



Building a Climate-Ready Nation

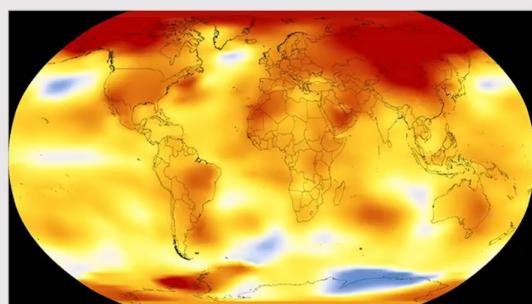
# Building a Climate-Ready Nation

July 2022

[Companion story map \(508 compliant\)](#)

## The Washington Post

OCTOBER 12, 2021



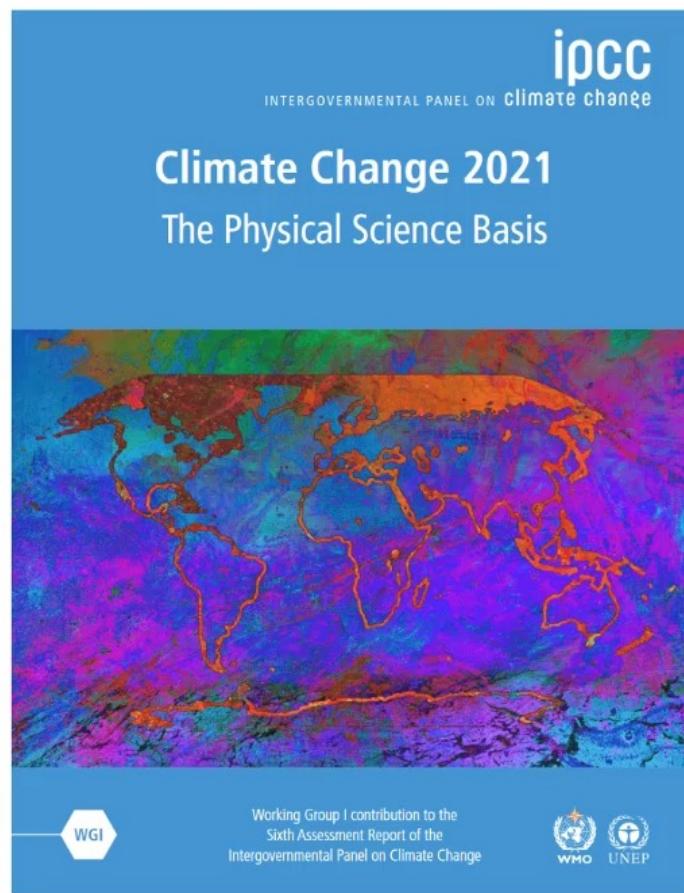
**Most  
now feel  
climate  
impacts**

**DISASTERS WORSEN  
FOR 85% OF WORLD**

## Headlines tell the story.

*From 2021's record wildfires and catastrophic drought, to the hottest July in history, people are feeling the effects of extreme weather where they live and work.*

*Last fall, The Washington Post reported that, in the prior three months, nearly one in three people lived in a U.S. county struck by a weather disaster — severe storms, fires, hurricanes, coastal storms and floods — all "turbocharged" by climate change.*



*In Climate Change 2021, the UN's Intergovernmental Panel on Climate Change (IPCC) definitively tied together human influence, climate change, and extreme weather events. IPCC reports continue to show that the window of opportunity to prevent the most severe impacts of climate change is closing rapidly.*

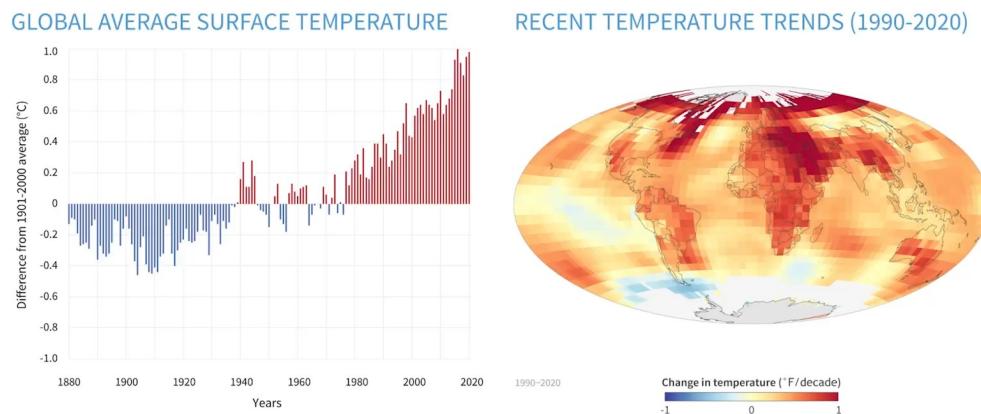
## **There's also a more positive story to tell.**

*The latest IPCC report, released in February 2022, indicated that over three billion people live in contexts that are highly vulnerable to climate change, but also noted that, "Progress in adaptation planning and implementation has been observed across all sectors and regions, generating multiple benefits." While efforts are currently unevenly distributed, the report identified widely applicable paths to resilience.*

*NOAA authors indicated that progress in enacting climate solutions requires an all-hands-on-deck approach to building a thriving climate-ready nation where prosperity, health, safety, and continued growth benefit from a shared understanding of, and collective action to reduce, the impacts of climate change.*

*Identifying and implementing equitable solutions at a local and national level are central to addressing the climate crisis.*

*Drawing on a proud track record, NOAA is helping our nation's communities and businesses understand the climate crisis and build the resiliency necessary to mitigate its impacts.*



NOAA Climate.gov  
Data: NCEI

***NOAA has a long history of understanding climate and the risks of a***

## warming world.

*Created in 1970 with unique responsibility for defining the ocean-atmosphere link, NOAA, along with two legacy agencies, the Weather Bureau and the Environmental Science Services Administration, pioneered an understanding of how the ocean and atmosphere interact to influence climate.*

*An early climate model developed at NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey predicted how changes in temperature, currents, and other factors can lead to climate change, a breakthrough of enormous importance to weather forecasting and climate science.*

*NOAA has been at the forefront of climate science and services ever since, reaching into every U.S. community and territory and around the globe to protect lives, property, and economic prosperity, from family businesses to national and multi-national corporations.*

*As the U.S. and the world face increasingly frequent and costly climate-related disasters, demand for NOAA's climate services is rising fast. NOAA data show that, in the 1980s, the average*

time between billion dollar disasters in the U.S. was 82 days. Today it's just 18 days.

*NOAA is committed to bringing climate science to public attention and putting this science to work for the public good. An integral part of this effort is fostering a more climate-literate society.*

### ***Climate.gov is a public gateway to climate literacy.***

*NOAA's Climate.gov is a popular gateway to climate literacy, providing a deep dive into a vast amount of publicly-shared climate information. From historical perspectives and maps, data, and videos, to news that puts climate threats at our doorstep, the site is a vital link to understanding and addressing current and anticipated climate-related risks.*

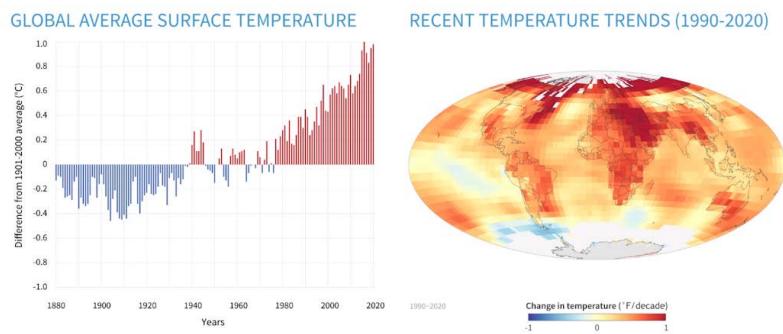
*Climate.gov's Teaching Section features classroom-ready materials, along with educator training and other professional development materials aimed at promoting climate literacy.*

*Partnering with the Climate Literacy and Energy Awareness Network (CLEAN), the site also provides guidance for integrating energy and climate topics across all grade levels. Climate.gov's versatile and complementary U.S. Climate*

Resilience Toolkit is packed with case studies, regional expertise, and digital tools to help communities build resilience.

As a long-time champion of climate literacy, NOAA's Office of Education offers an environmental literacy grants competition that is creating new models for how education can improve local resilience. Since 2015, the grants have helped residents understand community conditions, project future changes, and make decisions to reduce vulnerability.

From understanding changing seasons to climate data, climate monitoring, the carbon cycle and much more, NOAA Education features lively and instructive articles, often with related lesson plans and multimedia.



