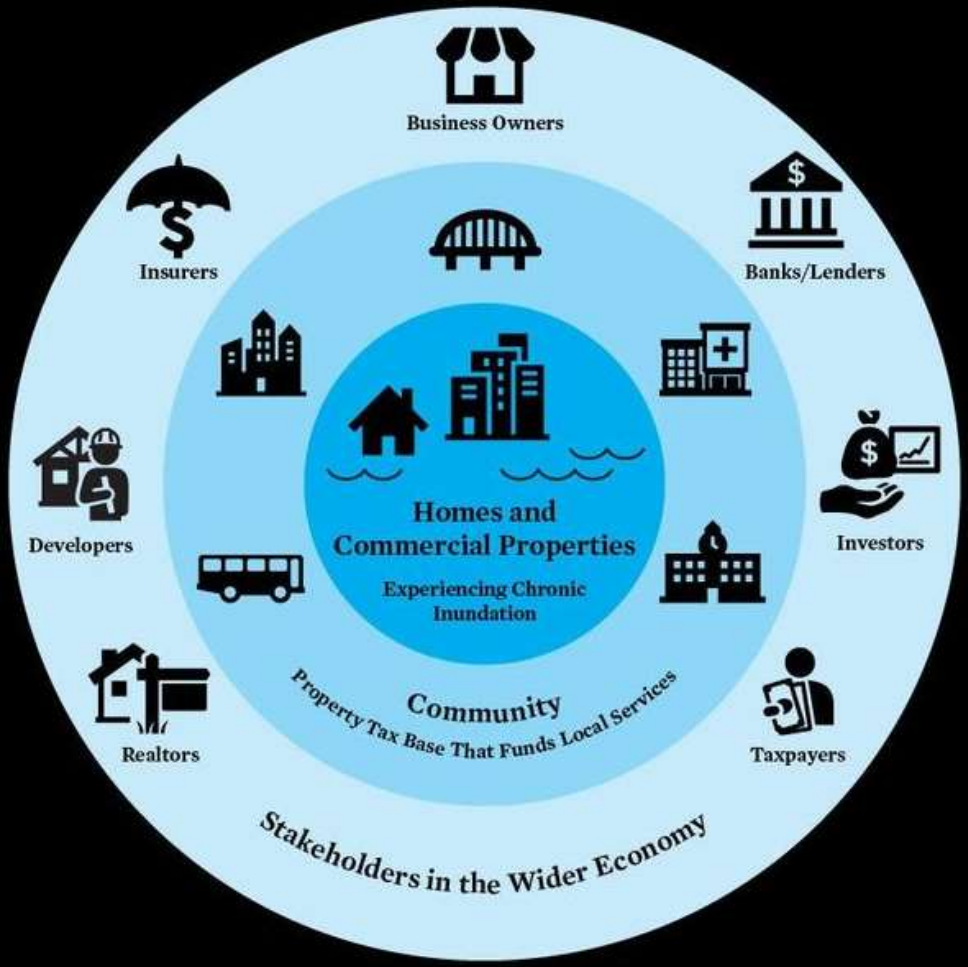
- **TEXAS AND NORTH CAROLINA:**
  - Generational wealth at stake
- **THE NORTHEAST AND THE NORTHWEST:**
  - Blue-collar America at risk
- **VACATION STATES:**
  - Tourist income at stake.

What about lower emissions and SLR?

- *By 2060 # homes at risk ↓ by nearly 80 % (500,000 fewer)*
- *In 2100 could avoid $782 billion in residential property value, housing 4.1 million, valued at and $10.4 billion in annual property tax revenue to municipal governments*



The Potential Economic Reverberations of Chronically Inundated Properties



Our Challenges and Choices

[Our Challenges and Choices

Knowing our risk
Closing the awareness gap

- Home-Buyer's
- State & local role
- Federal Role
- Market place

Realign policies and market incentives to reflect risk

Planning for a resilient future for all

Thank you

Authors:
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Shana Udvardy
Astrid Caldas
Pamela Worth

Realign policies and market incentives to reflect risk

Market experts: "Matrix of Voices"

"S&P Global Ratings see the uniform and transparent disclosure by governments of the potential effects of gradual environmental change and extreme weather events as both an important input into our assessment of management's ability to respond to the risks and <u>one</u> of the largest challenges to the market."

