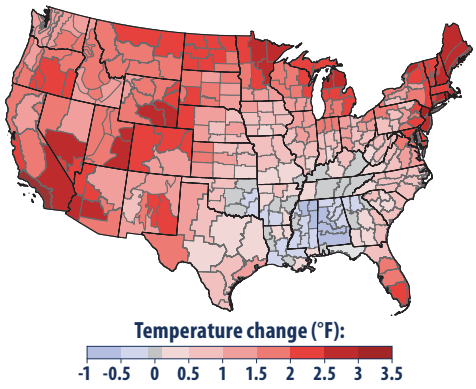
EPA United States Environmental Protection Agency

August 2016
EPA 430-F-16-029

What Climate Change *Means for* Nebraska

Nebraska's climate is changing. In the past century, most of the state has warmed by at least one degree (F). The soil is becoming drier, and rainstorms are becoming more intense. In the coming decades, flooding is likely to increase, yet summers are likely to become increasingly hot and dry, which would reduce yields of some crops, require farmers to use more water, and amplify some risks to human health.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.



Rising temperatures in the last century. The Panhandle has warmed more than the rest of Nebraska. Source: EPA, Climate Change Indicators in the United States.

Precipitation and Water Resources

Changing the climate is likely to increase the demand for water but make it less available. Soils will probably continue to become drier, because warmer temperatures increase evaporation and water use by plants, and average rainfall during summer is likely to decrease. More evaporation and less rainfall would reduce the average flow of rivers and streams.

Decreased river flows can create problems for navigation, recreation, public water supplies, and electric power generation. Commercial navigation can be suspended during droughts (or floods) when there is too little water to keep channels deep enough for barge traffic. Decreased river flows can also lower the water level in lakes and reservoirs, which may limit municipal water supplies and impair swimming, fishing, and other recreational activities. Lower flows during a summer drought can reduce hydroelectric power generation at a time of year when warmer temperatures increase the demand for electricity for air conditioning. Conventional power plants also need adequate water for cooling.

The severe drought of 2012 led to low flow in rivers across Nebraska. This photo shows the nearly dry riverbed of the Big Nemaha River near Falls City. Credit: Mike Andersen, USGS.

Higher temperatures and drier soils are likely to increase the use of water by more than 25 percent during the next 50 years, mostly because of increased irrigation. Approximately one-third of the farmland in Nebraska is irrigated with ground water, most of which comes from the High Plains Aquifer System, and municipal water supplies also reply primarily on ground water. In Nebraska, the aquifer is only being depleted in a few western areas. But water levels are declining throughout much of Kansas, where the average temperature today is similar to what the average temperature of Nebraska is likely to be 70 to 100 years from now.

Agriculture

Rising temperatures and changes in rainfall are likely to have both negative and positive effects on Nebraska's farms and ranches. Hot weather causes cows to eat less and grow more slowly, and it can threaten their health. Increased winter and spring precipitation could leave some fields too wet to plant, and warmer winters may promote the growth of weeds and pests. Hotter summers and drier soils would cause droughts to become more intense. Over the next 70 years, the number of days per year above 100°F is likely to double. Increased drought, along with a greater number of extremely hot days, could cause crop failures. Even where ample water is available, higher temperatures would reduce yields of corn.

Increased concentrations of carbon dioxide, however, may increase yields of wheat and soybean enough to offset the impact of higher temperatures. Warmer and shorter winters may allow for a longer growing season, which could allow two crops per year instead of one in some instances. Increased precipitation at the beginning of the growing season could also be beneficial to some crops.

Rainstorms and Tornadoes

Although summer droughts are likely to become more severe, floods may also intensify. During the last 50 years, the amount of rain falling during the wettest four days of the year has increased about 15 percent in the Great Plains. River levels during floods have become higher in eastern Nebraska. Over the next several decades, heavy downpours will account for an increasing fraction of all precipitation, and average precipitation during winter and spring is likely to increase. Both of these factors would further increase flooding.

Scientists do not know how the frequency and severity of tornadoes will change. Rising concentrations of greenhouse gases tend to increase humidity, and thus atmospheric instability, which would encourage tornadoes. But wind shear is likely to decrease, which would discourage tornadoes.

The Fort Calhoun Nuclear Power Plant in eastern Nebraska was surrounded by a Missouri River flood in June 2011. Credit: U.S. Army Corps of Engineers.

Research is ongoing to learn whether tornadoes will be more or less frequent in the future. Because Nebraska experiences more than 50 tornadoes a year, such research is closely followed by meteorologists in the state.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. The elderly may be particularly prone to heat stress and other heat-related health problems, including dehydration, cardiovascular strain, and respiratory problems. Those with low incomes may be particularly vulnerable due to a lack of air conditioning. Power failures due to severe weather can also present risks, especially in lightly populated areas where access to the necessary support services may be limited. Climate change may also increase the length and severity of the pollen season for allergy sufferers. For example, the ragweed season near Omaha has grown 10 days longer since 1995, because the first frost in fall is later.

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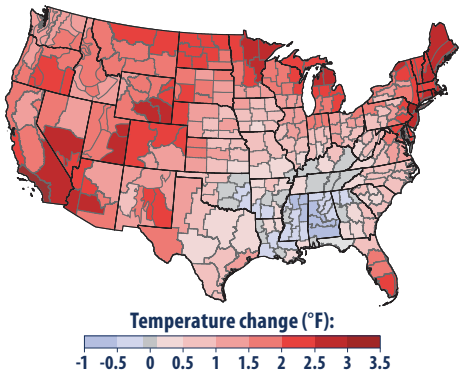
What Climate Change *Means for* Nevada

Nevada's climate is changing. The state has warmed about two degrees (F) in the last century. Throughout the southwestern United States, heat waves are becoming more common, and snow is melting earlier in spring. In the coming decades, the changing climate is likely to decrease the flow of water in the Colorado and other rivers in Nevada, increase the frequency and intensity of wildfires, and decrease the productivity of ranches and farms.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed one degree during the last 80 years. Warming is causing snow to melt earlier in spring.



Rising temperatures in the last century. The last decade was the warmest on record in the Southwest. Source: EPA, Climate Change Indicators in the United States.

Snowpack

As the climate warms, less precipitation falls as snow, and more snow melts during the winter. That decreases snowpack—the amount of snow that accumulates over the winter. Since the 1950s, snowpack has declined in Nevada, as well as in the other states in the Colorado River Basin.

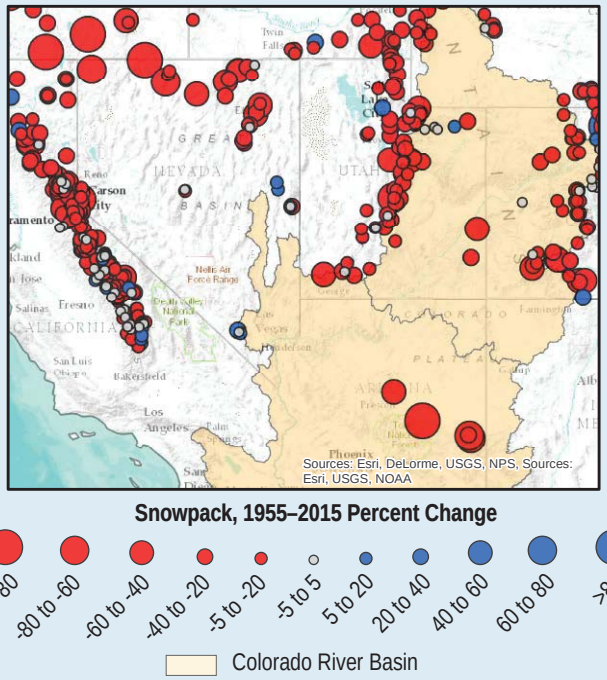
Diminishing snowpack can shorten the season for skiing and other forms of winter tourism and recreation. The tree line may shift, as subalpine fir and other high-altitude trees become able to grow at higher elevations. A higher tree line would decrease the extent of alpine tundra ecosystems, which could threaten some species.

Water Availability

The changing climate is likely to increase the need for water but reduce the supply. Higher temperatures increase the rate at which water evaporates (or transpires) into the air from soils, plants, and surface waters. Irrigated farmland would thus need more water. But less water is likely to be available, because precipitation is unlikely to increase enough to make up for the additional water lost to evaporation. Annual rainfall is more likely to decrease than increase. So soils are likely to be drier, and periods without rain are likely to become longer, making droughts more severe.

Lake Mead viewed from Hoover Dam in 2009. Decreased flows in the Colorado River have lowered the water level, which prompted the Southern Nevada Water Authority to build a new drinking water intake that could supply Las Vegas even if the lake falls below Hoover Dam's lowest outlet. © Chris Lamie; used by permission.

The decline in snowpack could further limit the supply of water for some purposes. Mountain snowpacks are natural reservoirs. They collect the snow that falls during winter and release water when the snow melts during spring and summer. Over the past 50 years, snowpack has been melting earlier in the year. Dams capture most meltwater and retain it for use later in the year. But upstream of these reservoirs, less water is available during droughts for ecosystems, fish, water-based recreation, and landowners who draw water directly from a flowing river.



Trends in April snowpack in Nevada and the Colorado River Basin, 1955–2013. Snowpack has decreased at most monitoring sites. Source: EPA.

Agriculture

Increasing droughts and higher temperatures are likely to interfere with Nevada's farms and cattle ranches. Less water is likely to be available for ranches or farmers who irrigate crops. Hot weather can threaten cows' health and cause them to eat less, grow more slowly, and produce less milk. Livestock operations could be further impaired by fire and changes in the landscape from grassland to woody shrubs more typical of a desert.

Wildfires and Changing Landscapes

Higher temperatures and drought are likely to increase the severity, frequency, and extent of wildfires in Nevada, which could harm property, livelihoods, and human health. On average, about 5 percent of the land in Nevada has burned per decade since 1984. Wildfire smoke can reduce air quality and increase medical visits for chest pains, respiratory problems, and heart problems.

In 2005, the Southern Nevada Complex Fire burned more than half a million acres, making it the largest wildfire in the state's recorded history. Credit: Bureau of Land Management, Ely Field Office files.

The combination of more fires and drier conditions may change parts of Nevada's landscape. Many plants and animals living in arid lands are already near the limits of what they can tolerate. In some cases, native vegetation may persist as the climate changes. But when drought, grazing, or fire destroy the natural cover, native plants may be replaced by non-native grasses. Because non-native grasses are generally more prone to intense fires, native plants may be unable to re-establish themselves.

Pests

Warmer and drier conditions also make forests more susceptible to pests. Droughts reduce the ability of trees to mount a defense against attacks from pests such as bark beetles, which infested 28,000 acres of Nevada's forests in 2014. Temperature controls the life cycle and winter mortality rates of many pests. With higher winter temperatures, some pests can persist year-round, and new pests and diseases may become established.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High temperatures can cause dehydration and heat stroke, and affect people's cardiovascular, respiratory, and nervous systems. Higher temperatures are amplified in urban settings where paved and other surfaces tend to store heat. Construction crews may have to increasingly operate on altered time schedules to avoid the heat of the day.

Rising temperatures can also increase the formation of ground-level ozone, a key component of smog. Ozone has a variety of health effects, aggravates lung diseases such as asthma, and increases the risk of premature death from heart or lung disease. EPA and the Nevada Division of Environmental Protection have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will become more difficult.

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United States Environmental Protection Agency

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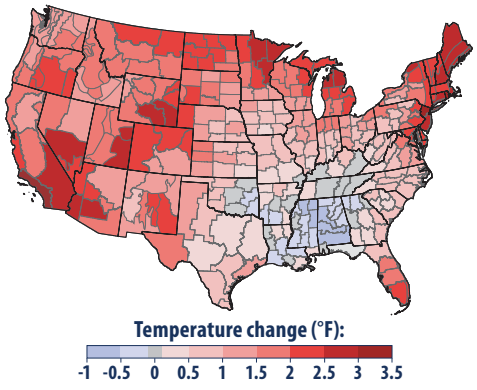
What Climate Change Means for New Hampshire

New Hampshire's climate is changing. Most of the state has warmed two to three degrees (F) in the last century. Throughout the northeastern United States, spring is arriving earlier and bringing more precipitation, heavy rainstorms are more frequent, and summers are hotter and drier. Sea level is rising, and severe storms cause floods that damage property and infrastructure. In the coming decades, the changing climate is likely to increase flooding, harm ecosystems and winter recreation, disrupt farming, and increase some risks to human health.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. New Hampshire has warmed twice as much as the rest of the contiguous 48 states. Source: EPA, Climate Change Indicators in the United States.

Increasing Temperature and Changing Precipitation Patterns

Rising temperatures and shifting rainfall patterns are likely to increase the intensity of both floods and droughts. Average annual precipitation in the Northeast increased 10 percent from 1895 to 2011, and precipitation from extremely heavy storms has increased 70 percent since 1958. During the next century, average annual precipitation and the frequency of heavy downpours are likely to keep rising. Average precipitation is likely to increase during winter and spring, but not change significantly during summer and fall. Rising temperatures will melt snow earlier in spring and increase evaporation, and thereby dry the soil during summer and fall. So flooding is likely to be worse during winter and spring, and droughts worse during summer and fall.

Torrential downpours flooded Alstead and neighboring communities in 2005, causing millions of dollars of damage. Credit: EPA.

Winter Recreation

Warmer winters may bring more rain and less snow to New Hampshire. A decline in snowfall would shorten the season during which the ground is covered with snow, which could harm recreational industries like skiing, snowboarding, and snowmobiling, and the local economies that depend on them.

Agriculture

Climate change may pose challenges for agriculture. Some farms may be harmed if more hot days and droughts reduce crop yields, or if more flooding and wetter springs delay their planting dates. Other farms may benefit from a longer growing season and the fertilizing effect of carbon dioxide.

Sea Level Rise, Wetland Loss, and Coastal Flooding

Rising sea level erodes wetlands and beaches and increases damage from coastal storms. Tidal wetlands are inherently vulnerable because of their low elevations, and shoreline development prevents them from migrating inland onto higher ground. Human activities such as filling wetlands have destroyed about one third of New England's coastal wetlands since the early 1800s. Wetlands provide habitat for many bird species, such as osprey and heron, as well as several fish species. Losing coastal wetlands would harm coastal ecosystems and remove an important line of defense against coastal flooding.

Coastal cities and towns will become more vulnerable to storms in the coming century as sea level rises, shorelines erode, and storm surges become higher. Storms can destroy coastal homes, wash out highways and rail lines, and damage essential communication, energy, and wastewater management infrastructure.

The Great Bay area has marshes and infrastructure that are at risk from sea level rise. © Ben Miller; used by permission.

Ecosystems

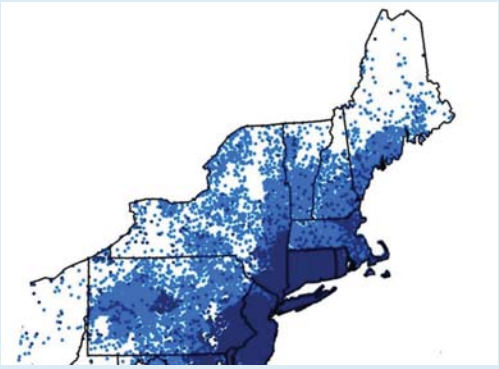
Changing the climate threatens ecosystems by disrupting relationships between species. Wildflowers and woody perennials are blooming—and migratory birds are arriving—sooner in spring. Not all species adjust in the same way, however, so the food that one species needs may no longer be available when that species arrives on its migration. Rising temperatures allow deer populations to increase, reducing forest underbrush, which makes some animals more vulnerable to predators.

Climate change can allow invasive species to expand their ranges. For example, the hemlock woolly adelgid has infested hemlock trees in southern New Hampshire. Infestation eventually kills almost all hemlock trees, which are replaced by black oaks, black birch, and other hardwoods. Warmer temperatures are likely to enable the woolly adelgid to expand northward. The loss of hemlock trees would remove the primary habitat for the blue-headed vireo and Blackburnian warbler. It could also change stream temperatures and cause streams to run dry more often, harming brook trout and brown trout.

Human Health

Changes in temperature and precipitation could increase the incidence of acute and chronic respiratory conditions such as asthma. Higher temperatures can increase the formation of ground-level ozone (smog), a pollutant that can contribute to respiratory problems. Rising temperatures may also increase the length and severity of the pollen season for plants such as ragweed—which has already been observed in other regions. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

The risk of some diseases carried by insects may also increase. The ticks that transmit Lyme disease are active when temperatures are above 45°F, so warmer winters could lengthen the season during which ticks can become infected or people can be exposed to the ticks. Higher temperatures would also make more of New England warm enough for the Asian tiger mosquito, a common carrier of West Nile virus. The number of cases may or may not increase, depending on what people do to control insect populations and avoid insect bites.



Increase in Lyme disease between 1996 and 2013. Each dark dot shows one case reported in 1996; light dots show 2013. The increased range shown here has been attributed to factors other than climate change. Nevertheless, additional warming will lengthen the season during which people are exposed to Lyme disease and may allow the disease to spread to colder areas. Source: CDC.

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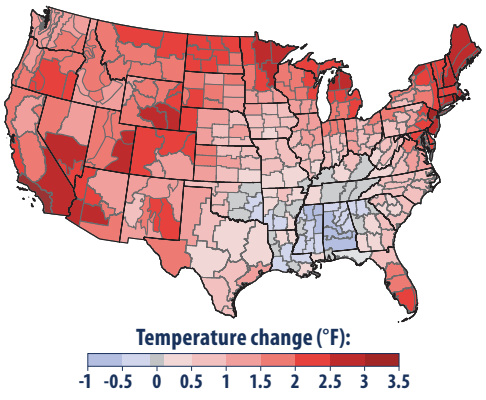
What Climate Change *Means for* New Jersey

New Jersey's climate is changing. The state has warmed by about three degrees (F) in the last century, heavy rainstorms are more frequent, and the sea is rising about one inch every six years. Higher water levels are eroding beaches, submerging low lands, exacerbating coastal flooding, and increasing the salinity of estuaries and aquifers. In the coming decades, changing the climate is likely to increase coastal and inland flooding, harm coastal and inland ecosystems, disrupt fishing and farming, and increase some risks to human health.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. New Jersey has warmed more than twice as much as most of the nation. Source: EPA, Climate Change Indicators in the United States.

Increasing Temperature and Changing Precipitation Patterns

Rising temperatures and shifting rainfall patterns are likely to increase the intensity of both floods and droughts. Average annual precipitation in New Jersey has increased 5 to 10 percent in the last century, and precipitation from extremely heavy storms has increased 70 percent in the Northeast since 1958. During the next century, annual precipitation and the frequency of heavy downpours are likely to keep rising. Precipitation is likely to increase during winter and spring, but not change significantly during summer and fall. Rising temperatures will melt snow earlier in spring and increase evaporation, and thereby dry the soil during summer and fall. So changing the climate is likely to intensify river flooding during winter and spring, and drought during summer and fall.

Rising Seas and Retreating Shores

Sea level is rising more rapidly along the New Jersey shore than in most coastal areas because the land is sinking. If the oceans and atmosphere continue to warm, the sea is likely to rise eighteen inches to four feet along the New Jersey shore in the next century.

As sea level rises, the lowest dry lands are submerged and become either tidal wetland or open water. Many wetlands will be submerged, but not all: the freshwater wetlands along the Delaware River upstream from the Commodore Barry Bridge build their own land by capturing sediments carried by the river, and these wetlands are likely to keep pace with the rising sea during the next century. Nevertheless, most salt marshes between Cape May and the Meadowlands are unlikely to keep pace if sea level rises three feet. Wetlands along Delaware Bay in Cumberland County are even more vulnerable, and likely to be lost if the sea rises two feet. Tidal flats are also likely to become open water.

Beaches erode as sea level rises. A higher ocean level makes it more likely that storm waters will wash over a barrier island or open new inlets. The United States Geological Survey estimates that barrier islands of the New Jersey shore from Bay Head to Cape May would be broken up by new inlets or lost to erosion if sea level rises three feet by the year 2100, unless people take actions to reduce erosion. Bay beaches may also be eliminated in some areas. Many of Delaware Bay's beaches are narrow, with wetlands immediately inland. Along parts of Delaware Bay and bay sides of most barrier islands, people have built walls and other shore protection structures that eliminate the beach once the shore erodes up to them.

This beach in Pennsville along the Delaware River could be lost as sea level rises, if the shore erodes up to the shore protection wall to the right. © James G. Titus; used by permission.

Coastal Ecosystems

The loss of tidal marshes could harm fish and birds that depend on a marsh for food or shelter. Blue crab, perch, weakfish, flounder, and rockfish rely on the tidal marshes in Delaware Bay to hide from predators and to feed on mussels, fiddler crabs, and other species. Sea turtles and shorebirds also feed on some of the species that inhabit these marshes. Great blue herons, black ducks, ospreys, red-winged blackbirds, and several other bird species also use the salt marshes in Delaware Bay. As marshes erode, fish may benefit initially as more tidal channels form, which would make more of the marsh accessible. But after a point, the continued erosion would make less marsh available, so populations of fish and birds could decline. In Barnegat Bay and Little Egg Harbor, the rising sea is already eroding and submerging small marsh islands, which are important nesting areas that protect common terns, black skimmers, and oystercatchers from land-based predators.