NOAA Climate.gov  
Data: NCEI

**From the depths of the sea to the surface of the sun, NOAA collects and shares**

***data, telling the story of our world and providing the expertise to help people and communities plan, prepare, and adapt to climate change.***

***Working closely with our partners, NOAA is building a climate-ready nation with science, service, stewardship, and a sharp focus on equity.***



*5:1 is the benefit-cost ratio for municipal governments using this framework. The U.S. Climate Resilience Toolkit offers over 180 case studies and more than 500 digital tools to help communities understand risks and build resilience to climate-related hazards.*

*NOAA **science** provides the foresight to be climate smart. Built on sound data, modeling, and monitoring, NOAA science drives policies, services, and the decisions that Americans make every day. As a pillar of NOAA's work, climate science reveals how our world is changing, helping communities to anticipate risks, reduce uncertainty, and mitigate economic losses.*

*Climate science allows communities to identify what they need to build resiliency, and enables NOAA to help them build it.*

*NOAA **services** put climate science on the ground, from daily weather forecasts and helping coastal communities adapt to sea-level rise, to homeowners determining whether to rebuild or relocate after the latest flood. Insurers seek data about climate risks. Municipalities check that new construction will be climate ready. Early drought warnings shape farming decisions that make a difference on supermarket shelves. Governments and businesses rely on NOAA data for decisions that impact local to global economies.*

*NOAA **stewardship** creates jobs, promotes business development, funds projects to protect communities and coastal habitat, and trains new generations of climate-ready workers. Just as the U.S. commercial weather sector, once a start-up and now a multi-billion-dollar enterprise, climate is rapidly becoming a growth industry that will expand with fast-rising demand for climate services. Aligned with the new blue economy, NOAA stewardship opens fresh opportunities for business development in current and new ocean sectors and economic growth based on sound science.*

**Equity** is a top NOAA priority. Recent actions include awarding \$171 million for dozens of projects aimed at advancing environmental justice

*and prioritizing resilience planning. Last year, NOAA convened eight Climate and Equity Roundtables -- from Alaska to Louisiana -- to learn from stakeholders how NOAA can better serve the regionally-specific needs of vulnerable communities. Listening to community groups, academic partners, religious leaders, and local government representatives yielded important and actionable insights, ranging from targeting messages to ensure that climate information is useful in driving decisions to embedding NOAA staff in communities as trusted resources for climate information and incorporating local knowledge into NOAA products and services.*

## ***NOAA observes the world with a vast array of game-changing technology.***

*NOAA's response to climate change is science-based and data-driven, contributing significantly to a global network of climate information.*

*The vast amount of data collected by NOAA's myriad of observing platforms, including satellites, ships and highly-specialized aircraft, inform weather forecasts, climate models, flood maps, municipal water resources, coastal resilience, and much more.*



*For critical data on the ocean, atmosphere, and much of the land, the world relies on NOAA's observing and measuring systems. NOAA operates more than half of the world's ocean observing platforms and devices that measure the global ocean, which has an enormous influence on Earth's weather and climate.*

***With boots-on-the-ground, NOAA collaboratively tackles local and regional climate-related challenges.***



*California-Nevada RISA collaborated with the American Planning Association to propose a regional framework for climate resilience planning. While planning often focuses on reducing greenhouse gas emissions and climate change impacts, this report goes further, detailing how collaborative planning can make communities more resilient to those impacts, placing particular emphasis on the needs of vulnerable and underserved communities.*

Regional Climate Service  
Directors and staff of Regional Climate Centers and Regional Integrated Sciences and Assessments, along with staff of many other NOAA offices, build widely diverse partnerships, identifying place-based challenges and vulnerabilities, tailoring support, and leveraging insights to inform future climate science and services.

*NOAA Regional Climate Centers are hubs of regionally-targeted data, services, and expertise,*

*adding valued perspective to the study and monitoring of climate and weather and their impacts, and informing decisions across just about every public and private sector.*

*In building local partnerships and supporting community needs, Regional Integrated Sciences and Assessments, or RISA teams, connect science with local knowledge. RISA, for example, supported Ready & Resilient: Climate Preparedness in Saint Paul, Minnesota, a report documenting lessons learned about investing in local capacity to reduce urban vulnerability. Another RISA project generated a report documenting barriers to climate adaptation and proposed mitigation strategies for Alaskan Native communities.*

*RISA projects help communities prepare for and adapt to climate-driven hazards by incorporating climate and social science expertise into planning for a range of issues, including stormwater management, public health, infrastructure, transportation, housing, and small business issues. Through our RISA and Climate-Smart Communities Initiatives programs, NOAA is contributing to PREPARE, the President's Emergency Plan for Adaptation and Resilience, which helps vulnerable countries and communities*

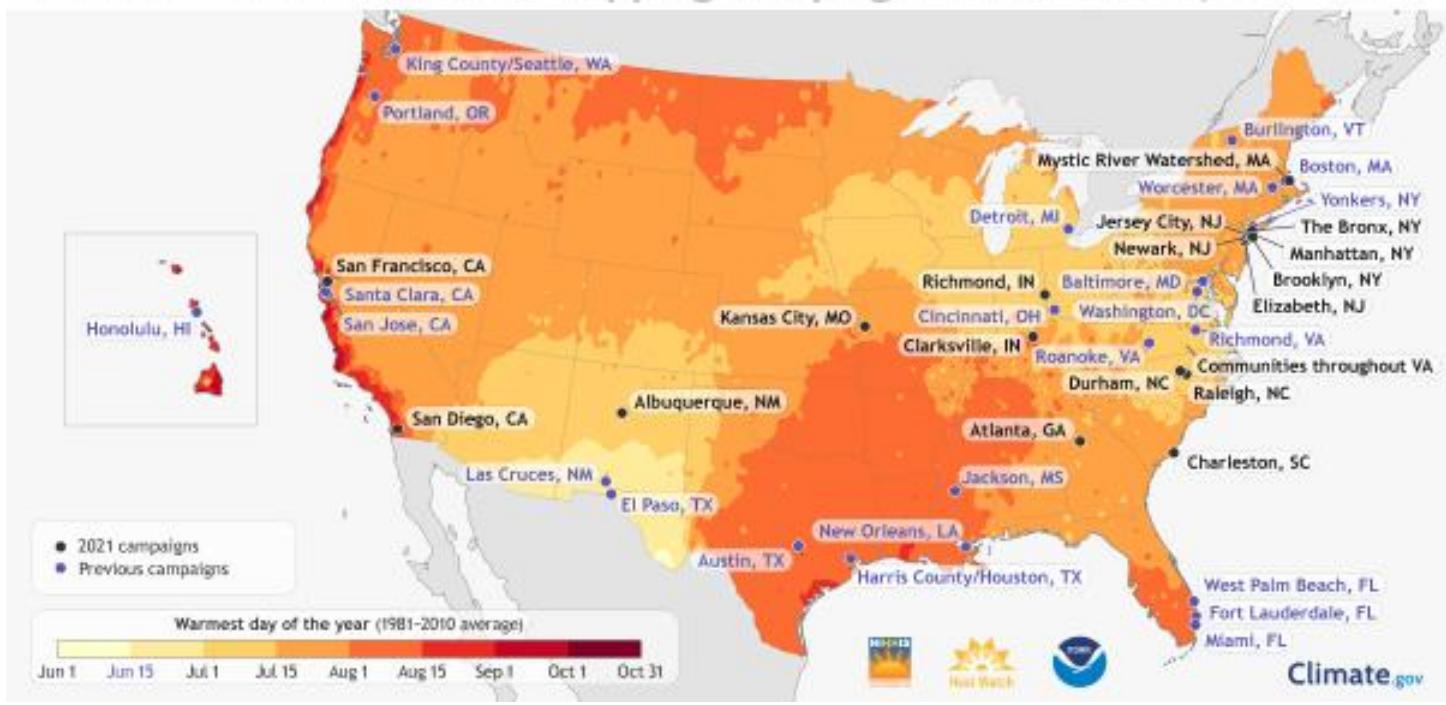
*adapt to and manage the impacts of climate change.*

*Across our nation, the National Centers for Environmental Information and Climate Prediction Center, Fisheries Science Centers, Coastal Zone Management and Habitat Restoration Programs, Sea Grant Colleges, Weather Forecast Offices, and River Forecast Centers are among numerous NOAA initiatives putting science to work to strengthen resilience in states and U.S. territories.*

***Following is a look at how NOAA turns climate science into climate services, mitigating risks and driving solutions:***

***Heat: Measuring the inequity of urban hotspots***

## NIHHIS Urban Heat Island Mapping Campaigns: All Locations, 2017-2021



Extreme heat kills more people than any other U.S. weather event. But not everyone's risk is the same.  
As part of the ongoing Urban Heat Island campaign, NOAA and our partners have shown striking differences in temperature, even at the same time on the same day in nearby areas.

With NOAA support, Climate Adaptation Planning + Analytics, or CAPA Strategies, and local groups rally citizen scientists, put electronic sensors on their cars and bikes, provide training, and identify routes for them to log temperature, humidity, and GPS data in a range of urban communities.