- Kurt Forsgren, Managing Director – Infrastructure Sector Lead
S&P Global – Ratings U.S. Public Finance

Knowing our risk
Closing the awareness gap

- Home-Buyer's
- State & local role
- Federal Role
- Market place

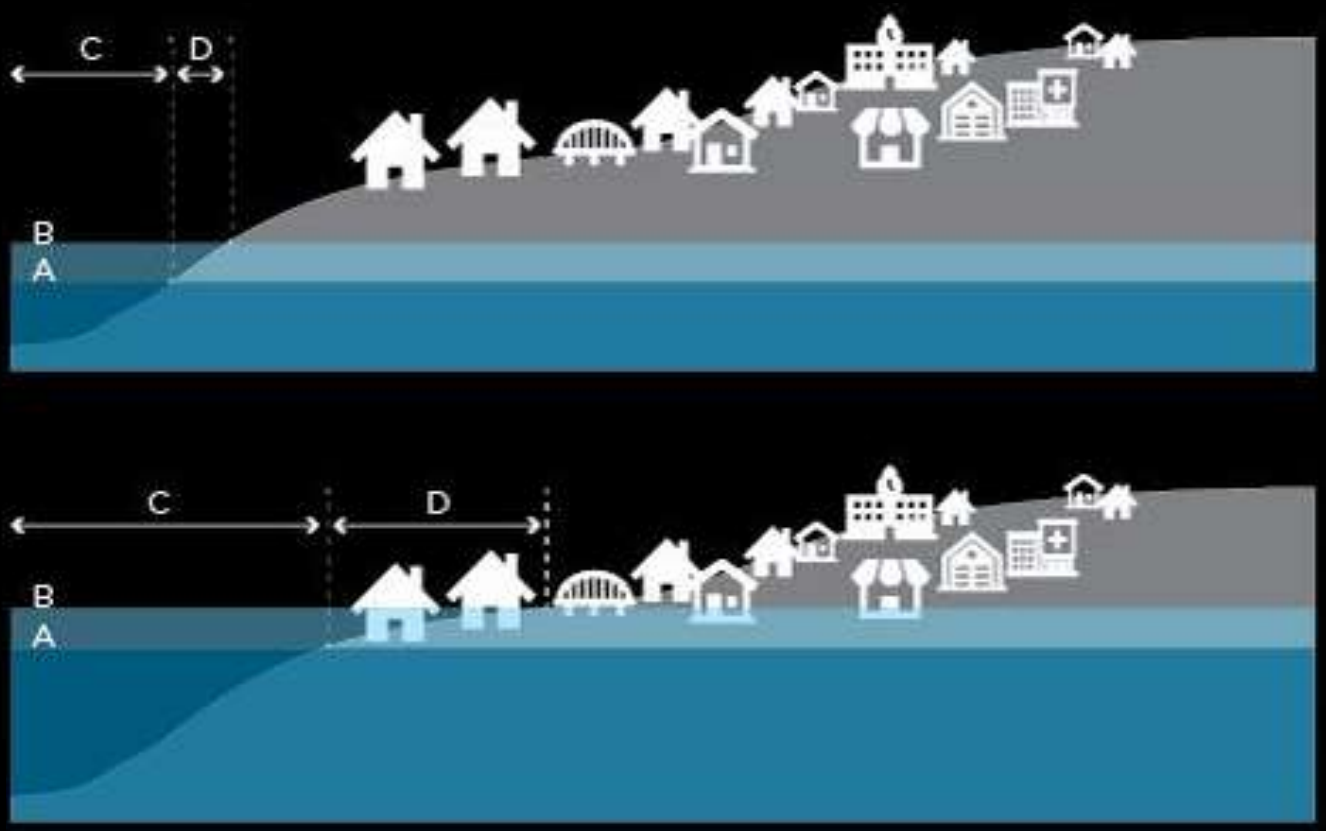
Extra slides

Market experts: “Matrix of Voices”

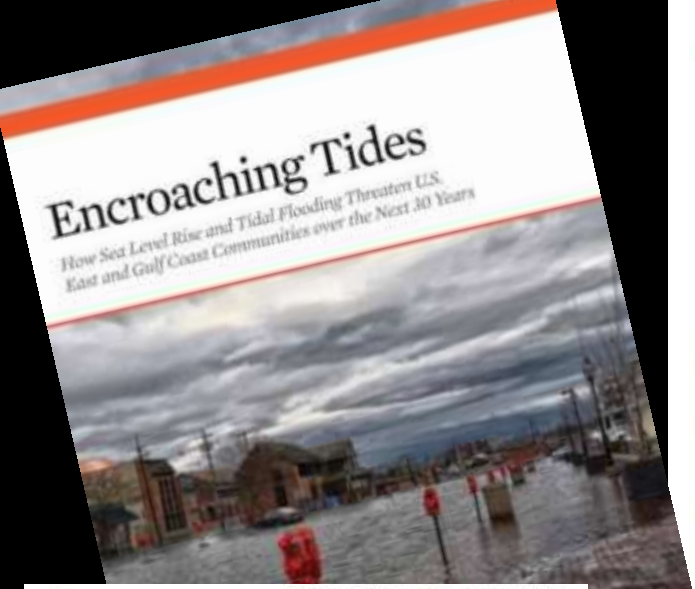
The six main insights that emerged from the experts consulted were:

1) The financial risks of sea level rise are largely **unaccounted for in the current market**.
2) **Barriers exist** to doing so—including a lack of standardized data/metrics for assessing risks and the market’s bias toward investment horizons.
3) Some **federal and local policies,** in their current form—particularly those related to disaster risk response, flood insurance, and zoning regulations—unintentionally serve to mask the risks to coastal communities.
4) A **coastal property market correction is inevitable**, but the form and severity it will take in specific locations, and its timing, are still uncertain.
5) **Some communities will be hit harder than others**, especially if policy interventions are not made ahead of a steep downward adjustment in property values.
6) **Standards and guidelines for risk disclosure** are an important first step for market actors to be able to account for these risks in their business models.

