United States Environmental Protection Agency
Office of Policy (2111)
EPA 236-F-98-007v
September 1998

EPA Climate Change And Rhode Island

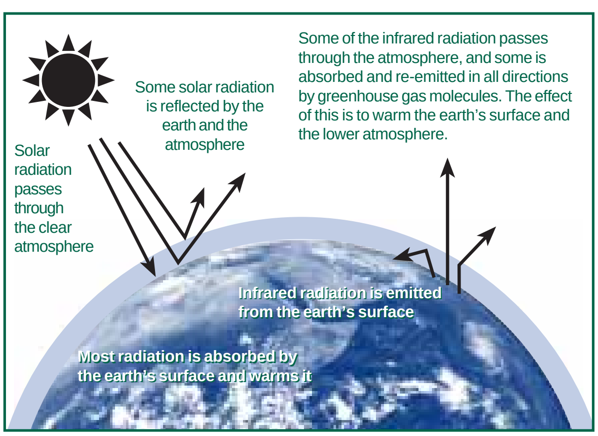
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed. Although there is uncertainty about exactly how and when the earth's climate will respond to enhanced concentrations of greenhouse gases, observations indicate that detectable changes are under way. There most likely will be increases in temperature and changes in precipitation, soil moisture, and sea level, which could have adverse effects on many ecological systems, as well as on human health and the economy.

The Climate System

Energy from the sun drives the earth's weather and climate. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the energy from the sun, creating a natural "greenhouse effect." Without this effect, temperatures would be much lower than they are now, and life as known today would not be possible. Instead, thanks to greenhouse gases, the earth's average temperature is a more hospitable 60°F. However, problems arise when the greenhouse effect is ***enhanced*** by human-generated emissions of greenhouse gases.

Global warming would do more than add a few degrees to today's average temperatures. Cold spells still would occur in winter, but heat waves would be more common. Some places would be drier, others wetter. Perhaps more important, more precipitation may come in short, intense bursts (e.g., more than 2 inches of rain in a day), which could lead to more flooding. Sea levels would be higher than they would have been without global warming, although the actual changes may vary from place to place because coastal lands are themselves sinking or rising.

The Greenhouse Effect



Source: U.S. Department of State (1992)

Emissions Of Greenhouse Gases

Since the beginning of the industrial revolution, human activities have been adding measurably to natural background levels of greenhouse gases. The burning of fossil fuels — coal, oil, and natural gas — for energy is the primary source of emissions. Energy burned to run cars and trucks, heat homes and businesses, and power factories is responsible for about 80% of global carbon dioxide emissions, about 25% of U.S. methane emissions, and about 20% of global nitrous oxide emissions. Increased agriculture and deforestation, landfills, and industrial production and mining also contribute a significant share of emissions. In 1994, the United States emitted about one-fifth of total global greenhouse gases.

Concentrations Of Greenhouse Gases

Since the pre-industrial era, atmospheric concentrations of carbon dioxide have increased nearly 30%, methane concentrations have more than doubled, and nitrous oxide concentrations have risen by about 15%. These increases have enhanced the heat-trapping capability of the earth's atmosphere. Sulfate aerosols, a common air pollutant, cool the atmosphere by reflecting incoming solar radiation. However, sulfates are short-lived and vary regionally, so they do not offset greenhouse gas warming.

