Harnessing Nature

THE ECOSYSTEM APPROACH TO CLIMATE-CHANGE PREPAREDNESS

DEFENDERS OF WILDLIFE
Defenders of Wildlife is a national, nonprofit membership organization dedicated to the protection of all native wild animals and plants in their natural communities.

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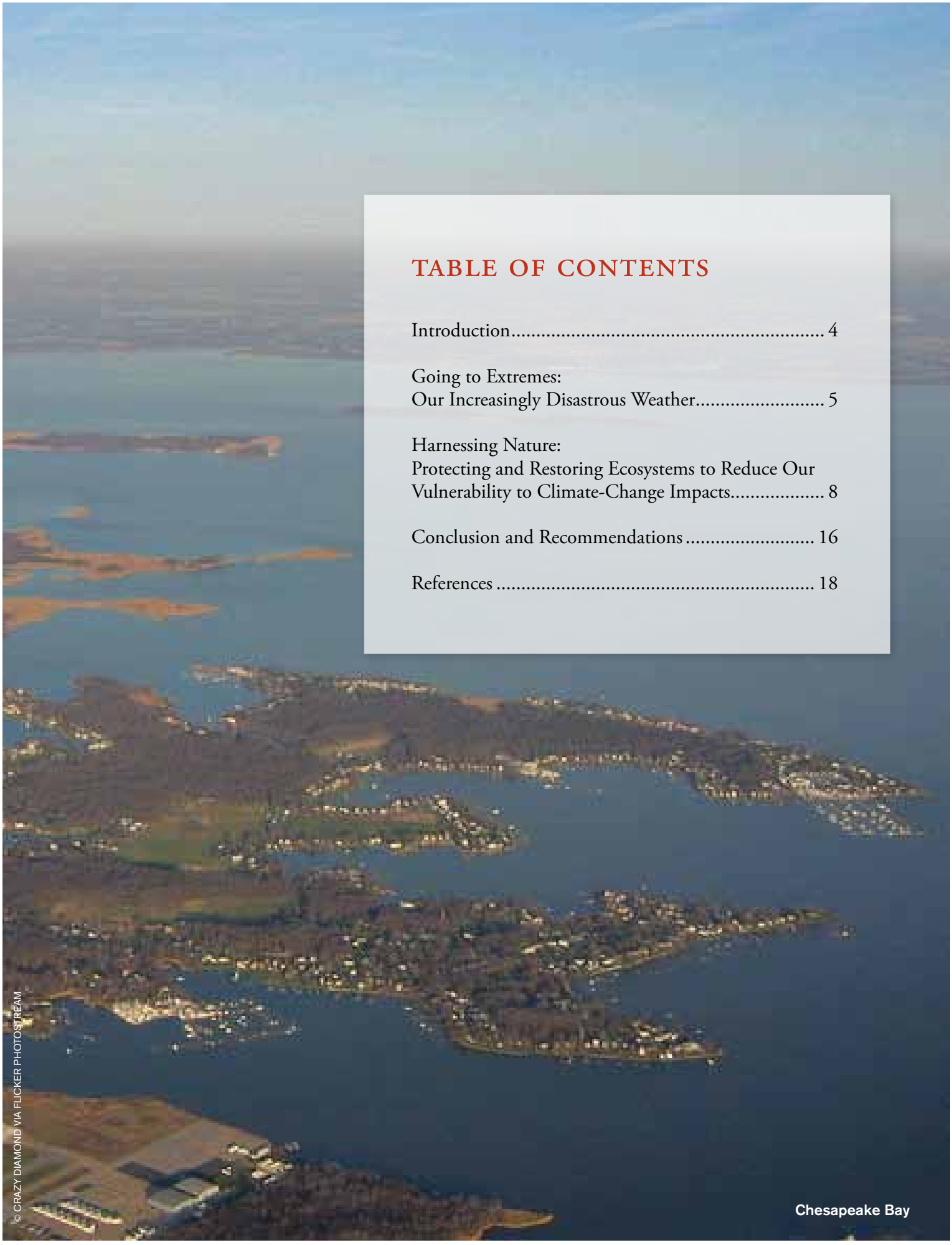
COVER: (clockwise from top) Jameson Island Chute Project, a floodplain restoration effort on Missouri's Big Muddy Refuge: U.S. Army Corps of Engineers; increased water release at Oahe Dam on the Missouri River in South Dakota to accommodate record rainfalls: Carlos J. Lazlo/ U.S. Army Corps of Engineers; a longleaf pine catches fire in Florida: John Maxwell/U.S. Fish and Wildlife Service



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INTRODUCTION

2011 WAS ONE FOR THE METEOROLOGICAL RECORD BOOKS. No fewer than 14 extreme-weather-related events—each one causing damages in the billion-dollar range—hit the United States in 2011, smashing the previous record of nine in 2008.

Undoubtedly a number of factors are driving the increase in storms, floods, droughts and other expensive disasters, not least of which is the growth of the U.S. population from 226 million to 311 million people over the past 30 years, which means more people and more infrastructure in the path of any given event. However, the warming trend in our climate is increasingly becoming a major factor in severe weather.

One of the most pronounced impacts of climate change is intensification in the water cycle: warmer air speeds up evaporation and also holds more moisture, so the dry areas get drier, and the storms get bigger and more intense. The root causes of the disasters of 2011 were mainly either not enough water or too much falling at once (or tornadoes associated with excessively powerful thunderstorms).

Climate change seems poised to continue to deliver more and deadlier punches in the future. And even if a serious effort to reduce global warming pollution gets underway soon, the carbon dioxide already in the atmosphere will stay there for centuries. With more years like 2011 undoubtedly to come, we must begin preparing for, and attempting to lessen, the risks associated with extreme weather.

Building bigger levees, higher dams and stronger seawalls might protect some areas from larger rains and floods, but could also put other communities at risk. Higher levees, for instance, funnel more water downstream, resulting in greater flooding there, as well as catastrophic consequences for local communities should a levee fail. Moreover, in an era of declining budgets at all levels of government, massive investments in "hard infrastructure" may not be forthcoming even in the face of serious climate threats.

By preserving and rebuilding our green infrastructure—floodplains, wetlands, forests and other natural components of our ecosystems that work together as a whole to provide "ecosystem services" such as flood control and water filtration—we can "harness nature" to help provide protection from extreme events.

