Underwater

Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate

Union of Concerned Scientists

Introduction

Along nearly 13,000 miles of coastline of the contiguous United States, hundreds of thousands of buildings lie in the path of rising seas: schools, hospitals, churches, factories, homes, and businesses. Long before these properties and infrastructure are permanently underwater, millions of Americans living in coastal communities will face more frequent flooding, as the tides inch higher and reach farther inland. As sea levels rise, persistent high-tide flooding of homes, yards, roads, and business districts will begin to render properties effectively unlivable, and neighborhoods—even whole communities—financially unattractive and potentially unviable.

Yet property values in most coastal real estate markets do not currently reflect this risk. And most homeowners, communities, and investors are not aware of the financial losses they may soon face.

BILLIONS OF DOLLARS OF PROPERTY AT RISK IN THE COMING DECADES

In the coming decades, the consequences of rising seas will strain many coastal real estate markets—abruptly or gradually, but some eventually to the point of collapse—with potential reverberations throughout the national economy. And with the inevitability of ever-higher seas, these are not devaluations from which damaged real estate markets will recover.

This analysis estimates the number of homes and commercial properties throughout the coastal United States that will be put at risk from chronic, disruptive flooding—defined as flooding that occurs 26 times per year or more (Dahl et al. 2017; Spanger-Siegfried et al. 2017)—in the coming decades. It brings together data on coastal regions that are projected to experience this type of flooding, and data on existing properties provided by Zillow*, the online real estate company. Our findings indicate that sea level rise, driven primarily by climate change and even absent heavy rains or storms, puts more than 300,000 of today's homes and commercial properties in the contiguous United States at risk of chronic, disruptive flooding within the next 30 years. The cumulative current value of the properties that will be at risk by 2045 is roughly $136 billion. In those 30 years—encompassing the terms of a typical mortgage taken out today—what will the properties be worth if they are flooding on a chronic basis? And how will the broader coastal real estate market fare in the long term? Our analysis finds that by the end of the 21st century nearly 2.5 million residential and commercial properties, collectively valued at $1.07 trillion today, will be at risk of chronic flooding.

> ***By the end of the 21st century, nearly 2.5 million properties will be at risk of chronic flooding.***

Many experts in risk assessment, credit ratings, real estate markets, insurance markets, and flood policy (dozens of whom were consulted for this report), recognize that the risk of sea level rise to coastal real estate is significant and growing—and that for the most part, financial markets do not currently account for these risks.

RISKS BELOW THE RADAR

In many cases, the risks are masked by short-sighted government policies, market incentives, and public and private investments that prop up business-as-usual choices and fail to account for sea level rise (McNamara et al. 2015). Even in places such as Miami-Dade County, which is already experiencing disruptive tidal flooding, the real estate market is only just beginning to adjust (Tampa Bay Times 2017; Corum 2016; Urbina 2016; Spanger-Siegfried, Fitzpatrick, and Dahl 2014). This disconnect can be attributed to a lack of information about risks; subsidized, myopic development choices; and the continued attraction of seaside property and vibrant coastal economies (Keenan, Hill, and Gumber 2018). Other smaller, less in-demand locations, such as in coastal Louisiana and the eastern shore of Maryland, are already facing a chronic flooding reckoning (Spanger-Siegfried et al. 2017).

Properties will not be the only things to flood. Roads, bridges, power plants, airports, ports, public buildings, military bases, and other critical infrastructure along the coast also face the risk of chronic inundation. The direct costs of replacing, repairing, strengthening, or relocating infrastructure are not captured in our analysis, nor do we account for the indirect costs of flooded infrastructure, including disruptions to commerce and daily life (Neumann, Price, and Chinowsky 2015; NCA 2014; Ayyub and Kearney 2012). Taken together, these costs of chronic flooding of our coastal built environment—both property and infrastructure—could have staggering economic impacts.

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* *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 are those of the Union of Concerned Scientists and do not reflect the position of Zillow Group.*

Cover photo: David Harp

Will Brown

Homes and businesses in hundreds of US communities will face an unprecedented challenge as sea levels rise. Many of those communities, such as the barrier island town of Hampton Beach, New Hampshire, pictured here, developed over time for greatest-possible proximity to the ocean—but today the ocean is on the move, and the cost of that proximity is becoming evident. Although constructing seawalls and installing storm water pumps, for example, can serve to buy time in some places, most defensive measures are expensive to build, are not currently designed to fend off rising seas, and cannot prevent losses uniformly or indefinitely.

A NARROWING WINDOW OF OPPORTUNITY TO MAKE BETTER CHOICES

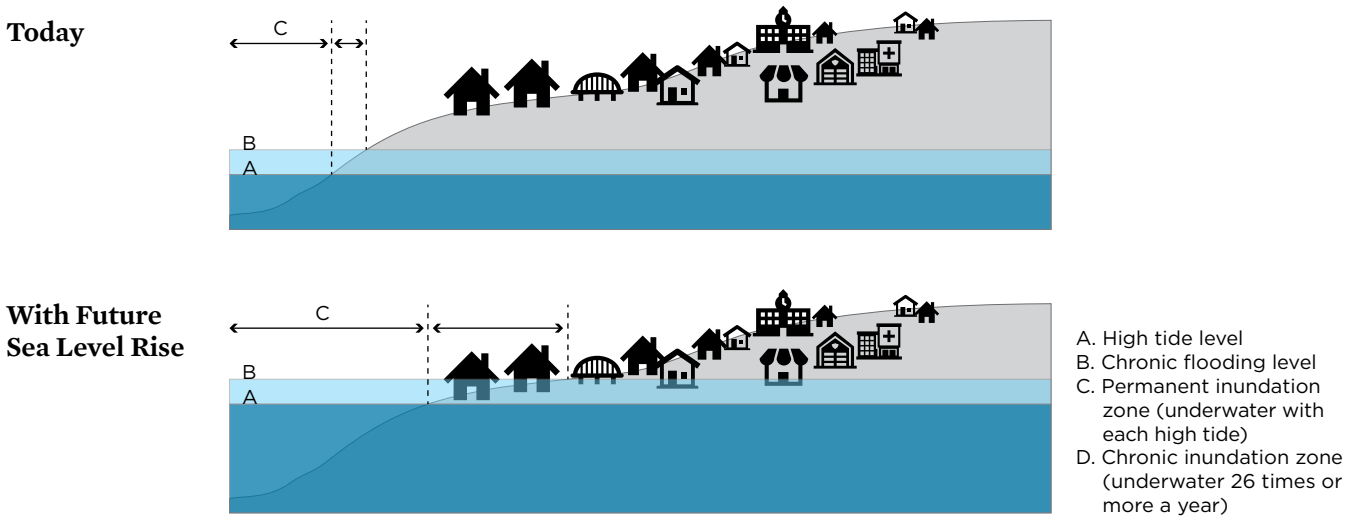
Even when these risks are understood, there are seldom easy solutions. As chronic flooding increases in coastal communities, a tricky cycle begins: investments in adaptation measures could be made to potentially forestall the flooding of properties and the subsequent decline in the tax base. But for communities to maintain credit-worthiness and access to the capital needed for these investments, they would increasingly need to show that they have already made smart decisions and investments to adapt and build resilience (Moody's Investors Services 2017; Walsh 2017; S&P 2016). Falling behind in this cycle, or lacking the means to invest in the first place, could have grave fiscal consequences.

There are many stakeholders in the coastal real estate market, from individual homeowners and business owners, to lenders, taxpayers, developers, insurers, and investors. Whether a property market crashes, or property values steadily decline in response to worsening flooding, these stakeholders are poised to sustain large collective losses. Many coastal residents, whether they own homes or not, will be affected as shrinking property tax bases prevent cities and towns from fully funding schools, emergency services, and infrastructure repairs, or as property tax rates rise for all residents to compensate for those properties devalued by flood risks.

As a nation, we have a narrowing window of opportunity to make better choices and ameliorate risks. The actual physical risks from sea level rise are growing and risk perceptions in the marketplace can shift abruptly, both of which leave communities vulnerable to economic hardships that many will not be able to cope with on their own. This creates a national imperative to prepare individuals and brace our communities and economies for an irreversible decline in the value of many coastal homes and commercial properties, even as we create pathways to new beginnings in safer locations. Given the scale of this challenge, action from the local to the national level will be required, engaging many sectors of the economy. The federal government has a unique and critical leadership role to help provide the tools, funding, resources, and policies that can guide more resilient choices and equitable outcomes along our imperiled coasts.

There will be no simple solution. But continued inaction is unacceptable; we must use the remaining response time wisely to meet this serious threat and protect coastal communities as effectively as we can.

FIGURE 1. What is Chronic Inundation?



With higher sea levels come higher high tides, which can reach onto normally dry land. As sea level rises further, this occasional flooding can become chronic, as even less extreme tides begin to cause flooding. The top panel shows the current reach of high tide (C) and the current extended reach of extreme tides, which defines a current chronic inundation zone where flooding occurs at least 26 times per year (D). The bottom panel shows how sea level rise expands the reach of not just extreme tides but also more typical tides such that some more land is permanently inundated and a portion of the community becomes chronically flooded.

Findings

In this analysis, we identified residential and commercial properties at risk of chronic inundation as sea levels rise, defined as experiencing at least 26 floods per year (Figure 1) (Dahl et al. 2017; Spanger-Siegfried et al. 2017). Using data provided by Zillow (Zillow 2017)*, we determined these properties' current collective value and contribution to community tax bases. We looked at outcomes for the entire coastline of the contiguous United States at multiple points in time through the end of the century, based on localized projections of three different sea level rise scenarios developed for the 2014 National Climate Assessment (Huber and White 2015; Walsh et al. 2014; Parris et al. 2012). In addition, we examined basic demographics of at-risk communities, including the number of people currently housed in these properties and at risk of being displaced, as well as factors such as race, age, and income that could make some populations more vulnerable than others to the physical and financial risks of flooding (Cleetus, Bueno, and Dahl 2015; US Census Bureau 2010; Cutter, Boruff, and Shirley 2003). For more information see Appendix: About this Analysis, p. 22.