The loss of bay beaches and tidal flats would also threaten some species. Delaware Bay is a major stopover area for six species of migratory shorebirds that feed on its beaches and tidal flats, including most of the Western Hemisphere's red knot population. Nearly a million birds feed on the horseshoe crab eggs on the bay's sandy beaches. Diamondback terrapin nest on estuarine beaches in New Jersey.

Changing temperatures could also disrupt ecosystems. For example, if water temperatures exceed 86°F during summer, eelgrass could be lost, which would remove a key source of food for many fish.

Saltwater Intrusion

As sea level rises, salt water can mix farther inland or upstream in bays, rivers, and wetlands. Because water on the surface is connected to ground water, salt water can also intrude into aquifers near the coast. Soils may become too salty for the crops and trees that currently grow in low-lying areas.

Storms, Homes, and Infrastructure

As sea level rises, coastal homes and infrastructure flood more often because storm surges become higher as well. Although hurricanes are rare, homes along the ocean are vulnerable to erosion and storm waves. The bay sides of several barrier islands are so low that some streets and yards flood at high tide when strong winds blow from the east. During Hurricane Sandy, flooding and storm waves destroyed coastal homes and recreational facilities, washed out roads, inundated rail tunnels, and damaged essential power and wastewater management infrastructure.

A flooded restaurant on Long Beach Island. © James G. Titus; used by permission.

Seaside Heights in the aftermath of Hurricane Sandy. Official White House photo by Sonya N. Herbert.

Wind speeds and rainfall intensity during hurricanes and tropical storms are likely to increase as the climate warms. Rising sea level is likely to increase flood insurance rates, while more frequent storms could increase the deductible for wind damage in homeowner insurance policies.

Fishing and Farms

Changing the climate may harm commercial fishing in New Jersey. Higher ocean acidity would impair the ability of young scallops and surf clams to build shells, and potentially reduce the populations of these two shellfish, which account for about two-thirds of New Jersey's commercial fishing revenues. Higher acidity in estuaries, as well as the loss of wetlands and eelgrass, could harm crabs and hard shell clams, which account for another 15 percent of fishing revenues. As ocean temperatures rise, some fish species are moving northward or into deeper waters to remain within their normal temperature ranges.

Climate change may also pose challenges for agriculture: some farms may be harmed if more hot days and droughts reduce crop yields, or if more flooding and wetter springs delay their planting dates. Other farms may benefit from a longer growing season and the fertilizing effect of carbon dioxide.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Warmer temperatures can also increase the formation of ground-level ozone, a component of smog that can contribute to respiratory problems. Rising temperatures may also increase the length and severity of the pollen season for plants such as ragweed.

The risk of some diseases carried by insects may also increase. The ticks that transmit Lyme disease are active when temperatures are above 45°F, so warmer winters could lengthen the season during which ticks can become infected or people can be exposed to the ticks. Higher temperatures would also expand the area that is warm enough for the Asian tiger mosquito, a common carrier of West Nile virus. The number of cases may or may not increase, depending on what people do to control insect populations and avoid insect bites.

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What Climate Change *Means for* New Mexico

New Mexico's climate is changing. Most of the state has warmed at least one degree (F) in the last century. Throughout the southwestern United States, heat waves are becoming more common, and snow is melting earlier in spring. In the coming decades, our changing climate is likely to decrease the flow of water in the Colorado, Rio Grande, and other rivers; threaten the health of livestock; increase the frequency and intensity of wildfires; and convert some rangelands to desert.

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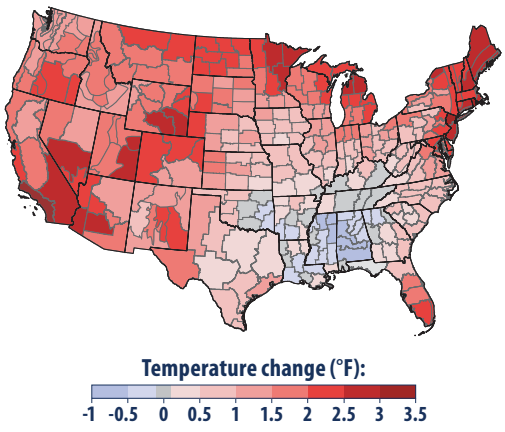
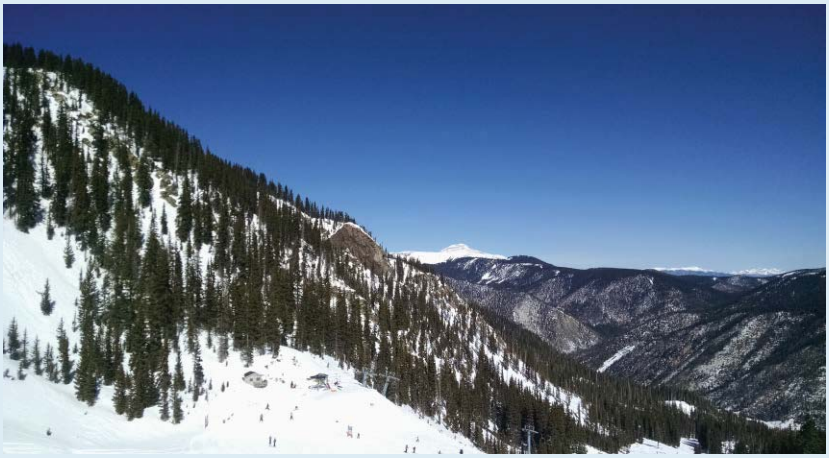


Rising temperatures in the last century. The last decade was the warmest on record in the Southwest. Source: EPA, Climate Change Indicators in the United States.

Snowpack

As the climate warms, less precipitation falls as snow, and more snow melts during the winter. That decreases snowpack—the amount of snow that accumulates over the winter. Since the 1950s, the snowpack has been decreasing in New Mexico, as well as in Colorado, Utah, and Wyoming, which matters because the headwaters of the Rio Grande, San Juan, Colorado, and Navajo rivers are in those states.

Diminishing snowpack in northern New Mexico will shorten the season for skiing and other forms of winter tourism and recreation. The tree line may shift, as subalpine fir and other high-altitude trees become able to grow at higher elevations. A higher tree line would decrease the extent of alpine tundra ecosystems, which could threaten some species.

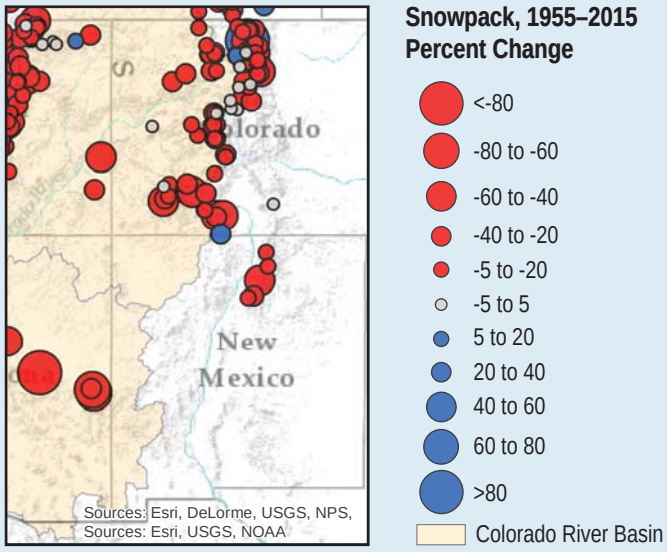


Ski areas like Taos Ski Valley (shown here) depend on seasonal snowpack, which has declined at all long-term monitoring sites in the Sangre de Cristo range. © Chris Lamie; used by permission.

Water Availability

The changing climate is likely to increase the need for water but reduce the supply. Warmer temperatures increase the rate at which water evaporates (or transpires) into the air from soils, plants, and surface waters. Irrigated farmland would thus need more water. But less water is likely to be available, because precipitation is unlikely to increase enough to make up for the additional water lost to evaporation. Annual rainfall is more likely to decrease than increase. So soils are likely to be drier, and periods without rain are likely to become longer, making droughts more severe.

The decline in snowpack could further limit the supply of water for some purposes. Mountain snowpacks are natural reservoirs. They collect the snow that falls during winter and release water when the snow melts during spring and summer. Over the past 50 years, snowpack has been melting earlier in the year (see map on back page). Dams capture most meltwater and retain it for use later in the year. But upstream of these reservoirs, less water is available during droughts for ecosystems, fish, water-based recreation, and landowners who draw water directly from a flowing river.



Trends in April snowpack in New Mexico and Colorado, 1955–2013. The snowpack has declined at most monitoring sites in both states. Source: EPA.

Agriculture

Increasing droughts and higher temperatures are likely to interfere with New Mexico's farms and cattle ranches. Hot weather can threaten cows' health and cause them to eat less, grow more slowly, and produce less milk. Livestock operations could also be impaired by fire and changes in the landscape from grassland to woody shrubs more typical of a desert. Reduced water availability would create challenges for ranchers, as well as farmers who irrigate fruits, vegetables, pecans, and other nut trees.

Wildfires and Changing Landscapes

Higher temperatures and drought are likely to increase the severity, frequency, and extent of wildfires, which could harm property, livelihoods, and human health. On average, more than 2 percent of the land in New Mexico has burned per decade since 1984. Wildfire smoke can reduce air quality and increase medical visits for chest pains, respiratory problems, and heart problems.

The combination of more fires and drier conditions may expand deserts and otherwise change parts of New Mexico's landscape. Many plants and animals living in arid lands are already near the limits of what they can tolerate. A warmer and a drier climate would generally extend the Chihuahuan desert to higher elevations and expand its geographic range. In some cases, native vegetation may persist and delay or prevent expansion of the desert. In other cases, fires or livestock grazing may accelerate the conversion of grassland to desert in response to the changing climate. For similar reasons, some forests may change to desert or grassland.

In 2012, New Mexico experienced the largest wildfire in the state's recorded history, the Whitewater-Baldy Complex Fire. Credit: Gila National Forest.

Pests

Warmer, drier conditions make forests more susceptible to pests. Drought reduces the ability of trees to mount a defense against attacks from pests such as bark beetles, which have infested 200,000 acres in New Mexico. Temperature controls the life cycle and winter mortality rates of many pests. With higher winter temperatures, some pests can persist year-round, and new pests and diseases may become established.

Extreme Heat

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular, respiratory, and nervous systems. Higher temperatures are amplified in urban settings where paved and other surfaces tend to store heat. Warmer air can also increase the formation of ground-level ozone, a key component of smog. Construction crews may have to increasingly operate on altered time schedules to avoid the heat of the day.

Tribal Communities

Climate change threatens natural resources and public health of tribal communities. Rising temperatures and increasing drought are likely to decrease the availability of certain fish, game, and wild plants on which the Navajo and other tribes have relied for generations. Water may be less available for domestic consumption, especially for those who are not served by either municipal systems or reliable wells, which includes about 30 percent of the people on the Navajo Nation, who must haul water to meet daily needs. Recurring drought and rising temperatures may also degrade the land itself. On the Arizona portion of the Navajo Nation, for example, the Great Falls Dune Field has advanced almost a mile in the last 60 years, threatening roads, homes, and grazing areas. Extreme heat may also create health problems for those without electricity, including about 40 percent of the people on the Navajo reservation.

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United States Environmental Protection Agency

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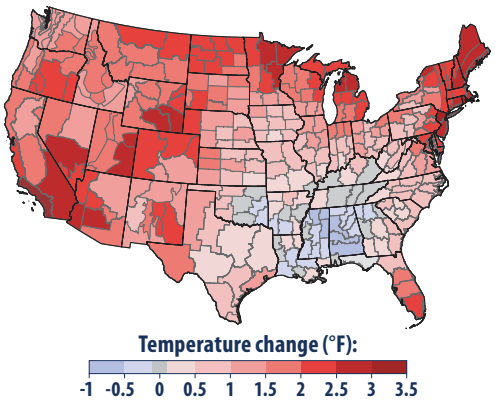
What Climate Change *Means for* New York

New York's climate is changing. Most of the state has warmed one to three degrees (F) in the last century, heavy rainstorms are more frequent, and the sea is rising about one inch every decade. Higher water levels are eroding beaches, submerging low lands, and exacerbating coastal flooding. In the coming decades, changing the climate is likely to increase coastal and inland flooding, disrupt farming and winter recreation, and increase some risks to human health.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. The eastern part of New York has warmed more than the western part of the state. Source: EPA, Climate Change Indicators in the United States.

Increasing Temperature and Changing Precipitation Patterns

Rising temperatures and shifting rainfall patterns are likely to increase the intensity of both floods and droughts. Average annual precipitation in the Northeast has increased 10 percent since 1895, and precipitation from extremely heavy storms has increased 70 percent since 1958. During the next century, annual precipitation and the frequency of heavy downpours are likely to keep rising. Precipitation is likely to increase during winter and spring, but not change significantly during summer and fall. Rising temperatures will melt snow earlier in spring and increase evaporation, and thereby dry the soil during summer and fall. As a result, changing the climate is likely to intensify flooding during winter and spring, and drought during summer and fall.

Rising Sea Level

Sea level is rising more rapidly along New York's coast than in most coastal areas because the land surface is sinking. If the oceans and atmosphere continue to warm, tidal waters in New York are likely to rise one to four feet in the next century.

As sea level rises, the lowest dry lands are submerged and become either tidal wetland or open water. Wetlands can create their own land and keep pace with a slowly rising sea. But if sea level rises three feet or more during the next century, most existing wetlands along the south shore of Long Island are likely to be submerged.

Coastal Storms

Rising sea level increases the vulnerability of coastal homes and infrastructure to flooding because storm surges become higher as well. Although hurricanes are rare, much of the infrastructure in the New York metropolitan area is vulnerable to flooding. In 2012, high waters during Hurricane Sandy flooded Amtrak, PATH, and subway tunnels, as well as electrical substations, wastewater treatment plants, telecommunication facilities, hospitals, and nursing homes. Wind speeds and rainfall rates during hurricanes and tropical storms are likely to increase as the climate warms. Rising sea level is likely to increase flood insurance premiums, while more frequent storms could increase the deductible for wind damage in homeowner insurance policies.

Breezy Point, Queens, in the aftermath of an electrical fire ignited by floodwaters during Hurricane Sandy. Credit: Andrea Booher, FEMA.

Shoreline Erosion

Beaches also erode as sea level rises. A higher ocean level makes it more likely that storm waters will wash over a barrier island or open new inlets. The United States Geological Survey estimates that the barrier islands in Southampton would be broken up by new inlets or lost to erosion if sea level rises three feet by the year 2100, unless people take measures to reduce erosion.

Coastal Ecosystems

Rising sea level could disrupt ecosystems along the Atlantic Ocean and adjacent estuaries such as the Hudson River and Long Island Sound. Wetlands threatened by rising sea level currently support clapper rail, sharp-tailed sparrow, marsh wren, and the northern harrier, a threatened species. Beaches along Long Island Sound and other estuaries may be squeezed between development and the advancing sea. Those beaches provide nesting sites for horseshoe crabs, which are a key source of food during spring for migrating shorebirds, such as the endangered red knot. Other shorebirds feed on these beaches throughout the year. Vulnerable tidal flats provide habitat for soft clam, hard clam, bay scallop, and blue mussel.

Bird feeding on invertebrates that inhabit a tidal beach vulnerable to rising sea level along Peconic Bay in Riverhead. © James G Titus; used by permission.

The Great Lakes

Lake ecosystems may also be impaired as the climate changies. Warmer temperatures tend to cause more algal blooms, which can be unsightly, harm fish, and degrade water quality. If severe storms become more frequent, then sewer overflows will become more frequent, and more pollutants are likely to run off from the land into the Great Lakes. Increased algal blooms and water pollution could threaten water supplies and require recreational beaches to be closed more often for health reasons.

One advantage of climate change is that warmer winters reduce the number of days that ice prevents navigation on rivers and in the Great Lakes. Between 1994 and 2011, reduced ice cover lengthened the shipping season on the Great Lakes by eight additional days. The Great Lakes are likely to warm another 3° to 7°F in the next 70 years, which will further extend the shipping season.

Winter Recreation

Warmer winters may bring more rain and less snow to upstate New York. A decline in snowfall would mean less snow cover for recreational industries, like skiing, snowboarding, and snowmobiling, and it would harm the local economies that depend on them. Conversely, the amount of lake effect snow has increased with the longer ice-free season on the Great Lakes. Although scientists are not certain whether this trend will continue, increased snow would benefit winter recreation areas to the immediate east of Lake Erie and Lake Ontario.

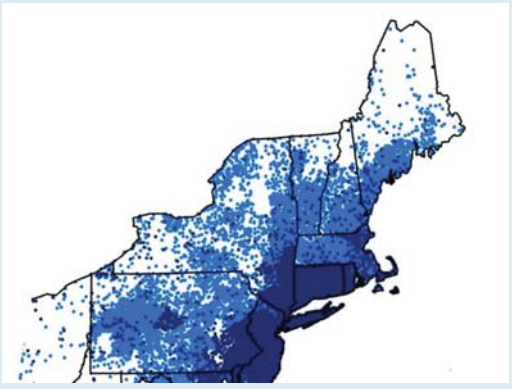
Agriculture

Changing the climate will have both beneficial and harmful effects on farming, but the net effect is unknown. During an average year, longer frost-free growing seasons and higher concentrations of atmospheric carbon dioxide would increase yields for many crops, notably soybeans. But increasingly hot summers are likely to reduce yields of corn, the state's most important crop. Higher temperatures cause cows to eat less and produce less milk, so a warming climate could reduce the output of milk and beef, which together account for more than half the state's farm revenues.

Human Health

Climate change is likely to amplify some threats to human health. Higher temperatures can increase the formation of ground level ozone, a pollutant that can contribute to respiratory problems. Rising temperatures may also increase the length and severity of the pollen season for plants such as ragweed. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

The risk of some diseases carried by insects may also increase. The ticks that transmit Lyme disease are active when temperatures are above 45°F, so warmer winters could lengthen the season during which ticks can become infected or people can be exposed to the ticks. Higher temperatures would also expand the area that is warm enough for the Asian tiger mosquito, a common carrier of West Nile virus. The number of cases may or may not increase, depending on what people do to control insect populations and avoid insect bites.



Increase in Lyme disease between 1996 and 2013. Each dark dot shows one case reported in 1996; light dots show 2013. The increased range of the disease has been attributed to factors other than climate change. Nevertheless, additional warming will lengthen the season during which people are exposed to Lyme disease and may allow the disease to spread to colder areas. Source: CDC.

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United States Environmental Protection Agency

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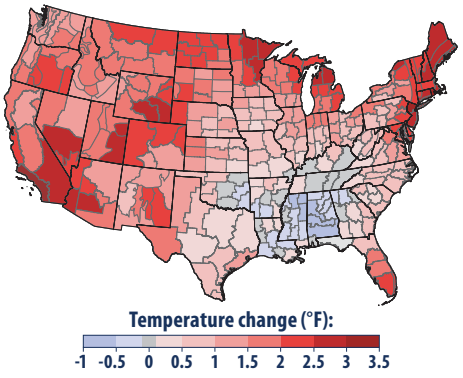
What Climate Change *Means for* North Carolina

North Carolina's climate is changing. Most of the state has warmed one-half to one degree (F) in the last century, and the sea is rising about one inch every decade. Higher water levels are eroding beaches, submerging low lands, exacerbating coastal flooding, and increasing the salinity of estuaries and aquifers. The southeastern United States has warmed less than most of the nation. But in the coming decades, the region's changing climate is likely to reduce crop yields, harm livestock, increase the number of unpleasantly hot days, and increase the risk of heat stroke and other heat-related illnesses.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. North Carolina has warmed less than most of the United States. Source: U.S. EPA, Climate Change Indicators in the United States.

Rising Seas and Retreating Shores

As the oceans warm, seawater expands and raises sea level. Melting ice adds more water to the ocean, further raising sea level. Along much of the Atlantic Coast, including parts of North Carolina, the land surface is sinking, so the observed rate of sea level rise relative to the land is greater than the global average rise. Sea level is likely to rise one to four feet in the next century along the coast of North Carolina.

As sea level rises, the lowest dry lands are submerged and become either tidal wetland or open water. Most existing wetlands can create their own land and keep pace with a slowly rising sea. But if sea level rises three feet in the next century, most of the wetlands on the Albemarle-Pamlico peninsula are likely to be submerged by the higher water level.

Beaches also erode as sea level rises. A higher water level makes it more likely that storm waters will wash over a barrier island or open new inlets. The United States Geological Survey estimates that the lightly developed Outer Banks between Nags Head and Ocracoke could be broken up by new inlets or lost to erosion if sea level rises two feet by the year 2100. Eroding shores will threaten most coastal towns unless people take measures to halt the erosion.

Beach houses in Nags Head are vulnerable to severe storms, flooding, and coastal erosion. © James G Titus; used by permission.

Coastal Ecosystems

As sea level rises, salt water can mix farther upstream and farther inland in aquifers and wetlands. Increasing salinity can kill some types of trees found in swamps. Salt water also reacts with some wetland soils, which causes the surface of the wetlands to sink below the water, adding to the loss of wetlands.

Trees killed by increasing salinity near Camden Point. © James G. Titus; used by permission.