The purpose of this report is to promote this strategy of harnessing nature as an essential, viable and cost-effective approach to climate-change preparedness. To underscore the urgency of the need to act now, the report begins with a review of the extreme weather events of 2011 and a sobering summary of the latest weather trends and scientific predictions about climate events. It summarizes the promise and benefits of strengthening and enhancing our green infrastructure and offers inspiring case studies of communities around the country that are already harnessing nature to lessen the impacts of floods, storms, droughts, wildfires and rising sea levels. The report concludes with recommendations to help agencies and communities incorporate ecosystem-based measures into their climate-change adaptation plans, i.e., to harness the power of nature.

GOING TO EXTREMES:

Our Increasingly Disastrous Weather

NO MATTER WHERE YOU LIVE, chances are you experienced some extreme weather in 2011. Perhaps your state was buffeted by one—or more—of the 14 extreme weather-related, billion-dollar disasters that hit the United States.

With $60 billion in losses and damages, the weather events of 2011 rank among the most costly. Only a handful of times in recent decades have we seen more weather-related damages (in 2011 dollars): 2005, when hurricanes Katrina, Rita and Wilma ravaged the Gulf Coast; the drought-stricken years of 1980 and 1988; and 2008, when we endured nine extreme, billion-dollar weather events.

A look back at some the extreme events of 2011 shows just what we're up against.

Heavy Precipitation and Flooding in the Midwest

The first round of record-breaking flooding hit the Mississippi River in early May 2011, resulting mainly from huge amounts of snow and rain that fell in the upper Midwest and Ohio River Valley in the late winter and spring. To prevent the flooding of Cairo, Illinois, the Army Corps of Engineers breached the Birds Point Levee and flooded 130,000 acres of farmland. Nonetheless, the river marched on: Record river crests were recorded in Vicksburg and Natchez, Mississippi, prompting the opening of the Morganza Spillway (for the first time since 1973) to save New Orleans from a second watery devastation in less than a decade. The flooding caused estimated economic losses of $3 billion to $4 billion, and the losses would likely have been even higher if not for the actions to divert the waters away from cities and towns and onto agricultural lands.

As the Mississippi River floodwaters were making their way to the ocean, a new round of flooding was starting on the Missouri River. Huge snowstorms in the Rocky Mountains during the winter time created snowpack levels twice the size of those observed in recent years. Dozens of recording stations in the Rockies saw 20-year records. When all that snow melted in the spring the water had to go somewhere. That "somewhere," on the eastern side of the Continental Divide, was the Missouri, Platte, and Souris rivers. The snowmelt was joined in late May by the outpouring from storms that brought five or more inches of rain to eastern Montana. Nearly

PHOTO COURTESY U.S. ARMY CORPS OF ENGINEERS

A U.S. Coast Guard Disaster Area Response team rescues residents of flood-ravaged Shawneetown, Ill., in 2011, a record-breaking year for flooding on the Mississippi River.

11,000 people were evacuated from Minot, N.D., as the Souris River hit a record flood stage. Dams across the region posted record flows, and levees were breached in Iowa, Nebraska and Missouri. Roads, bridges and shipping channels became impassable, halting traffic and commerce. In some places, river levels exceeded the epic 1993 floods that had been considered a 1-in-500-year event. Estimated losses exceeded $2 billion in the United States and an additional billion in Canada.

Many of the storms that fed the flooding in the nation's midsection were accompanied by tornadoes, including some of the most deadly and costly in our country's history. Six separate tornado outbreaks killed a total of 550 people and caused a billion or more dollars in damage between April and June 2011.

FIG. 1. BILLION DOLLAR WEATHER/CLIMATE DISASTERS, 1980-MARCH 2012

SOURCE: NATIONAL CLIMATIC DATA CENTER

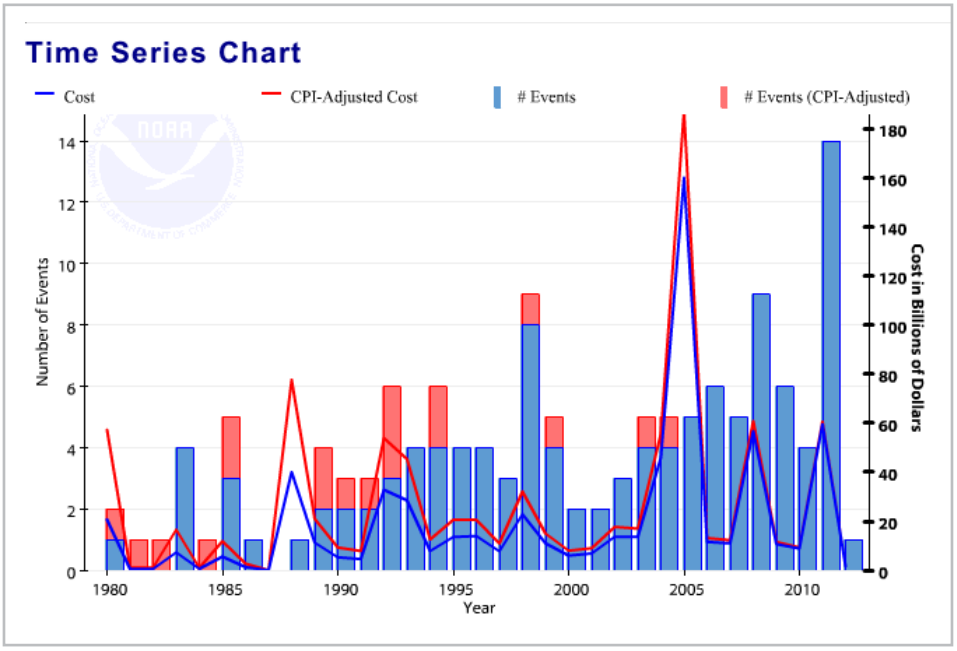


PHOTO COURTESY U.S. FISH AND WILDLIFE SERVICE

Residents of Bethel, Vt. survey a roadway washed out by flooding caused by the heavy rains of Hurricane Irene in 2011. Linked to damages and losses totalling $9.8 billion, Irene helped make 2011 the stormiest and most costly yet (Fig. 1).

Tropical Storms in the East

In late August, the Northeast, which had been largely spared from the astonishing rains and floods that played out across the country's midsection in the late spring and early summer, finally got theirs. In the space of 10 days, the region was hammered by two billion-dollar "tropical" storms, Hurricane Irene and Tropical Storm Lee.