Given the importance of individual properties to those who own or live in them, and the broader importance of the coastal real estate market to many market actors invested therein, the following results are based on the high sea level rise scenario, a scenario that results in 6.6 feet of global sea level rise by 2100 and should be used to inform decision-making where there is a low tolerance for risk (Parris et al. 2012).[1] Our results through the end of the century are generated based on today's existing property numbers, property values, and related data (Zillow 2017), and today's demographic statistics (US Census Bureau 2015; US Census Bureau 2010). Aside from rising sea levels and their direct threat to property, our results do not reflect what the future will bring in terms of additional coastal development, adaptation measures, the impact of major storms, population growth, other changes in property values, or other relevant factors. As a result, our findings may under- or overestimate the future number of properties, people, and value that will be affected over time (Hardy and Hauer 2018; Hauer 2017; Lentz et al. 2016).

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THE COAST-WIDE PICTURE

With this high sea level rise scenario, we found that within the next 15 years roughly 147,000 existing homes and 7,000 commercial properties—currently worth $63 billion—are at risk of being inundated an average of 26 times per year, or more. About 280,000 people are estimated to live in these homes today; in this time frame many will need to either adapt to regular floods or relocate.

By 2045—near the end of the lifetime of a 30-year home mortgage issued today—sea levels are projected to have risen such that nearly 311,000 of today's residential properties, currently home to more than half a million people, would be at risk of flooding chronically, representing a doubling of at-risk homes in the 15 years between 2030 and 2045. Not only are the mortgage loans on these homes at growing risk of default if the value of the properties drops, but each successful sale of one of these homes represents the potential transfer of a major latent financial liability. Eventually, the final unlucky homeowners will hold deeds to significantly devalued properties (Conti 2018). Our calculations show that in about 120 communities along US coasts, the properties that would be at-risk in 2045 currently represent a full 20 percent or more of the local property tax base, a crucial source of funding for schools, fire departments, law enforcement, infrastructure, and other public services. For about 30 communities, properties accounting for more than half of the local property tax base today would be at risk by 2045.

By the end of the century, as many as 2.4 million of today's residential properties and 107,000 commercial properties, worth $1.07 trillion today—roughly equivalent to the entire gross domestic product of Florida—would be at risk of chronic flooding (BEA 2018). Those properties are estimated to currently house about 4.7 million people, the equivalent of the entire population of Louisiana.

Together with previous studies of property at risk from rising seas, our findings illustrate a clear, rapidly growing risk to both coastal communities and the nation as a whole, given the deep financial stakes that both the private sector and the US taxpayer have in our coasts (Figure 2, p. 6) (Center for the Blue Economy 2018; Bretz 2017).

> ***In Florida, the number of today's homes that are at risk from sea level rise balloons to more than 1 million by 2100.***

COMMON THEMES AND STATE-LEVEL FINDINGS

As sea levels rise, each of the 23 coastal states in the contiguous US faces the loss of residential and commercial properties and frequent flooding of populated areas, posing new challenges for all communities and adding particular stressors for communities of color and low-income and working-class communities. The following is a selection of common themes that arise across many states. While our discussion of states and locations highlights areas of high risk, this does not mean that other locales face only minimal risk.

MOST TO LOSE? FLORIDA AND NEW JERSEY

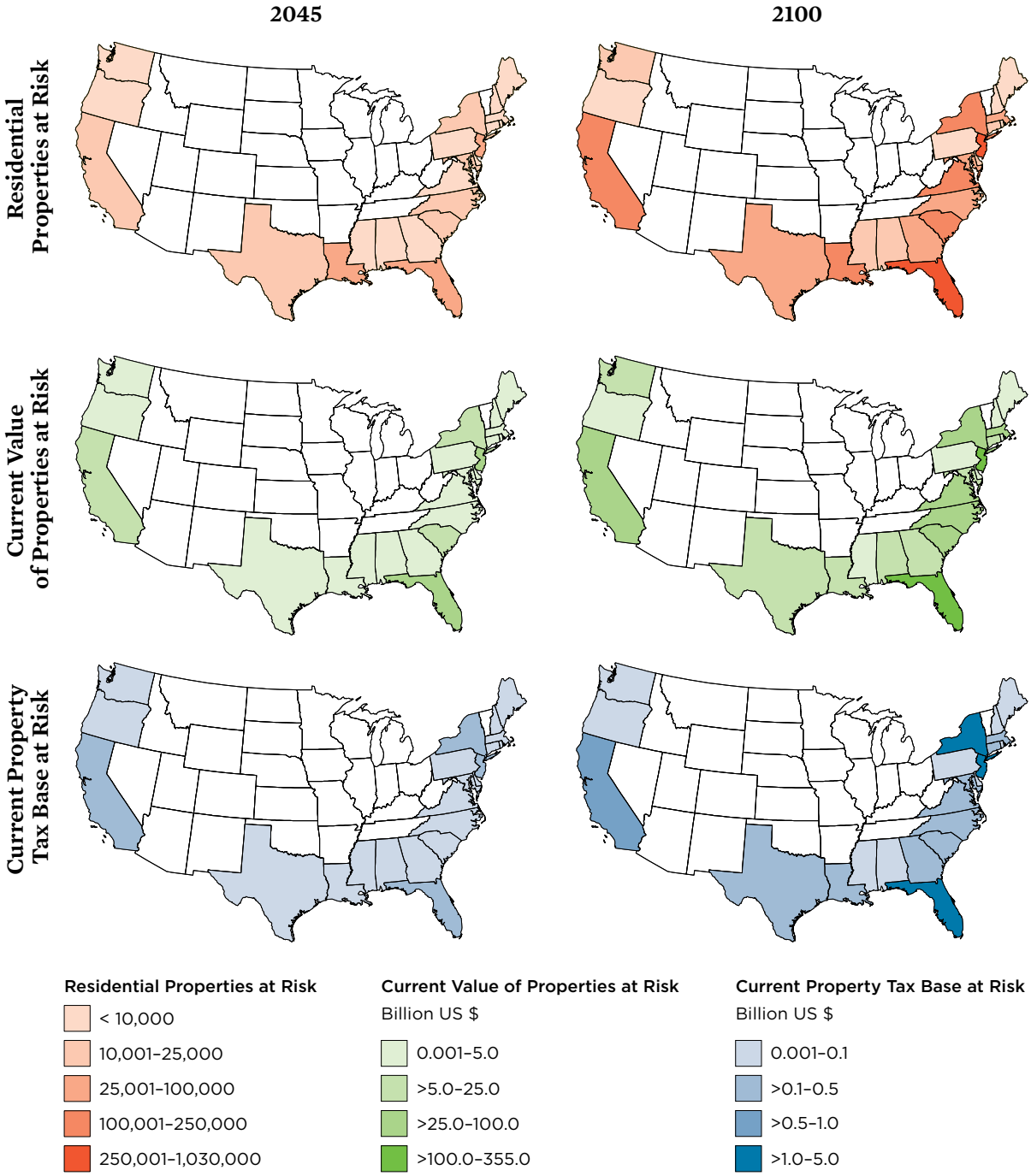
On the east coast of the United States, generations of people have made homes and set up shop close to the water, making this coast some of the most developed land in the country. Often this development has taken place within fragile environments such as barrier islands and filled wetlands; some of the gravest consequences of this overdevelopment will be along the New Jersey and Florida coasts.

Within the next 30 years, roughly 64,000 homes in Florida and 62,000 in New Jersey will be at risk of chronic flooding. Along the Florida coast, Miami Beach alone, with its iconic high rises located within steps of the beach, accounts for more than 12,000 of those homes.[2] Of New Jersey's beach towns, 10 are projected to have at least 1,500 at-risk homes by 2045. Ocean City tops the list with more than 7,200 at-risk homes.

Emily Michot/The Miami Herald via AP

Development in at-risk areas such as the coast of Florida has continued despite the increasingly apparent risks of sea level rise. Indeed, with the allure of its weather and beaches, Florida's housing market has remained strong, even as sunny-day flooding has become a familiar and disruptive reality. Measures to reduce tidal flood risks are hampered in Florida by factors including the porous limestone bedrock underlying much of the state's coastal regions and the large quantity of housing built on extremely low-lying barrier islands (such as Miami Beach, pictured here) and filled land.

