

**HIGHLIGHTS**

*In recent years tidal flooding in Miami-Dade County has grown from occasional to chronic—a visible sign of rising sea levels—and is causing disruption to the local economy and infrastructure. The problem, according to analysis by the Union of Concerned Scientists, is poised to expand rapidly. Using an Army Corps of Engineers scenario of sea level rise, this analysis suggests that the frequency of tidal flooding events will increase steeply over the next 15 to 30 years, while the land area exposed to flooding grows. Managing this projected disruption in a culturally, economically, and ecologically vital region requires a concerted response today. Aware that it is a national hot spot for risk of sea level rise, the county has strived to become a leader in coastal adaptation planning. With innovative and determined local action backed by serious state and federal support, the county—an icon of climate change impacts—can become a national leader in climate change resilience.*

# Encroaching Tides in Miami-Dade County, Florida

## *Investing in Preparedness to Manage the Impacts of Rising Seas*

By 2045, sea level in Miami-Dade County is expected to rise about 15 inches above current levels, according to a projection based on US Army Corps of Engineers data (SFRCCC 2015). With this increase, in just 30 years' time, flood-prone locations in Miami-Dade County's coastal communities would face roughly 380 high-tide flood events per year, and the extent of tidal floods would expand to affect new low-lying locations, including many low-income communities with limited resources for preparedness measures. The flood events that today snarl daily life in parts of the county only periodically would become widespread and, on average, a daily occurrence.

As sea levels rise, higher water levels can also increase the extent and impact of storm surge and can permanently inundate some locations. A one-foot increase in sea level is estimated to threaten up to \$6.4 billion in taxable real estate in the county overall (Climate Central 2015). In the *Unified Sea Level Rise Projection*, developed by Miami-Dade and its neighboring counties, the Army Corps projection outlines a one-foot rise in sea level in the county by about 2040—well within the lifetime of a typical home mortgage (SFRCCC 2015). But with these stark challenges come incentive and opportunity for Miami-Dade to be a national innovator, breaking new ground on two fronts: preparing for sea level rise and reducing global warming emissions.



**CASTLES BUILT ON SAND**

*A tourist mecca teeming with high-value real estate, low-lying Miami and Miami Beach are among the places most vulnerable, globally, to sea level rise (Nicholls et al. 2008). In 2014, 14.5 million tourists visited Miami-Dade County, many for its iconic beaches (Sampson 2015). Not only are these beaches eroding and in need of repeated “renourishing,” but with rising sea levels, salt water is encroaching onto the coastline, moving through porous limestone bedrock, and raising the water table in inland areas.*

“Miami-Dade County has the opportunity to become a global model for resiliency. If we don’t, our economy goes out with the tide. We can’t wait any longer.”

— Irela Bagué, Greater Miami Chamber of Commerce (Bagué 2016)

While efforts to reduce emissions, including by investing in energy efficiency and solar and other renewable forms of energy, are crucial if we are to avoid the worst consequences of climate change, this fact sheet focuses on preparedness. By investing in planning, tools, and measures that will reduce or manage risks accompanying sea level rise, the county can limit destructive and costly impacts today. And over the long term, it can save money. National and regional studies have concluded that pre-disaster investments save money in avoided damage and reduced recovery costs, roughly four dollars saved for every dollar invested in hazard mitigation (Schneider 2015; Rose et al. 2007; MMC 2005).

## What Do Sea Level Rise and Flooding Mean for Miami-Dade County?

Miami-Dade County faces a number of sea level rise risks, including increased urban flooding, degradation of land in the Everglades and increased saltwater intrusion, saltwater contamination of the drinking water supply, and flooding of power plant substations and ensuing power outages.