Although barely a Category 1 hurricane at landfall, Irene rearranged the landscape of North Carolina's Outer Banks before moving north and dumping eight to 12 inches of rain across eastern Pennsylvania, New Jersey, New York and New England. Entire villages in the Catskills and Vermont were completely cut off from the outside world by floodwaters. Ten of Vermont's 17 river systems flooded, damaging hundreds of bridges, washing out roads and displacing more than 1,400 families. Overall, at least 45 people were killed and more than 7 million utility customers lost power during the storm. Damages and losses totaled $9.8 billion.

Floodwaters from Irene had barely receded when Tropical Storm Lee barreled through the same region during the first week of September. Lee dumped more than 15 inches of rain on parts of Northern Virginia between September 4 and 8, including U.S. Army installation Fort Belvoir, which saw 7.03 inches of rain fall in a three-hour period on September 8—"off the charts above a 1,000-year rainfall," according to the National Weather Service. Multiple localities in the Washington-Baltimore region recorded rainfalls in the 1-in-100- to 1-in-500-year range. Binghamton, N.Y. saw a daily rain record of 8.7 inches September 7 to 8. This moisture, falling on ground already saturated by the passage of Hurricane Irene just 10 days earlier, caused record to near-record flooding along the Susquehanna River from Binghamton, New York, to Harrisburg, Pennsylvania. Flood damages in Pennsylvania alone exceeded $1 billion.

Heat Waves and Droughts in the South

While much of the country was flooding, large parts of the southern plains and Southwest were simultaneously undergoing the worst drought and heat wave in memory. July-August temperatures averaged 86.8 degrees F in Texas and 86.5 degrees F in Oklahoma—beating the latter's old Dust Bowl-era records (85.2 in 1934 and 84.4 in 1936) by over a full degree. Wichita Falls, Texas, suffered through over 100 days of 100+ temperatures, including a 52-day continuous stretch. Louisiana, with a July-August average of 84 degrees F, fared a bit better than Texas and Oklahoma but still edged into fourth place in the overall heat records.

All this heat was accompanied by a stunning lack of rain. Texas had its driest summer on record, achieving the dubious distinction of its worst drought year since record keeping began, with much of the state averaging a 15-inch rainfall deficit for the year. Losses to wheat, corn, cotton, sorghum, hay, and livestock in the state have been estimated at $7 billion to $8 billion. The Texas Forest Service also estimates that as many as 500 million trees across the state may have been killed by the drought. And the situation was nearly as bad across much of the South. Ironically, some farmers in Louisiana lost fields to the Mississippi floods on one side of a levee, and on the other side lost crops to the drought.

Wildfires in the Southwest

Where there's heat, there's fire. When extended drought parches the landscape, the danger of wildfire skyrockets. In the summer of 2011, Texas, Arizona and New Mexico experienced unprecedented wildfires.

Near Austin, Texas, the Bastrop fire burned from September 4 to October 10, destroying 1,673 homes and going down in history as Texas's the state's most costly wildfire. Over the course of 2011, Texas faced over 30,000 wildfires that altogether burned nearly 4 million acres. In June, both Arizona and New Mexico set new records for the largest single fire in state history: Arizona with the Wallow fire, which burned a total of 538,000 acres, and New Mexico with the Las Conchas fire, which consumed 156,000 acres near Los Alamos National Laboratory. Fire losses from those three states added up to yet another billion-dollar disaster.

A Preview of Things to Come?

A panel of scientists recently looked at trends and projections about climate events and came up with some sobering odds:

- Greater than 90 percent chance that the "length, frequency and/or intensity" of heat waves will increase over the course of this century;
- Greater than 66 percent chance that more heavy precipitation events will occur;
- Greater than 66 percent chance that the wind speeds and rainfall associated with tropical cyclones and hurricanes will increase; and
- Greater than 90 percent chance that rising sea levels, another side effect of climate change, will exacerbate storm damage to coastal areas. It all points to rising danger from more severe weather ahead, begging the question: What can we do to prepare?

A wildfire rages close to Bastrop, Texas in September 2011. The fire burned for more than a month, destroying 1,673 homes and going down in the record books as the most costly wildfire in state history.

HARNESSING NATURE:

Protecting and Restoring Ecosystems to Reduce Our Vulnerability to Climate-Change Impacts

One of the most cost-effective, practical and sustainable ways to prepare for the changes ahead is to "harness nature" by restoring and protecting our green infrastructure—the floodplains, wetlands, forests and other components of our ecological systems that help protect us in extreme weather.

Ecosystems deliver a huge array of benefits we often take for granted. Recreation opportunities and scenic views readily come to mind, but "ecosystem services" encompass a much broader suite of benefits. In healthy ecosystems, plants take up carbon dioxide from the air and add oxygen; wetlands filter pollutants out of the water; soil microorganisms break down decaying materials so that crops and other plants can access the minerals they need; many types of animals pollinate fruit crops and other plants; and a variety of habitats support the fish and game species on which subsistence hunters, commercial fishermen and others rely.

Unfortunately, many of our ecosystems are seriously degraded, limiting the services they can provide. For instance, significant pollution in the Chesapeake Bay, the nation's largest estuary, has reduced its ability to sustain populations of crabs, oysters and other fisheries. The same is true for many of the ecosystems that could help ameliorate the damages from climate impacts. Ninety percent of our river floodplains, which in their natural state act as sponges soaking up excess river flows, are so altered they can no longer perform this increasingly vital function. In the upper Mississippi River basin, agriculture and development have drained and converted 35 million acres of wetlands—an area the size of Illinois. Similarly, agriculture, development, shipping and shrimp farms have depleted the coastal mangrove forests, which can buffer local communities from storm surges, hurricanes and tsunamis, by 35 percent worldwide and by about 25 percent in Florida. Deforestation is linked not only to loss of species and declining water quality, but also to a heightened risk of landslides following large rain events.

The good news is that protecting and restoring our natural systems can help reinstate all the benefits they provide, including added protection from climate and weather disasters. Restoring ecosystems is thus an important community strategy for preparing for and adapting to a warming climate. Green infrastructure is typically more cost-effective than "hard" infrastructure like levees, less prone to devastating failure and provides ancillary benefits in terms of ecosystem services. In addition, the trees and other vegetation used in many efforts to restore and revitalize green infrastructure reduce the levels of climate pollution in the atmosphere by taking up carbon dioxide and storing it in their tissues.