Many species of birds and fish in North Carolina depend on coastal wetlands threatened by rising sea level. Blue crabs, shrimp, and southern flounder use marshes for both feeding and evading larger predators. Larger fish such as sea trout and red drum also feed in these marshes. Many types of birds feed on fish in the marsh, including egrets and herons. Wetlands along the Alligator River are the principal habitat in the wild for the endangered red wolf. Pocosin swamps provide refuge for black bears and bobcats, and they help to maintain water quality in the nearby sounds.

Storms, Homes, and Infrastructure

Tropical storms and hurricanes have become more intense during the past 20 years. Although warming oceans provide these storms with more potential energy, scientists are not sure whether the recent intensification reflects a long-term trend. Nevertheless, hurricane wind speeds and rainfall rates are likely to increase as the climate continues to warm.

Water covering front yards near Swan Quarter. © James G. Titus; used by permission.

Whether or not storms become more intense, coastal homes and infrastructure will flood more often as sea level rises, because storm surges will become higher as well. Rising sea level is likely to increase flood insurance rates, while more frequent storms could increase the deductible for wind damage in homeowner insurance policies. Many cities, roads, railways, ports, airports, oil and gas facilities, and water supplies in the Southeast are vulnerable to the impacts of storms and sea level rise. People may move from vulnerable coastal communities and stress the infrastructure of the communities that receive them.

Increased rainfall may further exacerbate flooding in some coastal areas. Since 1958, the amount of precipitation during heavy rainstorms has increased by 27 percent in the Southeast, and the trend toward increasingly heavy rainstorms is likely to continue.

Agriculture

Changing the climate will have both harmful and beneficial effects on farming. During the next few decades, hotter summers are likely to reduce yields of corn. But higher concentrations of atmospheric carbon dioxide increase crop yields, and that fertilizing effect is likely to offset the harmful effects of heat on cotton, soybeans, wheat, and peanuts—if enough water is available. More severe droughts however, could cause crop failures. Higher temperatures are also likely to reduce livestock productivity, because heat stress disrupts the animals' metabolism.

Energy

Seventy years from now, temperatures are likely to rise above 95°F approximately 20 to 40 days per year in most of the state, compared with about 10 days per year today. Greater use of air-conditioning will increase electricity consumption.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems. Warmer air can also increase the formation of ground-level ozone, a key component of smog. Ozone has a variety of health effects, aggravates lung diseases such as asthma, and increases the risk of premature death from heart or lung disease, so EPA and the North Carolina Division of Air Quality have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will become more difficult.

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United States Environmental Protection Agency

August 2016

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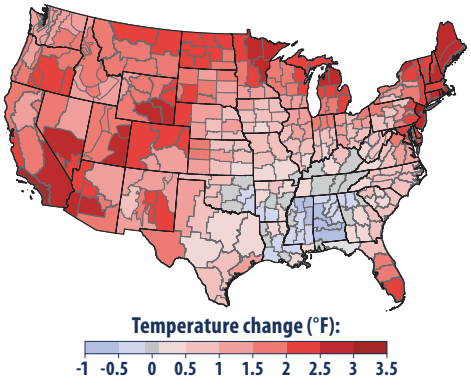
What Climate Change *Means for* North Dakota

North Dakota's climate is changing. In the past century, most of the state has warmed about two degrees (F). Rainstorms are becoming more intense, and annual rainfall is increasing. In the coming decades, longer growing seasons are likely to create opportunities for farmers, and increasing rainfall may benefit some farms but increase the risk of flooding.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmo-sphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years, and sea level is rising at an increasing rate. Warming is causing snow to melt earlier in spring.



Rising temperatures in the last century. North Dakota has warmed more than most of the United States. Source: EPA, Climate Change Indicators in the United States.

Precipitation and Water Resources

Changing the climate is likely to increase the demand for water and make it more available. Rising temperatures increase evaporation and water use by plants. But rainfall is also likely to increase, so soil moisture is likely to increase slightly or remain about the same as today. More water is likely to run off into the upper Missouri River and its tributaries.

The resulting increase in river flows could benefit recreational boating, public water supplies, and electric power generation. During droughts, decreased river flows can lower the water level in lakes and reservoirs, which may limit water supplies and impair swimming, fishing, and other recreational activities. But if more water flows through the rivers before or during a drought, these problems will become less likely. Higher water flows also increase hydropower production, which accounts for about 5 percent of all energy produced in North Dakota. Nevertheless, droughts are likely to become more severe in downstream states. When droughts lower water levels enough to impair navigation, the U.S. Army Corps of Engineers releases water from the upstream dams, making less water available to North Dakota.

Increased Flooding

Greater river flows, increasing precipitation, and more severe storms are each likely to increase the risk of flooding. The year 2011 was one of the wettest years on record: the Souris River near Minot crested at four feet above its previous record, with a flow five times greater than any in the past 30 years, and flooding occurred throughout the state. In the Red River watershed, river flows during the worst flood of the year have been increasing about 10 percent per decade since the 1920s.

Flooding of the Red River at Grand Forks in 1997. Flood magnitudes have been increasing since the 1920s in the Red River watershed. Credit: Tony Mutzenberger, USGS.

Heavy Storms

Warmer air tends to have more water vapor, so more water can be potentially released in a storm. During the last 50 years, the amount of rain falling during the wettest four days of the year has increased about 15 percent in the Great Plains. Over the next several decades, heavy downpours are likely to account for an increasing fraction of all precipitation.

Agriculture

Changing the climate is likely to have both positive and negative effects on agriculture in North Dakota. Warmer temperatures have extended the growing season by about 30 days since the beginning of the 20th century. Corn and soybeans are now grown in areas that were previously too cold for those crops, and warmer temperatures are likely to increase corn yields in the future. The fertilizing effect of increased concentrations of carbon dioxide is likely to further increase yields of corn and substantially increase yields of wheat and soybeans. The extended growing season might allow two crops per year instead of one in some instances. Increased precipitation at the beginning of the growing season is likely to help ensure that soils are sufficiently moist for the growing season.

Although the longer growing season benefits most crops, planting dates might be delayed if increased winter and spring precipitation leaves some fields too wet to plant. Rising temperatures may also reduce yields of wheat, partly offsetting the fertilizing effect of carbon dioxide. Warmer winters may promote the growth of weeds and pests. During drought years, hotter summers will dry the soil more than would otherwise occur. Over the next 70 years, the number of days above 100°F is likely to double, which could further stress crops during drought years.

Ecosystems

Rising carbon dioxide concentrations are likely to increase the productivity of grasslands. Although ecosystems generally benefit from higher productivity, several impacts of a changing climate may harm ecosystems. Changes in temperature and the length of the growing season may disrupt natural ecological processes and shift species' ranges. Many species of birds are shifting northward as temperatures rise, and warmer temperatures are causing flowers in North Dakota to bloom earlier in spring. Even small changes in the timing of plant development or animal migration can disrupt predator-prey relationships, mating behavior, or availability of food.

Human Health

Extremely hot and cold days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. The elderly may be particularly prone to heat stress and other heat-related health problems, including dehydration, cardiovascular strain, and respiratory problems. Those with low incomes may be particularly vulnerable due to a lack of air conditioning. Power failures due to severe weather can also present risks, especially in lightly populated areas where access to the necessary support services may be limited. While these risks will increase as the climate becomes warmer, illnesses and deaths due to cold weather and snow are likely to decline.

Climate change may also increase the length and severity of the pollen season for allergy sufferers. For example, the ragweed season in Fargo has grown 19 days longer since 1995, because the first frost in fall is later.

A photo of a ragweed plant, a common source of allergens in North Dakota. Like many crops and pollen sources, ragweed will have a longer growing season as temperatures rise. Stock photo.

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United States Environmental Protection Agency

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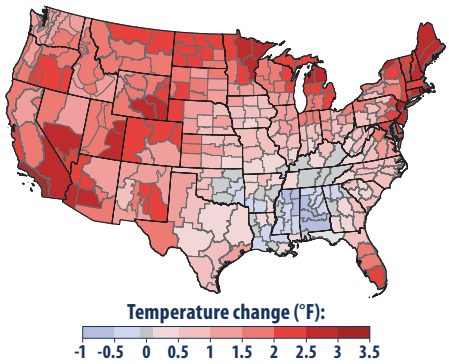
What Climate Change *Means for* Ohio

Ohio's climate is changing. Most of the state has warmed by about one degree (F) in the last century. Floods are becoming more frequent, and ice cover on the Great Lakes is forming later or melting sooner. In the coming decades, the state will have more extremely hot days, which may harm public health in urban areas and corn harvests in rural areas.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has also warmed about one degree during the last 80 years. Although warmer temperatures cause sea level to rise, the impact on water levels in the Great Lakes is not yet known. Warmer air also melts ice and snow earlier in spring.



Rising temperatures in the last century. All regions of Ohio have warmed. Source: EPA, Climate Change Indicators in the United States.

Heavy Precipitation and Flooding

Changing the climate is likely to increase the frequency of floods in Ohio. Over the last half century, average annual precipitation in most of the Midwest has increased by 5 to 10 percent. But rainfall during the four wettest days of the year has increased about 35 percent, and the amount of water flowing in most streams during the worst flood of the year has increased by more than 20 percent. During the next century, spring rainfall and average precipitation are likely to increase, and severe rainstorms are likely to intensify. Each of these factors will tend to further increase the risk of flooding.

Ohio River

Flooding occasionally threatens both navigation and riverfront communities, and greater river flows could make flooding worse. In 2011, a combination of heavy rainfall and melting snow caused a flood that closed the lower Ohio River to navigation. Heavy rains and melting snow in March 2015 caused the Ohio River and its tributaries to flood parts of Cincinnati and Anderson Township.

Five inches of rain over 48 hours flooded Marietta in September 2004. Credit: National Weather Service.

Although springtime in Ohio is likely to be wetter, summer droughts are likely to be more severe. Higher evaporation and lower summer rainfall are likely to reduce river flows. The drought of 2005 caused portions of the lower Ohio River to be closed to commercial navigation, which delayed shipments of crops and other products to and from upstream states like Ohio. In 2012, a drought caused navigation restrictions on the lower Mississippi River, which cost the region more than $275 million.

One advantage of climate change is that warmer winters reduce the number of days that ice prevents navigation.

Great Lakes

The ice-free season along the Great Lakes is also becoming longer. Between 1994 and 2011, reduced ice cover lengthened the shipping season on the lakes by eight days. The Great Lakes are likely to warm another 3° to 7°F in the next 70 years, which will further extend the shipping season.

In Lake Erie, the changing climate is likely to harm water quality. Warmer water tends to cause more algal blooms, which can be unsightly, harm fish, and degrade water quality. During August 2014, an algal bloom in Lake Erie prompted the City of Toledo to ban drinking and cooking with tap water. Severe storms also increase the amount of pollutants that run off from land to water, so the risk of algal blooms will be greater if storms become more severe. Increasingly severe rainstorms could also cause sewers to overflow into the Great Lakes more often, threatening beach safety and drinking water supplies.

A satellite view shows ice forming on Lake Erie, particularly at the western end. In a typical year, nearly the entire surface of the lake freezes. Credit: NOAA CoastWatch.

Agriculture

Changing the climate will have both beneficial and harmful effects on farming. Longer frost-free growing seasons and higher concentrations of atmospheric carbon dioxide would increase yields for some crops during an average year. But increasingly hot summers are likely to reduce yields of corn and possibly soybeans. Seventy years from now, Ohio is likely to have 5 to 15 more days per year with temperatures above 95°F than it has today. More severe droughts or floods would also hurt crop yields.

Air Pollution and Human Health

Rising temperatures can harm air quality and amplify existing threats to human health. Warmer weather can increase the production of ground-level ozone, a pollutant that causes lung and heart problems. Ozone also harms plants. In rural Ohio, ozone levels are high enough to significantly reduce yields of soybeans and winter wheat. U.S. EPA and the Ohio EPA have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will become more difficult.

Hot days can be unhealthy—even dangerous. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Northern cities like Cleveland are vulnerable to heat waves, because many houses and apartments lack air conditioning, and urban areas are typically warmer than their rural surroundings. In recent decades, severe heat waves have killed hundreds of people across the Midwest. Heat stress is expected to increase as climate change brings hotter summer temperatures and more humidity. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

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EPA United States Environmental Protection Agency

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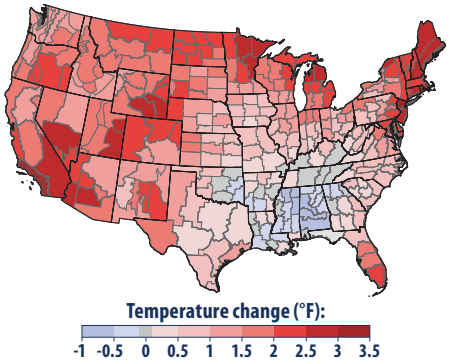
EPA 430-F-16-038

What Climate Change *Means for* Oklahoma

In the coming decades, **Oklahoma** will become warmer, and both floods and droughts may be more severe. Most of Oklahoma did not become warmer during the last 50 to 100 years. But soils have become drier, annual rainfall has increased, and more rain arrives in heavy downpours. In the coming decades, summers are likely to be increasingly hot and dry, which would reduce the productivity of farms and ranches, change parts of the landscape, and possibly harm human health.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

While most of the earth warmed during the last century, natural cycles and sulfates in the air cooled eastern Oklahoma. Sulfates are air pollutants that reflect sunlight back into space. Now sulfate emissions are declining, and the factors that once prevented parts of the state from warming are unlikely to persist.



Changing temperatures in the last century. While most of the nation has warmed, eastern Oklahoma has cooled. Source: EPA, Climate Change Indicators in the United States.

Precipitation and Water Resources

Changing the climate is likely to increase the demand for water but make it less available. As rising temperatures increase evaporation and water use by plants, soils are likely to become even drier. Average rainfall is likely to decrease during spring and summer. Seventy years from now, the longest period without rain each year is likely to be at least three days longer than it is today. Increased evaporation and decreased rainfall are likely to reduce the average flow of rivers and streams.

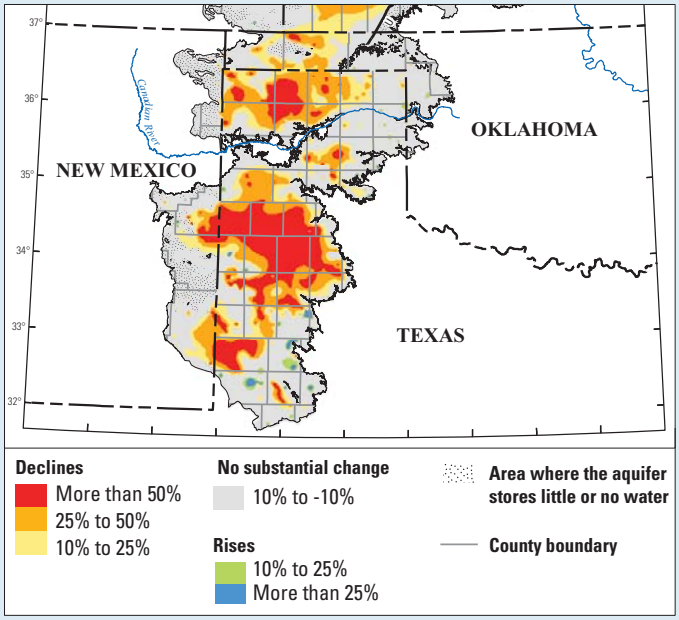
Drier soils will increase the need for farmers to irrigate their crops, but sufficient water might not be available. Approximately 16 percent of Oklahoma's farmland is irrigated. In the Panhandle, most irrigation water is ground water from the High Plains Aquifer System. As a result, this aquifer is becoming depleted. Since the 1950s, the amount of water stored in the aquifer has declined by more than 25 percent in parts of the Panhandle. (See map on back page.)

Decreased river flows can create problems for navigation, recreation, public water supplies, and electric power generation. Commercial navigation can be suspended during droughts when there is too little water to keep channels deep enough for barge traffic. Decreased river flows can also lower the water level in lakes and reservoirs, which may limit municipal water supplies; impair swimming, fishing, and other recreational activities; and reduce hydroelectric power generation. Conventional power plants also need adequate water for cooling. Compounding the challenges for electric utilities, rising temperatures are expected to increase the demand for electricity for air conditioning.

Agriculture

Increasing droughts and higher temperatures are likely to interfere with Oklahoma's farms and cattle ranches. Hot weather causes cows to eat less and grow more slowly, and it can threaten their health. Reduced water availability would create challenges for ranchers, as well as farmers who irrigate crops such as wheat. Yields are likely to decline by about 50 percent in fields that can no longer be irrigated. The early flowering of winter wheat could have negative repercussions on livestock farmers who depend on it for feed.

A dry cornfield in Canadian County during the 2011 drought. Credit: Ron Hays, Oklahoma Farm Report.



Percent depletion of ground water in the High Plains Aquifer, 1950–2013. Source: USGS.

Rainstorms and Tornadoes

Although summer droughts are likely to become more severe, floods may also intensify. During the last 50 years, the amount of rain falling during the wettest four days of the year has increased about 15 percent in the Great Plains. Over the next several decades, the amount of rainfall during the wettest days of the year is likely to continue to increase, which would increase flooding.

Three days of heavy rain in May 2013 led to flooding in Henryetta (shown here) and other communities. Credit: Bruce Jones, The Henryettan.

Scientists do not know how the frequency and severity of tornadoes will change. Rising concentrations of greenhouse gases tend to increase humidity, and thus atmospheric instability, which would encourage tornadoes. But wind shear is likely to decrease, which would discourage tornadoes. Research is ongoing to learn whether tornadoes will be more or less frequent in the future. Because Oklahoma experiences about 60 tornadoes a year, such research is closely followed by meteorologists in the state.

Hot Weather, Air Pollution, and Human Health

Hot days can be unhealthy—even dangerous. Seventy years from now, Oklahoma is likely to have three to four times as many days above 100°F as it has today. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. The elderly may be particularly prone to heat stress and other heat-related health problems, including dehydration, cardiovascular strain, and lung problems. Those with low incomes may also be vulnerable if they lack air conditioning.

Rising temperatures can also increase the formation of ground-level ozone, a key component of smog. Ozone has a variety of health effects, aggravates lung diseases such as asthma, and increases the risk of premature death from heart or lung disease. EPA and the Oklahoma Department of Environmental Quality have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will become more difficult.

Wildfires and Landscape Change

Higher temperatures and drought are likely to increase the severity, frequency, and extent of wildfires, which could harm property, livelihoods, and human health. On average, more than 1 percent of the land in Oklahoma has burned each decade since 1984. Wildfire smoke pollutes the air and can increase medical visits for chest pains, respiratory problems, and heart problems.

The combination of more fires and drier conditions may change parts of Oklahoma's landscape. Many plants and animals living in the dry lands of western Oklahoma are already near the limits of what they can tolerate. In some cases, native vegetation may persist as the climate changes. But when fire destroys the natural cover, the native grasses and woody plants may be replaced by non-native grasses, which can become established more readily after a fire. Because non-native grasses are generally more prone to intense fires, native plants may be unable to re-establish themselves.

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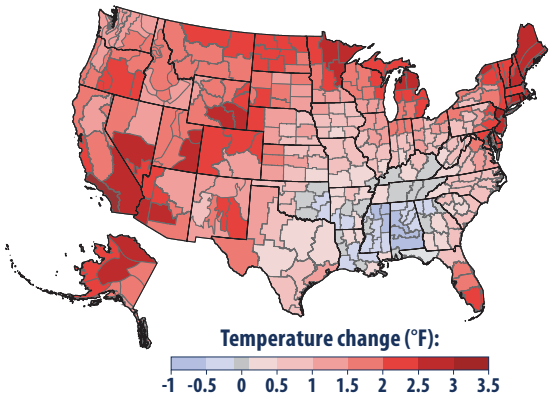
What Climate Change Means for Oregon

Oregon's climate is changing. Over the past century, most of the state has warmed about two degrees (F). Snowpack is melting earlier in the year, and the flow of meltwater into streams during summer is declining. In the coming decades, coastal waters will become more acidic, streams will be warmer, wildfires may be more common, and some rangelands may convert to desert.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. The warming in Oregon has been similar to the average warming nationwide. Source: EPA, Climate Change Indicators in the United States.

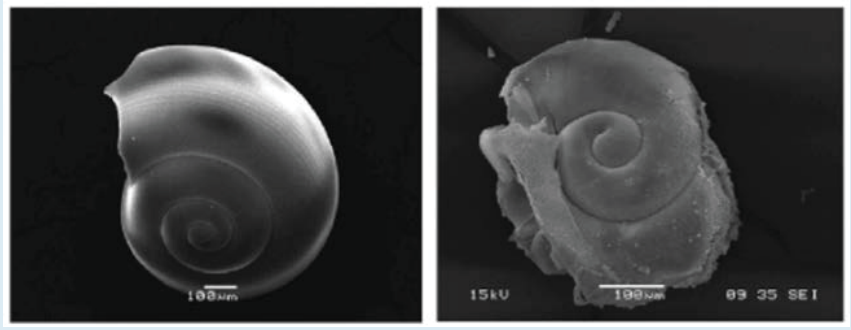
Marine and Coastal Ecosystems

Rising water temperatures, increasing ocean acidity, and changes in the marine ecosystem will amplify observed losses in commercially and recreationally important fish stocks in the region in the 21st century. Credit: NOAA.

