

Increased Flooding Risk: Global Warming's Wake-Up Call for Riverfront Communities

NATIONAL WILDLIFE FEDERATION 2009



U.S. Air Force

Global warming has caused more heavy rainfall events in the United States over the last few decades along with an increased likelihood of devastating floods. While no single storm or flood can be attributed directly to global warming, changing climate conditions are at least partly responsible for past trends. Because warmer air can hold more moisture, heavier precipitation is expected in the years to come. At the same time, shifts in snowfall patterns, the onset of spring, and river-ice melting may all exacerbate flooding risks.

Over-reliance on levees and other strategies for taming rivers have compounded the losses from major floods. Damages have more than doubled since the early 20th century as floodplains and wetlands have become more and more developed. At the same time, strategies to speed the water off the landscape (such as stream straightening and agricultural drainage tiles) and to enhance river navigation have created conditions conducive to larger floods.

Cities and towns, agriculture, and transportation infrastructure located along rivers and in floodplains have experienced major damages and disruptions from floods in recent years. Damages from the Midwest floods in May and June 2008 were more than \$15 billion, just 15 years after the same area was hit by a similarly devastating flood. The January 2009 floods in the Pacific Northwest caused \$125 million of damage, evacuations of more than 30,000 people, and shutdown of major roads and rail service. Significant damages were averted in Fargo, North Dakota when residents came together to build a massive sandbag levee, just barely high enough to hold back the Red River when it crested at a record high 40.8 feet.

We must confront the realities of global warming including the increasing frequency and intensity of heavy rainfall events across the country. Important steps include discouraging development in flood-prone areas and protecting the natural systems, such as wetlands, that help to buffer against floods, both for people and for the wildlife that depend upon them. And, we must aggressively reduce global warming pollution, thereby ensuring that we avoid the worst impacts.



CONFRONTING GLOBAL WARMING

Report

Global Warming Increases Flooding Risk

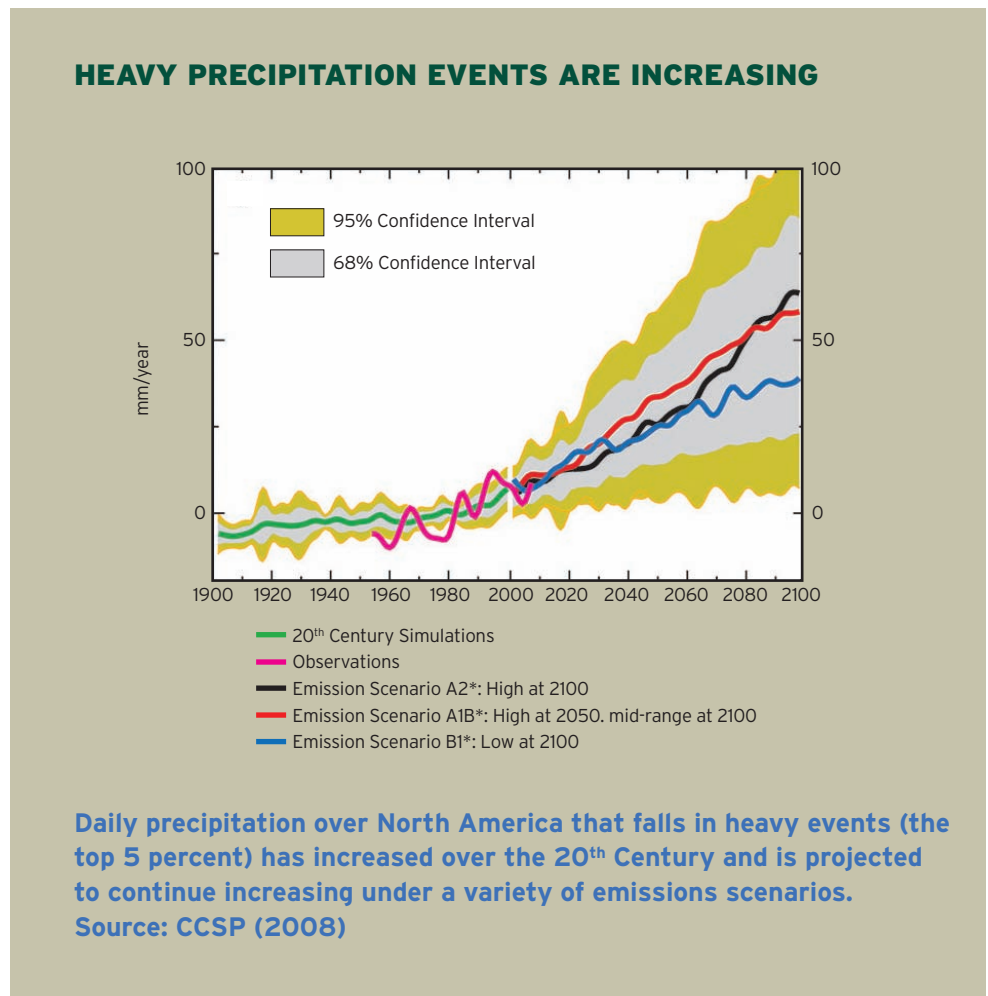
Global temperatures have increased by about 1.3 degrees Fahrenheit over the last century and we are on track to warm by another 2 to 11 degrees by 2100, depending on the extent to which global warming pollution is curbed.¹ This warming has brought a suite of climate shifts, including several that lead to larger flooding risk. Most notably, an increase in heavy rainfall events is one of the clearest trends observed over the past few decades and projected by climate models for the next century.²