*Their efforts result in maps contrasting heat in the hottest areas (urban heat islands) with neighboring areas. The immense output of campaign volunteers has provided about three million data points since 2017, yielding a detailed analysis of the inequitable distribution of urban heat.*

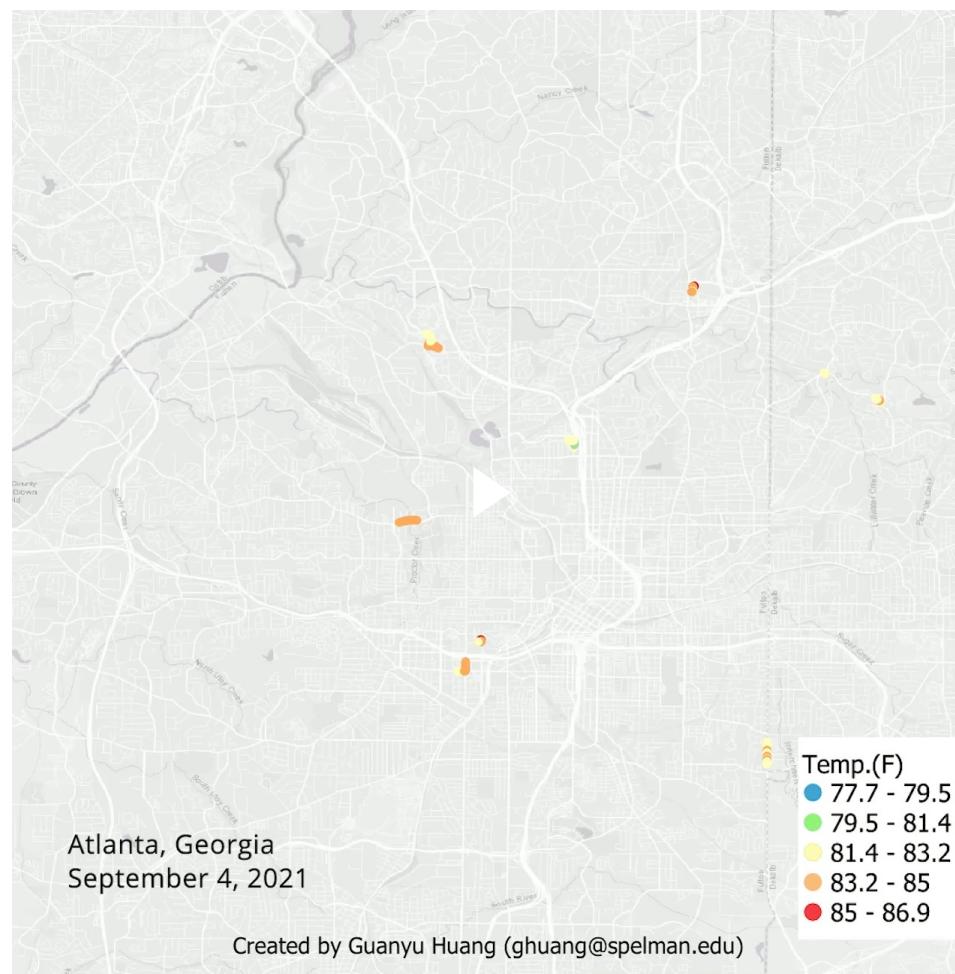


*Taken with an infrared camera, and overlaid on a regular photo, this image shows heat radiating from an urban community in Richmond, VA. Brighter colors reflect warmer temperatures.*

*Revealing the inequity of city heat, especially in lower income and historically underserved neighborhoods, the maps help target where and how communities can plan and prepare for*

increasing heat, which kills an average of 702 people each year and, during heat waves, causes emergency room visits to spike.

*During last year's 15-city mapping campaign, heat differences were documented in every city, including disparities of 18.1°F in Salem, VA; 15.6°F in San Diego, CA; and 12.5°F in Richmond, IN.*

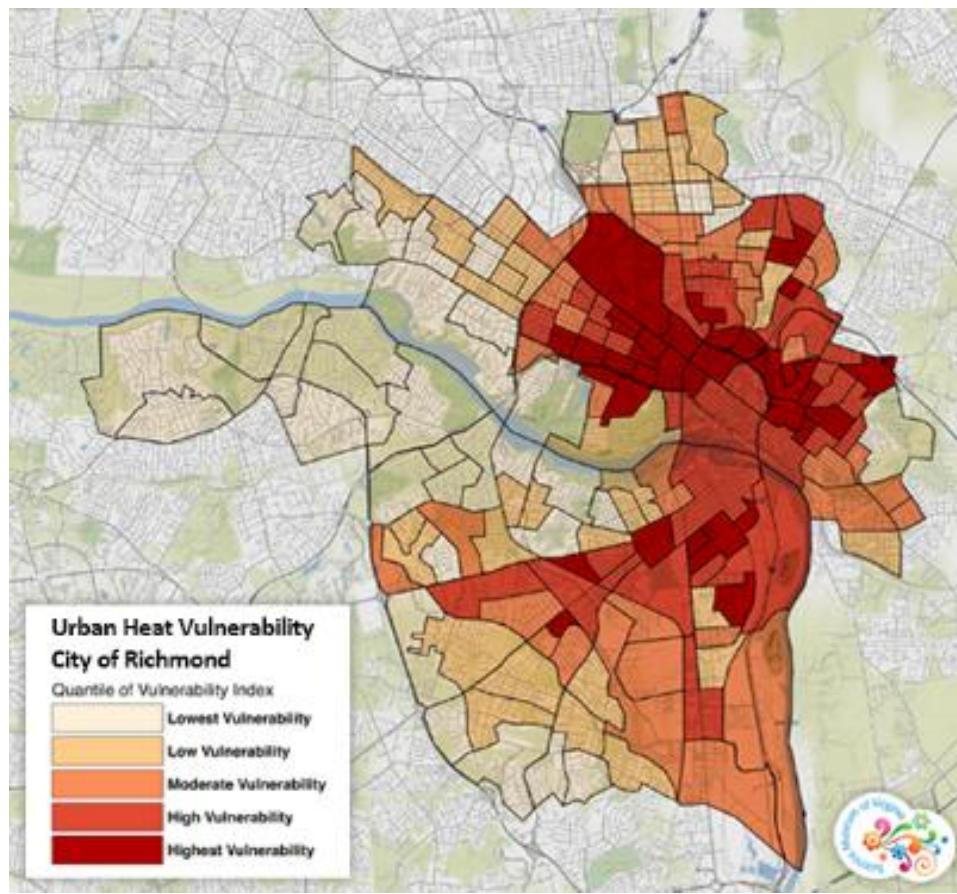


*Led by Spelman College, citizen scientists equipped with sensors on cars and bikes logged temperature data to map residential, industrial, and other communities in urban Atlanta. Seventy volunteers collected 80,000 data points showing a steep disparity in urban heat and that communities of color are likely to be both disproportionately exposed and among the most active in finding solutions. Reflecting the afternoon data shown here, greener communities were 10°F cooler than nearby areas that had less vegetation and more concrete and asphalt.*

*Mapping clearly ties infrastructure to heat disparities. The built environment can drive temperature up or down. Touch a city sidewalk on a hot day, then a neighboring grassy area. There is a marked difference.*

*The concrete, asphalt, steel, and other dark, heat-absorbing materials that build urban hotspots absorb, trap, and radiate more heat than nature's landscapes. Dense with housing and industry, and often in lower-income neighborhoods and in communities of color, these areas may lack vegetation that expels moisture into the air and cools naturally.*

*Mapping also helps drive solutions by pinpointing how and where communities can throw shade at heat. Planting trees, creating grassy areas, sheltering outdoor areas, whitewashing dark roofs, opening access to air-conditioned public spaces, and varying the height of new buildings to expand air flow are among strategies that cool extreme heat.*



*Targeting heat vulnerability in Richmond, VA, this map was developed by overlaying poverty and heat-illness census data over maps created with thousands of temperature data points logged by citizen scientists.*

*Supported by NOAA in a growing number of cities, vulnerability maps advance adaptation, such as Richmond's climate action plan, strategic tree plantings and infrastructure design in Houston, and protected bus shelters on a route senior citizens need to reach a King County, WA food bank.*