With its high water table, porous limestone bedrock, and low elevation, Miami-Dade is already susceptible to flooding (Renken et al. 2005). Between 1992 and 2012, sea level rose roughly three inches in the region (NOAA 2013), and, in recent years, flood-prone locations have seen around six tidal floods per year (Spanger-Siegfried, Fitzpatrick, and Dahl 2014). With more than 15 inches of additional sea level rise projected by mid-century, residents can expect the ocean to encroach onto shores where elevations are lowest and can expect drainage woes in low-lying inland communities to worsen (SFRCCC 2015; Moser et al. 2014). About one-fifth of urban Miami-Dade County (namely, the area outside of the Everglades) lies at elevations that are within one foot of sea level at high tide, and about one-third is within three feet (SFRCCC 2011).

Tidal flooding events, a chronic reminder of sea level rise, can impact the economy and way of life in the county—as well as the broader southeast Florida region—by affecting real estate, tourism, businesses, transportation, energy and water infrastructure, and port operations. The Port of Miami, which supports more than 207,000 jobs, is specifically



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### A POPULATION UNDER THREAT

Miami is famous for its unique character, shaped by a Spanish-speaking majority composed largely of Cuban Americans, but including immigrants from many other Latin American countries. As the reach of tidal flooding expands and flooding becomes more frequent, an increasing number of communities, homes, and businesses will be affected, as will the daily lives of those who call this vibrant region home.

concerned with—and planning for—the threat of climate change and sea level rise (Miami-Dade County 2015; PortMiami 2011). And while coastal cities are on the front line of climate change, cities farther inland such as Hialeah and Opa-locka also face increased flooding as rising seas complicate normal drainage (Wanless 2014; Morgan 2012).

Across the region, the dangers to drinking water grow. Encroaching salt water threatens to infiltrate the Biscayne Aquifer, a layer of very porous limestone that contains the underground fresh water that supplies much of the region. As sea levels rise, the zone where salt water meets fresh water is moving westward, causing saltwater intrusion into the region’s drinking water resource (Prinos et al. 2014).

Electricity infrastructure may be impacted by a combination of sea level rise and storm surge. Union of Concerned Scientists (UCS) analysis of electricity resilience found that critical substations are exposed to current and growing storm surge. In total, 31 (out of 152) substations and two (out of seven) power plants in Miami-Dade have the potential to be flooded by a Category 3 storm today, depending on the protective measures in place. With sea level rise, the number of exposed substations more than doubles by 2050, to 67 (McNamara et al. 2015). This includes substations around the Turkey Point nuclear facility. Although

the plant itself is unlikely to be flooded, the area around it would be, and outages of major substations in the area could prompt widespread power outages to homes and businesses.

The western part of Miami-Dade County extends into the Everglades, a national ecological treasure under threat from population growth, development, and, increasingly, sea level rise. The flow of fresh water in the Everglades from land to sea has historically protected this area against salt-water intrusion and recharged vital groundwater resources. But as sea levels rise, salt water pushes farther into these wetlands, disrupting the process. In a vicious cycle, saltwater intrusion contributes to the reduction in Everglades' peat soil, while the loss of peat soil lowers the land, exposing it to further saltwater intrusion and erosion (Hackney and Williams 2012). Rising salinity is a key driver of major ecosystem changes, including the loss of mangroves (Chambers et al. 2014). In June 2015, Miami-Dade County, recognizing the threats to biodiversity, drinking water resources, and the ecosystem as a whole, requested \$500 million from the Florida state legislature to improve freshwater flow to the Everglades and funding for the Everglades Restoration Project (Cuevas 2015).

## High-Tide Flooding in Miami-Dade County in 2030 and 2045

In southeast Florida, tidal flooding commonly occurs during extreme high tides. These tides are often associated with a full or new moon, when the combined gravitational pull of the sun and moon drives tides slightly higher and lower than normal. Several times a year, when the moon is closest to the earth, this phenomenon is amplified, and the so-called king tides occur. The more than 15 inches of sea level rise projected for Miami-Dade County by mid-century, on top of these normal tidal variations, will mean that tides can reach further inland and cause flooding with greater frequency (Spanger-Siegfried, Fitzpatrick, and Dahl 2014).