FIGURE 2. Residential Properties at Risk in 2045 and 2100

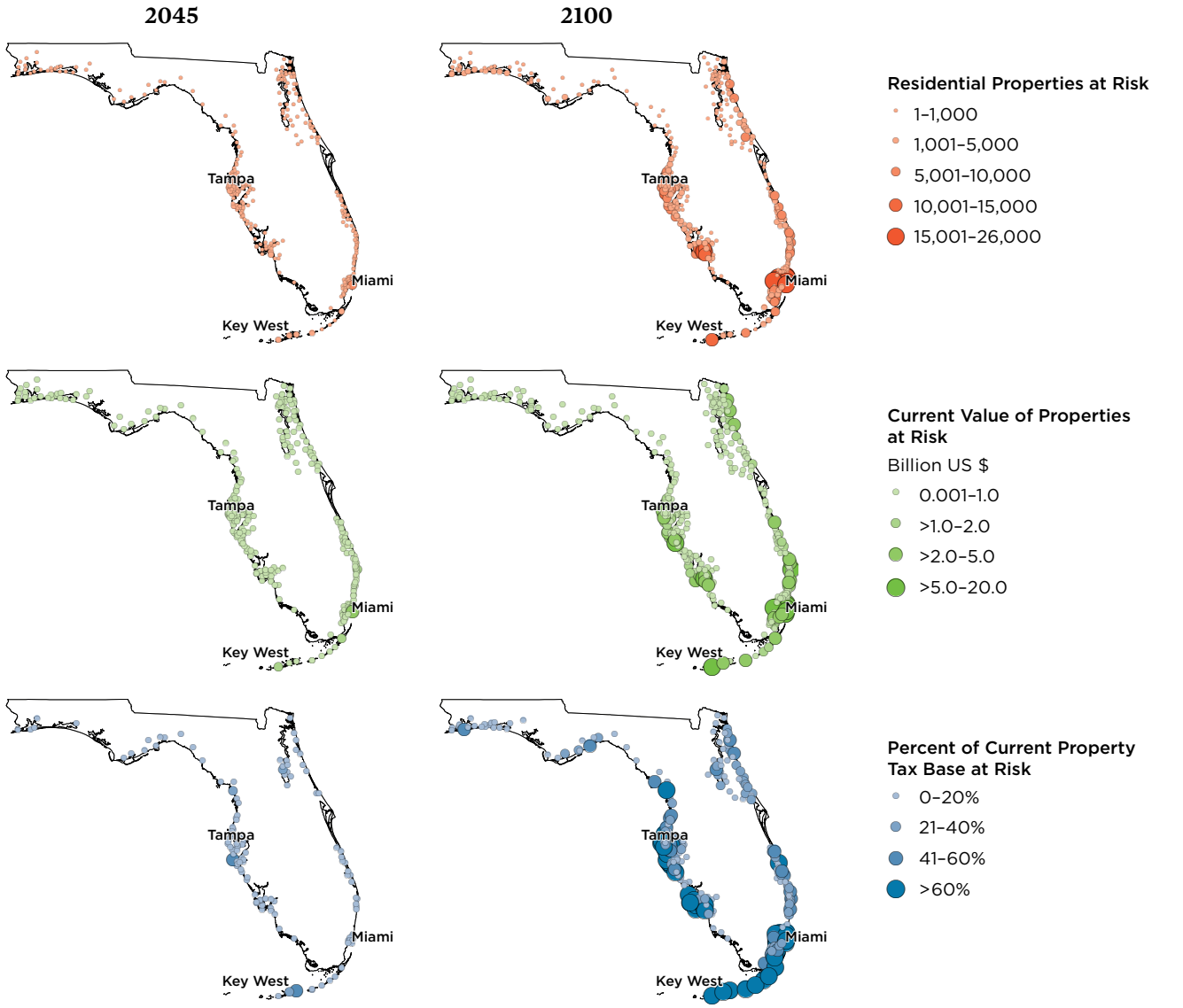


In the contiguous US, more than 310,000 existing homes are projected to be at risk of chronic inundation by 2045, a number that grows to nearly 2.4 million by the end of the century. Within the 30-year time frame represented in the 2045 maps shown here, the states with the most existing homes at risk are (in order) Florida, New Jersey, Louisiana, and California. Florida, New Jersey, and California also all rank in the top three in terms of current value of properties that would be at risk in 2045, and the current contribution of those properties to the local tax base. Note that in California, we have used assessed home values in place of market values, which makes our property value estimates for California conservative (see Appendix: About this Analysis on p. 22 for more details). Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

In Florida, the number of today's homes that are at risk from sea level rise balloons to more than 1 million by 2100, reflecting the scale of existing development in Florida's low-lying inland regions. By the end of the century, Florida alone would account for more than 40 percent of the nation's at-risk homes. In New Jersey, in the same time frame, more than 250,000 homes would be at risk.

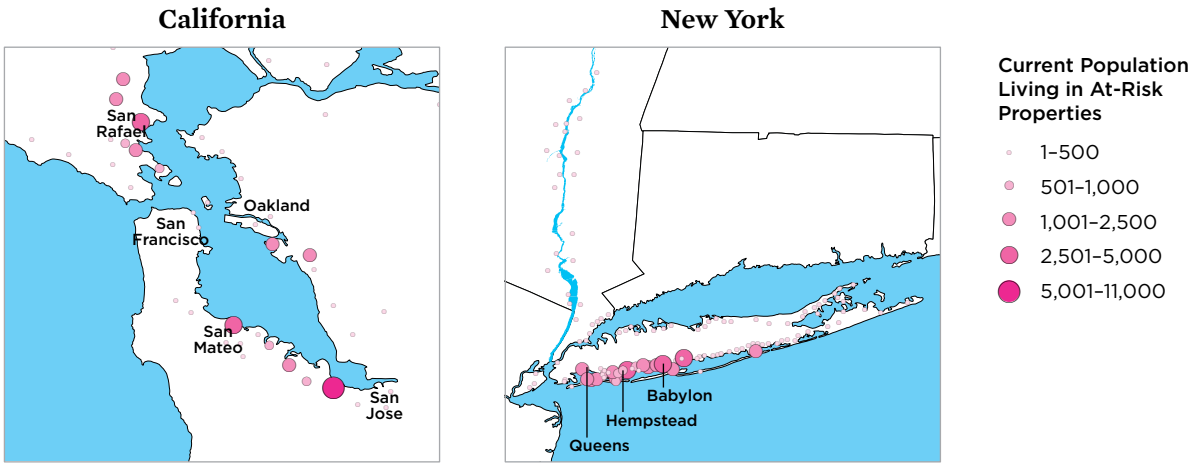
Even as the reality of sea level rise has become clearer, development in flood-prone locations has burgeoned. Fifteen to 20 percent of the at-risk homes in 2045 and 2100 in both Florida and New Jersey were built after the year 2000. Roughly 2,600 of the coastal New Jersey homes at risk by 2045 were built or rebuilt after Hurricane Sandy devastated the region in 2012.

FIGURE 3. Acute Exposure in Florida



Florida leads the nation in the number of homes—along with property value and tax base (based on current values for each)—at risk of chronic inundation through the end of the century. At the ZIP code level, shown here with symbols located at the center of each ZIP code area, the Miami area, the Florida Keys, and Tampa-St. Petersburg stand out as being the most highly exposed within the next 30 years. By the end of the century, nearly 100 ZIP code areas in Florida could see properties chronically flooded that today represent 40 percent or more of their property tax base. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

FIGURE 4. Communities at Risk: Snapshots from California and New York



The San Francisco Bay area, in California, and Long Island, in New York, are both densely populated areas that face significant exposure to chronic inundation by 2045. Within the nine Bay Area counties, roughly 13,000 homes that currently house 33,000 people are at risk of chronic inundation in the next 30 years. On Long Island, roughly 40,000 people currently live in about 15,000 existing homes at risk in this time frame. Housing at risk is shown at the ZIP code level, with symbols located at the center of each ZIP code area. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

HOUSING RISK HOTSPOTS: CALIFORNIA AND NEW YORK

Along the southern shore of Long Island, New York, and around the San Francisco Bay, proximity to major metropolitan areas has spurred development for decades (Figure 4). In both regions, some suburban communities may find themselves facing considerably more risk than the nearby urban centers of Manhattan and San Francisco. By 2045, the three counties that make up most of Long Island—Suffolk, Nassau, and Queens—could encompass nearly 15,000 homes at risk of chronic inundation. Today, there are roughly 40,000 people living in those homes, which are collectively valued at $7.7 billion. In contrast, Manhattan has no at-risk homes in this time frame. Similarly, while San Francisco itself has just 270 at-risk homes in 2045, in the nine counties surrounding the San Francisco Bay roughly 13,000 properties—home to more than 33,000 people and valued at $8.6 billion today—are at risk.[3, 4]

Within each of these regions, some communities are more exposed to chronic inundation than others. On Long Island, for example, Hempstead, Babylon, and Queens are projected to have more than 2,500 homes at risk by 2045, whereas there are only a few homes at risk in other towns. In the Bay Area, San Rafael, San Mateo, and San Jose are each projected to have more than 2,000 at-risk homes by 2045. Future impacts could also vary substantially within a metropolitan region, as some towns may invest in protective infrastructure, while others may choose not to, or may not be able to.

POVERTY, RACIAL INEQUITIES, AND TIDES CREATE HOTSPOTS OF RISK: LOUISIANA, MARYLAND, NORTH CAROLINA, AND NEW JERSEY

Communities with fewer resources to start with, or that are otherwise disadvantaged, will likely be most heavily affected by chronic flooding and its accompanying financial losses (Deas et al. 2017; Mearns and Norton 2010; Fothergill and Peek 2004). We used two metrics to identify communities that may have fewer resources to cope with chronic flooding: poverty rate and the percentage of the community composed of traditionally underserved groups—African Americans, Hispanic Americans, and tribal communities (US Census Bureau 2010).

In communities where the poverty level is above the national average, the erosion of the property tax base could have severe consequences for local residents.

Nearly 175 communities nationwide can expect significant chronic flooding by 2045, with 10 percent or more of their housing stock at risk. Of those, nearly 40 percent—or 67 communities—currently have poverty levels above the national average. The largest share of these is in Louisiana, where there are 25 communities with above-average poverty rates and with 10 percent or more of the homes at risk by 2045.[5] In several Terrebonne Parish communities such as Houma and Bayou Cane, between one in five and one in three residents lives in poverty. These and many other Louisiana regions are also home to large African American and tribal populations as well as other communities of color, where decades of systematic bias have limited personal and community-level financial resources (DHS 2018). In Terrebonne Parish communities, where up to one-third of the residents are living in poverty and half or more are African American, the projected chronic flooding of hundreds of homes and erosion of up to one-quarter of the property tax base could have severe consequences for local residents.

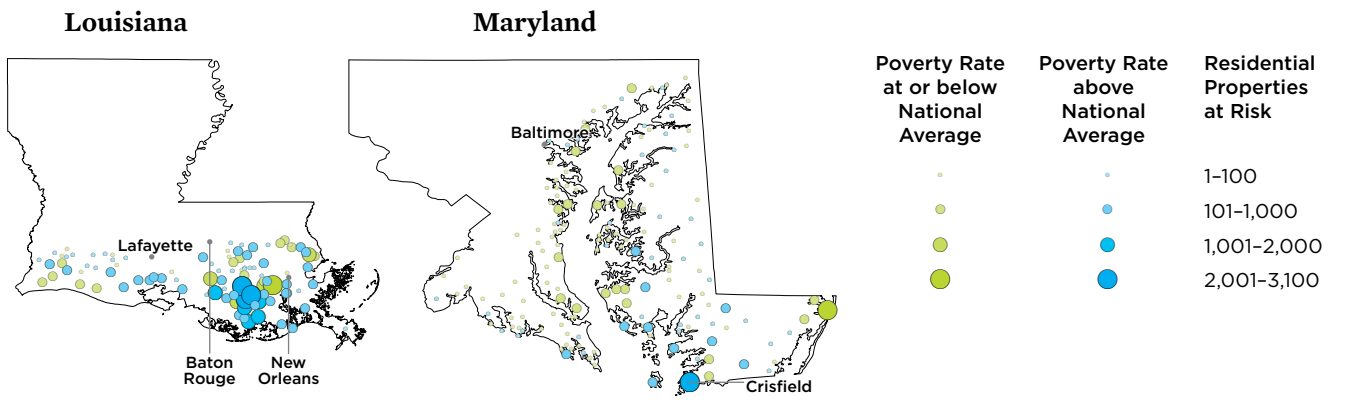
Louisiana is not the only state where poverty and exposure to chronic inundation intersect to create a hotspot of heightened risk. North Carolina, New Jersey, and Maryland also have significant numbers of highly exposed communities with above-average rates of poverty. Within the next 30 years, about a dozen communities along Maryland's eastern shore are projected to have one-third or more of their property tax base at risk. People living in these doubly vulnerable communities stand to lose the most, yet have fewer resources to adapt to flooding or relocate to safer areas.