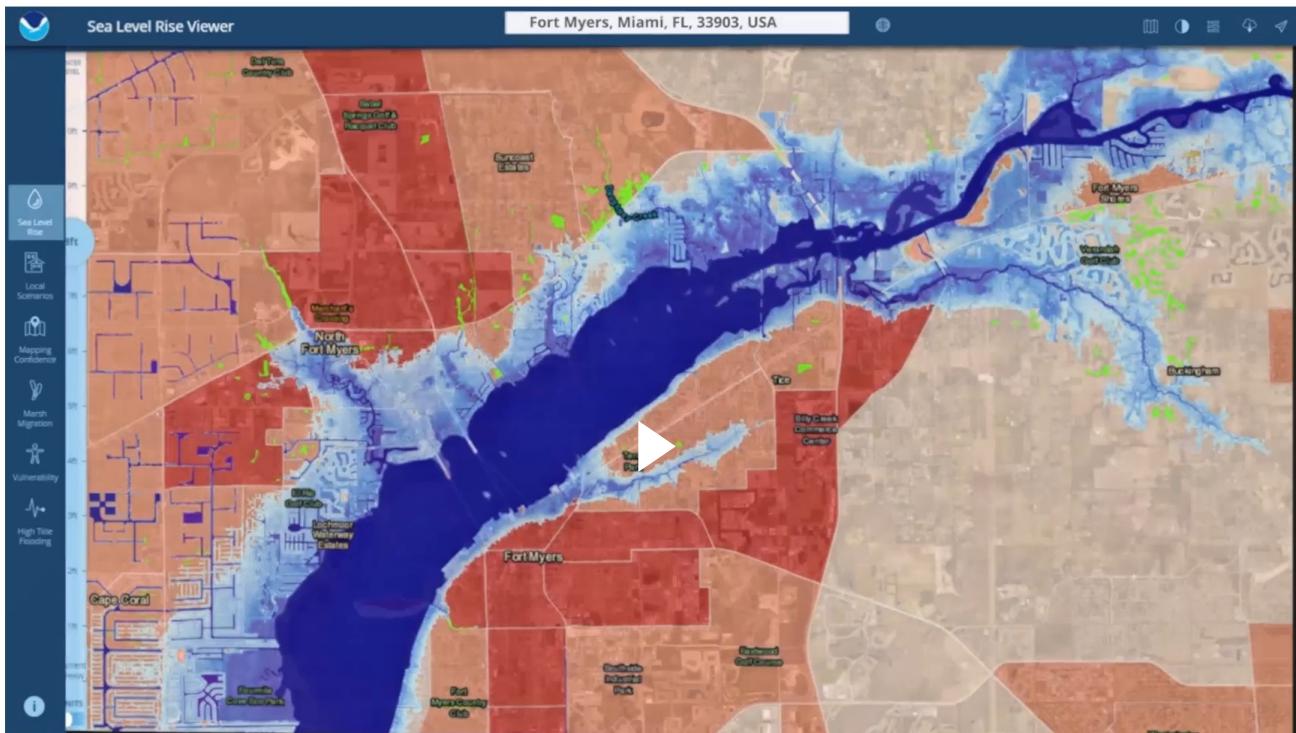
*With air quality a particular concern in urban hotspots, NOAA provides guidance to limit exposure to poor air quality and funds research through an equity lens, among other initiatives.*

*For excessive heat, NOAA issues outlooks 8-14 days as well as 3-7 days in advance and provides hourly forecasts, advisories, watches, and warnings when dangerous heat becomes likely or*

*imminent. When extreme heat is forecast, NOAA's local forecast offices work closely with community emergency managers.*

*To further protect the public, especially those who are most vulnerable, NOAA targets messages about heat safety indoors, outdoors, on the job, and in vehicles. Kids and pets are included, and there's a particular focus on preventing childhood deaths in vehicles. Each year, on June 1, NOAA kicks off a summer safety campaign.*

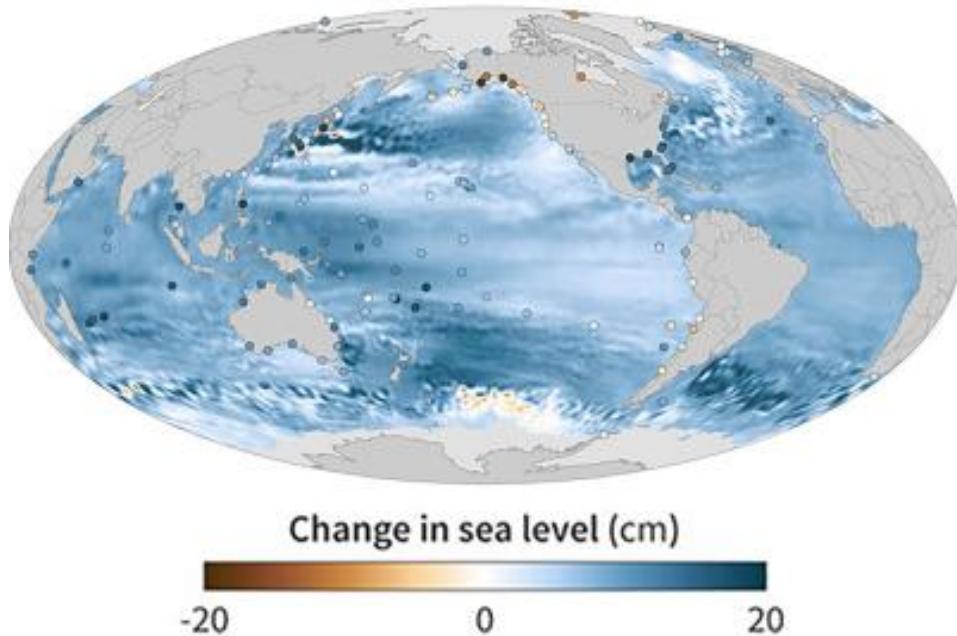
## **Sea Level: Mitigating the impacts of rising tides**



*A warming planet means rising seas. Melting glaciers add to rising sea levels, which, in turn, increase coastal erosion and elevate storm surge. Warming air and ocean temperatures create more frequent and intense storms. Last year, for the first time, two hurricane seasons in a row exhausted the list of 21 storm names.*

*Along our coasts, communities are grappling with flooded streets, overflowing sewers, and shorelines disappearing into the sea. In late summer, hurricane winds, rain, and storm surge left Louisiana reeling and soaked the Northeast.*

## SEA LEVEL CHANGE (1993-2020)



NOAA Climate.gov

Data: Philip Thompson, University of Hawaii

*Between 1993 and 2020, mean sea level rose across most of the global ocean (blue), in some cases by 6- inches. Local sea level (dots) along coasts may have risen more. Mean sea level is the average height of the surface of the ocean measured over time by tide gauges and from satellites.*

*A recent report from NOAA and our partners indicates that, as a consequence of sea-level rise and without further reducing widespread risks, both the frequency and severity of coastal flooding are projected to increase over the next 30 years.*

*By 2050, sea level along the U.S. coast is projected to rise an average of 10-12 inches. That's as much as it's risen over the last 100 years. This will create a profound shift in coastal flooding. Within 30*

*years, typically damaging flooding is expected to occur more than 10 times as often as it does today. Local factors can raise the stakes even higher.*

*Current and future emissions matter. At least two feet of additional sea-level rise, above 2020 levels, is increasingly likely by 2100 because of current emissions alone. Failing to curb future emissions could cause a rise of 3.5 to 7 feet by the end of this century.*



*This is a sunny day in Norfolk, VA. But just as on bright days in other coastal communities, the streets are swamped with water. Like tall rulers, posts help residents know where it's safe to walk and drive. Partnering with NOAA and others, the Department of Defense requires the Norfolk naval station and all coastal installations to consider how the impacts of sea-level rise can affect military readiness. Once rare, high tide flooding is projected to become increasingly disruptive.*

*With 210 stations working 24/7 throughout the U.S. and territories, NOAA's National Water Level Observation Network (NWLON) is the go-to source for accurate water level data. Updated every six minutes, real-time water-level information is the backbone of decision-making for coastal planning, safe navigation, building new infrastructure like bridges, and even knowing when to go boating and the best time to fish.*



*NWLON stations, like the one pictured here in the Great Lakes, are reinforced to withstand hurricanes and other major storm events, providing critical wind and water-level information to emergency responders.*

*About 25 percent of NWLON stations are located in the Great Lakes, providing water-level data for the global management of those water resources. Demand for data will grow. As the Arctic thaws, for example, ships will need more frequently updated water-level data for the Northwest Passage.*

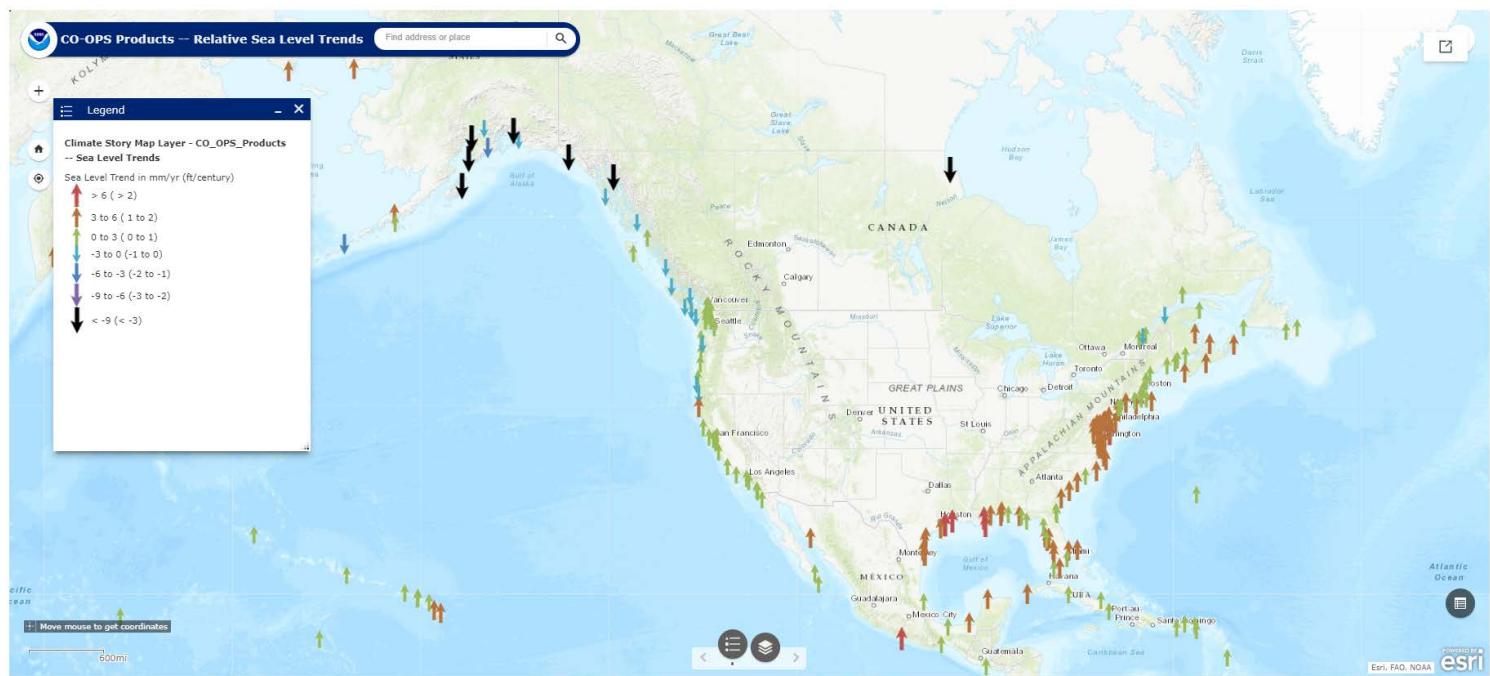
*Take a look at the adjacent [Sea Level Rise Viewer](#) demo, which visualizes how flooding affects communities. Enter an address and, with just a click, see regional sea-level rise projections and data about flood frequency, depth, socio-economic vulnerability, wetland loss, and much more.*