Chronic Inundation



A. High tide level
B. Chronic flooding level
C. Permanent inundation zone (underwater with each high tide)
D. Chronic inundation zone (underwater 26 times or more a year)



PLOS ONE

RESEARCH ARTICLE

Sea level rise drives increased tidal flooding frequency at tide gauges along the U.S. East and Gulf Coasts: Projections for 2030 and 2045

Kristina A. Dahl[1]*, Melanie F. Fitzpatrick[2], Erika Spanger-Siegfried[3]

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Abstract

Tidal flooding is among the most tangible present-day effects of global sea level rise. Here, we utilize a set of NOAA tide gauges along the U.S. East and Gulf Coasts to evaluate the potential impact of future sea level rise on the frequency and severity of tidal flooding. Using the 2001–2015 time period as a baseline, we first determine how often tidal flooding currently occurs. Using localized sea level rise projections based on the Intermediate-Low, Intermediate-High, and Highest projections from the U.S. National Climate Assessment, we then determine the frequency and extent of such flooding at these locations for two near-term time horizons: 2030 and 2045. We show that increases in tidal flooding will be substantial and nearly universal at the 52 locations included in our analysis. Long before areas are permanently inundated, the steady creep of sea level rise will force many communities to grapple with chronic high tide flooding in the next 15 to 30 years.

OPEN ACCESS

Citation: Dahl KA, Fitzpatrick MF, Spanger-Siegfried E (2017) Sea level rise drives increased tidal flooding frequency at tide gauges along the U. S. East and Gulf Coasts: Projections for 2030 and 2045. PLoS ONE 12(2): e0171343. doi: 10.1371/journal.pone.0171343

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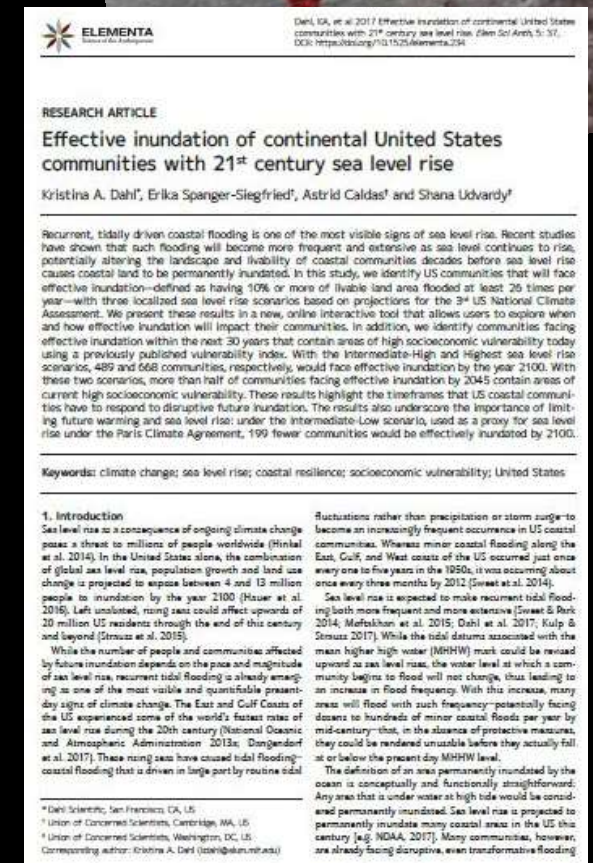
Introduction

Sea level rise has the potential to inundate significant stretches of the U.S. coastline by the end of this century [1]. With higher sea levels, local flooding thresholds can be reached more easily during average high tides. In the absence of coastal adaptation measures to protect against rising seas, some coastal areas could fall below the high tide line by the end of the century. Before that permanent inundation occurs, however, unprotected coastal areas could experience more frequent flooding with high tides.

Global sea level rose by an average of 1.2–1.7 mm per year over the course of the 20th century [2,3]. The rise in sea level is accelerating both globally and regionally in many places. From 1993 to 2010, the global rate has accelerated to 3.0 +/- 0.7 mm per year [2–5]. This acceleration is attributed mainly to ocean warming, a quickening pace of land ice loss, and a net transfer of groundwater from the land into the sea [6–9].