### TIDAL FLOODING WILL BECOME MORE FREQUENT

Using the Army Corps of Engineers scenario and tide gauge data from Virginia Key, UCS analysis projects that tidal flooding is likely to affect areas in Miami, Miami Beach, Coral Gables, and other nearby cities around 80 times per year by 2030 (compared to roughly six per year currently) and more than 380 times per year by 2045. In 2045, given normal variations in the tides, while some days would be flood-free, many days would see one or even two flood events—one with each high tide.

### SOME TIDAL FLOODS WILL BE VERY EXTENSIVE

As seas rise, some tidal floods will reach farther inland and have more serious impacts than most tidal floods today. The maps on the following pages illustrate the Army Corps of Engineers' projections of how sea level rise would expand tidal flooding zones. Lavender-colored areas represent typical tidal flooding today during an extreme tide. Indigo represents possible flooding during a tide of the same height in 2045. Green designates natural areas, such as parks.



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#### SUNNY-DAY FLOODING

Tidal flooding can affect roadways, badly disrupting traffic and damaging roads and vehicles. Efforts to stem current flooding are underway on Miami Beach, but as sea levels rise, those efforts and investments will need to increase to keep pace.

*“Living and working on projects on Miami Beach makes me keenly aware of the threat that rising and ‘king’ tides pose. In the short term, the new pumps in Miami Beach seem to be really helping. Over the long term . . . our unique geology and location . . . makes Miami especially vulnerable.”*

— John Wood, president, Amicon Construction (Wood 2015)

## Impacts in Communities

In **Miami Beach**, business as usual is being disrupted ever more often by tidewaters in streets and on sidewalks. The city kicked off a \$500 million pump project in 2014 that, with some recent exceptions, is helping to keep water off many streets (Fletchas 2014a). To pay for part of these improvements the city is relying on bonds and an increase in residents' storm water fees, from \$9 to \$16 per month (Fletchas 2014b). The city is also considering other measures, such as raising some roads and sidewalks by 1.5 to 2 feet along the Biscayne Bay side (Verchot 2015), and city leadership is seeking additional state and federal resources. As illustrated in the map, the city must prepare for an expansion in the area subject to tidal floods in coming decades.

In **Miami**, wealth and coastal risk intersect: with a majority of its land area in a flood zone, Miami has ranked seventh in the world in terms of purchasing power, first of all the world's major port cities in terms of value of assets exposed

FIGURE 1. Miami-Dade County Overview



*Miami-Dade County covers nearly 2,000 square miles, most of it flat, low elevation, and sitting atop porous limestone bedrock. The iconic wetlands of Everglades National Park account for one-third of the county's area. This map highlights the five locations discussed here, but sea level rise is a threat to low-lying areas along the entire coast, as well as to inland locations due to underground infiltration of salt water, an elevated water table, and backed-up rainwater in gravity-fed canals.*

Note: These maps are for discussion and research purposes only. They are not appropriate for detailed analysis. For more information, see the supporting technical document online at [www.ucsusa.org/encroachingtides](http://www.ucsusa.org/encroachingtides).

SOURCES: UCS ANALYSIS; MAP BASED ON DATA FROM THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION SEA LEVEL RISE VIEWER (NOAA 2014); OPENSTREETMAP 2014; US CENSUS BUREAU 2013.

to inundation today, and fourth globally in terms of population exposed (City Mayors 2012; Nicholls et al. 2007). In recent years, even as the threat of sea level rise has become more visible, the city witnessed a marked building boom in luxury units (Nehamas 2015). Miami also plays host to the intersection of coastal risk and economic struggle. With more than 20 percent of families with children in Miami-Dade County living

FIGURE 2. Miami Beach Extreme High Tide Flooding Today and in 2045



*Based on a US Army Corps of Engineers sea level rise projection, Miami Beach is poised to see flooding associated with extreme high tides across most of the west side of the island in 30 years' time. The city of Miami Beach, dogged by tidal flooding in recent years, is taking steps to keep the water at bay. Without a rapid ramp-up of adaptation efforts, tidal flooding will only grow more problematic for the city.*

SOURCES: UCS ANALYSIS; MAP BASED ON DATA FROM THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION SEA LEVEL RISE VIEWER (NOAA 2014); OPENSTREETMAP 2014; US CENSUS BUREAU 2013.