*NOAA's [Coastal Inundation Dashboard](#) brings water-level data right to desktops, showing real-time flooding and flooding two to three days later. Published quarterly, [High Tide Bulletins](#) predict likely days and sites of flooding three months in advance. An annual [High Tide Flooding Outlook](#) projects the (growing) number of flood days a year ahead.*

*Flying in tandem 830 miles above Earth, [Jason-2](#) and [Jason-3](#) oceanography satellites measure regional and global sea level, vital components in understanding climate change. The satellites are equipped with [radar altimeters](#). By measuring the*

*time it takes for a radar pulse to make a round-trip from the satellite to the sea surface and back, scientists can calculate sea-level height across the globe, accurately measuring it to within less than a half inch.*

*As shown on the following interactive map, Relative Sea Level Trends reflect changes in local sea level over time. At least 30 years of data are used. Continuously tracking changes is vital. Early signs of a change in the trajectory of sea-level rise may require a critical shift in planning.*



***Living shorelines can be the best line of defense.***



*Despite a direct hit from Hurricane Matthew in 2016, this living shoreline of plants and wooden terraces in New Smyrna, Florida had no visible damage.*

*Developed without the usual “hard” materials that often increase erosion and provide little habitat, the shoreline stayed resilient, despite over 90 mph winds and water four feet above normal. A survey of nearby hardened shorelines showed that least 50 percent required expensive repairs.*

*NOAA, Johns River Water Management District*



*Oyster reefs are breathing new life into Virginia's Elizabeth River. Just 1-2% of the Chesapeake's historic oyster population now remains.*

*A working waterway that flows into the Chesapeake Bay, the river has long been a hazardous waste site. Now, settlement funds for restoration, and 100,000 bushels of small fossilized oyster shells, are helping the Elizabeth River recover.*

*As oysters grow, larvae settle on top of adults. Layers form as the oysters spread, and the vital water filtering and other ecosystem services they provide grow along with them.*

*Restoring the waterway will benefit the area's residents and economy, and a new generation of oysters can return to their historic habitat.*

*NOAA, Elizabeth River Project, Virginia Marine Resources Commission, U.S. Fish and Wildlife Service, Commonwealth of Virginia*



*As the state memorial to World War II veterans, the USS NORTH CAROLINA is a valued and popular tourist site. But in recent years, increasingly frequent and severe “sunny day” flooding has disrupted services and forced closures.*

*Moored in over 2,000 acres of tidal wetlands, the site will soon have a new living shoreline, with native vegetation replacing the current hardened shoreline of loose rubble.*

*NOAA, Battleship NORTH CAROLINA*



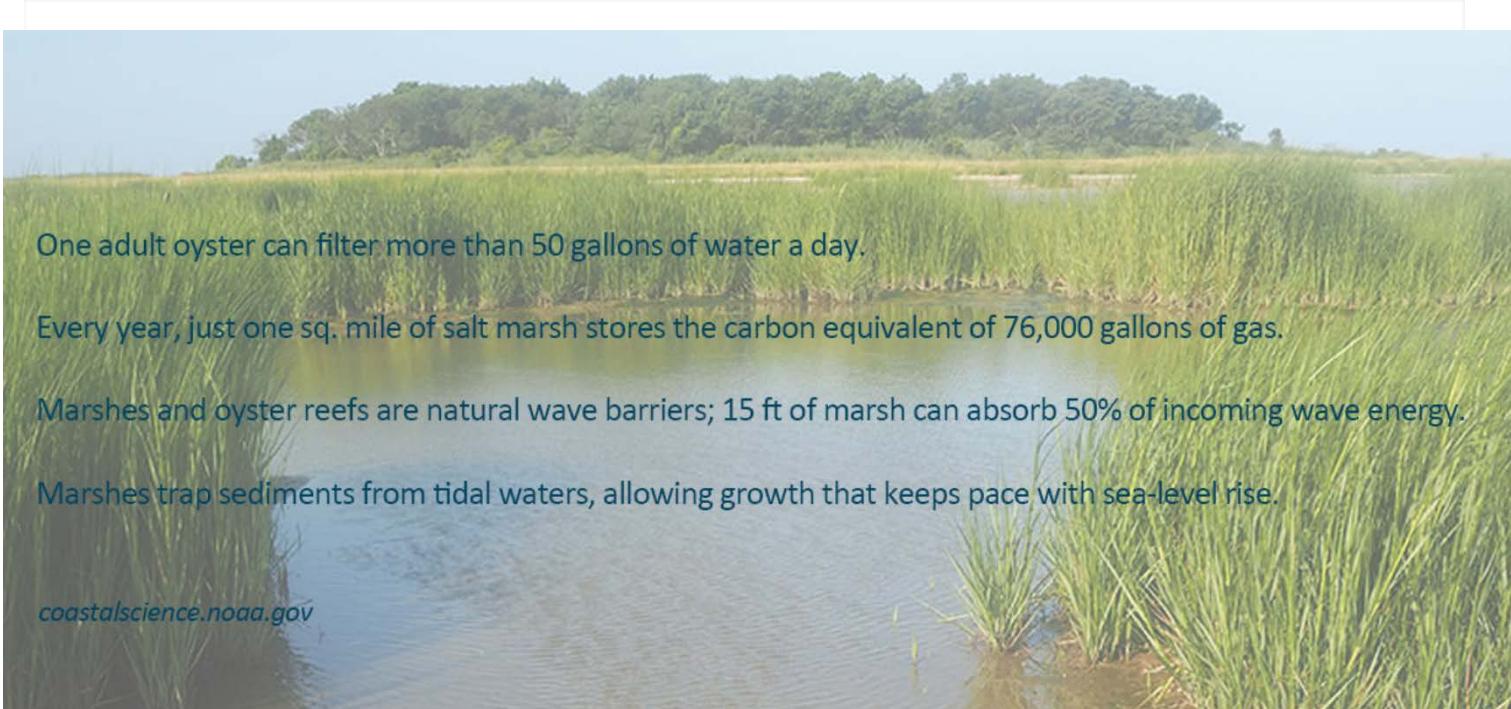
*In 2017, coral reefs buffered Florida and Puerto Rico from hurricanes, but were severely damaged by storm surge and waves. A recent assessment quantified the economic value of these reefs in protecting communities from flooding.*

*It showed that reef damage increased flood risk by over \$180 million annually and estimated that, as*

*reefs degrade, the risk would rise, growing by \$820 million annually. The assessment showed that restoring reefs across Florida and Puerto Rico would prevent over \$270 million in flood loss every year.*

*On this image, the full height of the bars reflects current expected flood risk in Miami's 100-year floodplain. Blue bar tops indicate risk that could be reduced with reef restoration and expected benefits. The orange line shows where potential reef restoration was assessed in models.*

*USGS, NOAA, University of California Santa Cruz*



One adult oyster can filter more than 50 gallons of water a day.