Oregon's coastal waters are vulnerable to acidification. The ocean here is more acidic than most of the ocean, because nearby currents bring relatively acidic water from the deep ocean to the surface, especially during spring and summer. Increasing acidity impairs the ability of some types of shellfish to capture minerals in the water to build their shells, which can lead to thinner shells—or even prevent shells from forming. At the Whiskey Creek Hatchery in Netarts Bay, for example, acidic seawater during spawning has reduced the growth rates and survival of young oysters. Acidity also thins the exoskeletons of many species of plankton, which could reduce the population of those plankton and the fish that feed on them, and alter the entire marine food web. For example, young salmon eat some of the types of shellfish and plankton that are vulnerable to acidification.

Rising ocean temperatures may also harm marine ecosystems. Warming waters can increase the frequency of toxic algae blooms (such as "red tide") that cause shellfish poisoning and lead to closures of beaches and shellfish beds. Warmer waters also allow invasive species from southern waters to move northward.

Sea level rise will threaten coastal development and ecosystems. Erosion will threaten homes and public property along the shore. Mudflats, marshes, and other tidal wetlands provide habitat for birds and fish. As water levels rise, wetlands and beaches may be submerged or squeezed between the rising sea and structures erected to protect coastal development.

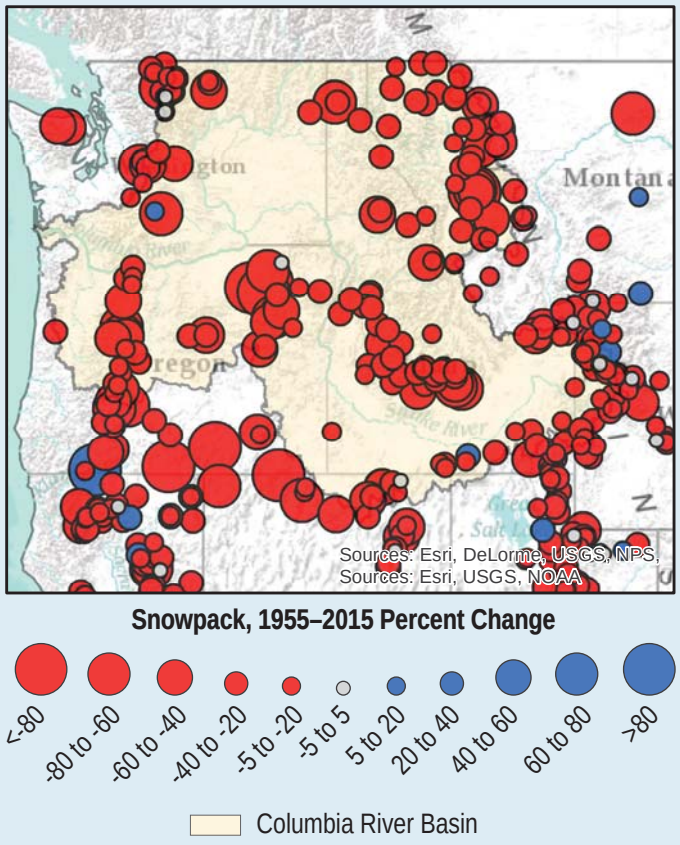


Pteropods, or "sea butterflies," are small free-swimming sea snails. They are an important source of food for North Pacific juvenile salmon, as well as whales and other marine species. The left panel shows a shell collected from a live pteropod from a region where acidity is not yet very high. The shell on the right is from a pteropod collected in a region where waters have acidified. Credit: Nina Bednaršek, NOAA.

Snowpack, Streamflows, and Water Availability

The flows of water in rivers and streams are increasing during late winter and early spring but decreasing during summer. Warmer winters have reduced average snowpack in the Cascades by 20 percent since 1950. The snowpack is now melting a few weeks earlier than during the 20th century, and, by 2050, it is likely to melt three to four weeks earlier. Decreasing snowpack means there will be less water flowing through streams during summer. Moreover, rising temperatures increase the rate at which water evaporates (or transpires) into the air from soils and plants. More evaporation means that less water will drain from the ground into rivers and streams.

Declining snow and streamflow would harm some economic sectors and aquatic ecosystems. Less snow means a shorter season for skiing and other winter recreation. Water temperatures will rise, which would hurt Chinook and sockeye salmon in the interior Columbia River Basin. The combination of warmer water and lower flows would threaten salmon, steelhead, and trout. Lower flows would also mean less hydroelectric power.



Trends in April snowpack in Oregon and the U.S. portion of the Columbia River Basin, 1955–2013. Snowpack has decreased at most monitoring sites in Oregon and the basin. Source: EPA.

Wildfires and Landscape Change

Climate change can increase the frequency and severity of fires that burn forests, grasslands, and desert vegetation. Since 1984, about 4 percent of the land in Oregon has burned per decade. The changing climate is likely to more than double the area in the Northwest burned by forest fires during an average year by the end of the 21st century. Although drier soils alone increase the risk of wildfire, many other factors contribute to fires, and forests in the Western Cascades may be less vulnerable to climate change than those in the Eastern Cascades.

Higher temperatures and a lack of water can also make trees more susceptible to pests and disease, and trees damaged or killed burn more readily than living trees. For example, climate change is likely to increase the area of pine forests in the Northwest infested with mountain pine beetles in the next few decades. Pine beetles and wildfires are each likely to decrease timber harvests. Increasing wildfires also threaten homes and pollute the air.

The combination of more fires and drier conditions may expand deserts and otherwise change the landscape in the dry eastern portion of the state. Many plants and animals living in arid lands are already near the limits of what they can tolerate. Warmer temperatures and a drier climate would generally extend the geographic range of the Great Basin desert. In some cases, native vegetation may persist and delay or prevent expansion of the desert. In other cases, fires or livestock grazing may accelerate the conversion of grassland to desert in response to the changing climate. For similar reasons, some forests may change to desert or grassland.

Agriculture

Climate change may also pose challenges for livestock and crops. Higher temperatures cause cows to eat less, grow more slowly, and produce less milk, and in extreme cases may threaten their health. Some farms may be harmed if more hot days reduce crop yields, or if the decline in summer streamflow reduces the water available for irrigation. Other farms may benefit from a longer growing season and the fertilizing effect of carbon dioxide.

Health and Vulnerable People

Climate change is likely to amplify some threats to health in Oregon. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

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EPA United States Environmental Protection Agency

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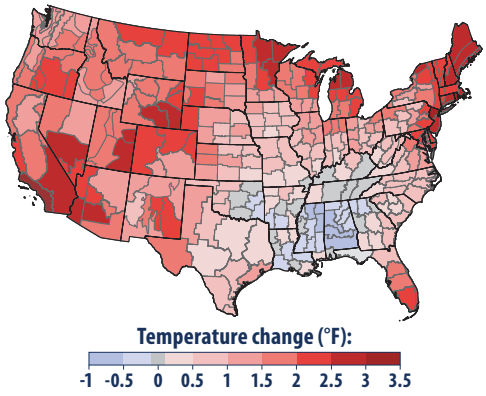
What Climate Change *Means for* Pennsylvania

Pennsylvania's climate is changing. The commonwealth has warmed more than half a degree (F) in the last century, heavy rainstorms are more frequent, and the tidal portion of the Delaware River is rising about one inch every eight years. In the coming decades, changing the climate is likely to increase flooding, harm ecosystems, disrupt farming, and increase some risks to human health.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. All regions of Pennsylvania have warmed. Source: EPA, Climate Change Indicators in the United States.

Increasing Temperature and Changing Precipitation

Rising temperatures and shifting rainfall patterns are likely to increase the intensity of both floods and droughts. Average annual precipitation in Pennsylvania has increased 5 to 10 percent in the last century, and precipitation from extremely heavy storms has increased 70 percent in the Northeast since 1958. During the next century, annual precipitation and the frequency of heavy downpours are likely to keep rising. Precipitation is likely to increase during winter and spring, but not change significantly during summer and fall. Rising temperatures will melt snow earlier in spring and increase evaporation, and thereby dry the soil during summer and fall. As a result, changing the climate is likely to intensify flooding during winter and spring, and drought during summer and fall.

In 2011, Hurricane Irene caused the Schuylkill River to overflow its banks, flooding a rail line, bike path, and other infrastructure in Philadelphia. Credit: Sarah Clark Stuart, Bicycle Coalition of Greater Philadelphia.

Higher Tides Along the Delaware River

Sea level is rising more rapidly along Pennsylvania's shoreline than in most coastal areas because the Delaware Valley is sinking. If the oceans and atmosphere continue to warm, the tidal portion of the Delaware River is likely to rise one to four feet in the next century. Parts of Philadelphia International Airport and neighborhoods to the north are within two or three feet above the average high tide on the Delaware River. In downtown Philadelphia, Penn's Landing and the Northeast Corridor railroad tracks at 30th Street Station are currently in the 100-year floodplain. Along the Delaware and Schuylkill rivers, a higher sea level could increase the extent of flooding caused by either coastal storms or severe rainstorms, unless communities take measures to hold back the rising rivers.

Tidal marshes like this one at Tinicum are vulnerable to destruction and saltwater intrusion as sea level rises. Credit: Partnership for the Delaware Estuary.

The tidal freshwater wetlands along the Delaware River are likely to capture enough sediment for their land surfaces to keep pace with rising sea level. But both rising sea level and increasing drought enable salt water to mix farther up the Delaware River, which could kill wetland plants. In places where that occurs, wetlands might be replaced by either salt-tolerant wetland plants or shallow waters. Higher salinity could also create problems for Philadelphia's water supply during droughts, if salty water moves upstream to the city's drinking water intake at Torresdale.

Inland Waters

Extraordinarily high river flows occasionally cause problems for commercial navigation along the Ohio and Allegheny rivers, and riverfront communities along the Susquehanna River and smaller tributaries occasionally flood. Heavier storms and greater river flows could make these problems worse. In 2011, heavy rainfall caused record flooding on the Susquehanna and the evacuations of Wilkes-Barre. Conversely, lower summer rainfall and higher evaporation could leave some rivers too shallow for navigaton during droughts.

One advantage of climate change is that warmer winters reduce the number of days that ice prevents navigation on rivers and in the Great Lakes. Between 1994 and 2011, reduced ice cover lengthened the shipping season on the Great Lakes by eight additional days. The Great Lakes are likely to warm another 3° to 7°F in the next 70 years, which will further extend the shipping season. The impact of climate change on water quality is less likely to be beneficial. Warmer temperatures tend to cause more algal blooms, which can be unsightly, harm fish, and degrade water quality. Severe storms also increase the amount of pollutants that run off from the land into the water, further increasing the risk of algal blooms.

Ecosystems

Changing the climate threatens ecosystems by disrupting the existing relationships between species. Wildflowers and woody perennials are blooming—and migratory birds are arriving—sooner in spring. Not all species adjust in the same way, however, so the food that one species needs may no longer be available when that species arrives on its migration. As a result, for example birds in western Pennsylvania have had lower body weights during warm years. Warmer temperatures allow deer populations to increase, leading to a loss of forest underbrush, which, in turn, makes some animals more vulnerable to predators. Rising temperatures also enable invasive species to move into areas that were previously too cold.

Agriculture

Changing climate will have both beneficial and harmful effects on farming, but the net effect is unknown. Longer frost-free growing seasons and higher concentrations of atmospheric carbon dioxide would increase yields for many crops during an average year, notably soybeans. But increasingly hot summers are likely to reduce yields of corn, Pennsylvania's most important crop. The earlier arrival of spring may increase populations of major crop pests, such as the corn earworm and aggressive weeds. Higher temperatures cause cows to eat less and produce less milk, so a warming climate could reduce the output of milk and beef, which together account for more than one-third of the commonwealth's farm revenues.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Warmer temperatures can also increase the formation of ground-level ozone, a key component of smog that can contribute to respiratory problems. Rising temperatures may also increase the length and severity of the pollen season for plants such as ragweed.

The risk of some diseases carried by insects may also increase. The ticks that transmit Lyme disease are active when temperatures are above 45°F, so warmer winters could lengthen the season during which ticks can become infected or people can be exposed to the ticks. Higher temperatures would also expand the area that is warm enough for the Asian tiger mosquito, a common carrier of West Nile virus. The number of cases may or may not increase, depending on what people do to control insect populations and avoid insect bites.

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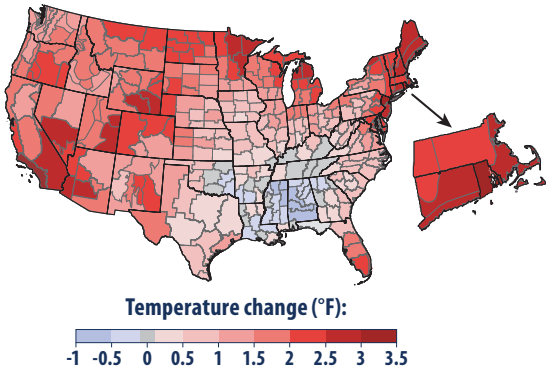
What Climate Change *Means for* Rhode Island

Rhode Island's climate is changing. The state has warmed about three degrees (F) since the year 1900. Throughout the northeastern United States, spring is arriving earlier and bringing more precipitation, heavy rainstorms are more frequent, and summers are hotter and drier. Sea level is rising, and severe storms increasingly cause floods that damage property and infrastructure. In the coming decades, the changing climate is likely to increase flooding, harm ecosystems, disrupt fishing, and increase some risks to human health.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. Rhode Island has warmed twice as much as the rest of the contiguous 48 states. Source: EPA, Climate Change Indicators in the United States.

Increasing Temperature and Changing Precipitation Patterns

Rising temperatures and shifting rainfall patterns are likely to increase the intensity of both floods and droughts. Average annual precipitation in the Northeast increased 10 percent from 1895 to 2011, and precipitation from extremely heavy storms has increased 70 percent since 1958. During the next century, average annual precipitation and the frequency of heavy downpours are likely to keep rising. Average precipitation is likely to increase during winter and spring, but not change significantly during summer and fall. Rising temperatures will melt snow earlier in spring and increase evaporation, and thereby dry the soil during summer and fall. So flooding is likely to be worse during winter and spring, and droughts worse during summer and fall.

Historically heavy rains in spring 2010 caused the Pawtuxet River to flood the Warwick wastewater treatment plant (shown here) and many homes and businesses. Credit: Warwick Sewer Authority.

Ecosystems

Changing climate threatens ecosystems by disrupting relationships between species. Wildflowers and woody perennials are blooming—and migratory birds are arriving—sooner in spring. Not all species adjust in the same way, however, so the food that one species needs may no longer be available when that species arrives on its migration. Warmer temperatures allow deer populations to increase, leading to a loss of forest underbrush, which makes some animals more vulnerable to predators. Rising temperatures also enable invasive species to move into areas that were previously too cold.

Sea Level Rise, Wetland Loss, and Coastal Flooding

Rising sea level erodes wetlands and beaches and increases damage from coastal storms. Tidal wetlands are inherently vulnerable because of their low elevations, and shoreline development prevents them from migrating inland onto higher ground. Human activities such as filling wetlands have destroyed about one third of New England's coastal wetlands since the early 1800s. Wetlands provide habitat for many bird species, such as osprey and heron, as well as several fish species. Losing coastal wetlands would harm coastal ecosystems and remove an important line of defense against coastal flooding.

Coastal cities and towns will become more vulnerable to storms in the coming century as sea level rises, shorelines erode, and storm surges become higher. Storms can destroy coastal homes, wash out highways and rail lines, and damage essential communication, energy, and wastewater management infrastructure.

Hurricane Sandy caused a storm surge that breached the barrier beach at Trustom Pond in Charlestown in 2012. Sea level rise leads to higher, more damaging storm surge. Credit: Greg Thompson, U.S. Fish and Wildlife Service.

Fishing and Agriculture

Parts of Rhode Island's fishing and farming sectors may suffer as climate changes. Rising water temperatures can lower oxygen levels and otherwise alter freshwater and marine ecosystems. Some fish such as bass may flourish in the Northeast's warming waters, but key ocean fisheries, such as cod and lobster south of Cape Cod, are expected to decline. The loss of coastal wetlands could harm commercially important fish and shellfish, such as bass and clams. Climate change may also pose challenges for agriculture: Some farms may be harmed if more hot days and droughts reduce crop yields, or if more flooding and wetter springs delay their planting dates. Other farms may benefit from a longer growing season and the fertilizing effect of carbon dioxide.

Human Health

Changes in temperature and precipitation could increase the incidence of acute and chronic respiratory conditions such as asthma. Higher temperatures can increase the formation of ground-level ozone (smog), a pollutant that can contribute to respiratory problems. Rising temperatures may also increase the length and severity of the pollen season for plants such as ragweed—which has already been observed in other regions. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

The risk of some diseases carried by insects may also increase. The ticks that transmit Lyme disease are active when temperatures are above 45°F, so warmer winters could lengthen the season during which ticks can become infected or people can be exposed to the ticks. Higher temperatures would also make more of New England warm enough for the Asian tiger mosquito, a common carrier of West Nile virus. The number of cases may or may not increase, depending on what people do to control insect populations and avoid insect bites.

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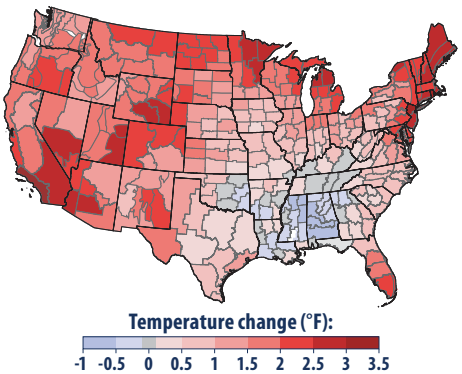
What Climate Change *Means for* South Carolina

South Carolina's climate is changing. Most of the state has warmed by one-half to one degree (F) in the last century, and the sea is rising about one to one-and-a-half inches every decade. Higher water levels are eroding beaches, submerging low lands, and exacerbating coastal flooding. Like other southeastern states, South Carolina has warmed less than most of the nation. But in the coming decades, the region's changing climate is likely to reduce crop yields, harm livestock, increase the number of unpleasantly hot days, and increase the risk of heat stroke and other heat-related illnesses.

Our climate is changing because the earth is warming. Since the late 1700s, people have increased the amount of carbon dioxide in the air by 40 percent. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. South Carolina has warmed less than most of the United States. Source: EPA, Climate Change Indicators in the United States.

Rising Seas and Retreating Shores

As the oceans warm, seawater expands and raises sea level. Melting ice adds more water to the ocean, further raising sea level. In South Carolina, the land surface is sinking, so the observed rate of sea level rise relative to the land is greater than the global average rise in sea level. If the oceans and atmosphere continue to warm, sea level is likely to rise one to four feet in the next century along the coast of South Carolina.

As sea level rises, the lowest dry lands are submerged and become either tidal wetland or open water. To some extent, wetlands can create their own land and keep pace with a slowly rising sea. But in many southeastern coastal areas, wetlands will not keep pace, and instead convert to open water. Many species of birds, fish, and shellfish in South Carolina depend on coastal wetlands that are threatened by rising sea level. Salt marshes provide habitat for clams, mussels, oysters, and other shellfish. They also provide nurseries and feeding grounds for many fish, and provide food for birds, such as egrets and the endangered wood stork.

Beaches also erode as sea level rises. A higher water level makes it more likely that storm waves will wash over a barrier island or open new inlets. Eroding shores will threaten homes throughout the South Carolina coast unless people take measures to prevent shore erosion.

Dead trees show how the beach has eroded at Hunting Island. © James G. Titus; used by permission.

Storms, Homes, and Infrastructure

Tropical storms and hurricanes have become more intense during the past 20 years. Although warming oceans provide these storms with more potential energy, scientists are not sure whether the recent intensification reflects a long-term trend. Nevertheless, hurricane wind speeds and rainfall rates are likely to increase as the climate continues to warm.

Whether or not storms become more intense, coastal homes and infrastructure will flood more often as sea level rises, because storm surges will become higher as well. Rising sea level is likely to increase flood insurance rates, while more frequent storms could increase the deductible for wind damage in homeowner insurance policies. Charleston and the barrier islands are especially vulnerable to the impacts of storms and sea level rise.

Changing the climate is also likely to increase inland flooding. Since 1958, the amount of precipitation during heavy rainstorms has increased by 27 percent in the Southeast, and the trend toward increasingly heavy rainstorms is likely to continue.

As sea level rises, Charleston's streets are increasingly prone to flooding at high tide. Credit: NOAA.

Agriculture

Changing the climate will have both harmful and beneficial effects on farming. During the next few decades, hotter summers are likely to reduce yields of corn. But higher concentrations of atmospheric carbon dioxide increase crop yields, and that fertilizing effect is likely to offset the harmful effects of heat on cotton, soybeans, wheat, and peanuts—assuming that adequate water is available. More severe droughts, however, could cause crop failures. Higher temperatures are also likely to reduce livestock productivity, because heat stress disrupts the animals' metabolism.

Forests

Higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in South Carolina, although the composition of trees in the forests may change. More droughts would reduce forest productivity, and climate change is also likely to increase the damage from insects and disease. But longer growing seasons and increased concentrations of carbon dioxide could more than offset the losses from those factors. Today forests cover two-thirds of the state. Loblolly pine trees dominate forests in most of the state, while oak, gum, and cypress trees are common in northeastern South Carolina; and oak and white pine are more common in the mountains. Changing the climate may alter the composition of forests throughout the state to more closely reflect the oak and white pine forests found today in the mountains.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems. Seventy years from now, temperatures are likely to rise above 95°F approximately 30 to 60 days per year in much of South Carolina, compared with about 15 such days today.