GENERATIONAL WEALTH AT STAKE: NEW JERSEY, MARYLAND, AND TEXAS

Elderly homeowners tend to live on fixed incomes, own their homes outright, and/or have a relatively large share of personal wealth tied up in their property (Kaul and Goodman 2017; Butrica and Mudrazija 2016). When their property—or even just their neighborhood—is chronically flooded and the value of their home drops, they stand to lose a larger share of their personal wealth, without means of recouping it through future income. People living on fixed incomes can also be hurt financially as taxes rise on non-inundated properties to compensate for municipal budget shortfalls or when services they depend on (such as public transportation) are cut as those budgets shrink.

Of the roughly 400 US communities with at least 50 homes at risk of chronic inundation in 2030, about 60 percent (roughly 240 communities) currently have large populations of elderly people—far above the national average of 14.5 percent of the total population. In towns such as Beach Haven and Tuckerton, New Jersey; Madison, Maryland; and Croatan, North Carolina; each of which has high elderly populations, more than 20 percent of homes, value, and tax base are at risk within the next 15 years. Similarly, in several communities along the Texas coast, including the Bolivar Peninsula, Rockport, and Fulton, where hundreds of properties are at risk of chronic inundation by 2030, between one in five and one in three residents is currently over the age of 65.

FIGURE 5. Communities at Risk: Snapshots from Louisiana and Maryland



Chronic inundation is poised to add new challenges to communities already struggling with high rates of poverty. Of the nearly 120 Louisiana communities with at least one home at risk of chronic inundation by 2045, 60 percent currently have poverty rates above the national average of 12.7 percent. In Maryland, 30 of the roughly 105 communities that contain at-risk properties in 2045 (shown at the ZIP code level, with symbols located at the center of each ZIP code area) have above average poverty rates. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

BLUE COLLAR AMERICA AT RISK: MASSACHUSETTS, DELAWARE, PENNSYLVANIA, MARYLAND, VIRGINIA, MISSISSIPPI, OREGON, AND WASHINGTON

Hundreds of blue collar towns dot the US coastline. To assess the impact of chronic inundation on low- to moderate-income homeowners, we assessed the number of properties that are at risk of chronic inundation in each state and are valued below that state's median home value, as defined by the Zillow Home Value Index (Zillow 2018; Zillow Research 2014).

In eight states—Massachusetts, Delaware, Pennsylvania, Maryland, Virginia, Mississippi, Oregon, and Washington—60 percent or more of the homes at risk of chronic inundation within the next 30 years are valued below the state median.[6] In Delaware and Oregon, nearly all (90 percent or more) of the chronic inundation risk is borne by residents of these lower-value properties. In Oregon, these properties are clustered around Coos Bay and Astoria, two working-class towns. Likewise, in Massachusetts, in 2045, there are large clusters of at-risk homes in Revere, Saugus, and Winthrop—all working-class suburbs of Boston.

Of the roughly 14,000 commercial properties at risk on US coasts within the next 30 years, more than one-third are in Florida and New Jersey.

BUSINESS AS USUAL? FLORIDA AND NEW JERSEY

Our nation's coasts are defined not just by homes and neighborhoods, but by commercial districts. From corner cafés to high-rise office buildings, these properties and the businesses they house are critical components of the coastal economy. The low-lying and highly developed coastlines of Florida and New Jersey make the commercial sector in both states particularly exposed to chronic flooding as sea levels rise. Of the

Maureen Drennan

For many Americans, to own a home on the coast is to claim a prized lifestyle and aesthetic—a "little slice of heaven." And in areas where they could afford to, many working-class communities have taken root there over the years. Unlike wealthier areas with larger homes and lots, smaller, lower-value homes cluster closely together in blue collar towns of Massachusetts, Delaware, Mississippi, New Jersey, and Oregon, to name a few. Many such clusters are in low-lying areas that rising tides will soon reach. For these residents, the loss of these properties could mean the loss of a large share of their personal wealth, as well as the loss of ways of life that have been shared over generations.

roughly 14,000 commercial properties at risk on US coasts within the next 30 years, more than one-third are in Florida and New Jersey. Those same two states are home to 45 percent of the commercial properties, coastwide, that would be at risk by end of the century.

The kinds of properties at risk are quite different in each state. In New Jersey, nearly all (96 percent) of the roughly 2,600 commercial properties that would be at risk in 2045, as well as the 11,000 at risk in 2100, are retail establishments: hotels, restaurants, gas stations, convenience stores, and pharmacies. In contrast, in Florida, 30 percent of the 2,300 commercial properties at risk in 2045 and 50 percent of the 38,000 at risk in 2100 are commercial office buildings, which include medical and financial offices, as well as more general offices and mixed-use buildings.

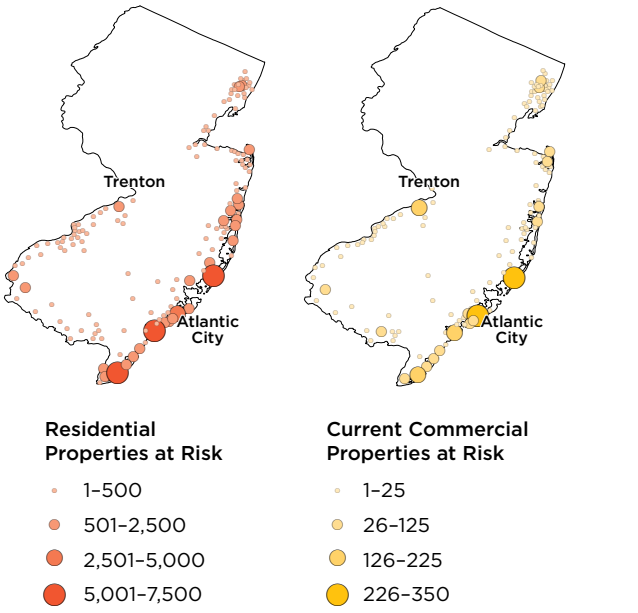
TOURISM REVENUE AT STAKE IN VACATION STATES: NEW JERSEY, NORTH CAROLINA, SOUTH CAROLINA, AND TEXAS

For many people, the coast is synonymous with beach vacations. Homes in coastal vacation destinations may be second homes or primary residences, rental properties, or beloved family homes passed down from generation to generation. The property taxes paid on these homes is often an important source of steady revenue in locations where tourism revenues are highly seasonal and weather-dependent. When a home in a beach town is at risk of chronic flooding, not only is the homeowner affected, but so is a larger network of people, from the vacationer who rents it for a week every summer to the year-round residents who benefit from the revenues generated by tourism. If a significant number of homes in the area are regularly flooded, the popularity of the town as a vacation destination could decline (Flavelle 2017a).

Tens of thousands of homes (if not more) in well-known coastal vacation destinations are projected to be at risk of chronic inundation in the next 30 years. Along the Texas coast, roughly 3,200 residential properties in Galveston and another 1,500 in Brazosport would be at risk, homes that currently represent 17 and 10 percent of the local property tax base, respectively. In South Carolina, nearly 1,500 homes on Kiawah Island would be at risk, and more than 2,700 on Hilton Head. On Kiawah Island, those homes represent nearly one-quarter of the local property tax base today. In North Carolina, the Outer Banks communities of Nags Head and Hatteras together would have nearly 2,000 at-risk homes in this timeframe. On the Jersey Shore, Ocean City alone would have more than 7,200 at risk homes by 2045, which today represents nearly 40 percent of the town's homes and nearly one-third of the local property tax base.

In many seaside communities, such as Galveston and Nags Head, homes are physically elevated. However, even if living spaces stay dry, if the access roads, surrounding land, and key infrastructure are flooded, home values and tourism would be adversely affected.

FIGURE 6. Communities at Risk: Snapshot of New Jersey



New Jersey leads the nation in the number of commercial properties at risk of chronic inundation in 2045 (right) and is second only to Florida in the number of residential properties at risk in that time frame (left). Results are shown at the ZIP code level, with symbols located at the center of each ZIP code area. Properties along the highly developed and much beloved Jersey Shore are particularly at risk. Nearly all of the commercial properties at risk in New Jersey are retail establishments including, but not limited to, shops, hotels and restaurants. Data provided by third parties through the Zillow Transaction and Assessment Dataset (ZTRAX).

A LOW SEA LEVEL RISE SCENARIO: RISKS TO REAL ESTATE DRASTICALLY REDUCED

The difference in impacts to real estate between high and low sea level rise scenarios is stark. A rapid decrease in carbon emissions coupled with slow melting of land-based ice could lead to substantially slower rates of sea level rise. With this low sea level rise scenario, by the year 2060, our analysis finds that the number of homes at risk of chronic inundation would be reduced by nearly 80 percent, from 625,000 with the high scenario to 138,000 with the low scenario. And by the end of the century, only 340,000 homes would be at risk with the low scenario, compared to 2.4 million with the high scenario.

If the global community adheres to the primary goal of the Paris Agreement of capping warming below 2°C

A rapid decrease in global carbon emissions coupled with slow melting of land-based ice could reduce the number of homes at risk of chronic inundation by 2060 by nearly 80 percent.

(UNFCCC 2018), and with limited loss of land-based ice, the United States could avoid losing residential properties that are currently valued at $780 billion, contribute $10 billion annually in property tax revenue, and house 4.1 million people.