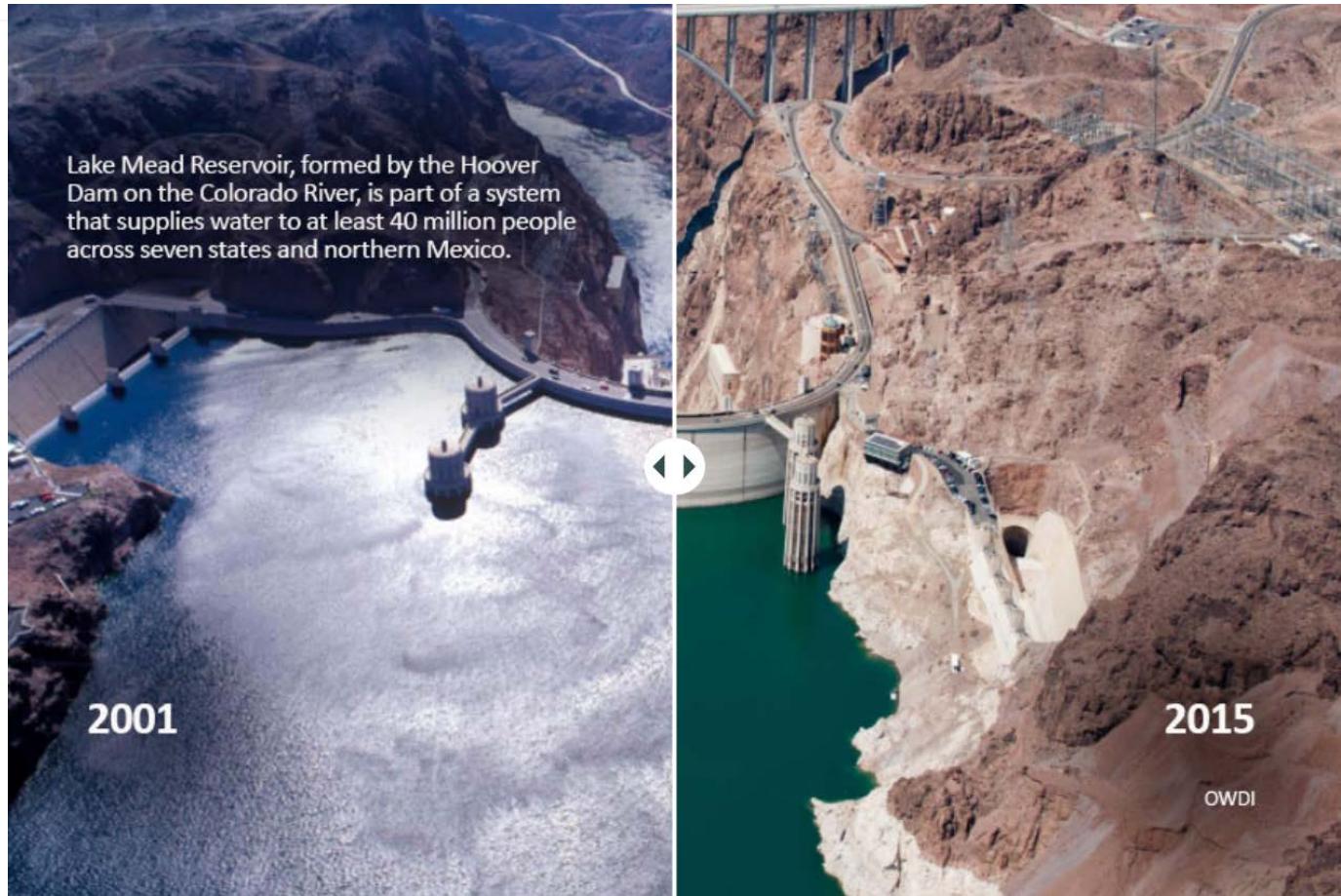
Every year, just one sq. mile of salt marsh stores the carbon equivalent of 76,000 gallons of gas.

Marshes and oyster reefs are natural wave barriers; 15 ft of marsh can absorb 50% of incoming wave energy.

Marshes trap sediments from tidal waters, allowing growth that keeps pace with sea-level rise.

[coastalscience.noaa.gov](http://coastalscience.noaa.gov)

## Drought: Addressing the challenges of a thirsty atmosphere



*Drought doesn't hit like a hurricane or snowstorm. It can develop in any region and arrive unannounced, creeping up slowly and silently with no start or end date.*

*As high temperatures make our atmosphere thirsty for moisture drawn from soil, rivers, lakes, and snowpack, continued global warming is projected to further intensify the severity of wet and dry events.*



*In December, nearly 47 percent of our nation was dealing with varying degrees of drought. In the Southwest, where NOAA has linked drought to human-caused climate change, the gripping drought is the most severe on record. The last two decades have been the region's driest two decades in at least 12 centuries.*

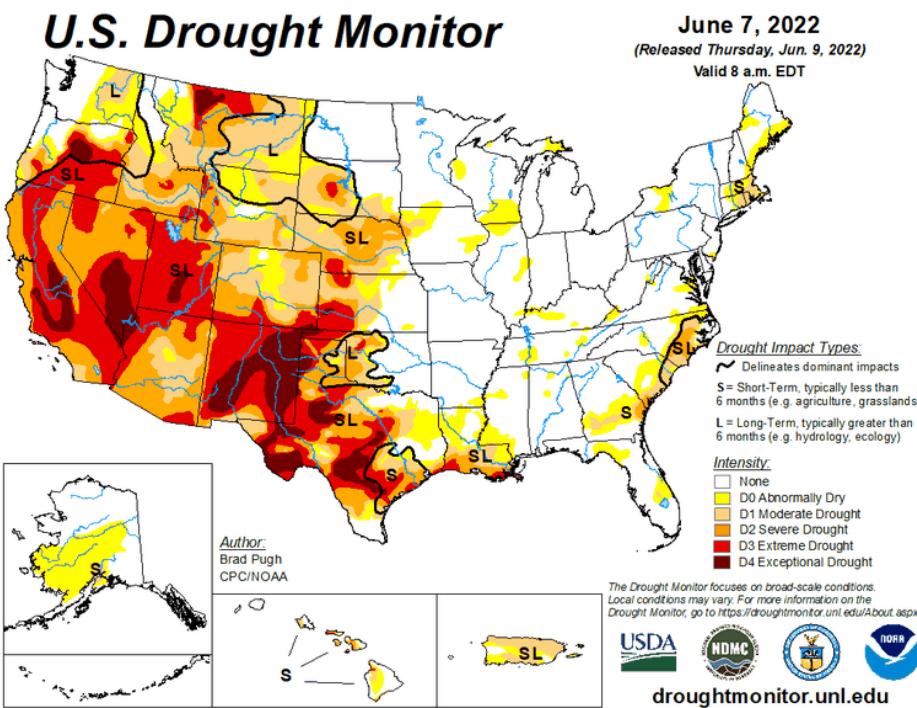
*The adjacent photos reflect Lake Mead's 121-foot decline in water between 2001 and 2015, exposing a white "bathtub ring" of mineralized rock around the shoreline and parts of Hoover Dam towers, which are critical to providing electricity. Currently, Lake Mead water levels are at an unprecedented low.*

*Last year, NOAA scientists led a drought task force, which concluded that, without efforts to control human-caused global warming, we should view the current extreme Southwest drought as a preview of coming regional events.*

*Drought's human and economic toll is immense. Farmers lose money when crops are destroyed. Ranchers must spend more to feed their animals. If dairy production goes down, the price of milk goes up. Plants and trees die, becoming fuel for wildfires. Electricity becomes a concern because hydroelectric dams need water to operate. When demand for water exceeds supply, conflicts can result.*

*Western drought and heat were on NOAA's 2021 list of billion-dollar weather-climate disasters. Last year, U.S. loss was nearly \$9 billion.*

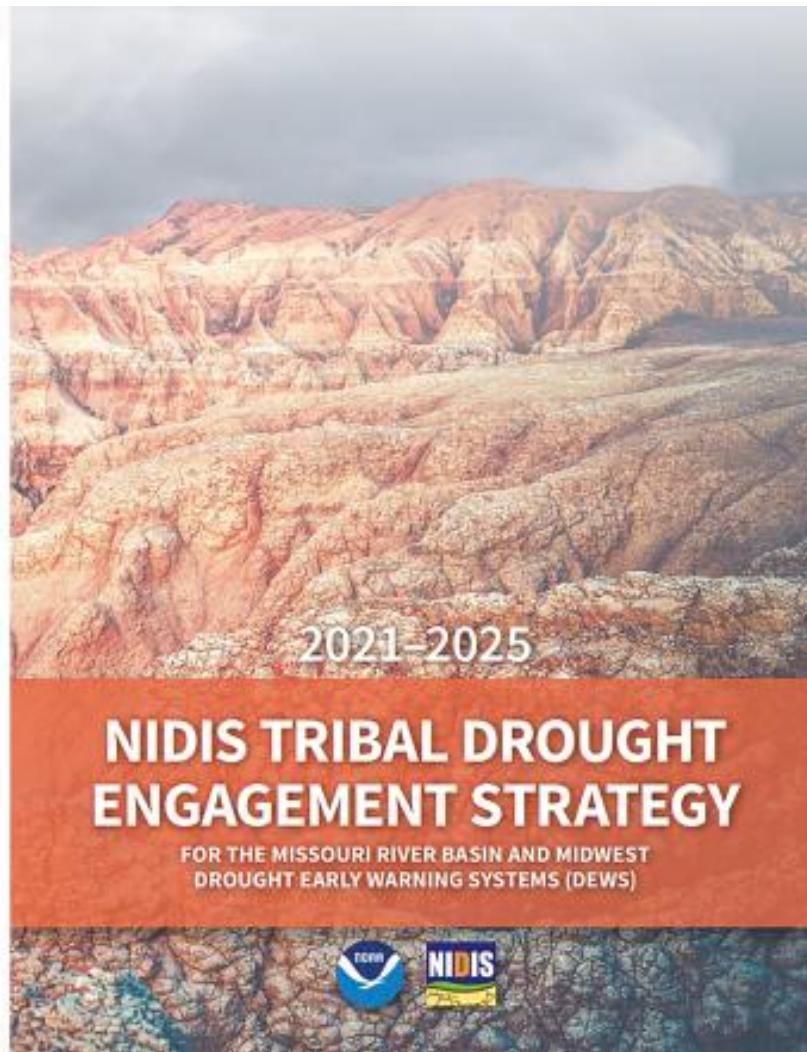
*NOAA's understanding of where drought is likely to develop and forecasts of worsening conditions are key to managing and mitigating the threats drought poses.*