Warmer air can also increase the formation of ground-level ozone, a key component of smog. Ozone has a variety of health effects, aggravates lung diseases such as asthma, and increases the risk of premature death from heart or lung disease. EPA and the South Carolina Department of Health and Environmental Control have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will be more difficult.

The sources of information about climate and the impacts of climate change in this publication are: the national climate assessments by the U.S. Global Change Research Program, synthesis and assessment products by the U.S. Climate Change Science Program, assessment reports by the Intergovernmental Panel on Climate Change, and EPA's *Climate Change Indicators in the United States*. Mention of a particular season, location, species, or any other aspect of an impact does not imply anything about the likelihood or importance of aspects that are not mentioned. For more information about climate change science, impacts, responses, and what you can do, visit EPA's Climate Change website at www.epa.gov/climatechange.

EPA United States Environmental Protection Agency

August 2016

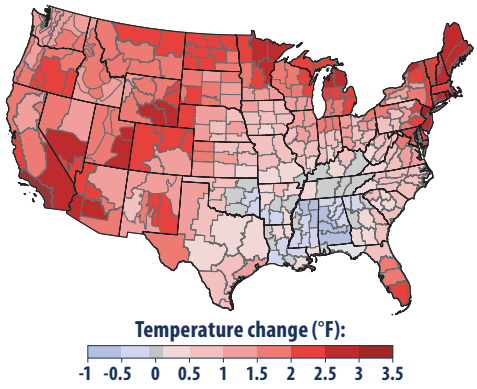
EPA 430-F-16-043

What Climate Change *Means for* South Dakota

South Dakota's climate is changing. In the past century, most of the state has warmed by one to two degrees (F). Rainstorms are becoming more intense, and annual rainfall is increasing. In the coming decades, summers are likely to become increasingly hot, which may amplify some risks to human health and decrease yields of some crops while lengthening the growing season for others.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years, and sea level is rising, at an increasing rate. Warming is causing snow to melt earlier in spring.



Rising temperatures in the last century. The warming in South Dakota has been more than the average warming nationwide. Source: EPA, Climate Change Indicators in the United States.

Precipitation and Water Resources

Changing climate is likely to increase the demand for water and make it more available. Rising temperatures increase evaporation and water use by plants, which make soils drier. But rainfall is likely to increase enough to allow soil moisture to increase slightly or remain about the same as today. More water is likely to run off into the Missouri River and its tributaries.

The resulting increase in river flows could benefit recreational boating, public water supplies, and electric power generation. During droughts, decreased river flows can lower the water level in lakes and reservoirs, which may limit municipal water supplies and impair swimming, fishing, and other recreational activities. But if more water flows through the rivers before or during a drought, these problems will be less likely. Higher water flows also increase hydropower production, which accounts for almost 40 percent of the energy produced in South Dakota. Nevertheless, droughts are likely to become more severe in downstream states. When droughts lower water levels enough to impair navigation, the U.S. Army Corps of Engineers releases water from the upstream dams, making less water available to South Dakota.

Rising Temperature and Heavy Storms

Warmer air tends to have more water vapor, so more water can be potentially released in a storm. During the last 50 years, the amount of rain falling during the wettest four days of the year has increased about 15 percent in the Great Plains. Over the next several decades, heavy downpours will account for an increasing fraction of all precipitation. Larger river flows and more intense rainstorms would each increase the risk of flooding.

Scientists do not know how the frequency and severity of tornadoes will change. Rising concentrations of greenhouse gases tend to increase humidity, and thus atmospheric instability, which would encourage tornadoes. But wind shear is likely to decrease, which would discourage tornadoes. Research is ongoing to learn whether tornadoes will be more or less frequent in the future.

Agriculture

Rising temperatures and changes in rainfall are likely to have both negative and positive effects on South Dakota's farms and ranches. Hot weather causes cows to eat less and grow more slowly, and it can threaten their health. Increased winter and spring precipitation could leave some fields too wet to plant, and warmer winters may promote the growth of weeds and pests. During drought years, hotter summers will dry the soil. Within 70 years, the frequency of days above 100°F is likely to double. Even where ample water is available, higher temperatures would reduce yields of corn in the warmest parts of the state.

The overall yield of corn, however, is likely to increase in cooler parts of the Great Plains. Although higher temperatures would reduce yields of wheat and soybeans, increased concentrations of carbon dioxide are likely to increase yields enough to offset the impact of higher temperatures. Increased precipitation at the beginning of the growing season could also benefit some crops. Warmer and shorter winters may allow for a longer growing season, which could allow two crops per year instead of one in some instances. Warmer winters may also benefit cattle, offsetting some of the harm from hotter summers: during the winter of 1996–1997, for example, high winds and heavy snow killed half of the newborn calves and 100,000 adult cows in the northern Great Plains.

Forests

Longer growing seasons and increased carbon dioxide concentrations could increase the productivity of forests. Although forests generally benefit from higher productivity, warmer conditions make forests more susceptible to pests. Temperature controls the life cycle and winter mortality rates of pests such as bark beetles, which have infested and killed trees in the Black Hills in recent decades. With higher winter temperatures, some pests can persist year-round, and new pests and diseases may become established.

Trees killed by a mountain pine beetle infestation in the Black Hills. Credit: Blaine Cook, USDA Forest Service.

Human Health

Extremely hot and cold days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. The elderly may be particularly prone to heat stress and other heat-related health problems, including dehydration, cardiovascular strain, and respiratory problems. Those with low incomes may be particularly vulnerable due to a lack of air conditioning. Power failures due to severe weather can also present risks, especially in lightly populated areas where access to the necessary support services may be limited. While these risks will increase as the climate becomes warmer, illnesses and deaths due to cold weather and snow are likely to decline.

Climate change may also increase the length and severity of the pollen season for allergy sufferers. For example, the ragweed season in the northern Great Plains and Upper Midwest is now 10 to 21 days longer than it was in 1995, because the first frost in fall is later.

A photo of a ragweed plant, a common source of allergens in South Dakota. Like many crops and pollen sources, ragweed will have a longer growing season as temperatures rise. Stock photo.

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EPA United States Environmental Protection Agency

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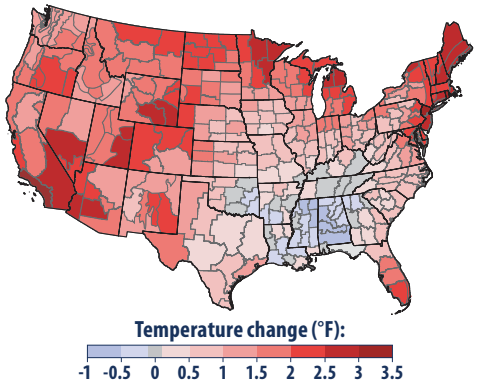
What Climate Change *Means for* Tennessee

Tennessee's climate is changing. Although the average temperature did not change much during the 20th century, the state has warmed in the last 20 years. Average annual rainfall is increasing, and a rising percentage of that rain is falling on the four wettest days of the year. In the coming decades, the changing climate is likely to reduce crop yields, threaten some aquatic ecosystems, and increase some risks to human health. Floods may be more frequent, and droughts may be longer, which would increase the difficulty of meeting the competing demands for water in the Tennessee and Cumberland rivers.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree (F) during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Natural cycles and sulfates in the air prevented much of Tennessee from warming during the last century. Sulfates are air pollutants that reflect sunlight back into space. Now sulfate emissions are declining, and the factors that once prevented Tennessee from warming are unlikely to persist.



Rising temperatures in the last century. Tennessee has warmed less than most of the United States. Source: EPA, Climate Change Indicators in the United States.

Changing Water Availability

Annual precipitation in Tennessee has increased approximately 5 percent since the first half of the 20th century. But rising temperatures increase evaporation, which dries the soil and decreases the amount of rain that runs off into rivers. Although rainfall during spring is likely to increase during the next 40 to 50 years, the total amount of water running off into rivers or recharging ground water each year is likely to decline 2.5 to 5 percent, as increased evaporation offsets the greater rainfall. Droughts are likely to be more severe, because periods without rain will be longer and very hot days will be more frequent.

Increased Flooding

Flooding is becoming more severe in the Southeast. Since 1958, the amount of precipitation falling during heavy rainstorms has increased by 27 percent in the Southeast, and the trend toward increasingly heavy rainstorms is likely to continue. To prevent serious floods, the Tennessee Valley Authority (TVA) and the U.S. Army Corps of Engineers release water from the reservoirs behind dams they operate before the winter flood season. Doing so lowers water levels and provides a greater capacity for the reservoirs behind those dams to prevent flooding. Nevertheless, the dams cannot prevent all floods. In May 2003, for example, heavy rains exceeded TVA's dam capacity, flooding low-lying areas in Chattanooga and other parts of Hamilton County; in 2010, high flows in the Cumberland River flooded Nashville.

The Cumberland River flooded parts of Nashville in 2010, damaging many businesses, including the Grand Ole Opry. Credit: USGS.

Droughts, Navigation, and Hydroelectric Power

Droughts also pose challenges for water management. If the spring is unexpectedly dry, reservoirs may have too little water during summer. During droughts, TVA and the Corps of Engineers release water from dams to keep the Tennessee and Cumberland rivers navigable. These rivers support $35 billion in annual shipping. The agencies try to keep channels at least eleven feet deep, because lower river levels can force barges to carry smaller loads, which increases transportation costs. During the drought of 2007, however, TVA could only release enough water to keep some channels nine feet deep. This release meant that lake levels were lowered tens of feet, which caused problems for recreational swimming and boating. If droughts become more severe, TVA and the Corps of Engineers will face this type of problem more often.

Dry years diminish the amount of electricity that TVA can produce from its 19 hydroelectric dams in Tennessee, which provide 12 to 15 percent of the electricity produced in the state. During the 2007 drought, TVA's hydroelectric plants produced 30 percent less than normal, which forced TVA to meet demand by using more expensive fuel-burning power plants.

Two views of a boat ramp in Douglas Lake during the 2007 drought. The lake is nearly dry and the 330-foot ramp is completely out of the water. Credit: NOAA.

Aquatic Ecosystems

Changing the climate can harm aquatic ecosystems. Warmer water lowers the level of dissolved oxygen in surface water, which can severely limit fish populations. Because fish cannot regulate their body temperatures, warmer water can make a stream uninhabitable for fish that require cooler water. Warmer temperatures can also increase the frequency of algal blooms, which can be toxic and further reduce dissolved oxygen. Summer droughts may amplify these effects, while periods of extreme rainfall can increase the impacts of pollution on streams.

Agriculture

Changing the climate will have both beneficial and harmful effects on agriculture. Longer frost-free growing seasons and increased concentrations of atmospheric carbon dioxide tend to increase yields for many crops during an average year. But more severe droughts and more hot days are likely to reduce yields, especially in the western half of Tennessee: 70 years from now, that part of the state is likely to have 15 to 30 more days with temperatures above 95°F than it has today. Even on irrigated fields, higher temperatures are likely to reduce yields of corn, and possibly soybeans. Warmer temperatures are also likely to reduce the productivity of dairy and other cattle farms.

Forest Resources

Higher temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Tennessee, but the composition of those forests may change. Forests cover about half the state, dominated by oak and hickory trees, and the forest products industry employs 180,000 people. Although more droughts would reduce productivity, longer growing seasons and increased carbon dioxide concentrations could more than offset those losses. Nevertheless, climate change is likely to increase the damage that certain insects and diseases cause in Tennessee's forests.

Human Health

Hot days can be unhealthy—even dangerous. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. Warmer air can also increase the formation of ground-level ozone, a key component of smog. Ozone has a variety of health effects, aggravates lung diseases such as asthma, and increases the risk of premature death from heart or lung disease. EPA and the Tennessee Department of Environment and Conservation have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will become more difficult.

The Smoky Mountains have always had a natural blue haze. But air pollution has increased that haze, and higher ozone levels could increase it further. This photo shows how haze obscures the view from the Look Rock Tower in Great Smoky Mountains National Park. Credit: National Park Service.

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EPA United States Environmental Protection Agency

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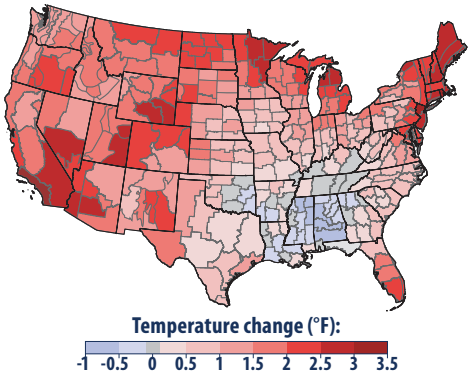
What Climate Change Means for Texas

Texas's climate is changing. Most of the state has warmed between one-half and one degree (F) in the past century. In the eastern two-thirds of the state, average annual rainfall is increasing, yet the soil is becoming drier. Rainstorms are becoming more intense, and floods are becoming more severe. Along much of the coast, the sea is rising almost two inches per decade. In the coming decades, storms are likely to become more severe, deserts may expand, and summers are likely to become increasingly hot and dry, creating problems for agriculture and possibly human health.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. The western part of Texas has warmed twice as much as the eastern part. Source: EPA, Climate Change Indicators in the United States.

Rising Seas and Retreating Shores

Sea level is rising more rapidly along the Texas coast than the rise caused by climate change alone, because the land is sinking, largely because of ground water pumping. If the oceans and atmosphere continue to warm, sea level is likely to rise two to five feet in the next century along much of the Texas coast.

Rising sea level submerges wetlands and dry land, erodes beaches, and exacerbates coastal flooding. Many types of birds and fish depend on tidal wetlands. Shore erosion can eliminate public access along the beach, especially where development is immediately inland.

Coastal Storms, Homes, and Infrastructure

Tropical storms and hurricanes have become more intense during the past 20 years. Although warming oceans provide these storms with more potential energy, scientists are not sure whether the recent intensification reflects a long-term trend. Nevertheless, hurricane wind speeds and rainfall rates are likely to increase as the climate continues to warm.

An eroded beach on North Padre Island impairs public access along the shore. © James G. Titus; used by permission.

Whether or not storms become more intense, coastal homes and infrastructure will flood more often as sea level rises, because storm surges will become higher as well. The rising sea is likely to increase flood insurance rates, while more frequent storms could increase the deductible for wind damage in homeowner insurance policies. Many cities, roads, railways, ports, airports, and oil and gas facilities along the Gulf Coast are vulnerable to the combined impacts of storms and sea level rise. People may move from vulnerable coastal communities and stress the infrastructure of the communities that receive them.

Rainstorms and Tornadoes

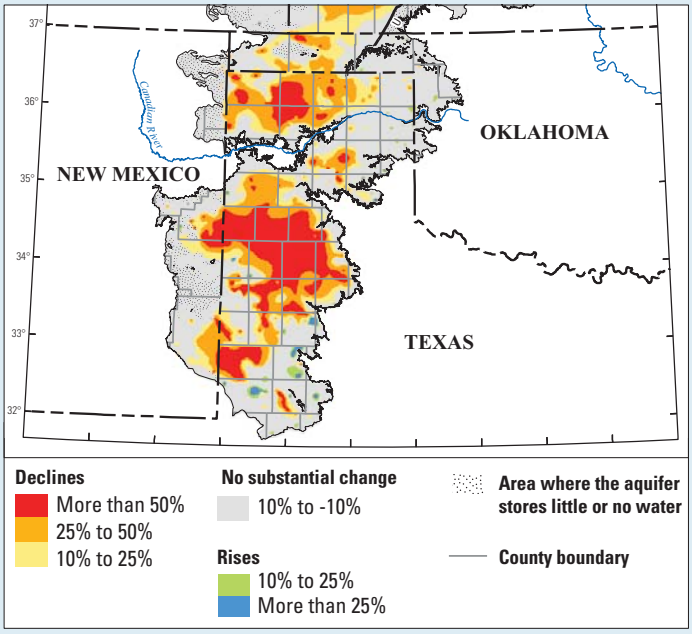
Changing the climate is also likely to increase inland flooding. During the last 50 years, the amount of rain falling during the wettest four days of the year has increased about 15 percent in the Great Plains. Over the next several decades, the amount of rainfall during the wettest days of the year is likely to continue to increase, which would increase flooding.

Scientists do not know how the frequency and severity of tornadoes will change. Rising concentrations of greenhouse gases tend to increase humidity, and thus, atmospheric instability, which would encourage tornadoes. But wind shear is likely to decrease, which would discourage tornadoes. Research is ongoing to learn whether tornadoes will be more or less frequent in the future.

Water Resources

Despite the increase in heavy storms, changing climate is likely to make water less available overall. As warmer temperatures increase evaporation and water use by plants, soils are likely to continue to become drier. Average rainfall is likely to decrease during winter, spring, and summer. Seventy years from now, the longest period without rain each year is likely to be at least three days longer than it is today. Increased evaporation and decreased rainfall are both likely to reduce the average flow of rivers and streams.

Drier soils will increase the need for farmers to irrigate their crops, but sufficient water might not be available. Approximately 14 percent of the farmland in Texas is irrigated; in the Panhandle and the plains to the south, most irrigation water is ground water from the High Plains Aquifer System. As a result, this aquifer is becoming depleted. Since the 1950s, the amount of water stored in the aquifer has declined by more than 50 percent in some parts of the state.



Percent depletion of ground water in the High Plains Aquifer, 1950–2013. Source: USGS.

Agriculture

Increasing droughts and higher temperatures are likely to interfere with Texas's farms and cattle ranches. Hot weather causes cows to eat less, grow more slowly, and produce less milk, and it can threaten their health. Reduced water availability would create challenges for ranchers, as well as farmers who irrigate crops. Yields would decline by about 50 percent in fields that can no longer be irrigated.

Wildfires and Landscape Change

Higher temperatures and drought are likely to increase the severity, frequency, and extent of wildfires, which could harm property, livelihoods, and human health. On average, more than 1 percent of the land in Texas has burned each decade since 1984. Wildfire smoke pollutes the air and can increase medical visits for respiratory and heart problems.

The combination of more fires and drier conditions may expand deserts and otherwise change parts of the Texas landscape. Many plants and animals living in arid lands are already near the limits of what they can tolerate. A warmer and drier climate would generally extend the Chihuahuan desert to higher elevations and expand its geographic range. In some cases, native vegetation may persist and delay or prevent expansion of the desert. In other cases, fires or livestock grazing may accelerate the conversion of grassland to desert in response to the changing climate. For similar reasons, some forests may change to desert or grassland.

The 2011 drought contributed to widespread wildfires in Texas, like this one behind the McDonald Observatory near Fort Davis. Credit: Frank Cianciolo, McDonald Observatory.

Hot Weather, Air Pollution, and Human Health

Hot days can be unhealthy—even dangerous. Seventy years from now, Texas is likely to have three or four times as many days per year above 100°F as it has today. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems.

Warmer air can also increase the formation of ground-level ozone, a key component of smog. Ozone has a variety of health effects, aggravates lung diseases such as asthma, and increases the risk of premature death from heart or lung disease. EPA and the Texas Commission on Environmental Quality have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will be more difficult.

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EPA United States Environmental Protection Agency

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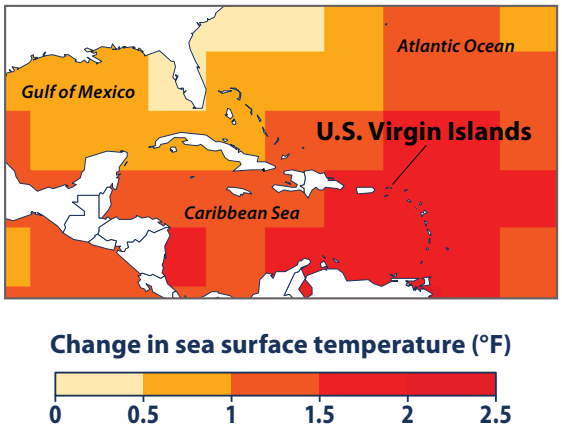
What Climate Change *Means for the* U.S. Virgin Islands

The climate of the **U.S. Virgin Islands** is changing. The air and ocean are warming, heavy rainstorms are becoming more severe, sea level is rising, and the ocean is becoming more acidic. In the coming decades, these environmental changes are likely to increase threats to life and property from severe storms, reduce the availability of fresh water during the dry season, harm or destroy much of the islands' coral reef ecosystems, and make air temperatures uncomfortably hot more often.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms—but also contributes to drought.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. Worldwide, the surface of the ocean has warmed about one degree during the last 80 years. Warming is causing mountain glaciers to retreat, and even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising sea surface temperatures since 1901. The waters around the U.S. Virgin Islands have warmed by nearly two degrees. Source: EPA, Climate Change Indicators in the United States.

Ocean Warming and Sea Level Rise

The waters around the U.S. Virgin Islands have warmed by nearly two degrees since 1901, and sea level has been rising by about an inch every ten years. As the oceans and atmosphere continue to warm, sea level is likely to rise one to three feet in the next century. Rising sea level submerges marshes, mangroves, and dry land; erodes beaches; and exacerbates coastal flooding. Although most of the territory is well above sea level, the waterfront blocks of Charlotte Amalie are generally within three or four feet of sea level.

Eroding shoreline at Cinnamon Bay on St. John. Credit: Elizabeth Pendleton, U.S. Geological Survey.