Unfortunately, the low, or best-case, scenario is not the track we are on, given current emissions and the vulnerability of the Antarctic ice sheet to warming temperatures, as indicated by the latest research. (Mengel et al. 2018; DeConto and Pollard 2016). The low emissions scenario is one we should work toward but not count on—and decisionmakers must plan for the likely need to manage greater risks.

FIGURE 7. The Potential Economic Reverberations of Chronically Inundated Properties

With chronic inundation, homeowners and owners of commercial properties are directly at risk of significant financial losses as the value of their properties declines. Such losses have ramifications for the local community, which could see its property tax base eroded and its ability to fund local services compromised. There will also be implications for the wider economy, including for banks with outstanding mortgage loans on properties at risk of inundation, coastal property developers, investors and insurers, business owners whose places of business may face flooding, and US taxpayers, broadly, who may face increased taxes to pay for measures to cope with flooding and to reduce flood risk.

Implications

The declining value and increasingly unlivable condition of coastal homes will be damaging, even devastating, to individual homeowners. It will also have more widespread consequences, including for affected communities, lenders, investors, and taxpayers. Unlike housing market crashes of the past, where property values eventually rebounded in most markets, properties chronically inundated by rising seas will only go further underwater, raising the urgent need for more proactive long-term solutions.

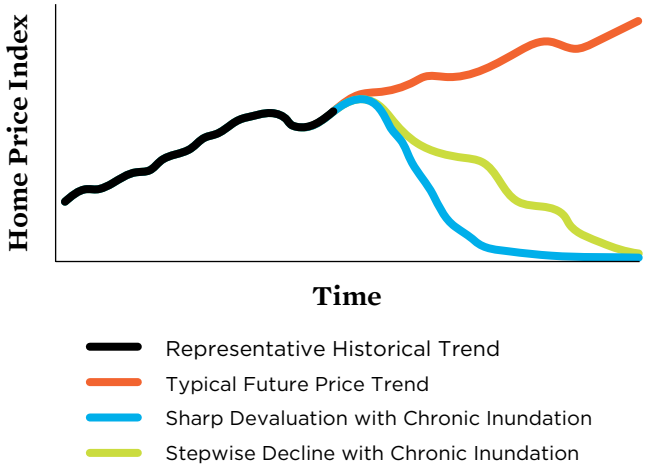
RISKS TO HOMEOWNERS AND BUSINESS OWNERS

With chronic inundation, average homeowners will risk being unable to capitalize on their greatest asset as their homes become undesirable on the real estate market and eventually unsellable. Flood insurance for chronically inundated coastal properties could become increasingly expensive—or not available at all (FEMA 2018; Dixon et al. 2017; Lieberman 2017; GAO 2017). A rash of coastal foreclosures and abandoned homes could ensue, causing neighborhood blight and millions of dollars in lost wealth, even as new real estate wealth is potentially created further inland. In some neighborhoods, even if many individual homes remain out of the chronic inundation zone, the large numbers of homes at risk could cause the neighborhood to collectively experience significant property value declines (Dixon et al. 2017).

Renters, too, could find themselves looking for new homes or putting up with flood-damaged properties—and perhaps facing a scarce local rental market and rising rents. In Miami, for example, developers are increasingly considering buying land in lower-income neighborhoods located farther inland and at higher elevations (Bolstad 2017). But without regulation and policy around these market-driven reactions to sea level rise, this practice can perpetuate racial and social inequities, as lower-income communities see their property values rise to unaffordable levels, creating climate gentrification (Keenan, Hill, and Gumber 2018; Beeler 2017).

Business owners are similarly at risk: flooded streets mean loss of traffic and in-person sales; flooded properties can mean loss of inventory and expensive clean-up; and flooded roads and parking lots can prevent workers from reaching and doing their jobs. Moreover, many business owners invest in the communities that host them, a revenue source that could dry up if those businesses are harmed by chronic flooding. Some commercial property owners will also see the value of their investments erode and may find it increasingly hard to secure long-term leases for properties that are at risk of inundation.

FIGURE 8: Loss in Home Value with Chronic Inundation



These curves depict illustrative trends in home prices with and without chronic inundation. The black line represents a typical historical trend. Going forward, home values in healthy real estate markets would typically trend upward over time (orange line). However, with chronic inundation some coastal real estate markets could face sharp devaluations if their risk is high or they do not have the resources to adapt (blue line); other communities with a longer time horizon to respond or the ability to invest in adaptation measures could face a slower, stepwise decline in property values (green line).

RISKS TO THE LOCAL TAX BASE: A VICIOUS CYCLE BEGINS

Falling property values mean reduced local tax revenue from those properties. In communities where a small share of homes is initially affected, local leaders may opt to raise the tax rate across all properties to mitigate the budget shortfall. However, when many homes are affected, the property tax base will be eroded more quickly, reducing municipal budgets (LILP/MCFE 2018).

Local tax revenues help fund the maintenance and new construction of infrastructure—including critical adaptation measures that could help protect homes, businesses, and infrastructure itself from chronic flooding. Access to additional capital for such projects depends on a municipality's credit rating; its credit rating depends on its financial health and degree of risk exposure, both of which are compromised as chronic flooding worsens. Ironically, communities may find it harder to raise funds for increasing their resilience to floods—through the bond market, for instance—if their credit rating is lowered because of flood risks. Turning again to the relatively wealthy city of Miami, in 2017 the city's residents voted in favor of a $400 million "Miami Forever" bond, which included $192 million for measures to help protect the city from sea

level rise–induced flooding (Smiley 2017). But many smaller municipalities will not be able to drum up similar resources or act quickly enough while they are still credit-worthy, highlighting the need for marshaling a national response to help ensure that there is equitable, timely access to adaptation measures for all communities.

RISKS TO THE WIDER ECONOMY: LENDERS, TAXPAYERS, DEVELOPERS, AND INVESTORS

Mortgages on homes that could be chronically flooded during the term of the loan are inherently riskier. As chronic inundation worsens, homeowners will begin to find themselves with mortgages that exceed the value of their homes, and with homes that grow unlivable or difficult to insure. With no obvious option for reversing that trend, some might choose to abandon their homes and allow banks to foreclose on their mortgages. Lenders who provide mortgages, however, rely on the surety that the value of the property will be maintained, or even appreciate, so that their financial position is secure even in the event of foreclosure. That may cease to be the case for many coastal properties, many of which today carry these risky mortgages with neither homeowner nor lender realizing it (Federal Reserve 2018). Mortgage-backed securities and

> ***Mortgages on homes that could be chronically flooded are inherently riskier, potentially with neither homeowner nor lender realizing it.***

Paul Zoeller/The Post And Courier via AP

Some communities and individuals are better positioned to absorb economic blows than others. And while wealthier homeowners, business owners, and communities may risk losing more value cumulatively, people who are less well-off risk losing a greater percentage of their wealth. Chronic flooding will place tremendous strain on low-income homeowners and renters, pressuring them, for example, to weigh costly flood-proofing investments against losing their homes. This mounting flood risk may spell deep losses for many, and without policies in place to help, will spell ruin for some.

bonds (essentially, investment vehicles created by bundling individual mortgages) tied into these riskier coastal real estate mortgages will thus also be at risk of losing value.

Real estate developers and investors risk sinking millions into properties that will shrink in value as chronic flooding increases. Insurers covering residential and commercial properties risk unsustainable payouts.

When enough major market actors become aware of and begin to act on these risks, it could potentially trigger a regional housing market crisis, or even a more widespread economic crisis.

Our Challenge–and Our Choices

The development along our nation's coasts today is the result of choices made over centuries. We've made our living from the sea; we've bought and built homes with ocean views; we've visited and vacationed in seaside towns, leaving behind money and taking away memories; we've toiled and built lives in coastal cities and small towns. Investors and developers have found ways to profit from this timeless pull to the seaside. Hundreds of years of history, personal and shared, painful and triumphant, are held in the homes, businesses, schools, roads, and treasured places that line our coasts. And much of it is at risk from sea level rise.

Despite long-available scientific information on observed and projected sea level, and the actual experience of flooding in some coastal communities, most coastal housing markets are a long way from reflecting the growing flood risks.

Imperfect information about localized risks and flawed policies have created a strong bias toward business-as-usual choices, greatly impeding science-based decisionmaking (Wing et al. 2018; Schwartz 2018). In the absence of adequate resources, or the wherewithal to invest in protective measures, many communities struggle to make more resilient choices. There are also significant questions about the accountability of local zoning regulators, developers, credit rating agencies, insurers, banks that proffer mortgages, and others who are effectively worsening the problem by ignoring or minimizing it (Allen 2017). In the near term, these policy and market incentives are serving to artificially prop up coastal real estate values (Becketti 2016).

But some experts and coastal residents are beginning to raise questions about the future of coastal real estate markets (Bernstein, Gustafson and Lewis 2018; Keenan, Hill, and Gumber 2018). Some real estate investors are also taking note (Coffee 2018; McConkey 2017). Zillow and Freddie Mac, two influential giants in the real estate sector, have both released reports in the last two years examining the impact of future sea level rise on coastal real estate (Rao 2017; Becketti 2016). Freddie Mac finds that sea level rise could "destroy billions of dollars in property and displace millions of people," with the resulting social and economic impacts "greater in total than those experienced in the housing crisis and Great Recession."

The prospect of these future losses compels action today. We must reorient policy and market forces toward solutions that work for people, ecosystems, coastal heritage, and the economy: by employing the best available science and information; by aligning existing policy and market incentives with the realities of sea level rise; and by investing in bold, transformative changes that limit harms and foster new frontiers of opportunity on safer ground.

KNOWING OUR RISK

To begin with, many homeowners and prospective home buyers are simply not sufficiently aware of the risks of sea level rise to their properties, whether present-day or future risks, and whether confined to major storms or chronic tidal flooding. This information is inadequately reflected in the Federal Emergency Management Agency's (FEMA) flood risk maps, for example, which only account for present-day flood risks (Schwartz 2018; Wing et al. 2018; Joyce 2017; Cleetus 2013). Although some individual states and localities have standards requiring real estate agents and home sellers to disclose flood risks at the time of a home sale, there are no uniform robust national requirements (Lightbody 2017).[7] Lenders and investors, especially those at a distance from the specific location, are also either largely unaware of growing tidal flood risks to properties or not adequately accounting for it in their business decisions (Farzad 2018; Allen 2017).