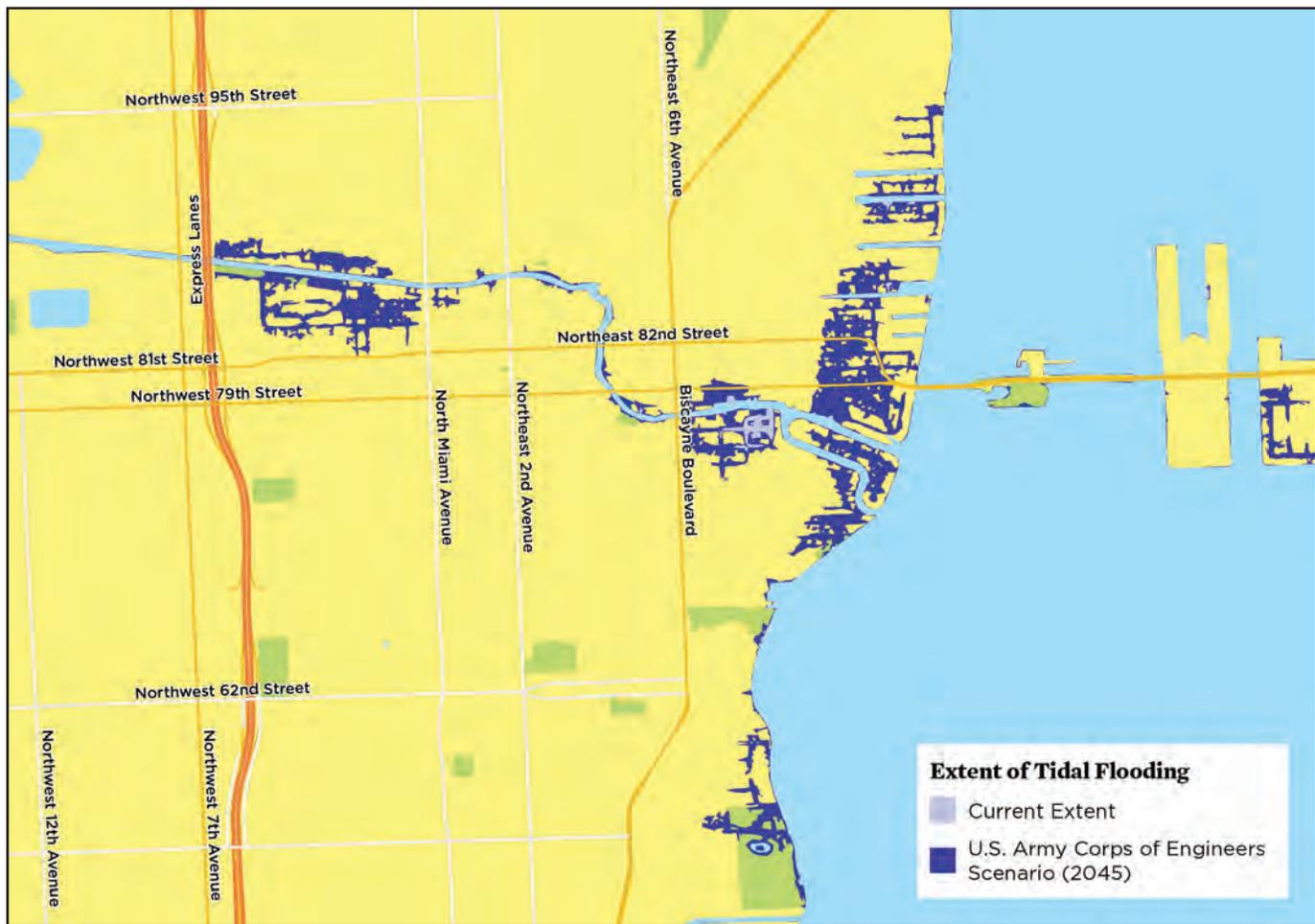
below the poverty line, coastal resilience-building is needed in areas like Miami’s low-lying, low-income neighborhoods.