Local sea level trends can differ from the global average due to factors including land subsi-



ELEMENTA

Dahl, KA, et al. 2017 Effective inundation of continental United States communities with 21st century sea level rise. Elem Sci Anth, 5: 37, DOI: https://doi.org/10.1525/elementa.234

RESEARCH ARTICLE

Effective inundation of continental United States communities with 21st century sea level rise

Kristina A. Dahl*, Erika Spanger-Siegfried†, Astrid Caldas‡ and Shana Udvardy§

Recurrent, tidally driven coastal flooding is one of the most visible signs of sea level rise. Recent studies have shown that such flooding will become more frequent and extensive as sea level continues to rise, potentially altering the landscape and livability of coastal communities decades before sea level rise causes coastal land to be permanently inundated. In this study, we identify US communities that will face effective inundation—defined as having 10% or more of livable land area flooded at least 26 times per year—with three localized sea level rise scenarios based on projections for the 3rd US National Climate Assessment. We present these results in a new, online interactive tool that allows users to explore when and how effective inundation will impact their communities. In addition, we identify communities facing effective inundation within the next 30 years that contain areas of high socioeconomic vulnerability today using a previously published vulnerability index. With the Intermediate-High and Highest sea level rise scenarios, 489 and 668 communities, respectively, would face effective inundation by the year 2100. With these two scenarios, more than half of communities facing effective inundation by 2045 contain areas of current high socioeconomic vulnerability. These results highlight the timeframes that US coastal communities have to respond to disruptive future inundation. The results also underscore the importance of limiting future warming and sea level rise: under the Intermediate-Low scenario, used as a proxy for sea level rise under the Paris Climate Agreement, 199 fewer communities would be effectively inundated by 2100.

Keywords: climate change; sea level rise; coastal resilience; socioeconomic vulnerability; United States

1. Introduction

Sea level rise as a consequence of ongoing climate change poses a threat to millions of people worldwide (Hinkel et al. 2014). In the United States alone, the combination of global sea level rise, population growth and land use change is projected to expose between 4 and 13 million people to inundation by the year 2100 (Hauer et al. 2016). Left unabated, rising seas could affect upwards of 20 million US residents through the end of this century and beyond (Strauss et al. 2015).

While the number of people and communities affected by future inundation depends on the pace and magnitude of sea level rise, recurrent tidal flooding is already emerging as one of the most visible and quantifiable present-day signs of climate change. The East and Gulf Coasts of the US experienced some of the world's fastest rates of sea level rise during the 20th century (National Oceanic and Atmospheric Administration 2013a; Dangendorf et al. 2017). These rising seas have caused tidal flooding—coastal flooding that is driven in large part by routine tidal fluctuations rather than precipitation or storm surge—to become an increasingly frequent occurrence in US coastal communities. Whereas minor coastal flooding along the East, Gulf, and West coasts of the US occurred just once every one to five years in the 1950s, it was occurring about once every three months by 2012 (Sweet et al. 2014).

Sea level rise is expected to make recurrent tidal flooding both more frequent and more extensive (Sweet & Park 2014; Moftakhari et al. 2015; Dahl et al. 2017; Kulp & Strauss 2017). While the tidal datums associated with the mean higher high water (MHHW) mark could be revised upward as sea level rises, the water level at which a community begins to flood will not change, thus leading to an increase in flood frequency. With this increase, many areas will flood with such frequency—potentially facing dozens to hundreds of minor coastal floods per year by mid-century—that, in the absence of protective measures, they could be rendered unusable before they actually fall at or below the present day MHHW level.

The definition of an area permanently inundated by the ocean is conceptually and functionally straightforward. Any area that is under water at high tide would be considered permanently inundated. Sea level rise is projected to permanently inundate many coastal areas in the US this century [e.g. NOAA, 2017]. Many communities, however, are already facing disruptive, even transformative flooding

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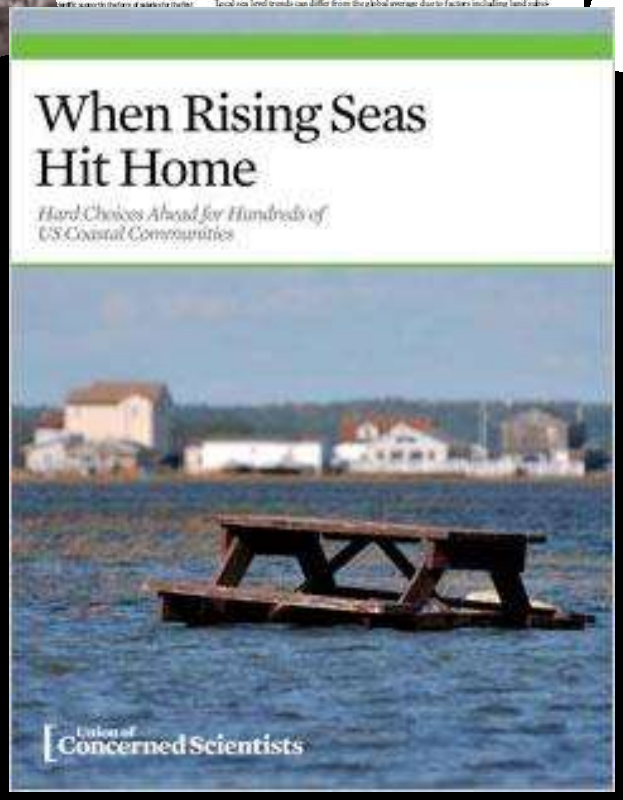