To address this gap in awareness, federal, state, and local policymakers, as well as members of the private sector, have important, complementary roles to play. These actions must be supplemented with resources and options for adaptation measures because greater awareness of flood risks will also bring challenges, especially to communities whose risks are revealed to be high. Actions should include the following:

1. The federal government must play a lead role in communicating risks to the public and incorporating those risks into its own policies and actions. Recent authoritative reports from the US Global Change Research Program and the National Oceanic and Atmospheric Administration (NOAA), together with online tools from federal government agencies such as the Environmental Protection Agency and NOAA, can serve a critical purpose in helping communities, policymakers, investors, and the broader public understand the risks of sea level rise (Sweet et al. 2018; EPA 2017; NOAA 2017a; USGCRP 2017). FEMA flood risk

maps—which help set flood insurance rates, guide local land-use policies, and inform infrastructure design standards—must be updated coast-wide to reflect sea level rise projections (TMAC 2016). This will help communicate the threat and encourage communities to take protective steps. Congress needs to increase funding beyond current levels and provide an explicit directive to FEMA to make this possible (ASFPM 2013).

2. State and local policymakers must help disseminate flood risk information to communities, and set local zoning and building regulations in line with these risks.

3. Flood-risk disclosure in the marketplace is vital to help individuals and businesses understand the risks to their investments and drive more resilient outcomes. National standards for flood-risk disclosure, including floods from sea level rise—for all real estate transactions—would go a long way toward making risks clear and transparent in coastal real estate markets. Mortgage underwriters and home appraisers can also play important roles in assessing and disclosing information about these risks to lenders and buyers.

   Widespread adoption of industry standards and best practices for disclosing flood and other climate-related risks is needed. Financial institutions have begun taking steps to internalize climate risks, albeit slowly (Bonanno and Teras 2018). In the wake of the 2015 Paris Agreement, the Financial Stability Board—an international body that monitors and makes recommendations about the global financial system—launched the Taskforce on Climate-Related Financial Disclosures. The taskforce has released a set of recommendations on governance, strategy, risk management, and metrics and targets for financial-sector companies to support more accurate pricing of climate-related risks and thereby more informed investment decisions (TCFD 2017). These recommendations and the taskforce's five-year climate disclosure implementation pathway have the support of more than 250 major corporations, including banks, insurers, and investors.

   Credit rating bodies also must start reflecting risks to coastal property, while rewarding proactive adaptation measures to limit those risks. For example, the credit rating agencies Moody's and Standard & Poor's have begun to evaluate and communicate how to account for climate risks in their credit ratings of municipal bonds (Bonanno and Teras 2018; Moody's Investors Services 2017; Walsh 2017; S&P 2016).

Cris Benton

The historic attractiveness and market value of coastal property have long driven coastal development, like this pulse of new home construction in Richmond, California, some 20 years ago. Though the risks of sea level rise have been evident for some time in cities like Miami, Florida; Charleston, South Carolina; Norfolk, Virginia; and Annapolis, Maryland; in many such places a brisk pace of new home construction continues.

REALIGNING POLICIES AND MARKET INCENTIVES TO REFLECT GROWING FLOOD RISKS

Well-intentioned but short-sighted federal, state, and local policies can mask risk and create incentives that reinforce the status quo, or even expose *more* people and property to risk. The market's bias toward short-term decisionmaking and profits can also perpetuate risky investment choices. Identifying and reorienting the principal policies and market drivers of risky coastal development is a necessary and powerful way to move the nation toward greater resilience.

Here we identify several existing federal and state policies that play a de facto role in how communities—and financial markets—perceive and respond to coastal risks. Each of these policies can be improved to better incentivize and enhance resilience:

1. Federal disaster aid, when not accompanied by explicit incentives to reduce residents' and businesses' exposure to risks, has led states and municipalities to rebuild in a business-as-usual way and underinvest in risk-reduction measures (Kousky and Shabnam 2017; Moore 2017). Post-disaster investments should instead be made with a view to reducing future risks through a range of protective measures, including home buyouts and investments in flood-proofing measures as appropriate, and a requirement for adequate insurance coverage. For now, communities and financial sector actors rely on the assumption that federal aid will continue in its current form. Credit rating agencies have cited this assumption of continued federal aid for rebuilding as a reason to avoid downgrading the credit rating of municipalities that are exposed to risks of sea level rise.

BOX 1.

Can't We Just Keep the Water Out?

As homeowners become more aware of the threat that chronic flooding poses to what is likely their most significant financial asset, interest in adaptation options—in particular, defensive measures that allow life to go on as usual—is likely to spike. And while adaptation is essential, there is cause for caution in embracing defensive measures as the sole or even primary solution.

Most community-level defensive measures are designed to help minimize wave action, reduce erosion, and protect against storm surge (NRC 2014). But keeping out normal, but higher, high tides is a different challenge. To defend large areas against chronic inundation, impervious seawalls (for example) would need to extend along large stretches of shoreline and avoid channeling incoming seas toward other exposed areas (NRC 2014). Or levees would need to be constructed, potentially requiring the use of large tracts of land and encouraging new development behind them (GAO 2016; Kousky 2014). As sea level rises, however, hard structures can aggravate coastal erosion, with natural habitat and beach loss, even as the walls fail to protect against infiltration of saltwater from below ground (Boda 2018; Vitousek et al. 2017; Moser et al. 2014; NRC 2014; Mazi, Koussis, and Destouni 2013; Barlow and Reichard 2010).

USACE

A seawall is constructed in New Jersey by the US Army Corps of Engineers. The hard defensive measures that are widely deployed today were typically built to dampen storm surge and limit erosion, not keep out normal but higher tides.

Such measures also come with an expiration date: either the defensive infrastructure reaches retirement age, or sea level rise catches up and necessitates further upgrades, at additional cost, lest it be overwhelmed.

Defensive measures can require investment—both initially and for ongoing maintenance and operation—on a scale that many communities will be unable to muster with diminished tax bases, particularly if they had fewer resources to start with. Individual property-level measures such as elevating buildings and installing doorway flood gates also require funding, and do not address the inundation of the roadways, commercial districts, septic systems, schools, etc. that those households and businesses rely on. Investing in defensive measures may help forestall chronic flooding in many locations, but for some home- and business owners there will be no practical or affordable way to keep the tide out of their property; for some communities, it will be similarly impractical or unaffordable to defend whole flooded areas. Options such as retreat and relocation will need to be part of the conversation.

2. Existing federal, state, and local policies could be effectively deployed for investments in measures that will both reduce risks ahead of time and help rebuild in a more resilient way (Kousky 2014). We should recognize coastal flood risk for the predictable, slow-moving disaster it is, rather than respond only episodically, i.e., in the aftermath of major storms. One way this can be done is by ramping up investments in FEMA's pre-disaster hazard mitigation grant program and the flood mitigation assistance program, and the community development block grant program administered by the US Department of Housing and Urban Development (HUD). A recent analysis by the National Institute of Building Sciences of almost a quarter century's worth of data found that for these types of flood risk mitigation programs, every $1 invested can save the nation $6 in future disaster costs (MMC 2017).

Reforming short-sighted policy and market drivers of risky coastal development is a necessary and powerful way to move the nation toward greater resilience.

3. The taxpayer-backed National Flood Insurance Program—while a vital program—has long been recognized as subsidizing some homeowners in flood-prone areas and inaccurately portraying flood risks because, in too many cases, insurance premiums and the flood risk maps that underlie them do not reflect true risks (Schwartz 2018; Joyce 2017; Kousky and Michel-Kerjan 2015). The most egregious examples are so-called repetitive loss properties that have received repeated payouts from the program despite being in places that are clearly too risky to insure (Moore 2017).[8] With sea level rise, the maps used by the National Flood Insurance Program are increasingly out of sync with the actual risks to coastal properties. Commonsense reforms to the program can ensure that it more effectively communicates flood risks, protects communities, and promotes better floodplain management.

4. A robust federal flood risk management standard should be restored and mandate that all federal investments take

BOX 2.

Insights from Market Experts on the Financial Risks of Sea Level Rise: Excerpts from the Matrix of Voices

To better understand the financial implications of the risks of sea level rise to coastal property markets and the wider economy, we gathered perspectives from market experts—including representatives from credit rating agencies, insurers, real estate investors, bond investment advisors, and mortgage and real estate industry experts—and municipal officials. Taken together, a picture emerges that highlights the likely impact of sea level rise on coastal property values, the property tax base, and the many inextricably connected market sectors, and reinforces the need for broad-based action to limit harmful consequences for people and the economy.

The **six main insights** that emerged from the experts consulted were (see the full Matrix of Voices at *www.ucsusa.org/underwater* for more details):

1. **The financial risks of sea level rise are real and significant—and they are largely unaccounted for in the current market.**

   "Sea level rise is an extremely serious issue with direct implications for municipal credit ratings, which will in turn affect the value of their bonds. Also, if the tax base contracts substantially, that will affect the ability of municipalities to pay back bond investors."
   — *Andrew Teras, vice president and senior analyst, Breckinridge Capital Advisors*

   "The impacts to coastal real estate markets, coastal businesses, and property tax bases will be geographically concentrated in the near term, but will become more widespread over time. Many of today's financial decisions do not consider sea level rise, but as the evidence evolves, market signals (insurance rates, community credit scores) may increasingly reflect a heightened risk."
   — *Roger Grenier, senior vice president, global resilience practice leader, AIR Worldwide, Consulting and Client Services*

   "As risks increase, insurers will pull out of markets and limit coverages, increase deductibles, or raise rates. When significant volumes of property value decline and mortgage delinquencies increase, there are major ramifications for our entire financial system, as we experienced in the 2008 financial collapse caused by the mortgage-market meltdown."
   — *Cynthia L. McHale, director, Ceres*

   "There is no risk, it's a guaranteed total loss. The only uncertainty is the timeline."
   — *Mayor Philip Stoddard, South Miami*

2. **Some initial steps are underway to try to incorporate these risks, but there are barriers to doing so.**

   "The challenge to incorporating climate risks like sea level rise into market-based decisions today is that there is no uniform way to communicate future risk conditions, nor consensus on the timeframe to consider in communication, or which model results/scenarios should form the basis of any outreach."
   — *Carolyn Kousky, PhD, director for policy research and engagement, Wharton Risk Management and Decision Processes Center, University of Pennsylvania*

   "As an investment manager, one of the biggest challenges is the disconnect between time horizons for our clients' investments in bonds—usually three to five years—and the time frame 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*

into account future flood risks in order to help protect vital federally funded infrastructure, ensure wise use of taxpayer dollars, and also set a valuable guidepost for communities. State and local building and zoning regulations that are solely focused on near-term economic outcomes, and thereby allow questionable coastal development, are essentially building new exposure to risk when they could and should be reducing such exposure (IBHS 2018). Additional important opportunities include more protective building standards and coastal zone management regulations to help encourage flood-resilience measures in floodplains, including the protection of wetlands and barrier islands and other natural flood-risk reduction methods.