As the city of **Hialeah** faces a changing climate, its location and inhabitants’ relatively low average income create a unique set of challenges. In Hialeah the median household income is just under \$30,000, 40 percent below the US average (US Census Bureau 2015). Built on drained marshland, after a rain the city relies on a series of gravity-dependent canals to discharge water into the ocean. Though the canals are designed to accommodate a certain amount of sea level rise, during some high tides the sea level can rise higher than water levels in the canals, making

drainage impossible and the flood-control systems inoperable. Between heavy rainfall and rising seas, these canals are increasingly unable to alleviate flooding. As a result, Hialeah is second only to Miami in the county-wide ranking of “repetitive flood losses,” homes or businesses with two or more claim payments of more than \$1,000 through the National Flood Insurance Program within a 10-year period.

The city of **Coral Gables** is known for its mansions, historic landmarks, and lush tree-lined streets. Home to the University of Miami, the seaside city has an average elevation of about four feet. The city is working to educate residents

FIGURE 3. A Closer Look at Miami Extreme High Tide Flooding Today and in 2045



*Because of Miami-Dade’s porous geology, low elevation, and gravity-dependent water management system, as sea level rises, flooding impacts can reach inland from the coast. Places in the Upper Eastside neighborhood, shown here, experience flooding today during extreme tides and should prepare for that flooding to grow more extensive in coming decades.*

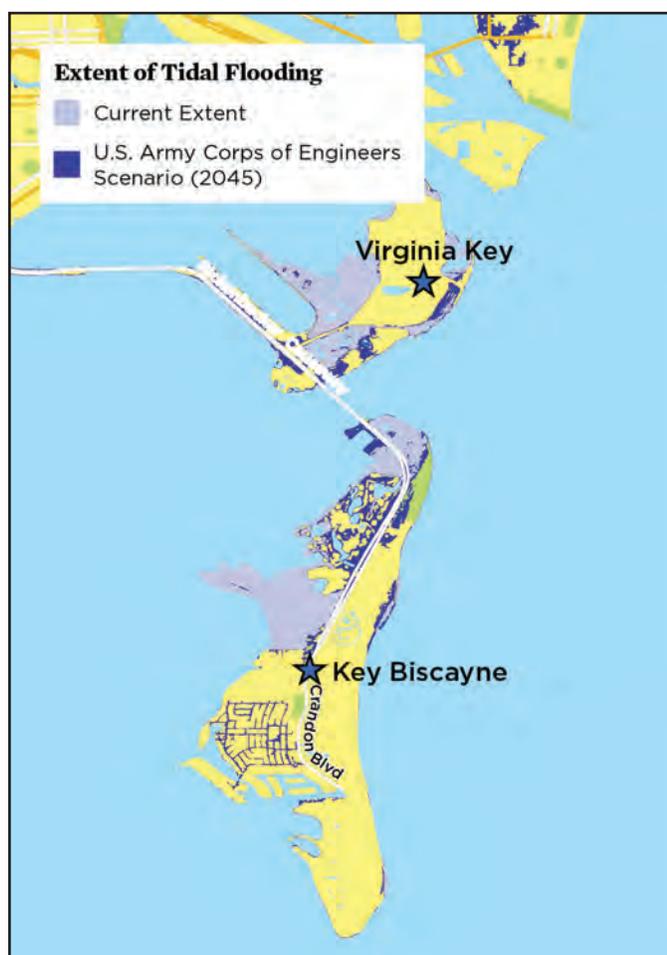
SOURCES: UCS ANALYSIS; MAP BASED ON DATA FROM THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION SEA LEVEL RISE VIEWER (NOAA 2014); OPENSTREETMAP 2014; US CENSUS BUREAU 2013.

about flooding and sea level rise risks and is seeking regional and federal support to implement projects that will increase community resilience. During 2014 and 2015, the city budgeted \$500,000 in staff salaries for flood protection services (City of Coral Gables 2014).