Coral Reefs and Ocean Acidification

In the next several decades, warming waters are likely to harm most coral reefs, and widespread loss of coral is likely due to warming and increasing acidity of coastal waters. Rising water temperatures can harm the algae that live inside corals and provide food for them. This loss of algae weakens corals and can eventually kill them. This process is commonly known as "coral bleaching" because the loss of algae also causes corals to turn white.

Increasing acidity can also damage corals. Ocean acidity has increased by about 25 percent in the past three centuries, and it is likely to increase another 40 to 50 percent by 2100. As the ocean becomes more acidic, corals are less able to remove minerals from the water to build their skeletons. Shellfish and other organisms also depend on these minerals, and acidity interferes with their ability to build protective skeletons and shells.

Warming and acidification could harm the U.S. Virgin Islands' marine ecosystems and economic activities that depend on them. Coral reefs provide critical habitat for a diverse range of species, while shellfish and small shell-producing plankton are an important source of food for larger animals. Healthy reefs and fish populations support fisheries and tourism.

Storms, Homes, and Infrastructure

Tropical storms and hurricanes have become more intense during the past 20 years. Although warming oceans provide these storms with more potential energy, scientists are not sure whether the recent intensification reflects a long-term trend. Nevertheless, hurricane wind speeds and rainfall rates are likely to increase as the climate continues to warm.

Towns, roads, and ports in the U.S. Virgin Islands are vulnerable to the impacts of both winds and water during storms. Greater wind speeds and the resulting damages can make insurance for wind damage more expensive or difficult to obtain. Coastal homes and infrastructure are likely to flood more often as sea level rises because storm surges will become higher as well. As a result, rising sea level is likely to increase flood insurance premiums for people living along the coast.

The changing climate is also likely to increase inland flooding. Rainfall during heavy storms has increased by 33 percent in neighboring Puerto Rico since 1958, and similar trends have been seen throughout the Caribbean. The trend toward increasingly heavy rainstorms is likely to continue. More intense rainstorms can increase flooding as dry guts resemble rivers more frequently, and more water accumulates in low-lying areas that drain slowly. In 2010, for example, flash flooding washed out sections of roadway in Frederiksted.

Flooding in Frederiksted on St. Croix in November 2010. © StCroixSource.com, used by permission.

Water Resources

Although heavy rainstorms have become more common, shifting weather patterns have caused total rainfall to decrease in the Caribbean region. Total rainfall is likely to continue to decrease, especially during spring and summer. Warmer temperatures also reduce the amount of water available because they increase the rate at which water evaporates (or transpires) into the air from soils, plants, and surface waters. With less rain and drier soils, the U.S. Virgin Islands may face an increased risk of drought, which in turn can affect water supplies, agriculture, and the economy. For example, during the 2015 drought, farmers lost crops and livestock, and some residents could no longer depend on rainwater collection or ground water, and had to instead rely on water from desalination plants, delivered by truck.

Forests

Warmer temperatures and changes in rainfall could expand, shrink, or shift the ranges of forest plants and animals, depending on the conditions that each species requires. For example, as summer rainfall decreases, plant species that prefer drier conditions could move into areas once dominated by wet forest species. Many tropical plants and animals live in places where the temperature range is fairly steady year-round, so they cannot necessarily tolerate significant changes in temperature.

Agriculture

Higher temperatures are likely to interfere with agricultural productivity in the U.S. Virgin Islands. Hot temperatures threaten animals' health and cause them to eat less and grow more slowly. Reduced water availability during the dry season could stress crops, while warmer temperatures could also reduce yields of certain crops. Studies in other tropical countries indicate that climate change may reduce plantain and banana yields. If storms become more severe, sugar cane crops in neighboring countries may be harmed more often, which could affect the availability of imported molasses for the rum industry.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. Rising temperatures will increase the frequency of hot days and warm nights. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems. Warm nights are especially dangerous because they prevent the human body from cooling after a hot day. Although reliable long-term temperature records for the U.S. Virgin Islands are unavailable, the frequency of warm nights in nearby Puerto Rico has increased by about 50 percent since 1950.

The U.S. Virgin Islands' climate is suitable for mosquito species that carry diseases such as malaria, yellow fever, and dengue fever. While the transmission of disease depends on a variety of conditions, higher air temperatures are likely to accelerate the mosquito life cycle and the rate at which viruses replicate in mosquitoes.

The warm marine environment of the Virgin Islands helps promote some water-related illnesses: Vibriosis is a bacterial infection that can come from direct contact with contaminated water or eating infected shellfish. Ciguatera poisoning comes from eating fish that contain a toxic substance produced by a type of algae found in this area. Higher water temperatures can increase the growth of these bacteria and algae, which may increase the risk of these associated illnesses.

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EPA United States Environmental Protection Agency

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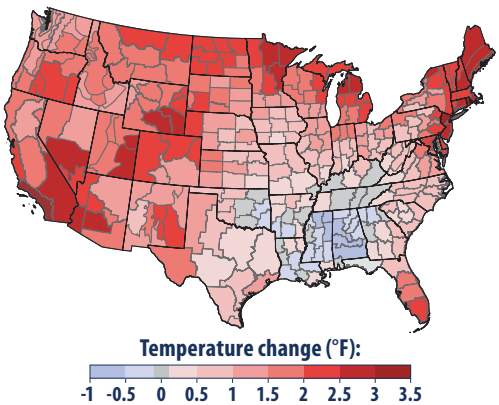
EPA 430-F-16-046

What Climate Change Means for Utah

Utah's climate is changing. The state has warmed about two degrees (F) in the last century. Throughout the western United States, heat waves are becoming more common, and snow is melting earlier in spring. In the coming decades, the changing climate is likely to decrease the flow of water in Utah's rivers, increase the frequency and intensity of wildfires, and decrease the productivity of ranches and farms.

Our climate is changing because Earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring.



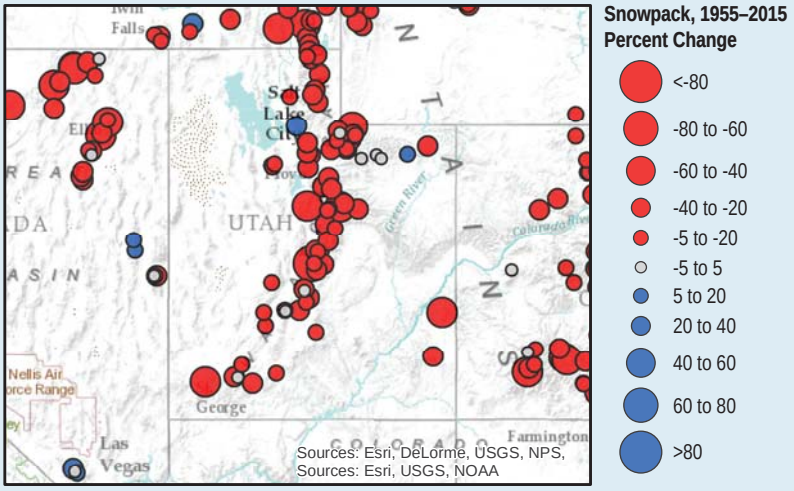
Rising temperatures in the last century. The last decade was the warmest on record throughout the West. Source: EPA, Climate Change Indicators in the United States.

Snowpack

As the climate warms, less precipitation falls as snow, and more snow melts during the winter. That decreases snowpack—the amount of snow that accumulates over the winter. Since the 1950s, the snowpack has been decreasing in Utah, as well as Wyoming and Colorado, which contribute snowmelt to the Green and Colorado rivers.

Diminishing snowpack can shorten the season for skiing and other forms of winter tourism and recreation. The tree line may shift, as subalpine fir and other high-altitude trees become able to grow at higher elevations. A higher tree line would decrease the extent of alpine tundra ecosystems, which could threaten some species.

A surveyor measures the depth of the snowpack at Mt. Baldy on the Wasatch Plateau in April 2015. The map below shows the results of many years of this type of measurement. Credit: Jordan Clayton, USDA Natural Resources Conservation Service.



Trends in April snowpack, 1955–2013. Snowpack has declined at most monitoring sites in Utah and the Upper Colorado River Basin. Source: EPA.

Water Availability

The changing climate is likely to increase the need for water but reduce the supply. Rising temperatures increase the rate at which water evaporates (or transpires) into the air from soils, plants, and surface waters. Soils are likely to be drier in most of the state, so irrigated farmland would need more water. But less water is likely to be available, because precipitation is unlikely to increase as much as evaporation.

The decline in snowpack could further limit the supply of water for some purposes. Mountain snowpacks are natural reservoirs. They collect the snow that falls during winter and release water when the snow melts during spring and summer. Over the past 50 years, snowpack has been melting earlier in the year. Dams capture most meltwater and retain it for use later in the year. But upstream of these reservoirs, less water is available during droughts for ecosystems, fish, water-based recreation, and landowners who draw water directly from a flowing river.

Agriculture

Increasing droughts and higher temperatures are likely to interfere with Utah's farms and cattle ranches. Hot temperatures threaten cows' health and cause them to eat less, grow more slowly, and produce less milk. Fire may also impair livestock operations. Reduced water availability would create challenges for ranches and irrigated farms, which account for 80 percent of the water used in the state.

Wildfires and Changing Landscapes

Higher temperatures and drought are likely to increase the severity, frequency, and extent of wildfires, which could harm property, livelihoods, and human health. The Milford Flat Fire in 2007 was the largest wildfire ever recorded in Utah. Wildfire smoke can reduce air quality and increase medical visits for chest pains, respiratory problems, and heart problems.

The combination of more fires and drier conditions may expand deserts and otherwise change parts of Utah's landscape. Many plants and animals living in arid lands are already near the limits of what they can tolerate. Higher temperatures and a drier climate would generally extend the Great Basin desert to higher elevations and expand its geographic range. In some cases, native vegetation may persist and delay or prevent expansion of the desert. In other cases, fires or livestock grazing may accelerate the conversion of grassland to desert in response to the changing climate. For similar reasons, some forests may change to desert or grassland.

Pests

Warmer and drier conditions make forests more susceptible to pests. Drought reduces the ability of trees to mount a defense against attacks from pests such as bark beetles, which infested 50,000 acres of Utah's forests in 2012. Temperature controls the life cycle and winter mortality rates of many pests. With higher winter temperatures, some pests can persist year-round, and new pests and diseases may become established.

In Utah's Uinta-Wasatch-Cache National Forest, bark beetles have killed more than 90 percent of the trees in some areas. Credit: Brendan Waterman, USDA Forest Service.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular, respiratory, and nervous systems. Higher temperatures are amplified in urban settings where paved and other surfaces tend to store heat. Construction crews may have to alter their work schedules to avoid the heat of the day.

Rising temperatures can also increase the formation of ground-level ozone, a key component of smog. Ozone has a variety of health effects, aggravates lung diseases such as asthma, and increases the risk of premature death from heart or lung disease. EPA and the Utah Department of Environmental Quality have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will be more difficult.

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United States Environmental Protection Agency

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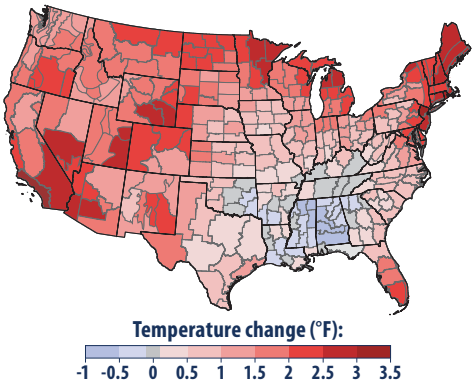
EPA 430-F-16-047

What Climate Change Means for Vermont

Vermont's climate is changing. The state has warmed by more than two degrees (F) in the last century. Throughout the northeastern United States, spring is arriving earlier and bringing more precipitation, heavy rainstorms are more frequent, and summers are hotter and drier. Severe storms increasingly cause floods that damage property and infrastructure. In the coming decades, changing climate is likely to harm ecosystems, disrupt agriculture and winter recreation, and increase some risks to human health.

Climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, causing river floods to occur earlier in the year.



Rising temperatures in the last century. Vermont has warmed almost twice as much as the rest of the contiguous 48 states. Source: EPA, Climate Change Indicators in the United States.

Increasing Temperature and Changing Precipitation Patterns

Rising temperatures and shifting rainfall patterns are likely to increase the intensity of both floods and droughts. Average annual precipitation in the Northeast increased 10 percent from 1895 to 2011, and precipitation from extremely heavy storms has increased 70 percent since 1958. During the next century, average annual precipitation and the frequency of heavy downpours are likely to keep rising. Average precipitation is likely to increase during winter and spring, but not change significantly during summer and fall. Rising temperatures will melt snow earlier in spring and increase evaporation, and thereby dry the soil during summer and fall. So flooding is likely to be worse during winter and spring, and droughts worse during summer and fall.

In 2011, Hurricane Irene caused major flooding and damaged infrastructure across Vermont, including this section of Route 107 in Stockbridge. Heavy storms are becoming more common as a result of climate change. Credit: Vermont Agency of Transportation.

Ecosystems

Changing climate threatens ecosystems by disrupting relationships between species. Wildflowers and woody perennials are blooming—and migratory birds are arriving—sooner in spring. Not all species adjust in the same way, however, so the food that one species needs may no longer be available when that species arrives on its migration. Warmer temperatures allow deer populations to increase, leading to a loss of forest underbrush, which makes some animals more vulnerable to predators.

Climate change can allow invasive species to expand their ranges. For example, the hemlock woolly adelgid has infested hemlock trees in southern Vermont. Infestation eventually kills almost all hemlock trees, which are replaced by black oaks, black birch, and other hardwoods. Warmer temperatures are likely to enable the woolly adelgid to expand northward. The loss of hemlock trees would remove the primary habitat for the blue-headed vireo and Blackburnian warbler. It could also change stream temperatures and cause streams to run dry more often, harming brook trout and brown trout.

Agriculture

Changing climate may reduce the output of Vermont's $700-million dairy industry, which provides 70 percent of the state's farm revenue. Higher temperatures cause cows to eat less and produce less milk. Climate change may also pose challenges for field crops: Some farms may be harmed if more hot days and droughts reduce crop yields, or if more flooding and wetter springs delay their planting dates. Other farms may benefit from a longer growing season and the fertilizing effect of carbon dioxide.

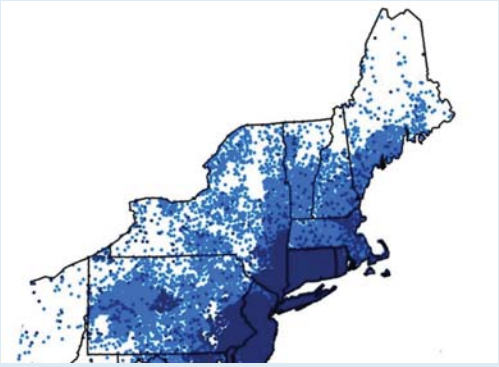
Warmer temperatures are likely to shift the suitable habitat for sugar maples farther north into Canada. Scientists do not know whether warming will reduce maple syrup production in Vermont over the next few decades: although Vermont is the nation's leading maple syrup producer, maple syrup is also produced in warmer places in Pennsylvania and southern New York.

Human Health

Climate change is likely to amplify some of the existing threats to health in Vermont. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

Warmer weather could increase the incidence of some diseases carried by insects and some respiratory conditions. The ticks that transmit Lyme disease are active when temperatures are above 45°F, so warmer winters could lengthen the season during which ticks can become infected or people can be exposed to the ticks.

Rising temperatures may also increase the length and severity of the pollen season for plants such as ragweed, which has already been observed in other regions.



Increase in Lyme disease between 1996 and 2013. Each dark dot shows one case reported in 1996; light dots show 2013. The increased range shown here has been attributed to factors other than climate change. Nevertheless, additional warming will lengthen the season during which people are exposed to Lyme disease and may allow the disease to spread to colder areas. Source: CDC.

Winter Recreation

Warmer winters may bring more rain and less snow to Vermont. A decline in snowfall would shorten the season during which the ground is covered with snow, which could harm recreational industries like skiing, snowboarding, and snowmobiling, and local economies that depend on them.

During the warm winter of 2015–2016, ski areas had less snow and fewer visitors than during a normal season, which forced several resorts to close early. This photo shows Mad River Glen's final day of skiing in mid-March. Credit: Eric Friedman, Mad River Glen.

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EPA United States Environmental Protection Agency

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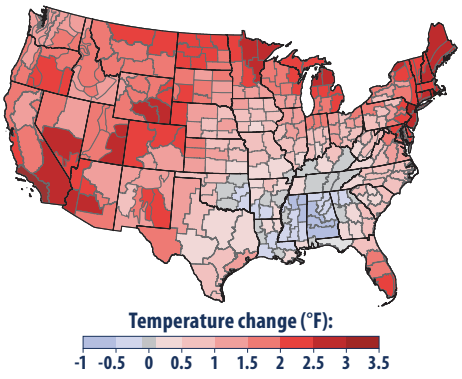
What Climate Change *Means for* Virginia

Virginia's climate is changing. Most of the state has warmed about one degree (F) in the last century, and the sea is rising one to two inches every decade. Higher water levels are eroding beaches, submerging low lands, exacerbating coastal flooding, and increasing the salinity of estuaries and aquifers. The southeastern United States has warmed less than most of the nation. But in the coming decades, the region's changing climate is likely to reduce crop yields, harm livestock, increase the number of unpleasantly hot days, and increase the risk of heat stroke and other heat-related illnesses.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. The eastern half of Virginia has warmed more than the western half. Source: EPA, Climate Change Indicators in the United States.

Rising Seas and Retreating Shores

Sea level is rising more rapidly along Virginia's shores than in most coastal areas because the land is sinking. If the oceans and atmosphere continue to warm, sea level along the Virginia coast is likely to rise sixteen inches to four feet in the next century.

Oceanfront houses in Virginia Beach are vulnerable to severe storms, flooding, and coastal erosion. © James G. Titus; used by permission.

As sea level rises, the lowest dry lands are submerged and become either tidal wetland or open water. The freshwater wetlands in the upper tidal portions of the Potomac, Rappahannock, York, and James rivers build their own land by capturing floating sediments, and they are likely to keep pace with the rising sea during the next century. But most salt marshes along the brackish portions of those rivers and along Chesapeake Bay are unlikely to keep pace if sea level rises three feet. The wetlands of Back Bay and the North Landing River are even more vulnerable and may be lost if the sea rises two feet.

Beaches also erode as sea level rises. A higher ocean level makes it more likely that storm waters will wash over a barrier island or open new inlets. The United States Geological Survey estimates that Virginia's barrier islands could be broken up by new inlets or lost to erosion if sea level rises two feet by the year 2100. Beach erosion will threaten the oceanfront portion of Virginia Beach, unless people take measures to offset the erosion. Rising sea level also threatens bay beaches and tidal flats.

Saltwater Intrusion

As sea level rises, salt water can mix farther inland or upstream in bays, rivers, and wetlands. Because water on the surface is connected to ground water, salt water can also intrude into aquifers near the coast. Soils may become too salty for farms or forests. For example, some of the freshwater swamps along the York River's tidal tributaries have standing dead trees that were killed by saltwater intrusion made possible by rising sea level.

Storms, Homes, and Infrastructure

Tropical storms and hurricanes have become more intense during the past 20 years. Although warming oceans provide these storms with more potential energy, scientists are not sure whether the recent intensification reflects a long-term trend. Nevertheless, hurricane wind speeds and rainfall rates are likely to increase as the climate continues to warm.

Whether or not storms become more intense, coastal homes and infrastructure will flood more often as sea level rises, because storm surges will become higher as well. Many roads, railways, and ports are vulnerable to the impacts of storms and sea level rise, and most of the heavily populated Hampton Roads area could be flooded by a major hurricane. Poquoson and a few other communities along Chesapeake Bay are so low that water in roadside ditches rises and falls with the tides. As sea level rises and storms possibly become more severe, homes and infrastructure in these communities will flood more frequently. As a result, rising sea level is likely to increase flood insurance rates, while more frequent storms could increase the deductible for wind damage in homeowner insurance policies.

Increased rainfall could further exacerbate flooding in both coastal and inland areas. The amount of precipitation during very heavy storms increased by 27 percent between 1958 and 2012 in the Southeast, and the trend toward increasingly severe rainstorms is likely to continue.

The rising sea threatens low-lying coastal towns such as Tangier, which is less than five feet above sea level. © James G. Titus; used by permission.

Coastal Ecosystems

The loss of tidal marshes could harm fish and birds that depend on a marsh for food or shelter. Marine organisms and small insects that feed in marshes are key sources of food for crabs, rockfish, and other commercially important fisheries. Striped bass, bluefish, sea trout, and summer flounder move into and out of marshes for food and shelter. Many birds inhabit the most vulnerable marshes along Chesapeake Bay, including great blue heron, bald eagle, American black duck, and snowy egret.

Marshes along the Atlantic coast provide forage for shorebirds, such as sandpipers and plovers, and several species of ducks and geese spend the winter in these marshes.

The loss of bay beaches would remove key habitat for diamondback terrapin, which nest on these beaches. Other species that depend on bay beaches include horseshoe crabs, tiger beetles, sand fleas, snails, and several crab species. The loss of those species would remove important sources of food for birds.