*Released every Thursday, the U.S. Drought Monitor shows the extent and severity of drought in our nation.*

*Because every aspect of a community is affected when water is scarce, NOAA scientists created the U.S. Drought Portal. From early warnings to support for planning and managing, the portal delivers the full story on drought, especially to those working in farming, energy, and other vulnerable sectors.*

*The NOAA-led National Integrated Drought Information System (NIDIS) developed the portal. A multi-agency partnership, NIDIS coordinates monitoring, forecasting, planning, and information at national, tribal, state, and local levels.*



*Just as in many regions, rising temperatures and drought have been a constant concern for the 62 tribal nations living in the Missouri River Basin and Midwest. Since 2000, all have experienced multiple droughts, some 30 percent of the time. Respecting tribal sovereignty and diverse cultural perspectives, NOAA helped develop a Tribal Drought Engagement Strategy to provide early warnings and strengthen resilience to pervasive drought.*

*NOAA's monthly and seasonal drought outlooks provide a look at where drought may develop, persist, improve, or most likely end in the months ahead.*

*Historical climate datasets for temperature, precipitation, and soil moisture underpin national*

*and international drought monitoring and help scientists and decision-makers put current conditions into a trusted context.*

*Emergency managers use data from NOAA's Joint Polar Satellite System to plan, predict, and respond to drought worldwide.*

## **Wildfires: Battling blazes from space, labs and the front line**



*As shown by last July's record-setting fire in California's Sierra Nevada, fires are burning farther and faster, and with more intensity and severity. The Dixie fire burned over one million acres and, joining another blaze, became the first fire in recorded history to cross the rocky peaks of the Sierra Nevada Mountains.*

*Since 1900, just six fires have burned over 200,000 acres in the Sierra Nevada, all in the past 10 years and four in the last two years.*



Once considered a career event for firefighters,  
mega blazes that char more than 100,000 acres are  
occurring with increasing frequency. In 2021,  
nearly 59,000 wildfires scorched over seven million  
acres. With climate change as the main driver,  
wildfire season now stretches through the year.

**As the adjacent video shows, NOAA tackles these wildfires on many fronts.**

*Large wildfires and severe heat are also happening more often at the same time, worsening air pollution across the western U.S. On one day in*

2020, more than 68 percent of the U.S. West, or about 43 million people, were affected by harmful levels of air pollution, the highest number in 20 years.

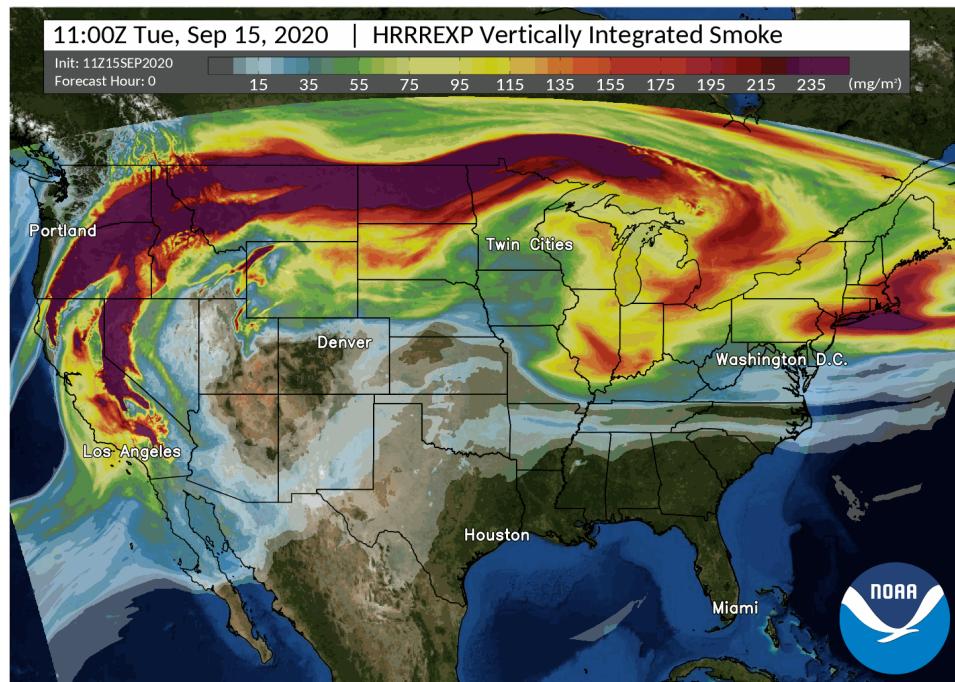


*Where there is fire, there is smoke, and NOAA, NASA, and university partners track its particles across the nation. Traveling far from a fire, smoke particles mix with the atmosphere, altering air quality and affecting weather patterns. Research is key to understanding how the particles affect ecosystems and the air we breathe.*

**"Smoke plumes from wildfires are not just a western problem."**

Wildfire smoke harms more people in the eastern U.S. than in the West. In recent years, about 75 percent of asthma cases and deaths from smoke pollution occurred east of the Rocky Mountains from smoke originating almost 3,000 miles across the country.

*The smoke carries fine particles that can penetrate deep into lungs, causing serious illness. Knowing where the smoke is moving is critical to public health. NOAA's experimental "WAVE" points the way by visualizing NOAA's game-changing HRRR Smoke model forecast.*



*This HRRR Smoke model forecast shows where wildfire smoke travels across the U.S., illustrating how smoke integrates into the atmosphere.*

*HRRR Smoke predicts the path and amount of wildfire smoke near the surface and up to nearly 83,000 feet above ground, and with it the pollutants affecting air quality. During the wildfire near Boulder, Colorado on December 30, the model showed smoke plumes traveling over three hospitals.*

*HRRR Smoke runs 24/7, producing a new weather and smoke model run every hour up to 48 hours in advance, ultimately resulting in more accurate forecasts.*

## **Marine Life: Building resilience to climate change**



Mark Sullivan/NOAA

Video taken with NOAA Fisheries Permit #16632 and #13707

*Climate change is profoundly affecting marine life. As the world heats up and ocean temperatures rise, many species of fish are shifting northward, separating predators from prey and causing economic disruption. When fish are less abundant or move out of range, fishing communities feel the impact.*

*Lobster traps in southern New England, for example, have become increasingly empty while Maine's lobster fishery has boomed. A NOAA-funded study projects that many fish in U.S. coastal waters will continue to move to cooler waters.*

*In the southern U.S., rising seas and sinking lands can mean loss of essential nurseries for shrimp, crabs, and other vital commercial and recreational species. More intense hurricanes can wreak havoc on marine ecosystems. A recent study indicates that, in a fast-warming Alaskan Arctic, widespread toxic algae blooms, once a rare phenomenon in the region, may become more frequent, potentially threatening a wide range of marine wildlife and local food resources.*



*NOAA is working to restore coastal wetlands in Louisiana. Every hour, wetlands the size of a football field disappear into the sea.*

*NOAA's Climate and Fisheries Initiative is designed to better understand and mitigate such impacts. Recognizing the urgency of anticipating and adapting to climate change, the cross-agency effort is building a nationwide operational ocean modeling and support system to inform climate-smart decisions.*

*The system works to strengthen resilience by providing the capacity to assess risks, target adaptation strategies, and safeguard marine and Great Lakes resources and the lives, livelihoods, and communities that depend on them. Every day,*

*NOAA staff work with partners to provide data essential to preparing for and responding to climate change.*

*There is much at stake. The most recent data show that, in 2018, marine fisheries and industries supported more than \$238 billion in sales and 1.7 million U.S. jobs.*

*There are also collaborative efforts to leverage. In California's Shasta River, for example, juvenile salmon needed access to cool water. But rising temperatures and vegetation changes were making the river too warm for salmon to tolerate. With The Nature Conservancy and the U.S. Fish and Wildlife Service, NOAA supported the restoration of high-quality, cold-water salmon spawning and rearing habitat.*



*To help restore the Shasta River, over 32 acres of vegetation were planted in and along streams. Natural rehabilitation of 125 additional acres is being supported. Creating fish-friendly irrigation supports more efficient water use.*