5. Increased funding for voluntary home buyout programs administered by FEMA and the HUD can also help homeowners move to safer locations. Communities in high-risk areas may also increasingly need relocation grants and technical assistance, and, correspondingly,

"Our first infrastructure challenge is going to be loss of septic tank function. Installing municipal sewer systems after a neighborhood is built-out is very expensive. We are looking at the costs and cringing. Nobody is going to help, not the feds, not the state, not the county. So, cost is the biggest barrier."
— *Mayor Philip Stoddard, South Miami*

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.**

"Flood insurance creates risky behavior when it is extended to new development. Zoning regulations should be considering the 100-year outlook for the land, including the future cost of providing access and infrastructure to the land, incenting construction in areas without sea level rise risk, and 'charging' areas with [sea level risk] to cover the future public costs of mitigating those risks."
— *Douglas M. Poutasse, executive vice president, head of strategy and research, Bentall Kennedy (US) LP*

"The existing government-backed system effectively creates a program of subsidized insurance coverage for Americans to live at the coast... In addition, current spending is heavily weighted towards post-disaster mitigation, instead of investing in communities before disasters occur... Finally, the economic incentives of the real estate industry, construction industry, and local chambers of commerce are often not aligned with risk-informed policies and practices."
— *Roger Grenier, senior vice president, global resilience practice leader, AIR Worldwide, Consulting and Client Services*

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.**

"If policymakers confront the National Flood Insurance Program's moral hazards and reduce the scope of coverage it provides, or increase premiums in line with the underlying risk, development or redevelopment of coastal lands might be constrained as they become uninsurable."
— *Kurt Forsgren, managing director, infrastructure sector lead, S&P Global Ratings*

"Once the properties enter the 'decline' phase, the behavior of owners changes. They invest less new capital in maintaining and improving their properties, because the shortened time frame to receive a return on additional investment necessitates a higher rate of return. This becomes a self-reinforcing mechanism, as properties with lower reinvestment become less attractive to tenants and occupants.
— *Douglas M. Poutasse, executive vice president and head of strategy and research, Bentall Kennedy (US) LP*

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.**

"The concern I always have is that, ultimately, only some portions of the vast US coastline will be protected, i.e., major urban areas. Many, many other portions of the coast, along with their respective people and livelihoods, will remain in harms' way."
— *Cynthia L. McHale, director, Ceres*

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.**

"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 one of the largest challenges to the market. Uniform risk disclosure is necessary for markets to price this risk accurately."
— *Kurt Forsgren, managing director, infrastructure sector lead, S&P Global Ratings*

communities that receive an influx of new residents may need financial resources. And as sea levels rise, federal, state, and local policies and resources should specifically target and address the needs of disadvantaged communities.

6. Banks, insurers, real estate investors, developers, and other major financial actors in coastal areas should establish guidelines and standards to incorporate the risks of sea level rise in their business models, thus better serving the long-term economic interests of their clients. A blinkered focus on near-term profits and market factors can obscure significant risks just beyond the horizon.

If there are changes in the perception of risk to coastal properties or if there is a growing political or social pressure to make changes, the marketplace or policymakers could make rapid changes to align incentives with risks. Potential examples of these types of shifts include changes in insurance premiums or criteria for insurability, changes in lending terms, and changes in credit ratings for communities. These types of tipping points could trigger very quick shifts in property values and the broader economic health of a coastal community.

Unfortunately, a rapid realignment of taxpayer and private-sector investments reflecting true risk could jeopardize the well-being of communities unless deliberate steps are taken to provide options for them ahead of time. The withdrawal of private-sector investment dollars, and even public dollars when places are deemed too costly to support, could bring disruptive local impacts and market speculation with inequitable outcomes, particularly for those communities with fewer resources. Rather than a wholesale rapid withdrawal of funding for these areas, a judicious scaling back of new investment in line with flood risks would be far preferable from a societal perspective, together with a redirection of those investments toward options to help communities cope and build resilience.

PLANNING FOR A RESILIENT FUTURE FOR ALL

As a nation, we must use wisely the diminishing response time that communities have to reduce their exposure to this threat, from the individual scale to the economy as a whole. For communities facing chronic flooding of properties in the near term, it is imperative to act quickly to phase out policies that perpetuate and increase risk, while considering options for retreat from the highest-risk places. For cities and towns where the effects of chronic inundation will become apparent by mid-century, a slightly longer time horizon might allow for more creative solutions and comprehensive policies and planning. Targeted resources must be made available for disadvantaged communities for whom any of these adaptive responses could pose steep challenges. Given the wide-scale nature of the risks to our nation, we need a holistic, timely response strategy.

Decisionmakers still have choices that can help limit threats to coastal cities and towns, and ultimately, to the national economy.

Decisionmakers still have choices that can help limit—even if they cannot eliminate—threats to coastal cities and towns, and ultimately, to the national economy. Three main strategies exist for adapting to sea level rise on any coast: defend, accommodate, and retreat. Decisions about which combination of strategies to employ, and when and where, require expertise, stakeholder engagement, and ultimately the resources to implement the chosen options. Many cities and towns can expect adaptation to be costly, and that some financial losses will be inevitable. Homeowners and communities cannot be expected to absorb all of these potentially crippling costs on their own, especially those with fewer resources. A range of relevant actors—chiefly, the federal government—can implement policies that will help support adaptation and limit the extent of financial loss, ensuring that these taxpayer-funded resources are wisely and equitably deployed. The private sector also has an important role in driving innovative risk-reduction measures and creating new loci of economic opportunities in areas further inland.

Sea level rise is challenging us to reimagine our coasts in many ways. Hundreds of communities will face losses. Retreat may be necessary from some of the highest-risk places. But there are opportunities to be had too—especially if we plan and invest wisely. Inland communities may be revitalized by the influx of new residents and new businesses. New communities can emerge, new infrastructure be built, and new economic opportunities created. All of this will only be possible with visionary leadership from policymakers, the private sector, and communities themselves.

Critically, the United States must also work with other nations to slow the pace and limit the magnitude of sea level rise through aggressive reductions in heat-trapping emissions, in order to allow as many communities and homes as possible—both at home and abroad—to avoid chronic inundation in the years ahead.

RESEARCH AGENDA FOR MEETING THIS CHALLENGE

Developing a coherent, just, and forward-thinking approach to the challenges we face will require further research on several fronts.

First, the many stakeholder groups within the coastal real estate sector—from individual homeowners to insurers—need to examine their tidal flooding tolerance and explore thresholds beyond which a pull-back (physically or financially) from affected areas is required. Within the private sector, for example, a careful examination of the risks could trigger decisions—such as not granting loans, raising insurance premiums, or downgrading credit—which will in turn drive big, sometimes painful, changes that begin to align market outcomes with those risks. Local-scale, community-specific modeling under different climate projections is a key piece of this research that can be built out.

Patricia Lane Evans

This Hampton Beach, New Hampshire, home captures both our desire to be close to the ocean and the risks as seas rise. Homeowners and communities have a narrowing window of time to take action. They require support from local, state, and national elected officials to manage what lies ahead.

Second, communities will need more complete information on whether and how they can be made more resilient in place: for example, through what measures, at what cost, for how long? Third, further research is needed around successful models for retreat that could lead to positive outcomes for coastal and inland communities, particularly considering lessons learned following buyouts and individual homeowner retreat after Hurricane Sandy (Binder and Greer 2016). Critical areas in which we need to build our understanding are the necessary governance structures that will best support coastal retreat, legal implications of historically dry land going underwater, and the relationship between market downturns and climate-induced migration (Flavelle 2018; Kousky 2014). Additionally, as communities increasingly face the challenge of frequent, disruptive flooding, they will need to marshal resources to rise to that challenge—which inherently puts communities with fewer resources at a disadvantage (ERG 2013). We will therefore need to deepen our understanding of how policies can be made equitable and how best to enact them (Deas et al. 2017).

Conclusion

The cliff's edge of a real estate market deflation due to flooding and sea level rise is already visible for many communities if they choose to look. The trajectory of our current actions—continued building in vulnerable places and ever-increasing global warming emissions—is propelling us closer to that edge. There are thresholds for properties at risk of chronic flooding from sea level rise beyond which regular life becomes unmanageable and financial loss becomes a better bet than struggling to live with floodwater. There are thresholds for communities beyond which economic and financial viability, and crucial public services, are threatened. When enough of those households and communities falter, entire real estate markets may face a tipping point. Whether we react to this threat by implementing science-based, coordinated, and equitable solutions—or walk, eyes open, toward a crisis—is up to us right now.

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DISCLOSURE

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 Union of Concerned Scientists and do not reflect the position of Zillow Group.

DISCLAIMER

This research is intended to help individuals and communities appreciate when sea level rise may place existing coastal properties (aggregated by community) at risk of tidal flooding. It captures the current value and tax base contribution of those properties (also aggregated by community) and is not intended to project changes in those values, nor in the value of any specific property. The projections herein are made to the best of our scientific knowledge and comport with our scientific and peer review standards. They are limited by a range of factors, including but not limited to the quality of property-level data, the resolution of coastal elevation models, the potential installment of defensive measures not captured by those models, and uncertainty around the future pace of sea level rise. More information on caveats and limitations can be found at www.ucsusa.org/underwater. Neither the authors nor the Union of Concerned Scientists are responsible or liable for financial or reputational implications or damages to homeowners, insurers, investors, mortgage holders, municipalities, or other any entities. The content of this analysis should not be relied on to make business, real estate or other real world decisions without independent consultation with professional experts with relevant experience. The views expressed by individuals in the quoted text of this report do not represent an endorsement of the analysis or its results.