MORE HEAVY RAINFALL

Global warming is bringing more heavy rainfall events because warmer air can hold more water. For every 1 degree Fahrenheit warming, atmospheric water vapor increases by about 3 to 4 percent. Satellite-based observations over the past 20 years³ combined with climate model studies⁴ have confirmed that such increases are indeed happening around the globe.

For the continental United States, the most intense rainfall events have been increasing at a rate of 20 percent per 100 years.⁵ These increases are correlated with a corresponding increase in days with heavy streamflow in the medium and large river basins of the Eastern United States.⁶

Major flooding—like the Red River Floods of 1997 and 2009—requires prolonged periods of higher-than-normal precipitation. Across North America, we are having more 90-day intervals with precipitation totals in the top 5 percent of the historical average. The last 25 years have seen 20 percent more of these episodes than any other 25-year window over the 20th century.⁷ The Western United States has also seen a shift to sequences of consecutive years with much above normal streamflow followed by multiyear extreme droughts,⁸ although it is not yet possible to attribute these



changes to global warming.⁹

As the climate continues to warm, the atmosphere will be able to hold more water. With more moisture in the air, the trend towards increasingly intense precipitation events will continue. In the Midwest and Northeast, big storms that historically would only be seen once every 20 years are projected to happen as often as every 4 to 6 years by the end of the 21st century.¹⁰

SHIFTING SNOWPACK AND SNOWFALL

Mountainous areas across western North America and in the Northeast have seen snow melt and peak streamflow happen earlier in the spring. For example, snow melt

discharge occurs 5 to 20 days earlier than it did 50 years ago at many observing stations in the Pacific Northwest.¹¹ This river discharge could be an additional 30 to 40 days earlier by the end of the 21st century if global warming pollution is not curbed. Dates of high flow in the Northeast are already 1 to 2 weeks earlier today than in the 1970s.¹² While these trends will likely mean water shortages in the summer and fall, they also will increase the risk of winter and early spring floods.

At the same time, winter precipitation is beginning to shift toward more rain instead of snow. The fraction of wintertime precipitation falling as snow has declined by 9 percent since 1949 in the Western

United States¹³ and by 23 percent in the Northeast.¹⁴ The biggest shifts from snow to rain are seen in March for all regions studied, December in New England, and January along the Pacific coast. The increase in winter rainfall will bring increased flooding risk during those months.

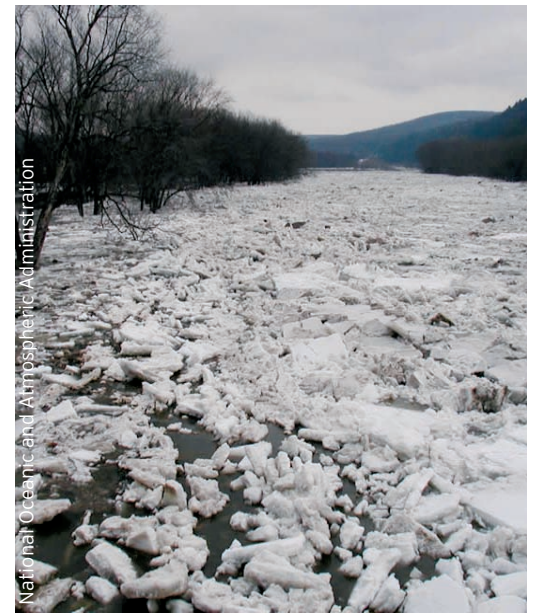
Rain-on-snow events can bring significant flooding from the combined rainfall and snow melt, as has been the case in several recent major flooding events in the Pacific Northwest. Some higher elevation areas in the West, where winter temperatures typically remain low enough to maintain snowpack, have seen a trend toward more rain-on-snow events, perhaps reflecting the increased likelihood of mid-winter rainfall events. Despite recent examples of severe rain-on-snow floods, the frequency of rain-on-snow events is decreasing

across much of the West because there is less snowfall overall.¹⁵

EARLIER SPRINGS AND ICE-JAM FLOODS

Regions where rivers freeze over in winter are susceptible to ice-jam floods when heavy rainfall or upstream melting raises the stream stage to the point of breaking up the ice cover.¹⁶ If it piles up on bridge piers or other channel obstructions, the ice can create dams that cause flooding behind it. Once the ice jam breaks up, downstream areas are vulnerable to flash floods.