The case studies below show how communities across the country are already tapping into nature's ability to adapt and heal itself to address specific challenges associated with climate-change impacts.

CHALLENGE

Protecting Communities from Storms and Floods

The importance of natural floodplains is often only recognized after their loss results in severe flooding events. Trying to combat the problem with more concrete and infrastructure only can lead to more damage without truly addressing the reason flood control is needed. This was made abundantly clear in 2011, when floods threatening to overtop levees resulted in targeted breaches to prevent the flooding of cities, sending the excess waters across agricultural lands, which are less effective at absorbing water than natural wetlands, to prevent flooding of cities. That led, of course, to huge economic losses for the affected producers.

CASE STUDY

Missouri River Basin, Missouri

Problem: The United States continues to take a haphazard approach to floodplain protection and develop-

Pent-up floodwaters rush from Oahe Dam in the Missouri River Basin.

ment: Between 1994 and 2005, the St. Louis area alone saw the construction of 28,000 new houses on lands that were submerged in 1993. The Missouri River Basin region is prone to large floods like the billion-dollar disaster of 2011, and climate change is projected to make them worse by fueling more extreme events.

Solution: The epic floods of 1993, the last to strike the region, taught residents and water managers some lessons, particularly about the wisdom of living in the floodplain of a major river and the value of beginning to reverse some of the wetland loss that can turn major rainfalls into major disasters. To address the loss of wetlands, the Army Corps of Engineers acquired an area called Overton Bottoms, nearly 30,000 acres of flood-prone land where Interstate 70 crosses the Missouri just west of Columbia. Part of that land was incorporated into the Big Muddy National Wildlife Refuge, which was established in 1994 and consists of 14 river-plain sites stretching from Kansas City to St. Louis. Local residents have noticed that the restored conservation areas provide relief in small floods.

These restorations are but a fraction of the millions of acres that have been lost, and much more work is needed to create functional floodplains capable of making a big difference in floods like those in 2011. After the 1993 floods, officials estimated that it would take 13 million acres of restored wetlands—-about a third of what's been lost—to make a sizeable dent in a large flood.

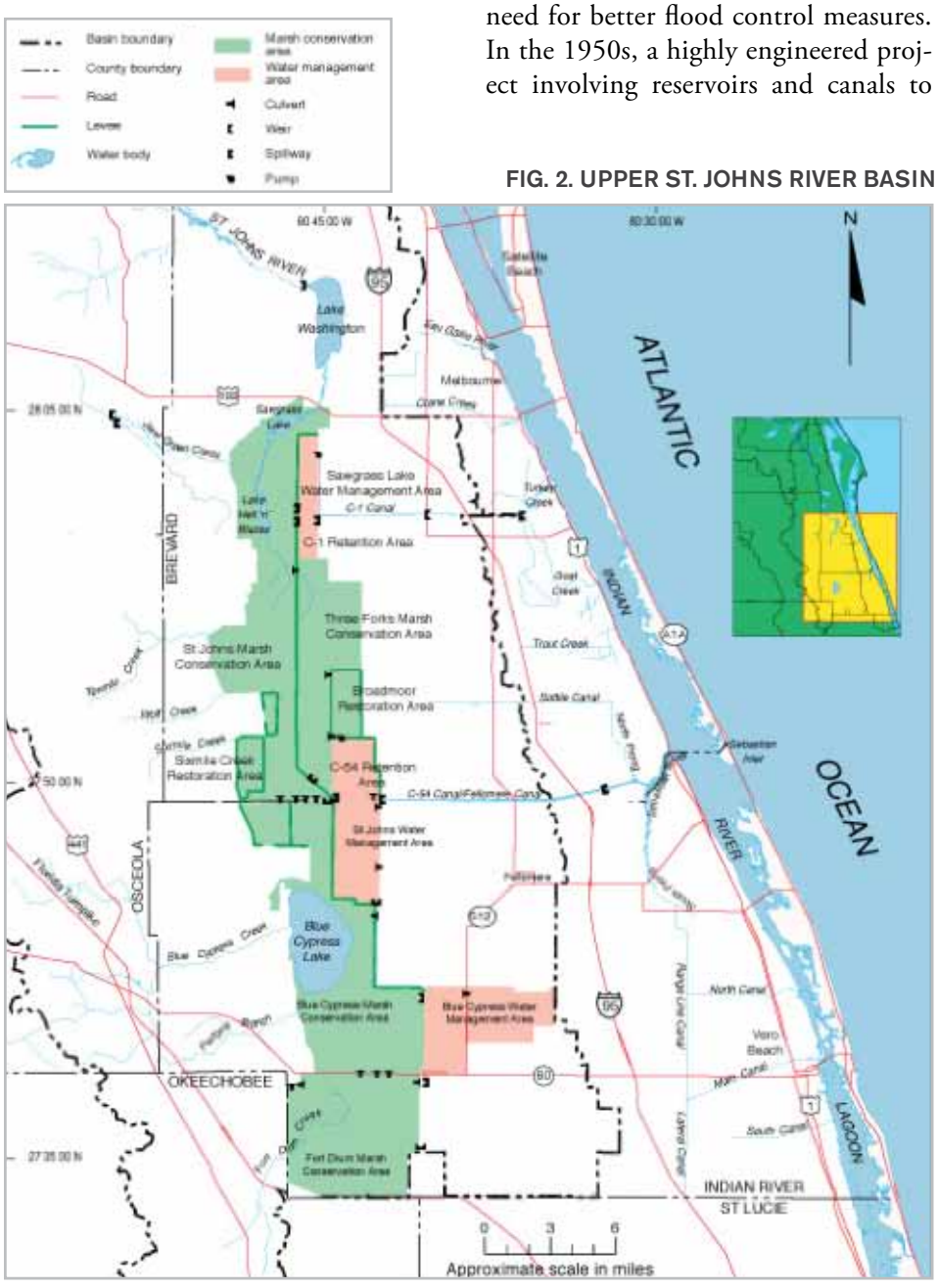
PHOTO COURTESY U.S. ARMY CORPS OF ENGINEERS

CASE STUDY

Upper St. Johns River Basin, Florida

Problem: The Upper St. Johns River Basin originally contained more than 400,000 acres of floodplains. By the 1970s, only 38 percent of these marshlands remained; drainage for agriculture had claimed the rest. In the 1920s and 1940s, after much of the floodplain had already been lost, the area was devastated by hurricanes, making evident the need for better flood control measures. In the 1950s, a highly engineered project involving reservoirs and canals to

FIG. 2. UPPER ST. JOHNS RIVER BASIN



SOURCE: ST. JOHNS RIVER WATER MANAGEMENT DISTRICT, 2011

divert water to the Indian River Lagoon was initiated. In 1973, the project was halted because the diversion of large amounts of fresh water to the salt water lagoon was diminishing water quality, reducing water storage and harming fish and wildlife populations.