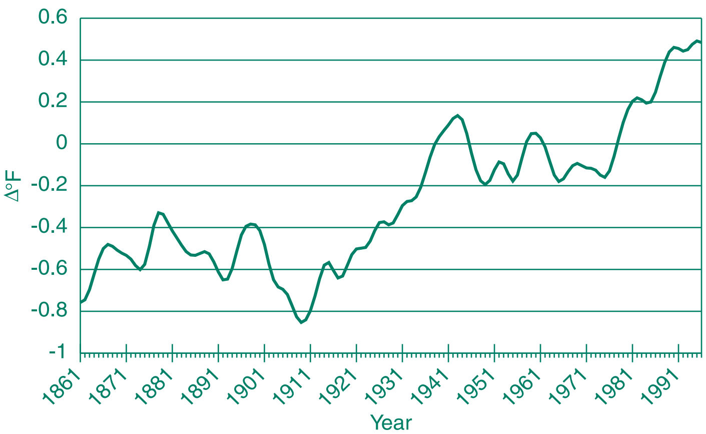
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and institutional developments. Several emissions scenarios have been developed based on differing projections of these underlying factors. For example, by 2100, in the absence of emissions control policies, carbon dioxide concentrations are projected to be 30-150% higher than today's levels.

Current Climatic Changes

Global mean surface temperatures have increased 0.6-1.2°F between 1890 and 1996. The 9 warmest years in this century all have occurred in the last 14 years. Of these, 1995 was the warmest year on record, suggesting the atmosphere has rebounded from the temporary cooling caused by the eruption of Mt. Pinatubo in the Philippines.

Several pieces of additional evidence consistent with warming, such as a decrease in Northern Hemisphere snow cover, a decrease in Arctic Sea ice, and continued melting of alpine glaciers, have been corroborated. Globally, sea levels have risen

Global Temperature Changes (1861–1996)



Source: IPCC (1995), updated

4-10 inches over the past century, and precipitation over land has increased slightly. The frequency of extreme rainfall events also has increased throughout much of the United States.

A new international scientific assessment by the Intergovernmental Panel on Climate Change recently concluded that ***"the balance of evidence suggests a discernible human influence on global climate."***

Future Climatic Changes

For a given concentration of greenhouse gases, the resulting increase in the atmosphere's heat-trapping ability can be predicted with precision, but the resulting impact on climate is more uncertain. The climate system is complex and dynamic, with constant interaction between the atmosphere, land, ice, and oceans. Further, humans have never experienced such a rapid rise in greenhouse gases. In effect, a large and uncontrolled planetwide experiment is being conducted.

General circulation models are complex computer simulations that describe the circulation of air and ocean currents and how energy is transported within the climate system. While uncertainties remain, these models are a powerful tool for studying climate. As a result of continuous model improvements over the last few decades, scientists are reasonably confident about the link between global greenhouse gas concentrations and temperature and about the ability of models to characterize future climate at continental scales.

Recent model calculations suggest that the global surface temperature could increase an average of 1.6-6.3°F by 2100, with significant regional variation. These temperature changes would be far greater than recent natural fluctuations, and they would occur significantly faster than any known changes in the last 10,000 years. The United States is projected to warm more than the global average, especially as fewer sulfate aerosols are produced.

The models suggest that the rate of evaporation will increase as the climate warms, which will increase average global precipitation. They also suggest increased frequency of intense rainfall as well as a marked decrease in soil moisture over some mid-continental regions during the summer. Sea level is projected to increase by 6-38 inches by 2100.

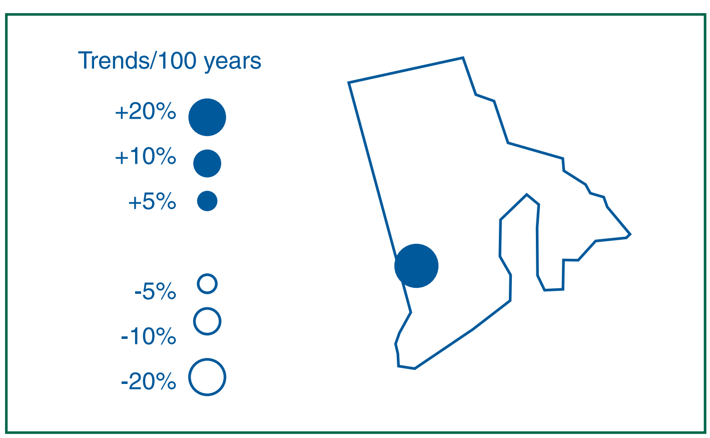
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency of hot or cold spells, and the intensity of associated fire and pest outbreaks) could increase.