Union of Concerned Scientists
EXECUTIVE SUMMARY

The US Military on the Front Lines of Rising Seas

Growing Exposure to Coastal Flooding at East and Gulf Coast Military Bases

HIGHLIGHTS

The US Armed Forces depend on safe and functional bases to carry out their stated missions, to provide the military forces needed to deter war and to protect the security of the country.

The US military and defense budget in fiscal year 2015 was just under $500 billion. Of that total, about one-third was earmarked for the maintenance and operation of bases, many of which are in the United States.

Given growing exposure to rising seas and storm surge, the analysis finds, the military is at risk of losing land where vital infrastructure, training and testing grounds, and housing for thousands of the personnel currently using them.

The Department of Defense (DOD) maintains more than 1,000 military installations in the United States—sites where the military tests weaponry, conducts training exercises, builds and launches ships, completes intelligence, develops new technology, and houses critical military commands (Hall et al. 2016). Many of these sites are also where officers, enlisted men and women, and their families live.

Given their central role in national security, such installations have historically been well protected. But sea level rise, increased tidal flooding, and heightened storm surges do not stop for checkpoints. These climate-driven trends are already causing three-foot increases in sea level around installations (NAS 2012). A roughly three-foot increase in sea level would threaten 128 coastal DOD installations in the United States (43 percent of which are naval installations, valued at roughly $160 billion) and the livelihoods of the people—both military personnel and civilians—who depend on them (NAS 2012).

To enable decision makers to better understand these threats, how they may unfold this century, and where and when they could become acute, the Union of Concerned Scientists (UCS) has performed a new analysis of 52 military installations along the East and Gulf coasts. We selected these sites for their strategic importance to the armed forces, for their potential exposure to the effects of sea level rise, and because they represent coastal installations nationwide in terms of size, geographic distribution, and service branch. By analyzing their changing

Our Challenges and Choices

1) Know the risk
2) Realign policies and market incentives to reflect risk
3) Planning for a Resilient Future for all

[Planning for a Resilient Future for all

[Using “Response Time” Wisely

Knowing our risk
Home-Buyer's

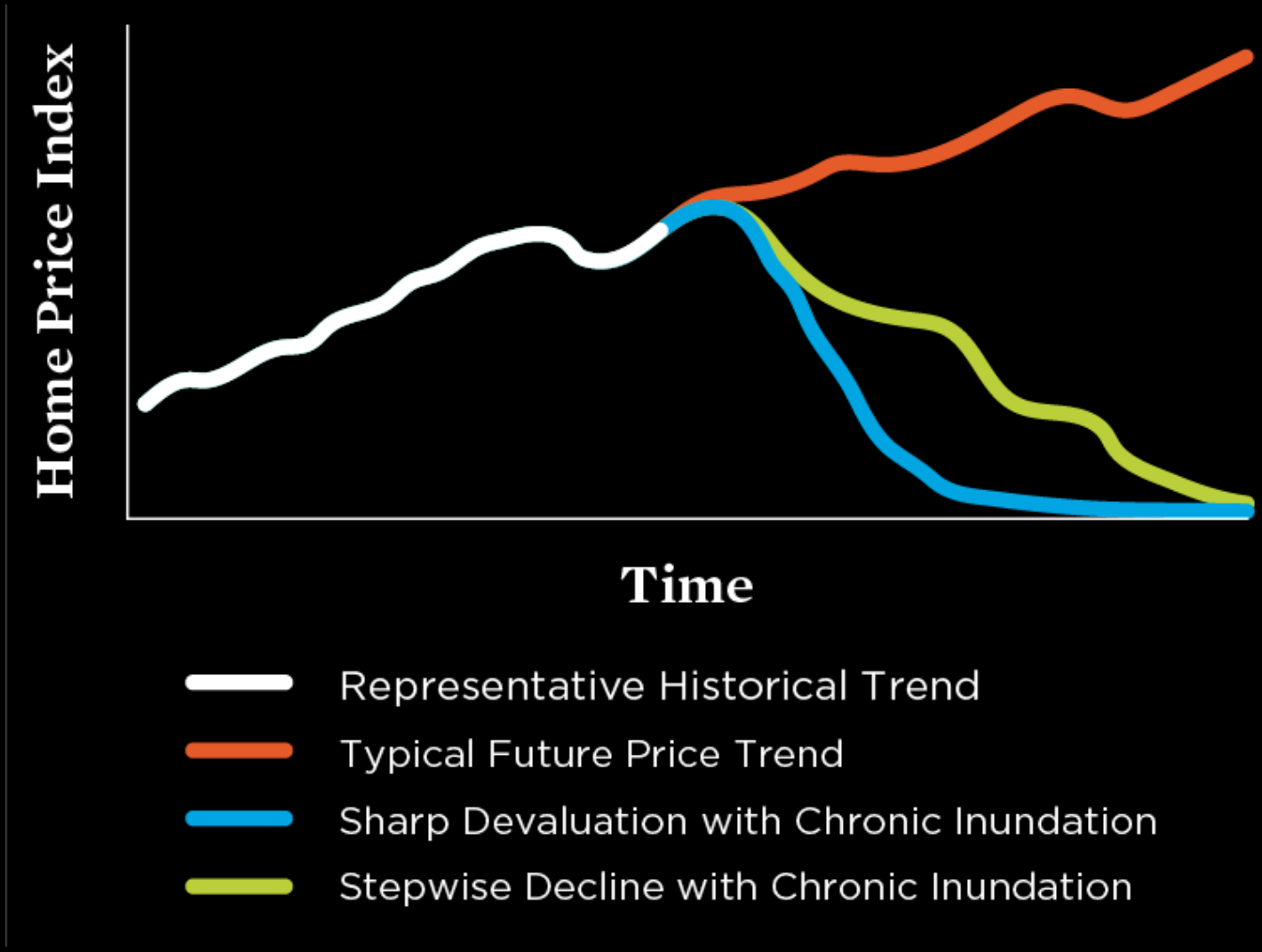
- ✓ Ask yourself
- ✓ Ask locals
- ✓ Ask Home inspector & / or Engineer
- ✓ Ask the Seller, Realtor, Town Planner's Office
- ✓ Ask your insurance agent