Global warming could create conditions ripe for ice-jam floods.¹⁷ The increasing possibility of mid-winter thaws and heavy rainfall events could increase the risk of sudden ice break up. Flooding can be further exacerbated if the ground is still



frozen and unable to soak up rainwater. The 2009 floods on the Red River in North Dakota exemplified this situation. The risk of ice jams may decrease in some regions if they no longer get cold enough to develop thick river ice.



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Poor Management Practices Exacerbate Severe Flooding

Misguided management of floodplains, watersheds, and rivers is also responsible for major flood damages in recent years. As our efforts to control rivers and streams expanded over the last century, development pushed closer to the edges of rivers and population in areas vulnerable to floods has increased significantly.¹⁸ Flood related damages have jumped from about \$3 billion a year in the first half of the 20th century to an average over the last 2 decades of \$6 to \$8 billion a year (depending on whether Hurricane Katrina is included).¹⁹

BUILDING IN FLOODPLAINS

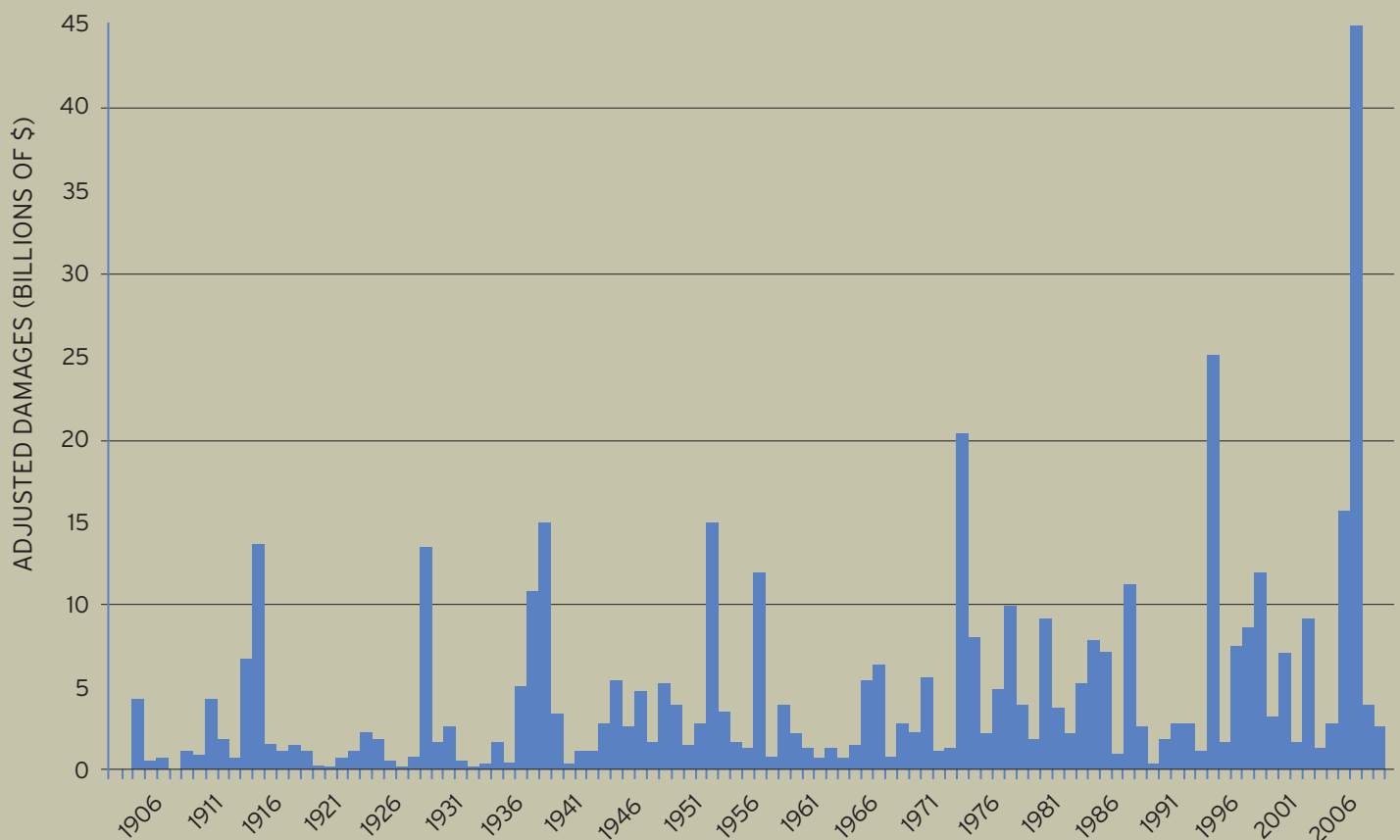
For decades, rivers and streams across the nation have been increasingly

altered by building dams and levees, filling in floodplains, draining wetlands, and other projects intended to increase inland waterway navigation, improve flood control, and expand usable land. However, because these efforts do not work in harmony with natural systems, they have actually *increased* the risk of major floods in some areas and promoted extensive development and agriculture in wetlands, along rivers and streams, and throughout floodplains. Re-evaluating the hidden costs of these projects is necessary for reducing the risk of future major flood disasters.