Amidst rising seas, the barrier-island beauty of **Key Biscayne** comes at a cost. The village has 8,469 structures in the storm surge zone, 31 of which are repetitive loss structures (Miami-Dade 2014). Critically, the one road on and off

the island is itself considered a flooding hot spot (Broward MPO 2015). Village leaders and residents are actively pursuing climate resilience projects, while in the private sector, local architects, for example, are investigating ways to design flood-resilient homes that maintain the island's aesthetic. The village is working to implement flood hazard-mitigation measures, including improved drainage and dune restoration, as well as climate adaptation and resiliency goals as part of its sustainability plan (Miami-Dade 2014; Village of Key Biscayne 2014).

FIGURE 4. Key Biscayne Extreme High Tide Flooding Today and in 2045



*Over the next 30 years, Key Biscayne, which boasts one of the country's highest-end real estate markets, is projected to see an expansion of flooding during extreme tides into currently unaffected areas.*

SOURCES: UCS ANALYSIS; MAP BASED ON DATA FROM THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION SEA LEVEL RISE VIEWER (NOAA 2014); OPENSTREETMAP 2014; US CENSUS BUREAU 2013.

## Opportunities for Action: Increasing Climate Resilience in Miami-Dade

The secure and economically vibrant future that Miami-Dade County is working to build will depend in part on the quality and comprehensiveness of local, state, and federal responses to climate change. Many municipal and county officials are beginning to lead on this issue (see below). And civic engagement and public awareness are rising.

But local action is not enough. Miami-Dade needs state and federal action on two fronts: increasing investments in preparedness so that impacts can be prevented and managed, and reducing global warming emissions so that the rate of sea level rise can be slowed over time. Investing in preparedness is fiscally responsible; according to multiple national and regional studies, pre-disaster investments save money in avoided damage and reduced recovery costs (Schneider 2015; Rose et al. 2007; MMC 2005).

A national commitment on both fronts, rolled out this decade, could reduce the costs of action over the long term, while creating jobs for Miami-Dade residents. Between August 2004 and February 2011, hazard-mitigation activities implemented in Florida created more than 12,000 full-time-equivalent jobs (FDEM 2011).

## Miami-Dade County Taking Climate Action

Over the last decade, Miami-Dade County and its municipalities have achieved a range of climate milestones including these:

- **2006:** The county established the Miami-Dade Climate Change Advisory Task Force.
- **2007:** Miami-Dade County committed to the US Cool Counties Climate Stabilization Declaration and the US Conference of Mayors' Climate Protection Agreement.
- **2008:** The city of Miami developed a climate action plan, MiPlan.



Marc Averette/Creative Commons (Wikimedia Commons)

#### RISING SEAS, BACKED-UP RIVERS

*A key factor in Miami-Dade’s sea level rise challenge is its reliance on gravity-fed canals for drainage. The Little River, shown here, connects to the Miami River canal near Hialeah before emptying in to Biscayne Bay. But as sea level rises, high tides can block this fresh water from draining, causing it to back up in canals and rivers, a problem today for some inland and lower-income communities like Hialeah. More than 20 percent of families with children in Miami-Dade County live below the poverty line, and residents in communities such as Hialeah and Miami’s low-income Little River neighborhood have limited resources to adapt to increased flooding (Brannigan 2014; Eisenhauer 2014).*