Solution: The upper basin project, initiated in 1977 with support from the St. Johns River Water Management District and the U.S. Army Corps of Engineers, took a less structural approach. The project partners plugged the canals and began creating a system of water management, marsh conservation and marsh restoration areas over 166,500 acres of floodplain. When completed, the project—now in its final stage with the construction of the 13,737-acre Three Forks Marsh Conservation Area—will have restored much of the original wetlands and conserved the remaining untouched land (Fig. 2). The restored basin will be capable of containing 500,000 acre-feet of water, a substantial benefit for flood control.

This natural approach to flood control has had other benefits, such as improved water quality and the return of fish and wildlife, including endangered species such as the snail kite and the wood stork. The shellfish industry in the Indian River Lagoon is no longer in danger from freshwater incursion, and water from agricultural sources is now kept in reservoirs, separate from the marshes, and reused for irrigation.

CHALLENGE

Safeguarding People and Water Supplies from Heat Waves and Droughts

Our warming climate will bring an array of problems to cities and towns. Two of the greatest challenges ahead are an increase in the frequency and severity of heat waves and more erratic rainfall patterns with longer periods of drought punctuated by intense rainfall and potential for flooding. For urban dwellers, heat waves are exacerbated by the "heat island effect," the absorption and retention of large amounts of heat by pavement and buildings. Urban dwellers also rely on municipal water supplies that will increasingly need to be made resilient to heated threats.

CASE STUDY

New York City Drinking Water

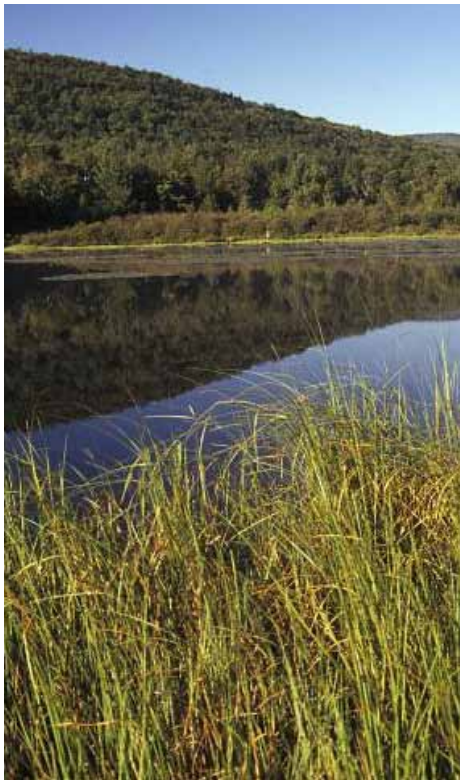


PHOTO COURTESY TINER RALPH/U.S. FISH AND WILDLIFE SERVICE

Protecting wetlands, like these in the western Catkills, and other water sources that furnish its drinking water is a green-infrastructure investment priority for New York City.

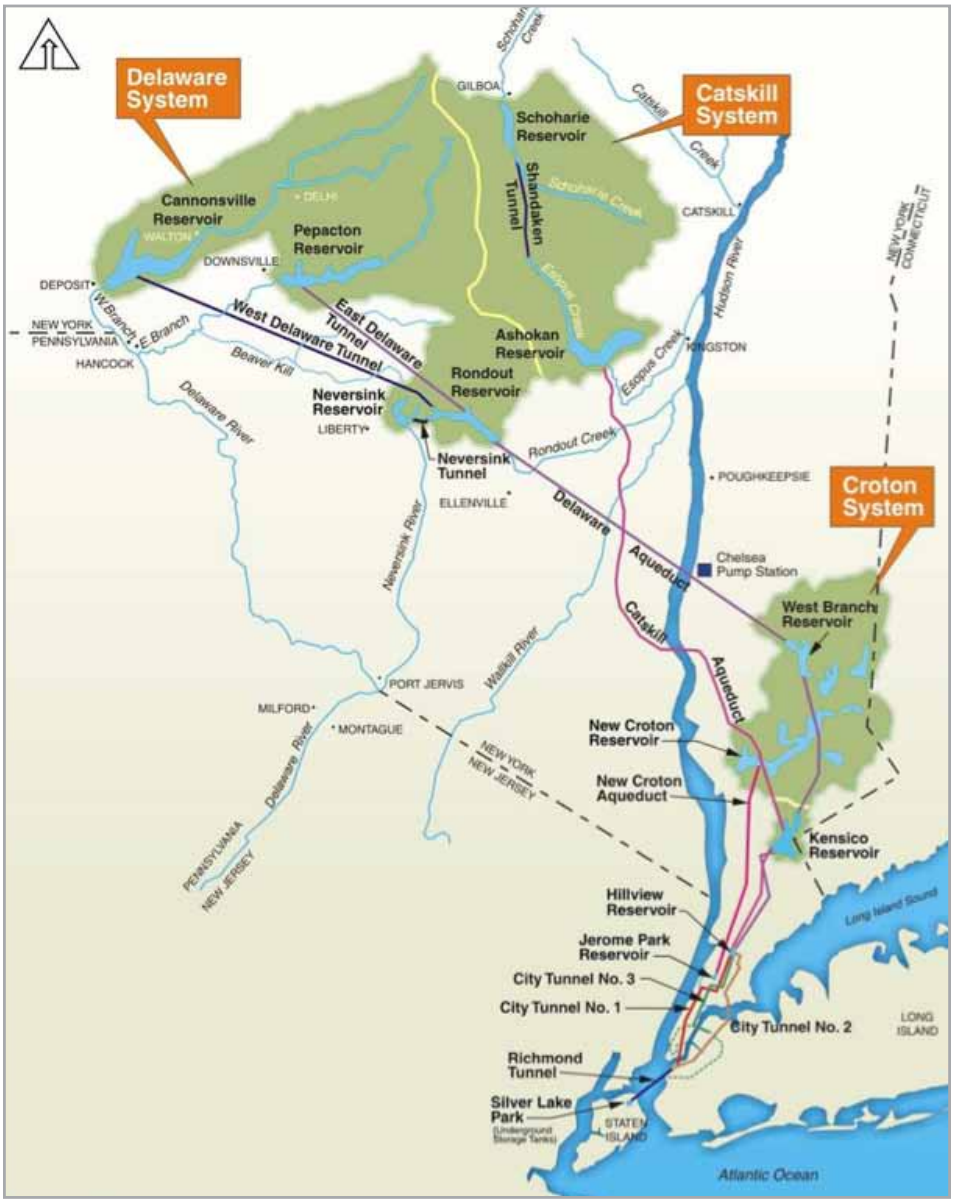
Problem: The 8.2 million residents of New York City (NYC) and 1 million people from surrounding municipalities require, in total, 1.1 billion gallons of drinking clean water per day, a significant challenge even without climate change. Nonetheless, assessments project that temperatures in NYC will rise by 4 to 7.5 degrees F and precipitation will increase 5 percent to 10 percent by the 2080s. These changes will most likely lead to increased water demand and a dwindling supply, since the increase in precipitation won't be enough to make up for the spike in evaporation due to the warmer temperatures. Furthermore, water quality is likely to decrease with more runoff of sediments, nitrogen and phosphorus resulting from heavy rainfall, leading to more outbreaks of harmful algae and increased risk of bacterial and parasitic contamination.