The unfortunate and peculiar interplay between the standards and requirements of the National Flood Insurance Program (NFIP) and the

Corps of Engineers flood control financing and project planning procedures has fostered an explosive growth in development in floodplains since the 1960s. Over this time, many levees were built only with the minimum 100-year (1 percent annual chance) levels of flood protection in order to avoid the NFIP's mandatory flood insurance purchase requirements for floodplain residents and the requirements for land-use and building controls for floodplain-located construction.²⁰ Additionally, NFIP policies allow developers to escape flood insurance and floodplain requirements by placing fill in the floodplain, thereby raising the base of the development above the 100 year

ANNUAL FLOOD DAMAGES ARE INCREASING IN THE UNITED STATES



Source: National Weather Service Hydrologic Information Center (2009)



U.S. Geological Survey

flood level. Of course, this practice reduces the flood absorbing functions of the floodplain and increases flooding severity by forcing the water to go elsewhere during floods. Development in areas behind levees or in filled areas has proceeded as if there was no flood risk, yet over the 30-year period of a typical mortgage there is a 26 percent chance of a flood equaling or exceeding the 100-year flood.²¹ Today there are more than 6 million buildings located in the mapped 100-year flood plain.²²

Despite the known risks of building in floodplains, the NFIP continues to have a growing problem with properties that suffer repeated flood losses. As of 1995, 74,501 properties had 2 or more claims within 10 years, costing a total of \$2.5 billion.²³ Today the number of repetitive loss properties has doubled and costs have quadrupled, despite some efforts to buy out and remove some frequently flooded properties.²⁴ These properties are one factor contributing to the NFIP's insurmountable \$19.2 billion debt to the U.S. Treasury.²⁵

SPEEDING WATER OFF THE LANDSCAPE

In addition, several watershed management strategies have decreased

the ability of the landscape to naturally respond to heavy rainfall events. Upstream practices, such as stream straightening and channelization of meandering streams, allow water to flow more quickly downstream, resulting in more damages from severe flood events.²⁶ Millions of miles of drain tiles have been placed under agricultural fields to speed drainage of stormwater into rivers and streams.

Furthermore, countless wetland areas have been drained in order to convert land for human use. In the mid 1990s, it was estimated that only 103 million acres of wetlands remain in the contiguous United States, less than half of the 221 million acres here when European settlement began.²⁷ Five of the six states with the largest wetlands loss are located in the Midwest (Ohio, Indiana, Illinois, Iowa and Missouri), where there was widespread conversion of wetlands for agricultural uses. These wetland conversions often add a significant area of impervious urban surfaces and deforested rural land right up to the edge of rivers and streams, or convert native grasslands and restored conservation reserve lands to row crops, destroying the very buffers that help absorb the impacts of floods.²⁸

Wetland loss not only speeds water to rivers, but it also removes valuable flood retention functions from the landscape. One acre of wetlands can typically store about 1 million gallons of water that would otherwise contribute to flooding.²⁹ Indeed, it has been estimated that restoration of lost wetlands in the Upper Mississippi basin would add enough storage capacity to the landscape to retain the amount of water that caused the devastating 1993 flood.³⁰ Another telling example is the Charles River basin in Massachusetts, where the Army Corps of Engineers averted annual flooding damages estimated at \$17 million by conserving wetlands in the river basin.³¹

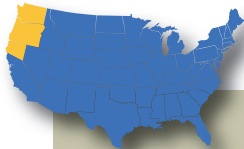
Wetland and watershed degradation slowed greatly after passage of the Clean Water Act in 1972.³² However, due to two fractured and confusing Supreme Court decisions (*SWANCC* in 2001 and *Rapanos* in 2006) the Clean Water Act's protections against degradation and destruction have been placed in doubt or effectively removed. As a result of these decisions and policies interpreting them, at least 20 percent of the remaining wetlands in the contiguous lower states have lost basic protections and many more are at risk.³³

Communities on the Frontlines

Floods and severe storms are among the most costly kind of weather and climate disaster in the United States, together costing the country more than \$115 billion from 1960-2005 in direct damages.³⁴ Crops are especially vulnerable, both during the storm and because excessively wet soil can create anoxic conditions, foster the spread of diseases and insects, and make it difficult to operate farm machinery needed to plant or harvest. One study estimates that flood-related losses to U.S. crops could double by 2030 due to increased frequency of excess soil moisture.³⁵

Large floods that overwhelm water treatment facilities can cause outbreaks of waterborne diseases. Such was the case in Milwaukee, Wisconsin, in 1993, when there were 403,000 cases of intestinal illness, resulting in 54 deaths, after a period of heavy rainfall. In fact, more than half of waterborne diseases reported nationwide between 1948 and 1994 were preceded by periods of heavy rainfall.³⁶

The following sections highlight four regions of the country that have experienced severe flooding in recent years and that are susceptible to more flooding as the climate continues to warm.