- **2010:** The county co-founded the Southeast Florida Regional Climate Change Compact (a collaboration among the region’s four counties) and developed Greenprint, a community-wide sustainability plan.
- **2013:** Miami-Dade incorporated climate change and sea level rise into its Comprehensive Development Master Plan and established the Sea Level Rise Task Force (Miami-Dade Green 2016).
- **2014:** The county established the Sea Level Rise Task Force and adopted a resolution “requiring all county infrastructure projects to consider the potential impact of sea level rise during all project phases and calling for an evaluation of existing infrastructure in the face of sea level rise” (Cuevas 2014).
- **2015:** The county passed six resolutions focused on implementing recommendations from the Sea Level Rise Task Force.

While these efforts are crucial and will support the county’s efforts to keep its residents safe and its economy healthy, in order to keep pace with growing risks the region must now shift to a phase of concerted action. To do that, it needs to tackle local trends such as rampant development without regard to sea level rise, and it will need state and federal support.

### More Climate Action Needed

The Southeast Florida Regional Climate Change Compact and the Miami-Dade County Sea Level Rise Task Force have developed a series of recommendations based on the best available science (Ravin et al. 2014). These recommendations include:

- Accelerate the implementation of urgently needed adaptation efforts, including flood protection, pump stations, and road and bridge designs, to name a few
- Implement adaptation action areas, an approach to local planning and management in flood-prone areas that incorporates sea level rise and storm surge risks utilizing best available science
- Continue Everglades restoration
- Identify insurance and other risk management options to address the needs of residents impacted by climate change

At the municipal level, where the rubber meets the road, some cities are taking action but face serious barriers. In lower-income communities, like Opa-locka, the costs of necessary infrastructure upgrades to keep pace with current sea level rise and flooding can be prohibitive, to say nothing of the investments necessary for long-term climate resilience.



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**A GLIMPSE OF THE FUTURE**

High tide leaves Matheson Hammock, a coastal park in Coral Gables, under water. With sea levels rising, large areas of Miami-Dade County will be at increasing risk of inundation within the lifetime of children today.

Wealthier communities like Miami Beach are also seeking federal funding to help match the scale of investment needed in flood prevention and management.

Even with vigorous actions at the county and local level, the effectiveness of these efforts will depend heavily on strong federal leadership with a federal commitment to prepare for climate change and reduce fossil fuel emissions. UCS recommendations for federal action on climate preparedness include:

- Increasing funding for coastal resilience building, including funding for the Federal Emergency Management Agency’s Flood Mitigation Assistance, Pre-Disaster

Mitigation, and Hazard Mitigation Assistance grant programs, as well as for the National Oceanographic and Atmospheric Administration’s Regional Coastal Resilience Grant Program

- Reforming national disaster policy to increase incentives to prepare for rising sea levels and to increase state and local accountability for inaction
- Supplementing existing federal hazard-mitigation programs and creating a national preparedness fund
- Increasing funding for monitoring key trends, gathering data, creating and deploying planning tools, and supporting local and regional planners in the use of these

*“We need to realize that sea level rise is happening. The county, the cities, and everyone need to take the proper steps to find solutions and improvements. For instance, we need to take sea level rise into account in county infrastructure projects. If not, we are going to be overspending taxpayer dollars years from now when we have to redo all these projects.”*

— Rebeca Sosa, Republican, Board of Miami-Dade County (Staletovich 2015)

- Increasing funds for restoring the Everglades
- Encouraging the use of the best available science in planning and infrastructure decision making at all levels

In each of these, federal resources must be targeted toward disadvantaged communities.

Robust investment in climate resilience can reduce the kinds of risks outlined here—risks to property, livelihoods, and the regional economy—that the county may face in just the next few decades. Reducing emissions can also, over the long term, slow the rate at which sea levels rise and thus reduce the potential frequency and intensity of the resulting floods. As Miami-Dade County, today the nation's symbol of sea level rise risk, strives to secure a vibrant future, it needs the federal government's action, making major strides on both fronts.

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