Changing temperatures could also disrupt ecosystems. If water temperatures exceed 86°F during summer, eelgrass could be lost, which would remove habitat for summer flounder, blue crab, and bay scallop. Brants, canvasback ducks, and American black ducks would also lose a food source.

Agriculture

Changing the climate will have both harmful and beneficial effects on farming. Higher temperatures are likely to reduce livestock productivity, because heat stress disrupts the animals' metabolism. In the next few decades, hotter summers are likely to reduce yields of corn. But higher concentrations of atmospheric carbon dioxide increase crop yields, and that fertilizing effect is likely to offset the harmful effects of heat on cotton, soybeans, wheat, and peanuts—assuming that adequate water is available. Rising temperatures are likely to increase the need for irrigation, and where water is scarce, increasingly severe droughts are likely to reduce crop yields.

Energy

Seventy years from now, temperatures are likely to rise above 95°F approximately 20 to 40 days per year in the southeastern half of Virginia, compared with about 10 days per year today. Warmer temperatures will increase the use of air-conditioning, which will increase electricity consumption.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Warmer temperatures can also increase the formation of ground-level ozone, a key component of smog. Because ozone has a variety of health effects, aggravates lung diseases such as asthma, and increases the risk of premature death from heart or lung disease, EPA and the Virginia Department of Environmental Quality have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will be more difficult.

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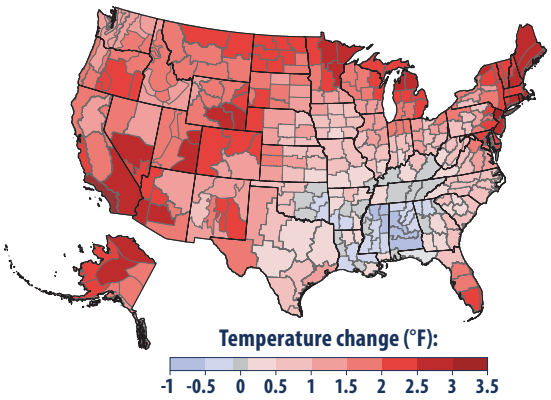
What Climate Change *Means for* Washington

Washington's climate is changing. Over the past century, most of the state has warmed one to two degrees (F). Glaciers are retreating, the snowpack is melting earlier in the year, and the flow of meltwater into streams during summer is declining. In the coming decades, coastal waters will become more acidic, streams will be warmer, populations of several fish species will decline, and wildfires may be more common.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



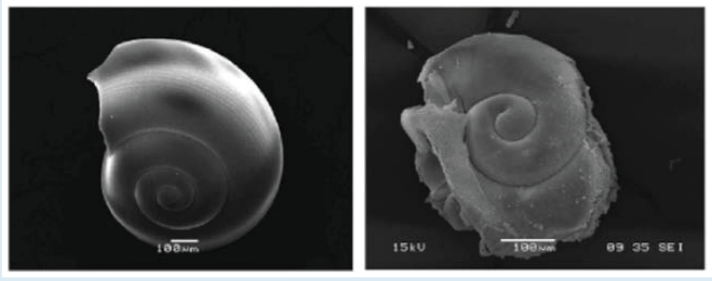
Rising temperatures in the last century. The warming in Washington has been similar to the average warming nationwide. Source: EPA, Climate Change Indicators in the United States.

Marine and Coastal Ecosystems

Rising water temperatures, increasing ocean acidity, and changes in the marine ecosystem will amplify observed losses in commercially and recreationally important fish stocks in the region in the 21st century. Credit: NOAA.

Washington's coastal waters are vulnerable to acidification. The ocean here is more acidic than most of the ocean, because nearby currents bring relatively acidic water from the deep ocean to the surface, especially during spring and summer. Increasing acidity impairs the ability of some types of shellfish to capture minerals in the water to build their shells, which can lead to thinner shells—or even prevent shells from forming. Oyster hatcheries in Washington are becoming less productive, because the water they draw from along the shore has become more acidic and corrosive, partly because of higher atmospheric carbon dioxide. Acidity also thins the exoskeletons of many species of plankton, which could reduce the population of those plankton and the fish that feed on them, and alter the entire marine food web. For example, young salmon eat some of the types of shellfish and plankton that are vulnerable to acidification.

Rising ocean temperatures may also harm marine ecosystems. Warming waters can increase the frequency of toxic algae blooms (such as "red tide") that cause shellfish poisoning and lead to closures of beaches and shellfish beds. Warmer waters also allow invasive species from southern waters to move northward.



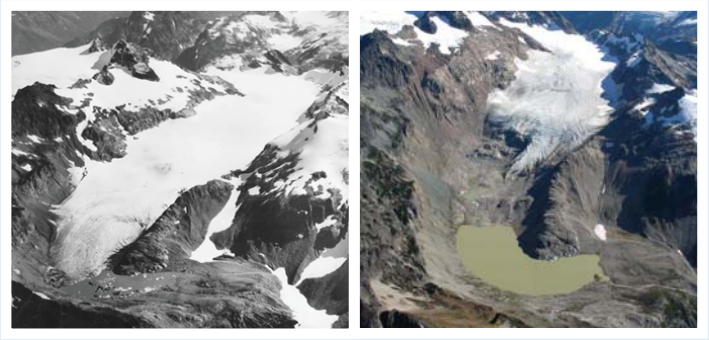
Pteropods, or "sea butterflies," are small free-swimming sea snails. They are an important source of food for North Pacific juvenile salmon, as well as whales and other marine species. The left panel shows a shell collected from a live pteropod from a region where acidity is not yet very high. The shell on the right is from a pteropod collected in a region where waters have acidified. Credit: Nina Bednaršek, NOAA.

Impacts of Sea Level Rise

Sea level rise will threaten coastal development and ecosystems. Erosion will threaten homes and public property along the shore. Increased flooding could threaten wastewater treatment plants, ferry terminals, highways, and railroads along Puget Sound. Mudflats, marshes, and other tidal wetlands provide habitat for birds and fish. As water levels rise, wetlands may be submerged or squeezed between the rising sea and structures built to protect coastal development.

Glacial Retreat

Three thousand glaciers cover about 170 square miles of mountains in Washington, but that area is decreasing in response to warmer temperatures. For example, South Cascade Glacier has decreased in size since the 1950s, with an accelerated rate of decline in recent years.



Aerial views of South Cascade Glacier in September 1955 (left) and September 2004 (right). Credits: Austin Post, USGS (left); © John Scurlock, used by permission (right).

Snowpack, Streamflows, and Water Availability

The flows of water in rivers and streams are increasing during late winter and early spring but decreasing during summer. Warmer winters have reduced average snowpack in Washington by 20 percent since 1950. The snowpack is now melting a few weeks earlier than during the 20th century, and, by 2050, it is likely to melt three to four weeks earlier. Decreasing snowpack means there will be less water flowing through streams during summer. Moreover, rising temperatures increase the rate at which water evaporates (or transpires) into the air from soils and plants. More evaporation means that less water will drain from the ground into rivers and streams.

Declining snow and streamflow would harm some economic sectors and aquatic ecosystems. Less snow means a shorter season for skiing and other winter recreation. Water temperatures will rise, which would hurt Chinook and sockeye salmon in the interior Columbia River Basin. The combination of warmer water and lower flows would threaten salmon, steelhead, and trout. Lower flows would also mean less hydroelectric power.

Drought and Wildfires

Changing the climate is likely to more than double the area in the Northwest burned by forest fires during an average year by the end of the 21st century. Although drier soils increase the risk of wildfire, other factors also contribute to fires, and forests in the Western Cascades may be less vulnerable to climate change than those in the Eastern Cascades. Higher temperatures and a lack of water can also make trees more susceptible to pests and disease, and trees damaged or killed burn more readily than living trees. Changing climate is likely to increase the area of pine forests in the Northwest infested with mountain pine beetles over the next few decades. Pine beetles and wildfires are each likely to decrease timber harvests. Increasing wildfires also threaten homes and pollute the air.

Agriculture

The changing climate will affect Washington's agricultural sector, particularly fruits and vegetables, which often require irrigation. Because streams rather than ground water provide most of Washington's irrigation water, the expected decline in streamflow would reduce the water available for irrigation. About two-thirds of the nation's apples come from Washington, and most are grown east of the Cascade Mountains where the dry climate requires irrigation. The Washington Department of Ecology is concerned that yields of apples and cherries may decline in the Yakima River Basin as water becomes less available. Alfalfa, potato, and wheat farmers also require substantial irrigation.

Health and Vulnerable People

Climate change is likely to amplify some threats to health in Washington. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

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United States Environmental Protection Agency

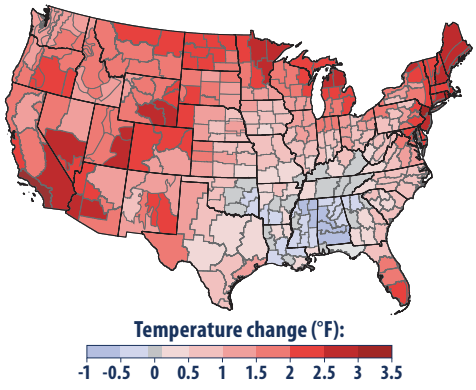
August 2016
EPA 430-F-16-050

What Climate Change *Means for* West Virginia

West Virginia's climate is changing. Most of the state has warmed one-half to one degree (F) in the last century, and heavy rainstorms are becoming more frequent. In the coming decades, a changing climate is likely to increase flooding, harm ecosystems, increase some health problems, and possibly threaten some recreational activities.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years, and sea level is rising at an increasing rate. Warming is causing snow to melt earlier in spring.



Rising temperatures in the last century. All regions of West Virginia have warmed, though they have warmed less than most of the United States. Source: EPA, Climate Change Indicators in the United States.

Increasing Temperature and Changing Precipitation Patterns

Rising temperatures and shifting rainfall patterns are likely to increase the intensity of both floods and droughts. Annual precipitation in most of West Virginia has increased since the first half of the 20th century, and precipitation from extremely heavy storms in the eastern United States has increased by more than 25 percent since 1958. During the next century, average annual precipitation and the frequency of heavy downpours are likely to keep rising. Average precipitation is likely to increase during winter and spring but not change significantly during summer and fall. Rising temperatures will melt snow earlier in spring and increase evaporation, and thereby dry the soil during summer and fall. As a result, changing the climate is likely to intensify flooding during winter and spring, and droughts during summer and fall.

Flooding, Drought, and Navigation

Flooding occasionally threatens riverfront communities, and heavier storms and greater river flows could increase this threat. The U.S. Army Corps of Engineers operates dozens of dams and reservoirs to help prevent serious floods in West Virginia. Nevertheless, dams and other flood control structures cannot prevent all floods. In recent decades, the state has had flood-related disaster declarations nearly every year. These disasters have often been associated with heavy rainstorms that also caused landslides and mudslides.

Floodwaters from the Little Kanawha River in Parkersburg. Credit: Ed Hupp, Wood County Emergency Management.

Meanwhile, increasingly severe droughts in West Virginia and nearby states could pose challenges for transportation on major rivers like the Ohio and the Kanawha. In 2005, a drought closed portions of the lower Ohio River to commercial navigation, which delayed shipments of products to and from West Virginia and adjacent states.

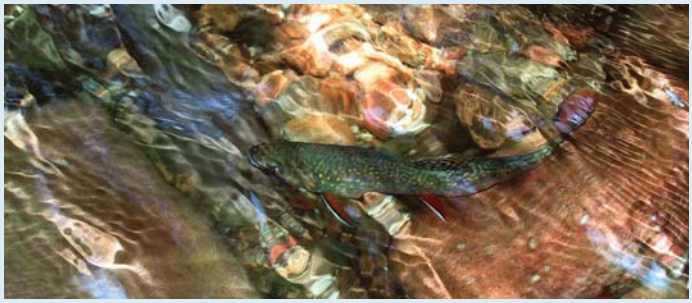
Ecosystems

A changing climate threatens ecosystems by disrupting the existing relationships between species. Wildflowers and woody perennials are blooming—and migratory birds are arriving—sooner in spring. Not all species adjust in the same way, however, so the food that one species needs may no longer be available when that species arrives on its migration. This can lead to animals not getting enough food. Warmer temperatures allow deer populations to increase, leading to a loss of forest underbrush, which, in turn, makes some animals more vulnerable to predators. Rising temperatures also enable invasive species to move into areas that were previously too cold.

Rising temperatures and changing precipitation could also harm aquatic ecosystems. Warmer water lowers the level of dissolved oxygen in surface water, which can severely limit fish populations. Because fish cannot regulate their body temperatures, warmer water can make a stream uninhabitable for fish that require cooler water. Warmer water can also increase the frequency of algal blooms, which can be toxic and further reduce dissolved oxygen. Summer droughts may amplify these effects, while periods of extreme rainfall can cause runoff that increases pollution in streams.

Recreation

Recreation and related tourism in West Virginia are closely tied to the weather. Many people enjoy whitewater rafting on West Virginia's rivers every year, including more than 60,000 on the Gauley River alone. The use of these rivers depends on the flow of water being sufficient for the thrilling rides that people seek. Native populations of brook trout, the official state fish, depend on West Virginia's mountain streams remaining cold. But suitable habitats for brook trout and other coldwater fish are likely to shrink as some streams become too warm to support them.



A native brook trout camouflaged against the rocky bottom of a cold West Virginia stream. Credit: Steve Brown, West Virginia Division of Natural Resources.

Higher temperatures are likely to shorten the season when the ground is covered by snow, and thereby shorten the season for skiing, snowboarding, and snowmobiling. Shorter seasons could harm local economies that depend on winter recreation. Increasingly heavy rains could increase pollution runoff and harm water qualify for fishing and swimming.

Forests and Farms

Rising temperatures and changes in rainfall are unlikely to substantially reduce forest cover in West Virginia, although the composition of those forests may change. More droughts would reduce forest productivity, and climate change is also likely to increase the damage from insects and disease. But longer growing seasons and increased carbon dioxide concentrations could more than offset the losses from those factors. Forests cover more than three-quarters of the state. Maple, beech, and birch are the most common tree species in the central part of the state, while oak and hickory dominate the forests elsewhere. As the climate changes, oak and hickory trees are likely to become more common in the central part of the state as well.

Climate change may also pose challenges for farmers. Longer frost-free growing seasons and increased concentrations of atmospheric carbon dioxide tend to increase yields for many crops during an average year. But more severe droughts and more hot days are likely to reduce yields. Higher temperatures are also likely to reduce livestock productivity: hot weather causes cows to eat less, grow more slowly, and produce less milk—and it can threaten their health.

Human Health

Hot days can be unhealthy—even dangerous. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

Changing the climate can harm air quality. The longer growing season may increase the length and severity of the pollen season for ragweed and other allergens. Higher temperatures increase the formation of ground-level ozone, a key component of smog that causes chronic and acute respiratory conditions. EPA and the West Virginia Department of Environmental Protection have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will be more difficult.

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United States Environmental Protection Agency

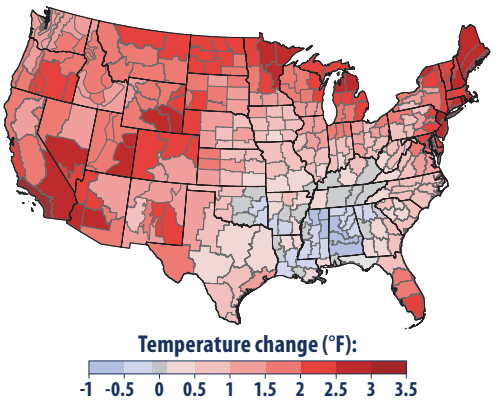
August 2016
EPA 430-F-16-051

What Climate Change *Means for* Wisconsin

Wisconsin's climate is changing. In the past century, most of the state has warmed about two degrees (F). Heavy rainstorms are becoming more frequent, and ice cover on the Great Lakes is forming later or melting sooner. In the coming decades, the state will have more extremely hot days, which may harm public health in urban areas and corn harvests in rural areas.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has also warmed about one degree during the last 80 years. Although warmer temperatures cause sea level to rise, the impact on water levels in the Great Lakes is not yet known. Warmer air also melts ice and snow earlier in spring.



Rising temperatures in the last century. All regions of Wisconsin have warmed. Source: EPA, Climate Change Indicators in the United States.

Heavy Precipitation and Flooding

Changing the climate is likely to increase the frequency of floods in Wisconsin. Over the last half century, average annual precipitation in most of the Midwest has increased by 5 to 10 percent. But rainfall during the four wettest days of the year has increased about 35 percent. During the next century, spring rainfall and annual precipitation are likely to increase, and severe rainstorms are likely to intensify. Each of these factors will tend to further increase the risk of flooding.

Flooding in Menominee County in 2014, caused by an ice jam in the Wolf River. Credit: National Weather Service.

Great Lakes

Changing the climate is also likely to harm water quality in Lake Michigan. Warmer water tends to cause more algal blooms, which can be unsightly, harm fish, and degrade water quality. Severe storms also increase the amount of pollutants that run off from land to water, so the risk of algal blooms will be greater if storms become more severe. Increasingly severe rainstorms could also cause sewers to overflow into the lake more often, threatening beach safety and drinking water supplies.

One advantage of climate change is that warmer winters reduce the number of days that ice prevents navigation. Between 1994 and 2011, the decline in ice cover lengthened the shipping season on the Great Lakes by eight days. The lakes are likely to warm another 3° to 7°F in the next 70 years, which will further extend the shipping season.

Winter Recreation

Ducks on Lake Mendota in Madison on a mild January day in 2015. Mendota is one of many lakes in the region that are freezing later and thawing earlier than they used to. Credit: Jeff Miller, University of Wisconsin–Madison.

Warmer winters are likely to shorten the season for recreational activities like ice fishing, snowmobiling, skiing, and snowboarding, which could harm the local economies that depend on them. Small lakes are freezing later and thawing earlier than a century ago, which shortens the season for ice fishing and ice skating. Since the early 1970s, winter ice coverage in the Great Lakes has decreased by 63 percent. The warmer climate is likely to shorten the season when the ground is covered by snow, and thereby shorten the season for activities that take place on snow. Nevertheless, annual snowfall has increased in much of the Great Lakes region, which could benefit winter recreation at certain times and locations.

Ecosystems

Changing the climate is likely to shift the ranges of plants and animals. For example, rising temperatures could change the composition of Wisconsin's forests. As the climate warms, the populations of paper birch, quaking aspen, balsam fir, and black spruce may decline in the North Woods, while oak, hickory, and pine trees may become more numerous. Climate change will also affect habitat for animals such as fish. Rising water temperatures will increase the available habitat for warmwater fish such as bass, while shrinking the available habitat for coldwater fish such as trout. Declining ice cover and increasingly severe storms would harm fish habitat through erosion and flooding.

Warming could also harm ecosystems by changing the timing of natural processes such as migration, reproduction, and flower blooming. Migratory birds are arriving in the Midwest earlier in spring today than 40 years ago. Along with range shifts, changes in timing can disrupt the intricate web of relationships between animals and their food sources and between plants and pollinators. Because not all species adjust to climate change in the same way, the food that one species eats may no longer be available when that species needs it (for example, when migrating birds arrive). Some types of animals may no longer be able to find enough food.

Agriculture

The changing climate may reduce the output of Wisconsin's multi-billion-dollar dairy industry, which generates more than half of the state's farm revenue. Higher temperatures cause cows to eat less and produce less milk. Climate change may also pose challenges for crops, but it could also have some benefits; the net effect is unknown. Longer frost-free growing seasons and higher concentrations of atmospheric carbon dioxide would increase yields of soybeans and wheat during an average year. But increasingly hot summers are likely to reduce yields of corn. Seventy years from now, much of Wisconsin is likely to have 5 to 10 more days per year with temperatures above 95°F than it has today. More severe droughts or floods would also hurt crop yields.

Air Pollution and Human Health

Changing the climate can harm air quality and amplify existing threats to human health. Higher temperatures increase the formation of ground-level ozone, a pollutant that causes lung and heart problems. Ozone also harms plants. In some rural parts of Wisconsin, ozone levels are high enough to reduce yields of soybeans and winter wheat. EPA and the Wisconsin Department of Natural Resources have been working to reduce ozone concentrations. As the climate changes, continued progress toward clean air will become more difficult.

Climate change may also increase the length and severity of the pollen season for allergy sufferers. For example, the ragweed season in Madison and La Crosse is two weeks longer than in 1995, because the first frost in fall is later. The risk of some diseases carried by insects may also increase. The ticks that transmit Lyme disease are active when temperatures are above 45°F, so warmer winters could lengthen the season during which ticks can become infected or people can be exposed to the ticks.