PACIFIC NORTHWEST

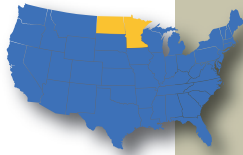
Seattle, Washington, has already seen an intensification of precipitation extremes, especially in fall and winter.³⁷ A 24-hour precipitation accumulation that would have only happened once every 50 years based on observations from 1956-1981, now occurs on average every 8.4 years.³⁸ In fact three of the four highest 1-day totals observed in Seattle since 1949 occurred in the last five years. Although these trends have not been observed uniformly across the Pacific Northwest, model projections for 2020-2050 indicate that more heavy rainfall events will afflict much of the region.³⁹ Combined with shifts toward more rain instead of snow and earlier snowpack melt, these trends portend more winter flooding risk (as well as more summer and fall water shortages).

The January 2009 storm in the Pacific Northwest is a prime example of how mild temperatures and record heavy rainfall in midwinter can create conditions for heavy flooding. The region had record snowstorms the previous month, so the flooding was exacerbated by melting of this snowpack. The impacts were widespread: more than 30,000 people were asked to evacuate, roads and rail service were closed, and the damages estimated at \$125 million.⁴⁰

Similar conditions led to the record-setting floods affecting Oregon and surrounding states in 1996. Nine lives were lost and approximately \$1 billion of damages incurred, when a February warm spell with persistent heavy rainfall accelerated snow melt, creating conditions for widespread flooding.⁴¹ The Willamette River crested at just 5 inches below the flood walls in Portland, just barely averting much more damage.⁴²



U.S. Air Force Photo by Tech. Sgt. Nick Choy, Oregon National Guard Public Affairs Office



NORTH DAKOTA AND MINNESOTA

The Red River floodplain, flowing northward between North Dakota and Minnesota, is an example of a region at great risk of flooding in coming decades. Located in a wide, flat glacial lake plain, the Red River Valley has long been prone to floods in the spring time.⁴³ Furthermore, because the water flows northward, the river is susceptible to ice jams as melting in the southern, upstream areas moves downstream to the still frozen northern areas. Six out of the last 13 years have had major floods, including one in 1997 that cost the Grand Forks, North Dakota region about \$3 billion in damages.



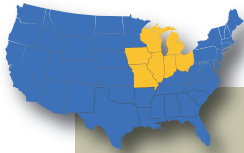
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The Red River had its worst flood on record in 2009, with the river cresting in Fargo, North Dakota at 40.8 feet on March 28.⁴⁴ In fall 2008, the North Central United States received heavy rainfall, enough to saturate the ground by the time it froze for the winter. The heavy precipitation continued through the winter leading to high snow accumulation. Many weather stations along the Red River had record-high levels of precipitation during January through March 2009.⁴⁵ When the region experienced a warm spell along with heavy rainfall in mid March, the new water and accelerated snow melt had no where to go. The land was either still frozen or already saturated. As the melt water flowed northward, severe ice jams resulted. A massive effort to build temporary sandbag levees and evacuate thousands of people averted major disaster.

Notably, Grand Forks, North Dakota, and East Grand Forks, Minnesota, just 80 miles north of Fargo, was largely spared in 2009. Following the 1997 floods, a \$417 million flood protection system was installed, consisting of new grass covered levees and removable flood walls.⁴⁶ In addition, the city took the bold action of buying out hundreds of properties in the floodplain and converting the land to parks, public recreation and habitat areas. At the same time, they moved the levees well back from the river's edge, thereby allowing more space for the river to swell as it would under natural conditions.⁴⁷ None of the major floods in recent years have caused significant damages to the city.