Market experts: “Matrix of Voices”

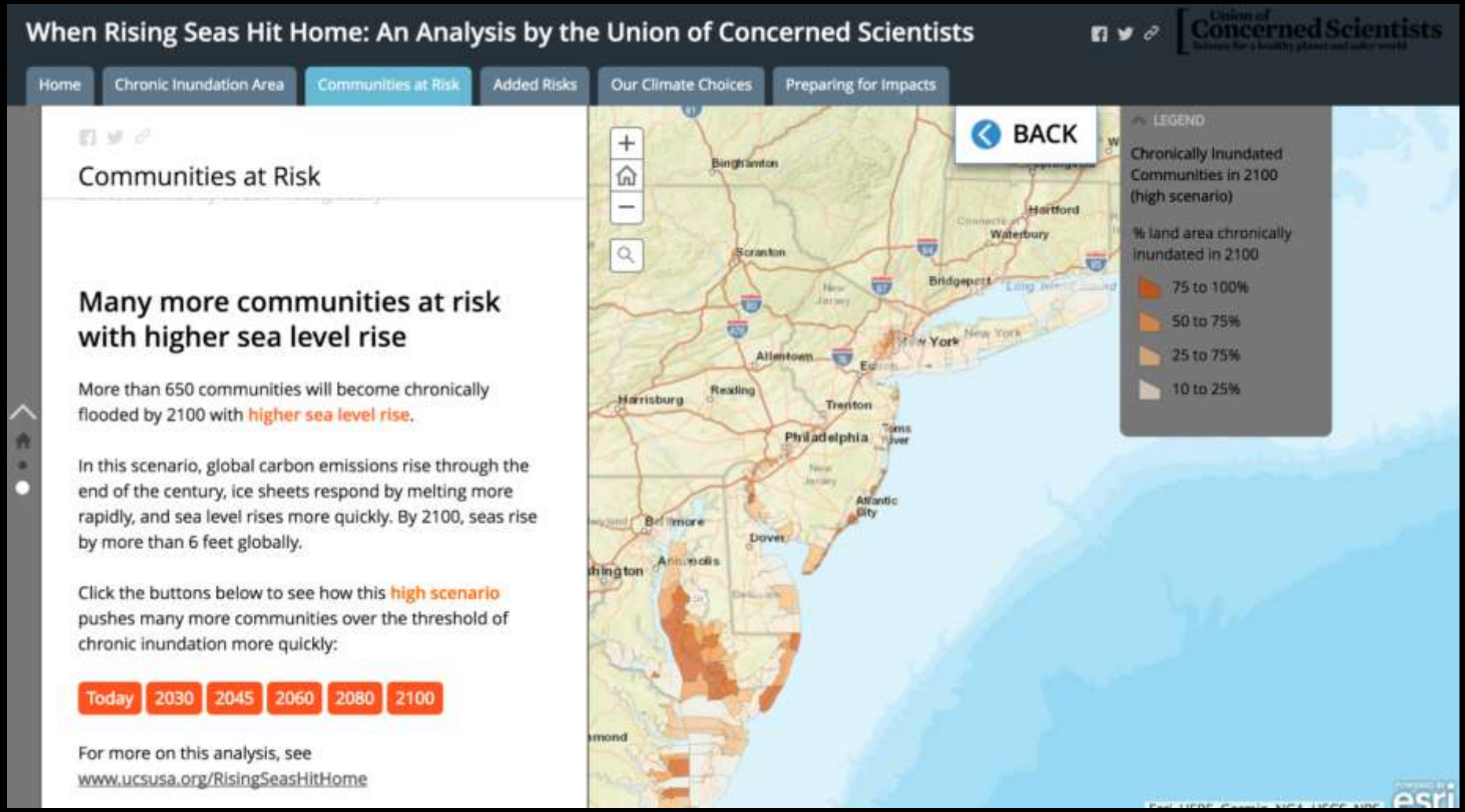
As an investment manager, one of the biggest challenges is the disconnect between time horizons for our clients’ investments in bonds—usually 3 to 5 years—and the timeframe for significant tipping points when, say, 50 to 70 percent of the tax base is at risk of flooding.”