Solution: To ensure a clean and abundant water supply, NYC began protecting its watershed in 1993 and continues to protect its water resources through various programs, which include the acquisition of land buffering reservoirs and lakes, land management, stream management and working with farms to reduce agricultural runoff. The city's water comes from 19 reservoirs and three lakes located up to 125 miles from the city (Fig. 3, opposite). The NYC Watershed Protection Program maintains water quality at such a standard that water from the Delaware and Catskill systems (the two largest) does not require filtration, saving the city the roughly $6 to $8 billion cost of building filtration plants.

In 2011, the city released an update of its *2007 PlaNYC*, an ambitious blueprint for facing challenges of population growth and climate change by making a "greener, greater New York." The plan calls for planting a million trees this decade, continuing and improving the Watershed Protection Program, expanding "green infrastructure," reducing stormwater runoff by replacing impervious surfaces with water-absorbing green space and natural water-capturing systems. If all goes according to plan, NYC will be well-prepared for the increased stress climate change places on its water supply.

FIG. 3. NEW YORK DEPARTMENT OF ENVIRONMENTAL PROTECTION'S WATER SYSTEM

SOURCE: ENVIRONMENTAL PROTECTION AGENCY, 2011

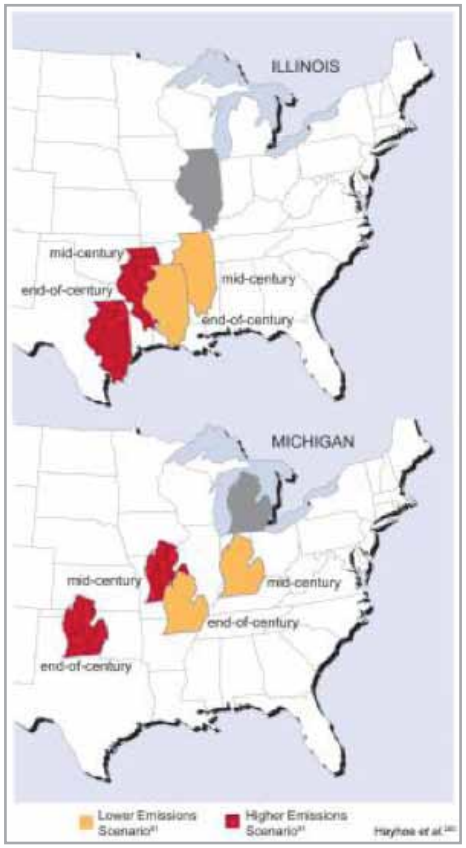


Forested lands help to combat the heat island effect by shading the area directly beneath them and by using the heat from the surrounding air to move water through their tissues, a process known as evapotranspiration. Temperatures in the vicinity of trees and other vegetation can be 4 to 9 degrees F lower than areas that are barren.

Forests, revegetated stream banks, and wetlands also combat flash flooding by acting like sponges to help absorb water after storms and release it more slowly. In addition, they provide habitats for a variety of animals, including pollinators and insect-eating birds and bats. As an added benefit, growing plants also absorb carbon dioxide, the main greenhouse gas pollutant.

The Chicago Wilderness Plan identifies 1.8 million acres of lands in the region with potential for protection and restoration, green infrastructure that will help the

FIG. 4 MODEL PROJECTIONS OF AVERAGE SUMMER TEMPERATURE AND PRECIPITATION CHANGES



CASE STUDY

Green Infrastructure in Chicago

Problem: According to the U.S. Global Change Research Program, the average temperature in the Chicago region has already risen by about 1.5 degrees F, and the amount of rain that falls in very heavy precipitation events has increased by 31 percent since the 1950s. Temperatures are projected to increase by 4 to 10 degrees F over the coming century, leaving Illinois with a climate more like that of Louisiana and Texas (Fig. 4).

The number of heat waves—and heat-related deaths—could double or even quadruple by the end of the century. Heavy precipitation events are also projected to overwhelm storm sewer systems and increase the incidence of flash flooding.

Solution: The Chicago Wilderness Plan, devised by a consortium of conservation-minded organizations, is guiding the rebuilding of northern Illinois' green infrastructure, which it defines as a network of forests, streams, wetlands and other natural areas.

region become more resilient to climate change and add value to surrounding communities. The city of Chicago is also beginning to recommend warm-weather-adapted trees for its urban forestry initiative in anticipation of the warmer plant hardiness zone it now borders moving north as average annual minimal temperatures in the area increase.

CHALLENGE

Reducing Losses from Wildfires

Across much of our nation's forested land, conditions are ripe for major fire events. Logging practices have played a role. Cutting down mature trees and opening large gaps in the forest results in dense stands of young trees, which burn more readily than their thick-barked, relatively fire-resistant predecessors. The active suppression of fires, practiced for many years with the belief that it improved timber yields, allowed unusually large amounts of highly combustible downed trees, branches and leaf litter to build up, creating conditions conducive to extensive and very hot fires capable of killing even the largest trees.