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MIDWEST

The largest trends in extremely heavy rainfall events have been in the Midwestern and South Central parts of the country, where the increases have been 3 percent or greater per decade.⁴⁸ In the upper Midwest, the number of days each year with precipitation greater than 4 inches has increased by 50 percent over the last century.⁴⁹ The remnants of tropical storms and hurricanes can also inflict significant inland flooding and wind damage in Lower Midwest states ranging from Arkansas eastward to Ohio. Global warming is also projected to bring more intense hurricanes.⁵⁰

The Great Flood of 1993 which devastated communities along the Mississippi River and its tributaries in nine Midwestern states, was one of the most costly natural disasters in the United States. Thousands of Americans were displaced from their homes and forced to leave their lives behind, 48 people died, and damages soared to an estimated \$21 billion.⁵¹ Some 1,043 federal and non-federal levees were over-topped or failed during the flood. Total federal response and recovery costs were \$4.2 billion, with the Federal Emergency Management Agency portion being \$1.14 billion, much of which was spent for voluntary buyouts and relocations, floodproofing and elevation of more than 12,000 damaged properties across the Midwest.⁵²

A mere 15 years later, history repeated itself as the rain-swollen Cedar, Illinois, Missouri and Mississippi Rivers and their tributaries topped their banks and levees, leaving hundreds of thousands of people displaced across the Midwest. Over \$15 billion of agricultural and property losses were racked up and 24 people lost their lives.⁵³ Following an extremely wet winter and spring, rainfall in May-June 2008 was about two to three times greater than the long-term average. More than 1,100 daily precipitation records were exceeded in the Midwest, mostly in Iowa, Illinois, Wisconsin and Missouri.⁵⁴ Impacts were felt across the region, from the draining of the man-made Lake Delton in the popular Wisconsin Dells when an earthen wall eroded, to upwards of \$8 billion in crop losses, of which more than half affected Iowa. About 30 percent of the nation's corn and soybean crops were lost, damaged, or delayed by these floods.⁵⁵

This remarkably quick return of such severe flooding is not anticipated by currently used out-of-date floodplain maps and reliance on historical flood frequencies. Yet it is what we should expect as global warming leads to more frequent and intense severe storms. Inadequate floodplain management is also responsible for the extent of damages from both floods, especially over-reliance on levees and the false sense of security they provide to those who live behind them. Over the past 15 years, about 28 percent of the total new development in seven states affected by the 1993 Mississippi floods has been in areas within the flood extent.⁵⁶



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NORTHEAST

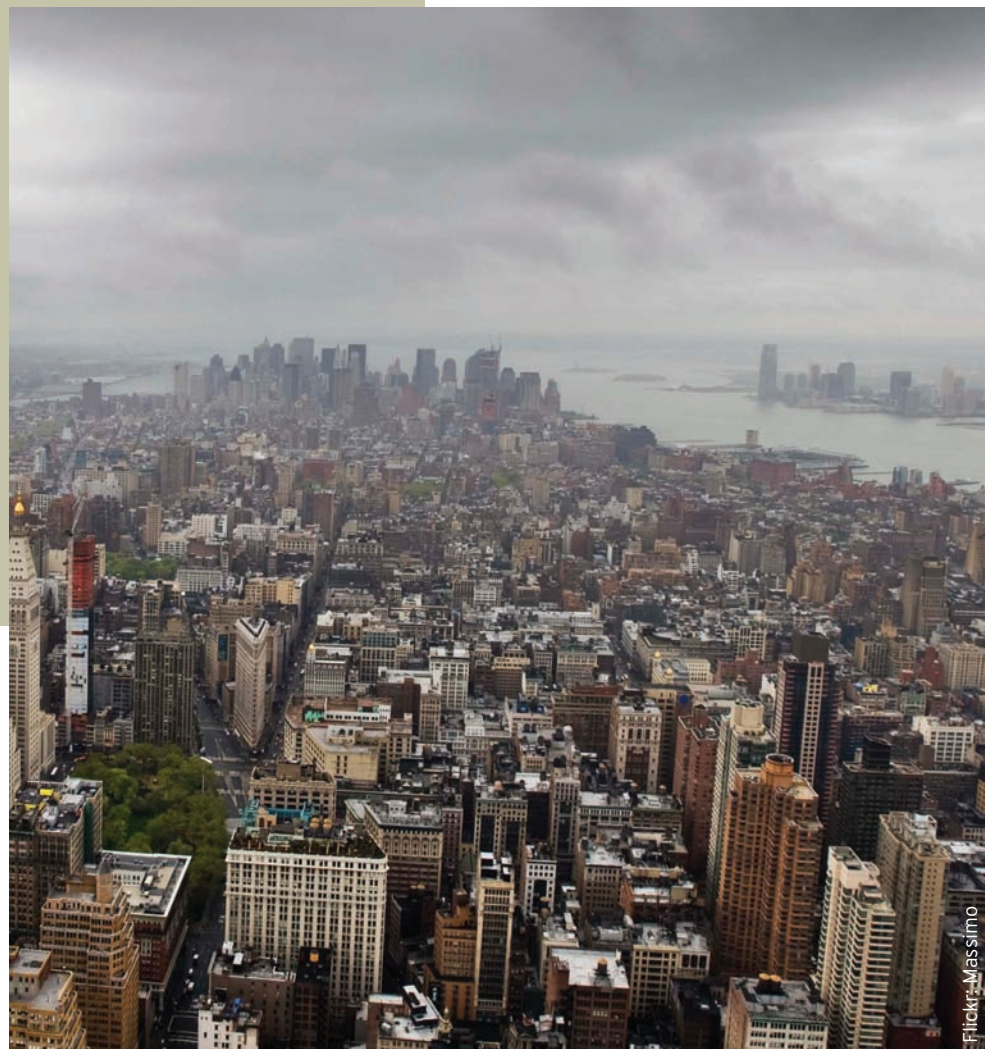
The Northeast United States has already seen an increase in annual average precipitation and more is on the way. While summers are getting drier, the rest of the year is getting wetter. Climate models project a 7 to 14 percent increase in annual precipitation by late this century. Winter precipitation is projected to increase by 12 to 30 percent. At the same time, the region will see a trend toward more of the heaviest precipitation events, leading to a 20 to 70 percent increase in the chance of streamflow greater than the 90th percentile of historical flows.⁵⁷ In addition, the region will see a shift from snow to rain during winter, accompanied by more runoff and an earlier onset of spring.