- ***Andrew Teras, Vice-President and Senior Analyst, Breckinridge Capital Advisors***

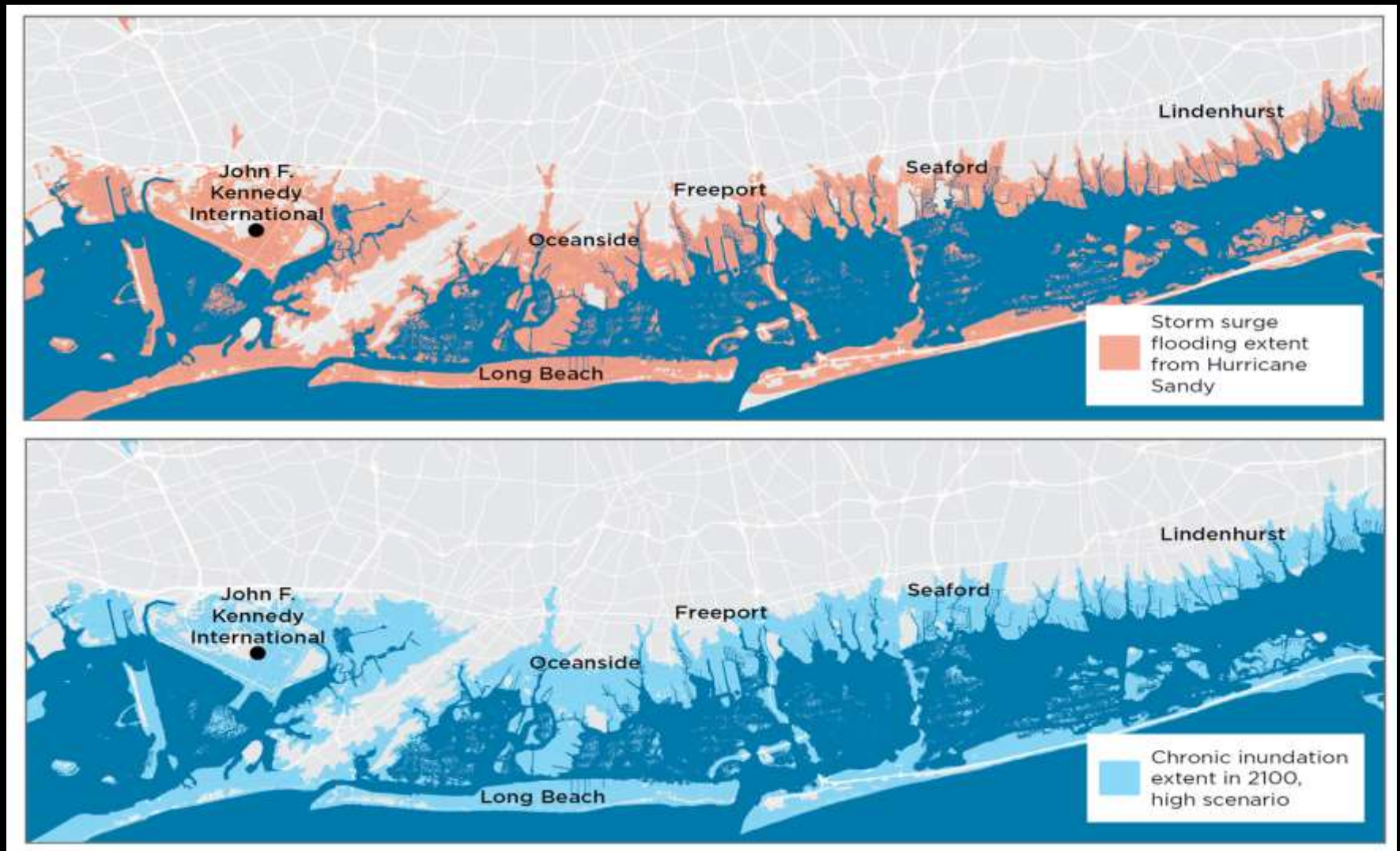
Loss in Home Value with Chronic Inundation