Climate changes are heightening the threat: Higher temperatures and lengthening periods of drought create dangerous tinderbox conditions by drying out the litter layer and stressing trees. Given that climate changes portend a future with more and larger fires and human lives and property are more at risk from wildfires now that more people are living at the urban-wildland interface, some managers are attempting to restore forests to historic conditions more suitable for a climate-changed future.

PHOTO COURTESY U.S. FISH AND WILDLIFE SERVICE

To reduce the risk of catastrophic forest fires that could reach populous areas near the Sierra National Forest in California, the Forest Service is restoring areas compromised by past forestry practices to historic, less combustible conditions. Wildlife, like the Pacific fisher (below), is also benefitting from the restoration.

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CASE STUDY

Forest Restoration in the West

Problem: Past forestry practices—logging the largest and most fire-resistant trees, leaving behind piles of logging slash, and suppressing the small, "cool" fires that reduce the fuel load—have helped set the stage for the excessively destructive fires we are seeing with greater frequency in the western United States. Climate change is adding to the stress by increasing the length and severity of drought conditions.

Solution: Managers across the West are working to restore forest lands to conditions that more closely represent their historic condition, simultaneously making them more resilient to future stresses. Restoration practices such as thinning or removal of small stands of young trees too dense to grow well, control of invasive species, and reintroduction of carefully controlled, prescribed fire can help reduce the threat of major, tree-killing, canopy

blazes. As an added benefit, these practices also restore the forest to a better condition for many species of wildlife.

The Forest Service is currently undertaking landscape-scale forest treatment projects in several states. In California, the Dinkey Landscape Restoration Project has identified more than 50,000 acres of wildland-urban interface areas in and around the Sierra National Forest of California, where over 5,000 homes are at risk from catastrophic wildfire. The project aims to reduce fuel loads on 34,000 acres and treat 40,000 acres with prescribed fire over a 10-year period. By restoring the forest to it historic condition, the project hopes to help it adapt to the future by providing "ecosystem resilience and adaptive capacity to wildfire, drought, insects, pathogens, invasive species, pollutants and climate change." The restoration will also improve habitat for two important declining species in the area, the California spotted owl and the Pacific fisher.

CASE STUDY

Longleaf Pine Restoration in the Southeast

Problem: The collision course of forestry practices and climate change is becoming more prevalent across the Southeast as the region seems to be in a pattern of alternating floods and droughts. Droughts cause stress to forest trees, leaving them more susceptible to attacks by bark beetles and vulnerable to catastrophic fires. And the number of powerful storms is on the rise, bringing flooding and winds with potential to damage or knock down hundreds or thousands of trees at a time. At the same time, longleaf pine, the historic forest cover adapted to these kinds of conditions, has been replaced across most of the Southeast with loblolly and other faster growing pines that are more valuable as timber.

Solution: Throughout much of the lowland Southeast, one of the best ways to help forests adapt to climate change is to restore the longleaf pine, the species that dominated the coastal plain and piedmont ecosystems. Longleaf pine is resistant to many of the dangers likely to increase with climate change: it is less susceptible to beetles than other pines, it has deep roots that resist wind-throw in storms, and it grows in a wide variety of habitats, from very wet to very dry. Both seedlings and mature trees can survive fires, which were historically an important natural part of this ecosystem.

Restoring longleaf pine will also benefit dozens of plant species that are found only in association with these ecosystems, and provide habitat for reptiles, amphibians

PHOTO COURTESY U.S. FISH AND WILDLIFE SERVICE

A longleaf pine catches fire—a force it is naturally resilient to and, in fact, needs to survive. It is also more resistent to insects and storms than the loblolly and other fast-growing trees that have usurped its habitat. The threats of climate change are spurring efforts to restore longleaf pine forests.

PHOTO COURTESY U.S. FISH AND WILDLIFE SERVICE

A tidal shoreline along the Potomac River in Maryland naturally resists erosion thanks to the state's "living shorelines" program. The program provides grants and guidance for planting native vegetation and using bioengineered materials, such as logs made out of coconut fiber, rather than concrete to protect waterfront property .

and birds, including the threatened red-cockaded woodpecker, which nests almost exclusively in mature longleaf pines.

The Forest Service, U.S. Fish and Wildlife Service and private landowners are partnering to restore 4.5 million acres of longleaf pine forest by 2024. Both seedlings and mature trees can survive fires, which were historically an important natural part of this ecosystem. In the Osceola National Forest, where four large wildfires in the last 15 years have burned more than 430,000 acres and cost more than $31 million to fight, managers are reintroducing prescribed fire. They are also removing dense undergrowth and hazardous slash, reducing the dominance of saw palmetto in the understory and restoring natural hydrology.

These practices provide opportunities for longleaf pine to re-establish and eventually regain dominance in the ecosystem. The changes are already having a positive effect on local communities: In 2007 during the Bugaboo Scrub Fire—at 600,000 acres the largest wildfire in the history of Florida and Georgia—part of nearby Lake City was saved from having to evacuate because the fire entered an area previously treated with controlled burning.

CHALLENGE

Coping with Sea-Level Rise

The one type of weather disaster we didn't have in 2011 was a major coastal storm. Even the two tropical systems that made the billion-dollar threshold did most of their damage inland. However, given the profound impact climate change is expected to have on sea level—a three- to four-foot rise in sea level by the end of the century—that is likely to change. The rise in average levels will threaten low-lying areas, exacerbate the storm-surge damage from increasingly powerful coastal storm and affect millions of people.

CASE STUDY:

Living Shorelines, Maryland

Problem: The Chesapeake Bay is poised to feel the effects of sea-level rise acutely, due to the peculiarities of its geology. This includes the fact that the land itself is slowly subsiding, a long after-effect of the last Ice Age. The more abrupt sea-level rise of the coming century will only compound these problems, and already many Chesapeake Bay landowners complain of failing seawalls and problems with erosion.