Spring 2006 brought two major flood events to the Northeast, which provide examples of how heavy rainfall impacts the region. In mid May, a two-part storm system hammered New Hampshire and Massachusetts with total rainfall amounts of 12 to 17 inches.⁵⁸ With the Merrimack River 6 feet above flood level and failures in sewage systems, homeowners were forced to evacuate.⁵⁹ Just over a month later, states from New York to Virginia were hit with another major storm. In Federalsburg, Maryland, more than 15 inches of rainfall were recorded over just 5 days, including 10 inches in a single 24-hour span.⁶⁰ Damages from this storm exceeded \$1 billion and at least 20 deaths were reported.⁶¹

New York City is already taking steps to prepare for greater flood risk. The city's Department of Environmental Protection is using projections of potential future climate conditions to update the old 100-year flood elevations and to evaluate modifications to infrastructure, operations, and policy.⁶² The department's 2008 plan has specific actions to address increased flooding risk, including increasing the size of sewer pipes, modifying pumping and cleaning protocols to better control flow, and promoting natural storage of rainwater in surrounding areas and in expanded green roof programs.⁶³



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Getting Ready for Stormy Weather Ahead: Reducing the Risk of Major Floods

We need to take these trends toward more flooding risk into account when managing our floodplains and watersheds, especially by discouraging development in flood-prone areas and protecting the natural systems that help to buffer against floods. We can no longer plan based on the climate we used to have. Across the country, it is paramount that sensible and responsible steps are taken to change the way the Army Corps of Engineers and the Federal Emergency Management Agency (FEMA) look at floodplains. To achieve these goals, we must:

Reduce global warming pollution to minimize future flooding. To limit the magnitude of changes to the climate and the impacts on communities and wildlife, we must curb global warming pollution as much and as quickly as possible. The

National Wildlife Federation recommends that policy makers, industry, and individuals take steps to reduce global warming pollution from today's levels by at least 80 percent by 2050.⁶⁴ This target is achievable with technologies either available or under development, but we need to take aggressive action now to avoid the worst impacts.

Avoid or drastically reduce reliance on levees for future development. The Army Corps of Engineers must adopt policies that restrict the construction of new levees in places that encourage high risk development or that are environmentally sensitive. The numerous levee failures in recent years make it apparent that this structural approach is not always sufficient to keep people and

communities safe, and can convey a false sense of security to the people living behind them. In some cases, moving the levees back from the river's edge can take advantage of the natural water storage capacity of the floodplain while also providing additional protection to communities located behind levees.

Ensure public safety where there are existing levees. Currently more than 100 levees nationwide are subject to potential decertification under the minimum standards of the National Flood Insurance Program (NFIP), due to deterioration, problems with maintenance or poor construction, and findings that they are not built to the 100-year specification as originally thought. These levees must be rapidly reevaluated. In addition, it must be