ENDNOTES

1. Complete results for the intermediate and low scenarios are available here at *www.ucsusa.org/underwater*. The high scenario used throughout this report is not now thought to be extreme, given recent observations and analysis of land-based ice melt (e.g., Kopp et al. 2017, Schroeder et al. 2017; DeConto and Pollard 2016). In addition, in 2017 the National Oceanic and Atmospheric Administration released new sea level rise scenarios that are comparable to these three and include an "extreme" scenario of a roughly eight-foot increase by 2100 (Sweet et al. 2017).
2. In southeast Florida, individual units in high-rise buildings (which have been constructed at a rapid pace on low-elevation land in recent years) account for many at-risk homes. In this analysis, ground-floor chronic flooding risk is applied to the entire building since the unit's access, functionality, and value are all impacted (see the full methodology at *www.ucsusa.org/underwater*.)
3. The shore line of the San Francisco Bay contains a vast network of locally controlled defensive structures such as seawalls and levees. This analysis explicitly accounts for only those structures identified by the Federal Emergency Management Agency as reducing flood risk—namely, those surrounding Foster City and the Oakland International Airport. As such, the statistics reported here likely do not reflect the varying levels of protection that other coastal defense structures could potentially provide to Bay Area communities.
4. California home values reflect assessed rather than market values, unlike all other coastal states in this analysis. See the full methodology at *www.ucsusa.org/underwater* for details.
5. Many Louisiana communities have locally controlled levees or other flood-control structures that were not explicitly included in this analysis. Federally controlled leveed areas as defined by the US Army Corps of Engineers were excluded from the analysis. See the full methodology at *www.ucsusa.org/underwater* for details.
6. If properties of all values were equally at risk, 50 percent of the at-risk homes would be valued below the state median.
7. In general, real estate agents and home sellers are required to disclose all material facts that could affect the price or desirability of a property. But in practice, unless they are shown to have actual knowledge of flood risks, there is no easy way to require agents and sellers to disclose projected sea level rise–related flood risk under current laws.
8. A recent study from the Natural Resources Defense Council, using data from FEMA, found that from 1978 through 2015 the agency paid $5.5 billion to repair or rebuild 30,000 severe repetitive loss properties that have been flooded an average five times or more. Texas, New Jersey, New York, and Florida ranked the highest in terms of both numbers of these properties and damage costs.

APPENDIX: ABOUT THIS ANALYSIS

Our basic methodology

This analysis intersects two existing datasets: 1) zones of chronic inundation along the US coastline, previously published by Dahl et al. 2017 and Spanger-Siegfried et al. 2017; and 2) the Zillow Transaction and Assessment Database (ZTRAX), which contains property data gathered by county assessors' offices and has been collated by the online real estate company Zillow. The chronic inundation zones are defined for a suite of future years and sea level rise projections, as described as follows. The overarching goal of the analysis is to evaluate the risks of chronic, disruptive flooding to the coastal real estate sector.

What is chronic inundation?

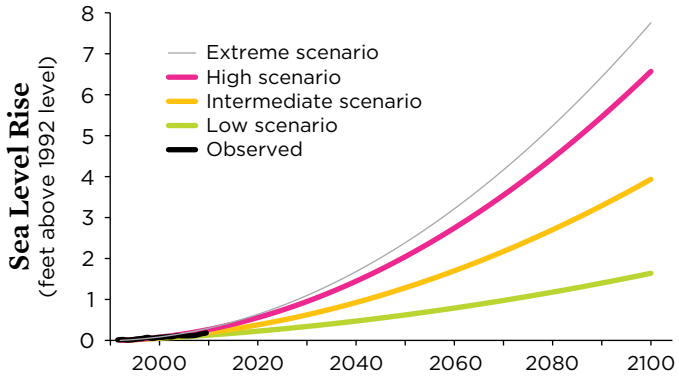
Building on prior research, this analysis defines a chronic inundation zone as any area where tidal flooding occurs 26 times per year (on average, twice a month) (Dahl et al. 2017). This frequency is based on previously published thresholds (e.g., Sweet and Park 2014), consultation with technical experts at universities and federal agencies, and perspective gained from local community experts. The flood tolerance of individual homeowners or homebuyers, however, will be highly subjective. Similarly, the willingness of private sector actors to bear financial exposure in flooded locations may change far earlier than the threshold used here. When it comes to real estate markets, it may take considerably less flooding to drive big choices and changes.

What sea level rise scenarios did we use and why?

We used three scenarios developed for the 2014 National Climate Assessment and localized for this analysis (Huber and White 2015; Walsh et al. 2014; Parris et al. 2012). We refer to our projections as the high, intermediate, and low scenarios (Figure A-1). The high scenario assumes rapid ice sheet loss and projects a global average sea level rise of 6.6 feet (2.0 m) above 1992 levels by the end of this century. The intermediate scenario assumes a moderate rate of ice sheet loss that increases over time for a rise of 4.0 feet (1.2 m) by the end of this century. The low scenario assumes curtailed warming and sea level rise that is driven primarily by ocean warming with very little contribution of ice loss, and projects a rise of 1.6 feet (0.5 m) by the end of this century. Because the total 21st-century warming in this scenario is in line with the Paris Agreement's goal of holding warming to less than 3.6°F (2°C) above preindustrial temperature levels, we use this scenario as a proxy for sea level rise under the Paris Agreement (Rasmussen et al. 2018).

We have made projections for at-risk properties under all three scenarios, but in this report, we lead with results of the high scenario. The high scenario is considered most applicable in situations with a low tolerance for risk. This makes it most suitable for estimating the scale of risk to residential properties, which typically represent a homeowner's greatest single asset. The full suite of results is available online at *www.ucsusa.org/underwater*.

FIGURE A-1. Projected 21st Century Sea Level Rise



How much the sea level rises this century depends on our past and future emissions of heat-trapping gases as well as how Earth responds to those emissions. We based our projections for sea level rise—our low, intermediate, and high scenarios—on the intermediate-low, intermediate-high, and highest scenarios from the Third National Climate Assessment (Parris et al. 2012). The Fourth National Climate Assessment includes an "extreme" sea level rise scenario predicated on our growing understanding of the sensitivity of Antarctic ice to warming temperatures (Sweet et al. 2017).

How were incomplete or inaccurate data in the ZTRAX dataset handled?

Within the ZTRAX dataset, issues such as missing values are common. We applied three broad corrections to the ZTRAX data. First, we removed properties that were duplicated in the database. Second, we re-geocoded each property using an external service (geocod.io) to ensure its positional accuracy. Finally, for properties missing a market value or a property tax value, we calculated the missing value based on the reported assessed value and county-specific information about the ratio between assessed and market values and/or effective tax rates. Missing market and property tax values were calculated only for residential properties. It is important to note that for California, where there is no simple ratio between assessed value, market value, and property tax value, we used assessed value in place of market value.

How were population and demographic statistics derived?

Estimates of the number of residents living in homes at risk of chronic inundation were derived using the housing unit method (Smith 1986) and 2010 census data on occupancy rate and number of people per household (US Census Bureau 2010). Population totals as well as racial demographics were also taken from the 2010 census. Community-level poverty rates were derived from the 2011–2015 American Community Survey.

What are the key caveats, assumptions, and limitations?

1. Our determination of the extent of chronic inundation is dependent upon the quality of the underlying elevation data, which were provided by the National Oceanic and Atmospheric Administration (Marcy et al. 2011; NOAA 2017b). These data vary in horizontal resolution and accuracy, and communities are encouraged to work with the highest resolution elevation data available to do more detailed mapping.
2. Even the highest-resolution elevation data used here do not fully capture many local coastal defenses, such as sea walls. Though most defenses are constructed to manage storm surge and erosion, not to keep out higher tides, areas with such structures in place may not experience as much flooding as suggested by our analysis.
3. Tidal dynamics vary greatly depending on local coastal morphology. Features such as bays, inlets, barrier islands, and wetlands can attenuate or amplify the tide relative to its level at the open ocean–facing tide gauges that were used to determine chronic inundation water levels.
4. This analysis makes no assumptions about adaptation measures that communities may implement in the future, such as building flood control structures or restoring wetlands. Several factors could affect whether and how communities implement adaption measures, including geography, resources, and the range of options available to any given community.
5. Population, demographics, number of properties, and associated property data are assumed to be constant at present-day levels. Studies incorporating future population growth into sea level rise studies tend to show greater population impacts, which suggests that our results may be conservative (Hauer, Evans, and Mishra 2016).

For more details on this analysis, see *www.ucsusa.org/underwater*.

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Underwater

Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate

> ***In the coming decades, many coastal real estate markets will be strained by tidal flooding, with potential reverberations throughout the national economy.***

As sea levels rise, more and more American homes and businesses will experience frequent, disruptive flooding that makes everyday life impossible. More than 300,000 of today's coastal homes are at risk of this untenable flooding within the term of a 30-year mortgage.

Yet property values in most coastal real estate markets do not currently reflect this risk. And with short-sighted investments and policies at all levels of government concealing this growing problem, homeowners, businesses, communities, and investors are not aware of the financial losses they may soon face.

In the coming decades, many coastal real estate markets will be strained by flooding, some to the point of collapse, with potential reverberations throughout the national economy. Individual homeowners and businessowners, banks, lenders, investors, developers, insurers, and taxpayers are poised to sustain large collective losses. Shrinking property tax bases could spell decline for many coastal cities and towns.

We have scant time remaining to brace our communities, and our local and national economies, for this challenge. While there are no easy solutions, knowing our risk—and using that knowledge to create bold new policies and market incentives—will help protect coastal communities. Whether we react to this threat by implementing science-based, coordinated, and equitable solutions—or walk, eyes open, toward a crisis—is up to us right now.

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