Local Climate Changes

Over the last century, the average temperature in Providence, Rhode Island, has increased 3.3°F, and precipitation has increased by up to 20% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, Rhode Island's climate may change even more. For example, based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre climate model (HadCM2), a model that accounts for both greenhouse gases and aerosols, by 2100 temperatures in Rhode Island could increase by 4°F (with a range of 1-8°F) in winter and spring and by 5°F (with a range of 2-10°F) in summer and fall. Precipitation is projected to increase by 10% in spring and summer (with a range of 5-15%), 15% in fall (with a range of 5-30%), and 25% in winter (with a range of 10-50%). Other climate models may show different results, especially regarding estimated changes in precipitation. The impacts described in the sections that follow take into account estimates from different models. The amount of precipitation on extreme wet or snowy days in winter is likely to increase. The frequency of extreme hot days in summer would increase because of the general warming trend. Although it is not clear how the severity of storms such as hurricanes might be affected, an increase in the frequency and intensity of winter storms is possible.

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

Human Health

Higher temperatures and increased frequency of heat waves may increase the number of heat-related deaths and the incidence of heat-related illnesses. Rhode Island, with its irregular, intense heat waves, could be susceptible. One study projects that a warming of 3-4°F could increase heat-related deaths during a typical summer in Providence by 50% from the current 50 to near 75 (although increased air conditioning use may not have been fully accounted for). This study also shows that winter-related deaths in Providence could rise by 25% given a 2°F warming. However, the exact reasons for this increase are unknown. The elderly, especially those living alone, are at greatest risk.

Climate change could increase concentrations of ground-level ozone. For example, high temperatures, strong sunlight, and stable air masses tend to increase urban ozone levels. Based on projections for New York City, a 4°F warming could increase concentrations of ozone, a major component of smog, by 4%. Currently, ground-level concentrations exceed the national ozone health standard throughout the state. All of Rhode Island is classified as a serious nonattainment area for ozone. Ground-level ozone is associated with respiratory illnesses such as asthma, reduced lung function, and respiratory inflammation. Air pollution also is made worse by increases in natural hydrocarbon emissions such as emissions of terpenes by trees and shrubs during hot weather. If a warmed climate causes increased use of air conditioners, air pollutant emissions from power plants also will increase.

Warmer temperatures could increase the incidence of Lyme disease and other tick-borne diseases in Rhode Island, because populations of ticks, and their rodent hosts, could increase under warmer temperatures and increased vegetation. Respiratory and eye allergies increase in warm, humid conditions.

Warmer winters, warmer temperatures, and heavy precipitation also can increase harmful algal blooms, that is, red tides; reduce water quality; and increase outbreaks of cryptosporidiosis and giardia. In addition, warmer seas could contribute to the intensity, duration, and extent of harmful algal blooms in the coastal waters of Rhode Island. These blooms damage habitat and shellfish nurseries and can be toxic to humans.

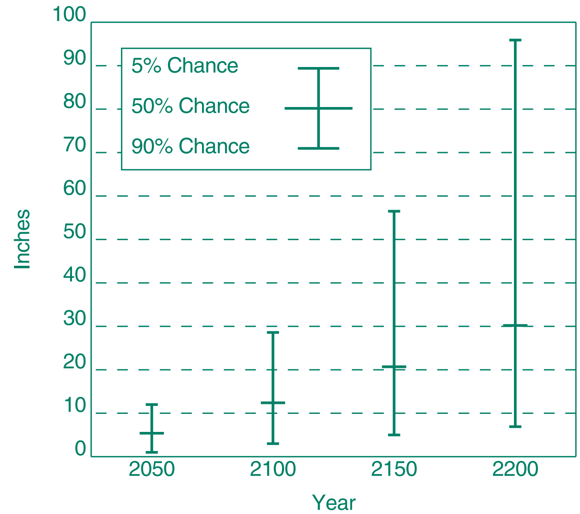
Developed countries such as the United States should be able to minimize the impacts of these diseases through existing disease prevention and control methods.