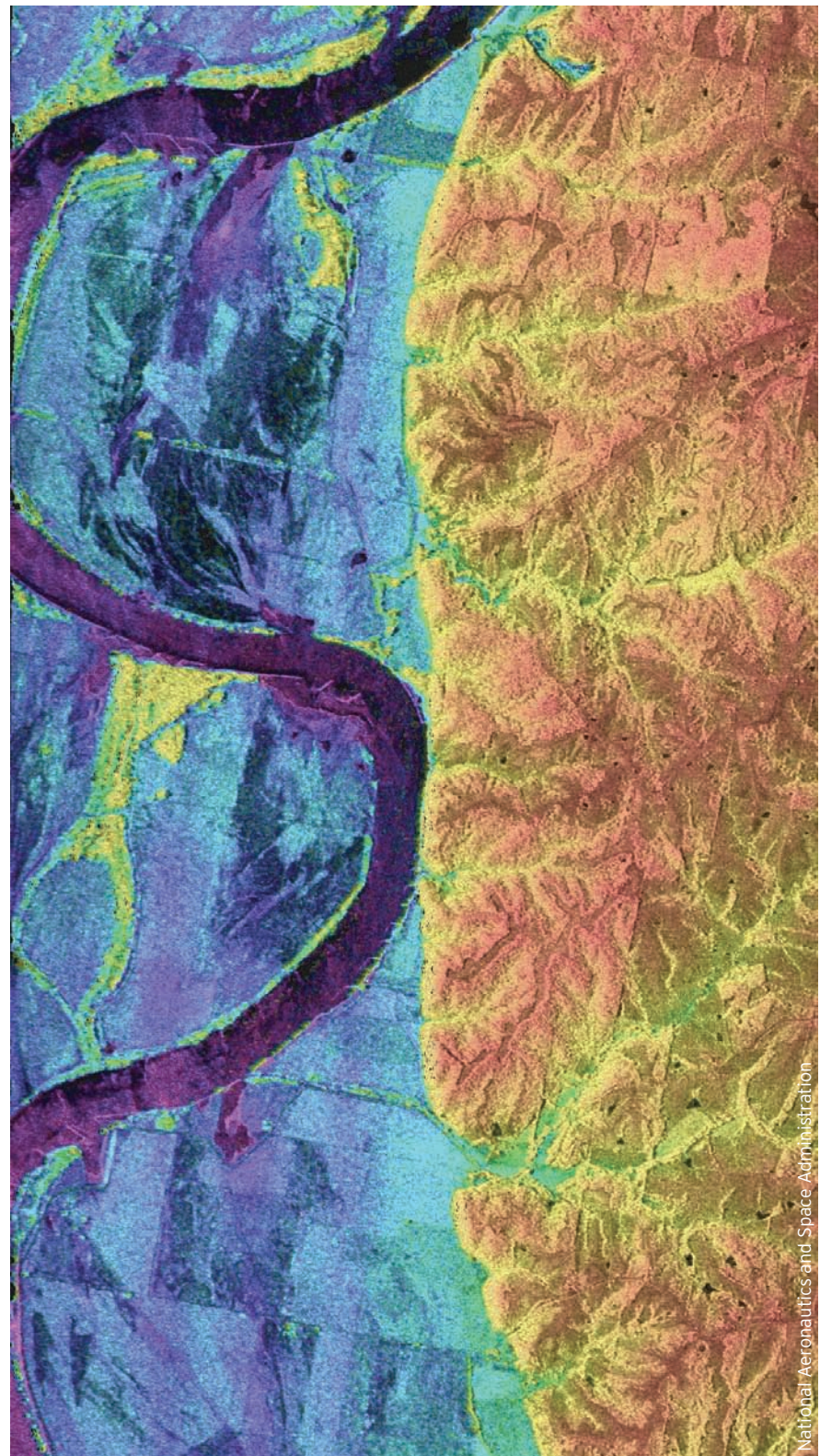


recognized that the NFIP 100-year flood standard is not generally an acceptable safety standard for most populated areas. Global warming will mean that more levees need to be reevaluated in light of increased flooding risk. Floodplain planning and maps must incorporate future anticipated conditions, including effects of climate change, urbanization and deforestation and accelerated drainage practices in upland watershed areas.⁶⁵ States and communities must take steps to educate those living in the floodplain about their risk and strengthen land-use and building codes in locations behind levees and below dams. People living in floodplains—even low-risk floodplains—need to know they are at risk, and should obtain flood insurance and work to mitigate their flood risks.

Discourage development in high risk areas such as floodplains.

With the NFIP more than \$19.2 billion in debt, it is both fiscally and environmentally irresponsible to encourage development in flood prone areas. Instead, FEMA should recommit to a national hazard mitigation policy with emphasis on voluntary buyouts of existing high-risk flood-prone properties and should dedicate these lands to open space uses or require increased building elevations, where practicable, to guide recovery and rebuilding. FEMA should be directed to require stronger land-use and building code standards of communities receiving flood insurance and disaster assistance. Additionally, policies that encourage the filling of floodplains or the construction of levees to remove areas from NFIP insurance flood-hazard maps must end.

Increase protection for wetlands, forests, and natural landscapes to provide natural buffers for flooding. During severe flood events, healthy wetlands and natural landscapes can act as sponges to



National Aeronautics and Space Administration

rising waters, protecting communities and livelihoods, especially agriculture. Significant investment in these natural resources will also provide healthy habitats for fish and wildlife. Important steps include fully funding restoration programs such as the Wetlands Reserve Program and enacting the federal Clean Water

Restoration Act to restore Clean Water Act protection for all wetlands, streams, and other waters placed at risk due the SWANCC and Rapanos decisions and resulting agency policies. Congress should also include dedicated funding to safeguard natural resources in comprehensive climate change legislation.

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