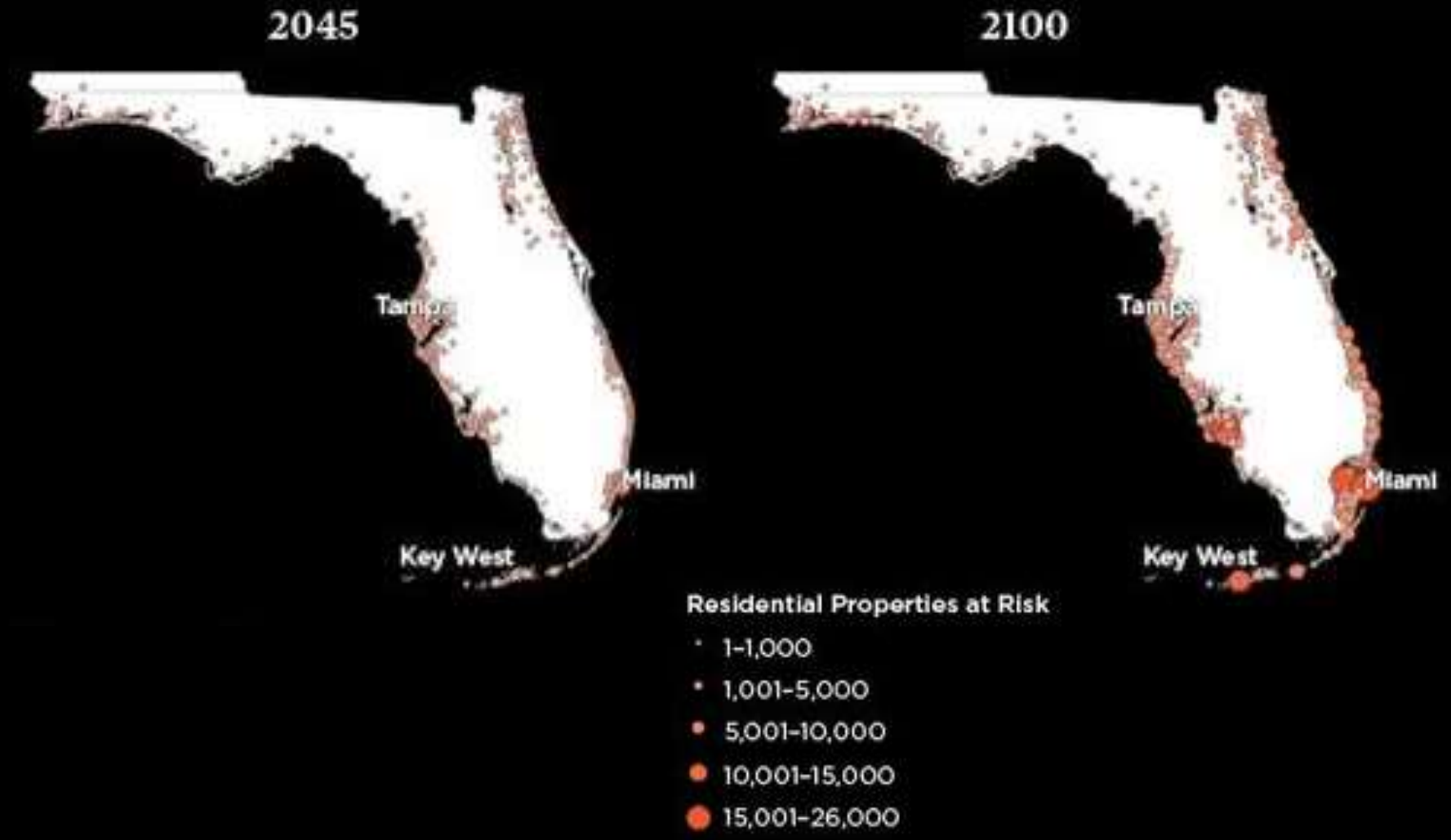
Web page and Interactive Map Tool:
Communities at Risk



Chronic inundation in 2100:
Equivalent to Hurricane Sandy flood extent



Acute Exposure in Florida:
Residential Properties at Risk



Knowing our risk
Home-Buyer's

- ✓ Ask yourself
- ✓ Ask locals
- ✓ Ask Home inspector & / or Engineer
- ✓ Ask the Seller, Realtor, Town Planner's Office
- ✓ Ask your insurance agent

Acute Exposure in Florida:
Residential Properties at Risk