Coastal Areas

Sea level rise could lead to flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater contamination of drinking water, and decreased longevity of low-lying roads, causeways, and bridges. In addition, sea level rise could increase the vulnerability of coastal areas to storms and associated flooding.

Rhode Island is endowed with over 400 miles of densely populated, tidally influenced shoreline, consisting of both sandy and gravel barrier beaches, and rocky cliffs. Block Island and Narragansett Bay contain relatively undisturbed salt marshes, tidal flats, rocky shores, and small islands. The beaches along the Rhode Island coast are highly developed and heavily used by hundreds of thousands residents and out-of-state visitors each year. These beaches have suffered severe damage during hurricanes and storm surges. In general, erosion is most severe at the barrier beaches on the south shore of Rhode Island and bluff areas on Block Island; these areas are likely to erode most if sea level rises. The northern shore of Narragansett Bay, including Cranston, Providence, and Pawtucket, is heavily armored with seawalls and other erosion control devices.

Future Sea Level Rise At Watch Hill



Source: EPA (1995)

At Watch Hill, sea level already is rising by 2 inches per century, and it is likely to rise another 12.4 inches by 2100. Possible responses to sea level rise include building walls to hold back the sea, allowing the sea to advance and adapting to it, and raising the land (e.g., by replenishing beach sand, elevating houses and infrastructure). Each of these responses will be costly, either in out-of-pocket costs or in lost land and structures. For example, the cumulative cost of sand replenishment to protect Rhode Island's coastline from a 20-inch sea level rise by 2100 is estimated at $90-$530 million. However, sand replenishment may not be cost-effective for all coastal areas in the state and, therefore, some savings could be possible.

Water Resources

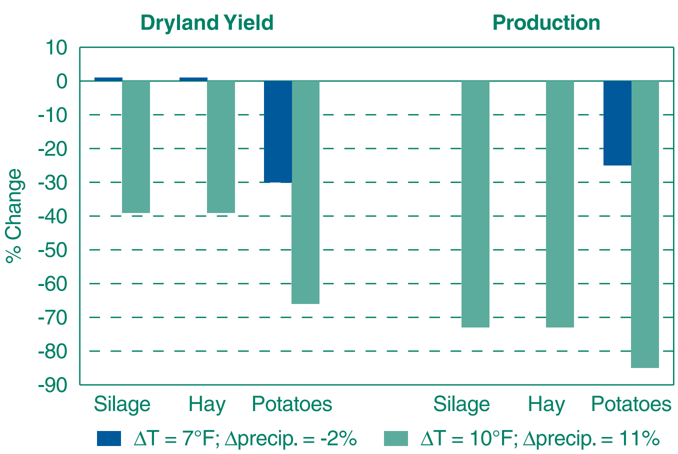
The principal rivers in Rhode Island are the Blackstone, the Pawtuxet, and the Pawcatuch, which drain toward Narragansett Bay and Block Island Sound. Water resources in Rhode Island are currently abundant and well developed. Most of the freshwater used in the state comes from reservoirs, lakes, and rivers. Sciture Reservoir, in southern Providence County, serves nearly one-half of the state's population. Winter snow accumulation and spring snowmelt strongly affect the state's rivers. A warmer climate would lead to an earlier snowmelt, resulting in higher streamflows in winter and spring. Without increases in precipitation, higher temperatures and increased evaporation would lower streamflows, lake levels, and groundwater levels in the summer and fall. This could aggravate water supply problems, particularly in the southern part of the state, where water demand is highest. Groundwater sources, recently developed to meet growing demand in the state, also could be reduced by lower spring and summer recharge. Lower summer streamflows and warmer temperatures also could increase water quality problems by concentrating pollutant levels, particularly in parts of rivers where effluent from municipal wastewater treatment facilities and industries is dumped. Increases in rainfall could mitigate these effects. Higher rainfall, however, could contribute to localized flooding, increased levels of pesticides and fertilizers from agricultural runoff, and increased pollution from urban runoff. During periods of high flow, the water quality in northern Narragansett Bay is particularly susceptible to pollution from sewer overflows and stormwater runoff from the highly urbanized area around Providence.