Hot days can be unhealthy—even dangerous. High temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Northern cities like Milwaukee are vulnerable to heat waves, because many houses and apartments lack air conditioning, and urban areas are typically warmer than their rural surroundings. For example, heat waves killed 91 people in Milwaukee County in 1995, and 11 people in 1999. Heat stress is likely to increase as climate change brings hotter summer temperatures and more humidity. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

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EPA United States Environmental Protection Agency

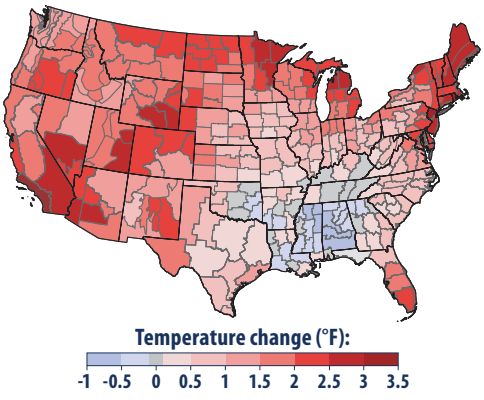
August 2016
EPA 430-F-16-052

What Climate Change *Means for* Wyoming

Wyoming's climate is changing. In the past century, most of the state has warmed by one to three degrees (F). Heat waves are becoming more common, and snow is melting earlier in spring. Rising temperatures and recent droughts have killed many trees by drying out soils, increasing the risk of forest fires, or enabling outbreaks of forest insects. In the coming decades, the changing climate is likely to decrease the availability of water in Wyoming, affect agricultural yields, and further increase the risk of wildfires.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree in the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

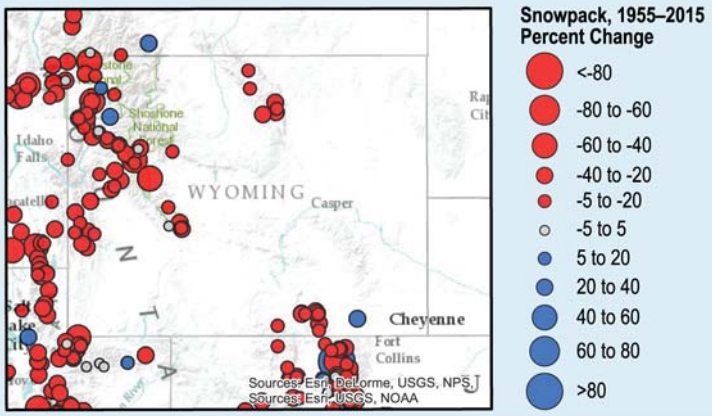
Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years, and sea level is rising at an increasing rate. Warming is causing snow to melt earlier in spring.



Rising temperatures in the last century. Wyoming has warmed more than most of the contiguous United States. Source: EPA, Climate Change Indicators in the United States.

Snowpack and Glaciers

As the climate warms, less precipitation falls as snow, and more snow melts during the winter. That decreases snowpack—the amount of snow that accumulates over the winter. Since the 1950s, the snowpack in Wyoming has been decreasing. Diminishing snowpack can shorten the season for skiing and other forms of winter tourism and recreation. The tree line may shift, as higher temperatures and a longer season without snow on the ground allow subalpine fir and other high-altitude trees to grow at higher elevations. A higher tree line would decrease the extent of alpine tundra ecosystems, which could threaten some species.



Trends in April snowpack in Wyoming, 1955–2013. The snowpack has declined at most monitoring sites in Wyoming. Source: EPA.

Wyoming's mountain ranges also contain 1,500 glaciers. As the climate warms, most of these glaciers will retreat and some could disappear altogether. Areas that are no longer covered by glaciers may still accumulate snowpack, but the snow will no longer remain year-round.

An unnamed glacier in the Wind River Range, along with some snowpack that has persisted into the summer. Credit: Sean D. Birkel, University of Maine.

Precipitation and Water Resources

The changing climate is likely to increase the need for water without necessarily increasing the supply. Rising temperatures increase the rate at which water evaporates (or transpires) into the air from soils, plants, and surface waters. Irrigated farmland would thus need more water. But less water is likely to be available in the Green River Basin, because precipitation is unlikely to increase enough to make up for the additional water lost to evaporation. In other parts of the state, annual rainfall is likely to increase on average, but soils are likely to become drier, and periods without rain may become longer, making droughts more severe. In southeastern Wyoming, drier soils could lead farmers to withdraw more water from the High Plains Aquifer, which is already being depleted in other parts of the Great Plains.

The decline in snowpack could further limit the supply of water. Mountain snowpacks are natural reservoirs that collect the snow that falls during winter and release water when the snow melts during spring and summer. Dams capture most meltwater and retain it for use later in the year. But as the snowpack declines, less water is available upstream of these dams during droughts for ecosystems, water-based recreation, and riparian landowners who draw water directly from a natural lake or flowing river.

Agriculture

Rising temperatures, drier soils, and changing water availability are likely to present challenges for Wyoming's farms and cattle ranches. Hot weather causes cows to eat less and grow more slowly, and it can threaten their health. Reduced water availability would create challenges for ranchers, as well as farmers who irrigate crops. Although warmer and shorter winters may allow for a longer growing season, they may also promote the growth of weeds and pests, and shorten the dormancy for many winter crops, which creates the potential for crop losses due to spring freezes.

Wildfires

Higher temperatures and drought are likely to increase the severity, frequency, and extent of wildfires in Wyoming, which could harm property, livelihoods, and human health. On average, about 1.4 percent of the land in the state has burned per decade since 1984. Wildfire smoke pollutes the air and can increase medical visits for chest pains, respiratory problems, and heart problems.

Cattle grazing after the 2012 Fontenelle Fire west of Big Piney. Credit: University of Wyoming Extension.

Forests

Longer growing seasons and increased carbon dioxide concentrations could increase the productivity of forests, but warmer, drier conditions also make forests more susceptible to pests. Temperature controls the life cycle and winter mortality rates of pests such as bark beetles, which have infested millions of acres and killed millions of trees across the West in recent decades. With higher winter temperatures, some pests can persist year-round, and new pests and diseases may become established. Drought also reduces the ability of trees to mount a defense against attacks from beetles and other pests.

Human Health

By 2050, Wyoming is likely to have twice as many days above 100°F as it has today. Extremely hot and cold days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. The elderly may be particularly prone to heat stress and other heat-related health problems, including dehydration, cardiovascular strain, and respiratory problems. Those with low incomes may be particularly vulnerable due to a lack of air conditioning. Power failures due to severe weather can also present risks, especially in lightly populated areas where access to necessary support services may be limited. While these risks will increase as the climate becomes warmer, illnesses, injuries, and deaths due to cold weather and snow are likely to decline.

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EPA United States Environmental Protection Agency

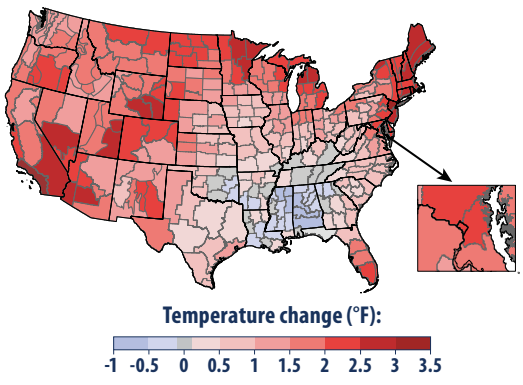
November 2016
EPA 430-F-16-064

What Climate Change *Means for the* District of Columbia

The **District of Columbia**'s climate is changing. The region has warmed by more than two degrees (F) in the last century, hot days and heavy rainstorms are more frequent, and the tidal Potomac is rising about one inch every eight years. In the coming decades, changing climate is likely to increase tidal flooding, cause more heavy rainstorms and sewer overflows, and increase some risks to human health.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. The surface of the ocean has warmed about one degree during the last 80 years. Warming is causing snow to melt earlier in spring, and mountain glaciers are retreating. Even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising temperatures in the last century. The District of Columbia has warmed more than most of the nation. Source: EPA, Climate Change Indicators in the United States.

Increasing Temperature and Changing Precipitation Patterns

Summer, fall, winter, and spring have all become warmer since the 1940s in the District of Columbia. Five of the six hottest summers on record have occurred since 2010. This trend is very likely to continue.

Rising temperatures and shifting rainfall patterns are likely to increase the intensity of both floods and droughts. Average annual precipitation in the DC area has increased by 5 to 10 percent in the last century, but precipitation from extremely heavy storms has increased by more than 25 percent across the eastern United States since 1958. Over the next century, average annual precipitation and the frequency of heavy downpours are likely to keep rising. During winter and spring, average precipitation is likely to increase. During summer and fall, precipitation is unlikely to change significantly, but rising temperatures will increase evaporation and thereby dry the soil. As a result, changing climate is likely to intensify flooding during winter and spring, and intensify drought during summer and fall.

Severe Storms, Flooding, and Wind Damage

As severe rainstorms become more frequent, flood damage to homes and other buildings is likely to increase. Most homes along the north side of Watts Branch—as well as Mayfair on the south side—are in the 100-year floodplain, and several homes and businesses along Oxon Run are also vulnerable to flash flooding. Almost all of the land in and adjacent to Federal Triangle is low-lying and vulnerable to flooding from severe rainstorms or high water levels in the Potomac River. During June 2006, a severe rainstorm flooded several federal buildings and museums around Federal Triangle and caused $10 million in damage across the region.

More heavy storms could also harm wastewater and other types of infrastructure. One-third of the District is served by a combined sewer system designed before 1900, which carries both sewage and stormwater in the same system of pipes. Heavy rainfall can overwhelm the system, forcing it to discharge raw sewage into the Anacostia River, Rock Creek, or the Potomac River. DC Water's Clean Rivers project is building wastewater treatment and stormwater storage facilities to reduce these sewer overflows. But capturing or treating all of this water will become more difficult if heavier storms release more water onto the city's streets, rooftops, and other impermeable surfaces. Storms can also harm transportation systems: for example, flash flooding temporarily closed the Cleveland Park Metro station in June 2016.

The changing climate may also increase damage caused by winds. Hurricanes and other tropical storms have become more intense during the past 20 years. Although warming oceans provide these storms with more potential energy, scientists are not sure whether the recent intensification reflects a long-term trend. Nevertheless, wind speeds and rainfall rates during hurricanes are likely to increase as the climate continues to warm. These storms can damage homes and disrupt power supplies and transportation networks. In 2003, Hurricane Isabel knocked down many trees throughout the District, and half of PEPCO's customers lost electric power—some for as long as a week. Downed power lines made many roads impassable in adjacent counties in Maryland. In 2011, Hurricane Irene also left hundreds of thousands of people without electric power in the Washington area.

Rising Sea Level and Tidal Inundation

Sea level is rising more rapidly along the shores of the Potomac and Anacostia rivers than along most shores because the land here is sinking. At the official tide gauge along the Southwest Waterfront, sea level has risen six or seven inches during the last 50 years. If the oceans and atmosphere continue to warm, sea level in the District is likely to rise sixteen inches to four feet in the next century.

As sea level rises, the lowest dry lands are submerged and become either tidal wetland or open water, while lands that are rarely flooded by the tides become flooded more frequently. The District has between one and two square miles of land within about three feet of the average high tide. These areas include most of Kenilworth Aquatic Gardens, the northern portion of Joint Base Anacostia-Bolling, and about half of East Potomac Park.

As sea level rises, occasional extreme high tides are able to reach farther inland. Most of the sidewalks along the Tidal Basin and part of the road to Hains Point in East Potomac Park, for example, are about one foot above the average daily high tide. This water level was only reached about six times per year during the 1950s, but now it is exceeded more than 30 times per year. By the time sea level rises one foot, these areas will be flooded during half the days of the year.

Although few homes in the District are close enough to sea level to be permanently submerged, sea level rise can exacerbate damage caused by storm surges and river flooding. A higher average water level in the Potomac and Anacostia provides a higher base for storm surges and river surges, which means that water pushed inland by storm winds could penetrate farther into adjacent dry land, as could flood waters from upstream. A higher water level also makes storm drains less effective.

Fishing at Hains Point in East Potomac Park (left) and flooding in the same area in September 2015 (right). Hains Point is one of several areas along the Potomac that could be regularly inundated at high tide as sea level rises. Credit: (left) James G. Titus, EPA; (right) NOAA.

Ecosystems

The tidal wetlands in the Washington area build their own land by capturing floating sediments, and they are generally likely to keep pace with the rising sea during the next century. Nonetheless, rising sea level could alter wetland habitat and harm fish and birds that depend on it for food or shelter. Areas at risk include freshwater marshes along tidal portions of the Anacostia River, where surveys have found nearly 200 bird species; marshes on Roosevelt Island; and other marshes downstream along the Potomac. The rise in sea level may also submerge parts of the swamp forest on Roosevelt Island.

Flooding at the Tidal Basin during cherry blossom season. As the climate changes, tidal flooding is occurring more often, while Washington's famous cherry trees are blooming earlier in the spring. Credit: National Park Service.

Rising temperatures are lengthening the growing season in the Mid-Atlantic region, and they could change the composition of woodlands and the timing of ecological processes. In many parts of our nation, wildflowers and woody perennials are blooming—and migratory birds are arriving—sooner in spring. Not all species adjust in the same way, however, so the food that one species needs may no longer be available when that species arrives on its migration. Washington's cherry trees are blooming earlier: since 1921, peak bloom dates have shifted earlier by approximately five days. The timing of the peak bloom is important to tourism and the local economy because the cherry blossoms draw more than one million people each year, many of whom are from out of town.

Human Health

Hot days can be unhealthy—even dangerous. Rising temperatures will increase the frequency of hot days and warm nights. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems. Warm nights are especially dangerous because they prevent the human body from cooling off after a hot day. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. Because the District of Columbia is warmer than surrounding areas, Washingtonians face a greater risk of heat-related illnesses—especially residents without air conditioning.

Warmer temperatures can increase the formation of ground-level ozone, a component of smog that can contribute to respiratory problems. Rising temperatures may also increase the length and severity of the pollen season for plants such as ragweed, which has already been observed in other regions.

The risk of some diseases may also increase. West Nile virus, transmitted by mosquitoes, could become more common due to rising temperatures, which speed up the mosquito life cycle and increase biting rates, as well as dry periods, which benefit the type of mosquito that transmits West Nile. But the effects are still uncertain and likely to vary by region. Increased flooding from more intense storms could lead to more indoor dampness and mold, which contribute to asthma, allergies, and respiratory infections.

The sources of information about climate and the impacts of climate change in this publication are: the national climate assessments by the U.S. Global Change Research Program, synthesis and assessment products by the U.S. Climate Change Science Program, assessment reports by the Intergovernmental Panel on Climate Change, and EPA's *Climate Change Indicators in the United States*. Mention of a particular season, location, species, or any other aspect of an impact does not imply anything about the likelihood or importance of aspects that are not mentioned. For more information about climate change science, impacts, responses, and what you can do, visit EPA's Climate Change website at www.epa.gov/climatechange.

EPA United States Environmental Protection Agency

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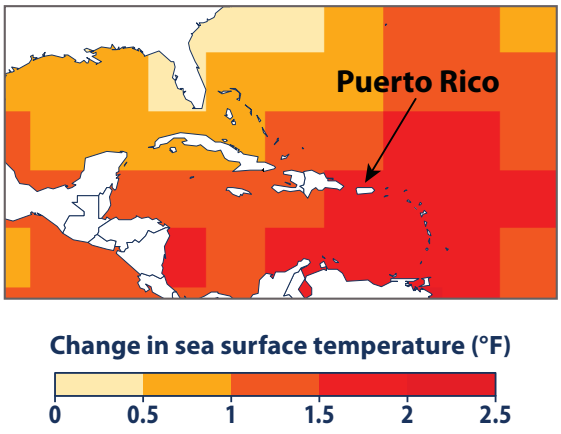
What Climate Change *Means for* Puerto Rico

Puerto Rico's climate is changing. The Commonwealth has warmed by more than one degree (F) since the mid-20th century, and the surrounding waters have warmed by nearly two degrees since 1901. The sea is rising about an inch every 15 years, and heavy rainstorms are becoming more severe. In the coming decades, rising temperatures are likely to increase storm damages, significantly harm coral reefs, and increase the frequency of unpleasantly hot days.

Our climate is changing because the earth is warming. People have increased the amount of carbon dioxide in the air by 40 percent since the late 1700s. Other heat-trapping greenhouse gases are also increasing. These gases have warmed the surface and lower atmosphere of our planet about one degree during the last 50 years. Evaporation increases as the atmosphere warms, which increases humidity, average rainfall, and the frequency of heavy rainstorms in many places—but contributes to drought in others.

Greenhouse gases are also changing the world's oceans and ice cover. Carbon dioxide reacts with water to form carbonic acid, so the oceans are becoming more acidic. Worldwide, the surface of the ocean has warmed about one degree during the last 80 years. Warming is causing mountain glaciers to retreat, and even the great ice sheets on Greenland and Antarctica are shrinking. Thus the sea is rising at an increasing rate.



Rising sea surface temperatures since 1901. The waters around Puerto Rico have warmed by nearly two degrees. Source: EPA, Climate Change Indicators in the United States.

Rising Seas and Retreating Shores

Sea level has risen by about four inches relative to Puerto Rico's shoreline since 1960. As the oceans and atmosphere continue to warm, sea level around Puerto Rico is likely to rise one to three feet in the next century. Rising sea level submerges marshes, mangroves, and dry land; erodes beaches; and exacerbates coastal flooding.

Storms, Homes, and Infrastructure

Tropical storms and hurricanes have become more intense during the past 20 years. Although warming oceans provide these storms with more potential energy, scientists are not sure whether the recent intensification reflects a long-term trend. Nevertheless, hurricane wind speeds and rainfall rates are likely to increase as the climate continues to warm.

Cities, roads, and ports in Puerto Rico are vulnerable to the impacts of both winds and water during storms. Greater wind speeds and the resulting damages can make insurance for wind damage more expensive or difficult to obtain. Coastal homes and infrastructure are likely to flood more often as sea level rises because storm surges will become higher as well. As a result, rising sea level is likely to increase flood insurance premiums for people living along the coast.

The changing climate is also likely to increase inland flooding. Since 1958, rainfall during heavy storms has increased by 33 percent in Puerto Rico, and the trend toward increasingly heavy rainstorms is likely to continue. More intense rainstorms can increase flooding as inland rivers overtop their banks more frequently, and more water accumulates in low-lying areas that drain slowly.

Storm surge in San Juan. Credit: Jorge Rodriguez/Creative Commons.

Water Resources

Although heavy rainstorms may become more common, total rainfall is likely to decrease in the Caribbean region, especially during spring and summer. Warmer temperatures also reduce the amount of water available because they increase the rate at which water evaporates (or transpires) into the air from soils, plants, and surface waters. With less rain and drier soils, Puerto Rico may face an increased risk of drought, which in turn can affect public water supplies, agriculture, and the economy. For example, during the 2015 drought—one of the worst in Puerto Rico's history—hundreds of thousands of people faced water restrictions, and some people's water was turned off for one or two days at a time.

Coral Reefs and Ocean Acidification

In the next several decades, warming waters are likely to harm most coral reefs, and widespread loss of coral is likely due to warming and increasing acidity of coastal waters. Rising water temperatures can harm the algae that live inside corals and provide food for them. This loss of algae weakens corals and can eventually kill them. This process is commonly known as "coral bleaching" because the loss of algae also causes corals to turn white.

Bleached corals off the coast of Puerto Rico. © Hector Ruiz; used by permission.

Increasing acidity can also damage corals. Ocean acidity has increased by about 25 percent in the past three centuries, and it is likely to increase another 40 to 50 percent by 2100. As the ocean becomes more acidic, corals are less able to remove minerals from the water to build their skeletons. Shellfish and other organisms also depend on these minerals, and acidity interferes with their ability to build protective skeletons and shells.

Warming and acidification could harm Puerto Rico's marine ecosystems and economic activities that depend on them. Coral reefs provide critical habitat for a diverse range of species, while shellfish and small shell-producing plankton are an important source of food for larger animals. Healthy reefs and fish populations support fisheries and tourism.

Ecosystems

Warmer temperatures and changes in rainfall could expand, shrink, or shift the ranges of various plants and animals in Puerto Rico's forests, depending on the conditions that each species requires. For example, as summer rainfall decreases, tree species that prefer drier conditions could move into areas once dominated by wet forest species. Other species might shift to higher altitudes. Many tropical plants and animals live in places where the temperature range is fairly steady year-round, so they cannot necessarily tolerate significant changes in temperature. Coqui frogs, bromeliads, mosses, and lichens are potentially vulnerable.

Freshwater ecosystems also face risks due to climate change. Rivers, streams, and lakes hold less dissolved oxygen as they get warmer, which can make conditions less hospitable for fish and other animals.

Agriculture

Higher temperatures are likely to interfere with agricultural productivity in Puerto Rico. Hot temperatures threaten cows' health and cause them to eat less, grow more slowly, and produce less milk. Reduced water availability during the dry season could stress crops, while warmer temperatures could also reduce yields of certain crops. Studies in other tropical countries indicate that climate change may reduce plantain, banana, and coffee yields.

Human Health

Hot days can be unhealthy—even dangerous. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor. Rising temperatures will increase the frequency of hot days and warm nights. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems. Warm nights are especially dangerous because they prevent the human body from cooling off after a hot day. Since 1950, the frequency of warm nights in Puerto Rico has increased by about 50 percent. Currently in San Juan, the overnight low is above 77 degrees about 10 percent of the time.

Puerto Rico's climate is suitable for mosquito species that carry diseases such as malaria, yellow fever, and dengue fever. While the transmission of disease depends on a variety of conditions, higher air temperatures will likely accelerate the mosquito life cycle and the rate at which viruses replicate in mosquitoes.

Certain types of water-related illnesses already occur in Puerto Rico, supported by its warm marine environment. These include vibriosis, a bacterial infection that can come from direct contact with water or eating infected shellfish, and ciguatera poisoning, which comes from eating fish that contain a toxic substance produced by a type of algae. Higher ocean temperatures can increase the growth of these bacteria and algae, which may increase the risk of these associated illnesses.

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