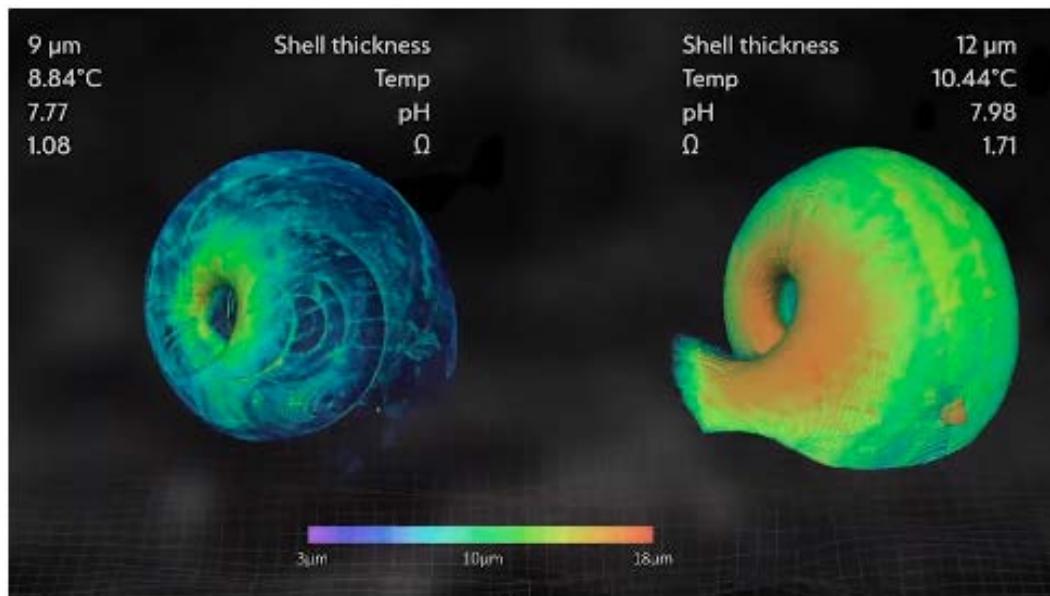
*Monitoring the Shasta River shows a striking decrease in summer water temperatures. In 2008, before restoration, water for coho salmon was suitable on only 25 percent of summer days. By 2019, the number was 95 percent.*

*Joint efforts to restore this valuable habitat supported the recovery of salmon populations and boosted their resilience to climate change.*

*Because the ocean and climate are fundamentally linked, climate change is also taking a toll on coral*

*reefs. While threatened with many stressors, a warming ocean is considered among the most serious. As temperatures rise, bleaching is becoming more frequent.*

*Ocean acidification, a process in which rising levels of atmospheric carbon dioxide make seawater more acidic, is inhibiting the ability of corals and other marine life to build and maintain protective shells and skeletons.*



*Just like coral reef skeletons, the fragile shells of microscopic sea snails, or pteropods, are vulnerable to acidifying waters. A study found that shells in increasingly acidified West Coast waters were about 37 percent thinner when exposed to carbon dioxide-rich waters from the deep ocean where corals live. Shells shown here were analyzed using 3D scans and sampled from pteropods collected during a NOAA Ocean Acidification Program research cruise onboard NOAA Ship Ronald H. Brown.*

*Corals are an extremely valuable habitat, and they need help. Hundreds of millions of people and about 25 percent of fish depend on healthy coral reefs, and they contribute over \$3 billion annually*

*to the U.S. economy. Yet, 30 to 50 percent of the world's reefs are gone.*

*NOAA's innovative approaches to protecting and saving coral reefs include growing and planting healthy corals in underwater nurseries and cultivating more resilient corals in novel indoor seawater systems.*

*Working closely with partners, NOAA is collecting detached corals, broken fragments and even fully-formed colonies, and growing them in dense coral nurseries. More than 20 coral nurseries are active throughout the Caribbean, providing more than 40,000 healthy corals for reef restoration across the region every year. NOAA is also working with local resource managers to build capacity in the Pacific Islands.*



*Mark Sullivan/NOAA*

*Video taken with NOAA Fisheries Permit #16632 and #13707*



*Corals get another chance at life. Broken coral fragments and even full colonies are collected and grown in underwater nurseries, then reattached to reefs with cement, zip ties and nails.*

*NOAA and partners are implementing Mission: Iconic Reefs, a first-of-its-kind approach to restoring corals at seven ecologically and culturally significant reef sites in Florida Keys National Marine Sanctuary. Once completed, coral cover will be restored from two percent to an average of 25 percent.*

*Cultivating more resilient corals in indoor seawater systems is yet another pioneering approach to restoring corals. To help save Florida reefs, young corals are reared in tanks large*

*enough to support hundreds to thousands of corals at multiple life stages.*

*Experiments with corals and fish, crabs, and other organisms that corals associate with in the wild will fill important gaps in understanding how corals can best stay resilient in changing ocean conditions.*

**NOAA and partners are mitigating local-to-global risks and driving solutions by:**

Building climate-smart communities

Advancing climate-ready infrastructure

Taking action on climate and equity

Redesigning NOAA Climate.gov -- a gateway to climate literacy

Activating one of the first regional climate plans in the U.S.

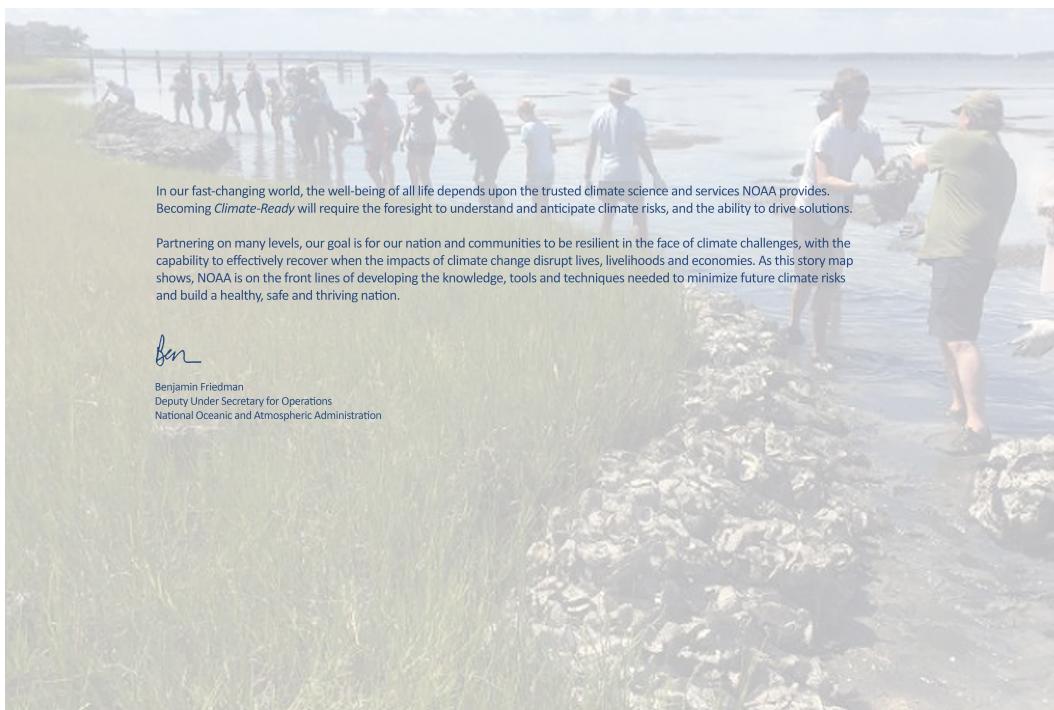
Putting federal data at the fingertips of local decision-makers

Improving early disaster warnings around the world

Launching the *NOAA Blue Carbon Inventory* to track progress on achieving climate goals in geographically-diverse countries

Expanding ocean acidification research and monitoring across the Pacific Islands

Establishing a global *Surface Ocean CO<sub>2</sub> Reference Network* to monitor carbon dioxide uptake and inform decisions about marine ecosystem health, among many others



In our fast-changing world, the well-being of all life depends upon the trusted climate science and services NOAA provides. Becoming *Climate-Ready* will require the foresight to understand and anticipate climate risks, and the ability to drive solutions.

Partnering on many levels, our goal is for our nation and communities to be resilient in the face of climate challenges, with the capability to effectively recover when the impacts of climate change disrupt lives, livelihoods and economies. As this story map shows, NOAA is on the front lines of developing the knowledge, tools and techniques needed to minimize future climate risks and build a healthy, safe and thriving nation.

*ben*

Benjamin Friedman  
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National Oceanic and Atmospheric Administration

## ***NOAA Story Maps***

### ***Building a Climate-Ready Nation, July 2022***

### ***A Window on the World: NOAA Barrow, Alaska, November 2021***

### ***Explore! Journey to Earth's Largest Habitat, June 2021***

### ***Probing the Unknown, November 2020***

### ***NOAA at 50, September 2020***

### ***Our Dynamic Marine Economy, June 2020***

**NOAA in Seattle, December 2019****NOAA Supports a Healthy Nation, September 2019****Inside Tornado Alley (NOAA Norman), July 2019****A Healthy Return on Investments, April 2019****The Arctic: Closer Than You Think, March 2019****NOAA Boulder, October 2018****Play It Safe, August 2018****Our Ocean, June 2018****The Power of the Crowd (Citizen Science), April 2018****Farming in Water, February 2018****NOAA Mitigates Impact of Killer Waves (Tsunamis), December 2017****Hurricanes Punched Hard this Season, October 2017**

**NOAA Protects America, Powers the Economy,  
July 2017**

**Ready for Hurricanes, May 2017**

**On the Front Lines of CA's Epic Winter, March  
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