Agriculture

The mix of crop and livestock production in a state is influenced by climatic conditions and water availability. As climate warms, production patterns could shift northward. Increases in climate variability could make adaptation by farmers more difficult. Warmer climates and less soil moisture due to increased evaporation may increase the need for irrigation. However, these same conditions could decrease water supplies, which also may be needed by natural ecosystems, urban populations, industry, and other users.

Understandably, most studies have not fully accounted for changes in climate variability, water availability, crop pests, changes in air pollution such as ozone, and adaptation by farmers to changing climate. Including these factors could change modeling results substantially. Analyses that assume changes in average climate and effective adaptation by farmers suggest that aggregate U.S. food production would not be harmed, although there may be significant regional changes.

Changes In Agricultural Yield And Production



Sources: Mendelsohn and Neumann (in press); McCarl (personal communication)

In Rhode Island, production agriculture is a $78 million annual industry, three-fourths of which comes from crops. Very few of the farmed acres are irrigated. The major crops in the state are silage, potatoes, and hay. Climate change could reduce potato yields by 30-66%. Silage, hay, and pasture yields could fall as much as 39% as temperatures rise beyond the tolerance level of the crop. Farmed acres may remain constant or could fall by as much as 14%. Estimated changes in yield vary, depending on whether land is irrigated.

Forests

Trees and forests are adapted to specific climate conditions, and as climate warms, forests will change. These changes could include changes in species composition, geographic range, and health and productivity. If conditions also become drier, the current range and density of forests could be reduced and replaced by grasslands and pasture. Even a warmer and wetter climate could lead to changes; trees that are better adapted to these conditions, such as oaks and pines, would thrive. Under these conditions, forests could become more dense. These changes could occur during the lifetimes of today's children, particularly if the change is accelerated by other stresses such as fire, pests, and diseases. Some of these stresses would themselves be worsened by a warmer and drier climate.

Although the extent of forested areas in Rhode Island could change little because of climate change, a warmer climate could change the character of those forests. Maple-dominated hardwood forests could give way to forests dominated by oaks and conifers, species more tolerant of higher temperatures. This change would diminish the brilliant autumn foliage as the contribution of maples declines. Across the state, as much as 30-60% of the hardwood forests could be replaced by warmer-climate forests with a mix of pines and hardwoods.

Ecosystems

The smallest state in the country, Rhode Island is almost entirely a coastal area. Its marshes, estuaries, and salt ponds are critical habitats for waterfowl and other migratory birds, as well as for many terrestrial animals. The many streams and rivers that enter Narragansett Bay provide important spawning habitat for shad, herring, and Atlantic salmon. Barrier reef islands such as Block Island in Narragansett Bay are important as refuges for a number of rare and endangered species, including the grasshopper sparrow, savannah sparrow, northern harrier hawk, and American burying beetle. These islands are also key stopover points for migratory songbirds.

The fragile coastal ecosystems of Rhode Island are particularly susceptible to destruction as sea level rises and barrier reef islands are inundated, and if the frequency and severity of storms increase. Such losses would reduce coastal habitat that supports diverse sea life and migratory waterfowl.

For further information about the potential impacts of climate change, contact the Climate and Policy Assessment Division (2174), U.S. EPA, 401 M Street SW, Washington, DC 20460, or visit http://www.epa.gov/globalwarming/impacts.