Solution: As landowners along the Chesapeake notice wooden bulkheads sagging and rock walls failing, they

are increasingly turning to an alternative promoted by the Maryland Department of Natural Resources: "living shorelines." Instead of armoring their shorelines, residents who choose this approach are stabilizing their waterfronts with "bio logs" made of temporary coconut-fiber and restoring them with vegetation appropriate to the salinity, water depth and level of wave action specific to their property. Ideally, a living shoreline will feature a mixture of plants, grading from woody shrubs and trees above the high tide line to increasingly brackish vegetation downslope and perhaps even an oyster reef and submerged vegetation farther out. In addition to being less costly than engineered revetments and more aesthetically pleasing, living shorelines provide better protection from erosion, natural pollution control by filtration of pollutants and sediments and habitat for a variety of wildlife.

CASE STUDY

Beach Grassland Restoration, Texas

Problem: Extensive withdrawals of groundwater have taken a toll on the Texas coast. Galveston has sunk about a foot over the past century, and nearby areas have subsided by as much as 10 feet. In addition, Galveston's position on a Gulf Coast barrier island puts it squarely in the danger zone for hurricanes and tropical storms. Rising seas will only make these dangers more pronounced and increase the likelihood of erosion and damage from routine high tides and storm surges.

Solution: In 2003, researchers at Texas A&M University implemented a coastal protection and restoration project at Loyola Beach using ecological engineering. This "soft" engineering approach, which incorporated riprap, fiber matting, geotextile (permeable fabric) and vegetation cover to control coastal erosion, was compared to the "hard" engineering solutions applied to protect a 750-foot concrete seawall in nearby Corpus Christi.

The soft approach has held up well, despite some damage sustained from Hurricanes Dolly and Ike. In particular, where saltmarsh cordgrass vegetation had taken hold, it substantially helped to stabilize the shoreline. The establishment of an ecological system to protect the shoreline also added aesthetic value and increased stormwater retention, which in turn may lower nutrient loadings in the marine environment. There are semi-annual some periodic maintenance costs associated with the ecological approach, but construction costs at Loyola Beach were one-third the price of building a conventional concrete seawall ($64,920 vs. $196,860). In response to the success of the project, the county extended this ecological approach to protect an additional 100 feet of shoreline.

Hurricane Ike hits the Texas coast hard in September 2008. The approach to protecting the state's shoreline now includes planting vegetation to reduce erosion and taking other ecological restortion steps rather than relying solely on concrete seawalls and other hard infrastructure.

Conclusion and Recommendations

PHOTO COURTESY U.S. FISH AND WILDLIFE SERVICE

Restoring longleaf pine forests and other ecosystems that are naturally resilient and adaptable to the impacts of climate change is one way to get the power of nature on our side.

ECOSYSTEM-BASED ADAPTATION practices have excellent potential for helping communities manage climate-change risks while also restoring wildlife habitat, enhancing water quality, improving fisheries and providing a better quality of life for local residents. As the case studies in this report demonstrate, by harnessing the power of nature we can:

- Reduce the risk of flooding by restoring flood plains that naturally absorb and slow flood waters.
- Reduce the risk of water shortages and water quality degradation by maintaining and restoring water-system watersheds.
- Reduce the risk of heat stress associated with heat waves by planting shade trees, replacing impervious surfaces with green spaces and restoring forests near built-up areas to lessen the "heat island" effect.
- Reduce the risk of wildfire by restoring forests near residential areas to more natural fire-adapted ecosystems.
- Reduce the risk of sea level rise and storm surge by maintaining and restoring coastal wetlands and developing "living shorelines" instead of hard seawalls.

These approaches must be mainstreamed as viable alternatives to structural solutions. The federal government took a first step by issuing *Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance*, in 2009. The order directs all federal agencies to develop climate-change-adaptation strategies—including ecosytem-based approaches—in their planning processes. The following recommendations are offered to help agencies and communities get started.

"Ecosystems provide valuable services to help build resilience and reduce the vulnerability of people and their livelihoods to climate-change impacts. Integrating the protection of biodiversity and ecosystem services into adaption strategies will increase resilience of human and natural systems to climate and nonclimate risks, providing benefits to society and the environment."

—*Implementing Climate Change Adaptation Planning in Accordance with Executive Order 13514,* March 4, 2011

Recommendations

Take stock of the risks climate change poses to an area and the opportunities for harnessing nature to address them.
All sectors and communities will face climate-change impacts and it is important that they take stock of the associated risks. Some impacts, like flooding, drought, wildfire and the effects of increased temperatures, may be lessened by the presence of intact or restored ecosystems. Identifying these opportunities to harness nature is the first step toward developing policies that embrace the ecosystem approach.

Evaluate the role of current policies in protecting—or imperiling—ecosystems that could provide climate adaptation benefits.
Policies ranging in scale from local (zoning, land-use planning) to national (flood insurance, national environmental laws) impact whether ecosystems and the services they provide are valued and protected. Small changes now, such as targeted easements or policies to encourage new developments to infill rather than sprawl into intact habitats, can help preserve ecosystem functions that will bring substantial benefits down the line.

Include ecosystem-based approaches when evaluating alternatives to reduce community risks.
Before beginning community development or infrastructure improvement projects, planners generally undertake a planning process that evaluates various options to determine whether they meet the community's objectives and if they have other environmental consequences. This evaluation generally takes the form of an Environmental Assessment or an Environmental Impact statement if there are federal permits or funding involved. Planners are not required to include ecosystem-based approaches, but including these alternatives would allow decision-makers to better compare the costs and benefits of "harnessing nature" to traditional infrastructure approaches.

Leverage funding.
With tight budgets at all levels of government, financing adaptation efforts is a perennial challenge. Ecosystem-based adaptation strategies may have an advantage, however, because they are usually less costly and confer ancillary benefits like improved water quality, recreation opportunities and higher property values. Grant-making agencies should prioritize ecosystem-based approaches in their funding criteria, and communities seeking to incorporate these approaches should explore a wide range of funding opportunities. A living shoreline project, for example, may qualify for funding under a water-quality improvement program because it reduces erosion and sedimentation.

Involve local stakeholders early.
It is crucial to involve local stakeholders in decision-making process to make sure they understand the details and benefits of a project and to get feedback and address their concerns. Issues like effectiveness of approaches, zoning changes or easements, water rights and other questions can generally be resolved satisfactorily with local involvement.

Look for opportunities to accomplish both climate-change adaptation and mitigation.
Protecting and restoring ecosystems may provide opportunities to protect human communities from the impacts of climate change and also to reduce carbon dioxide emissions by planting or retaining healthy vegetation.

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