United States Environmental Protection Agency
Office of Policy, Planning and Evaluation (2111)
EPA 230-F-97-008dd
September 1997

Climate Change And New Jersey

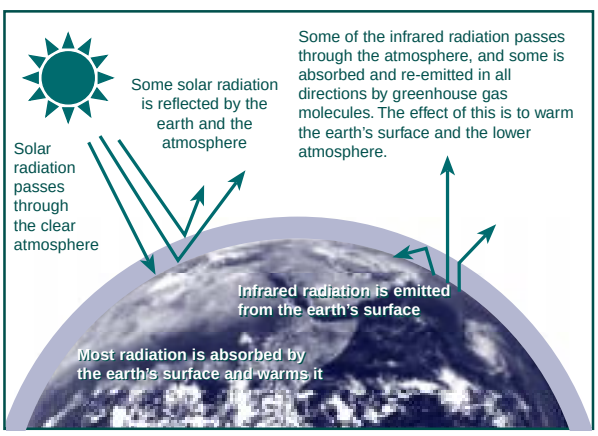
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed. 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.

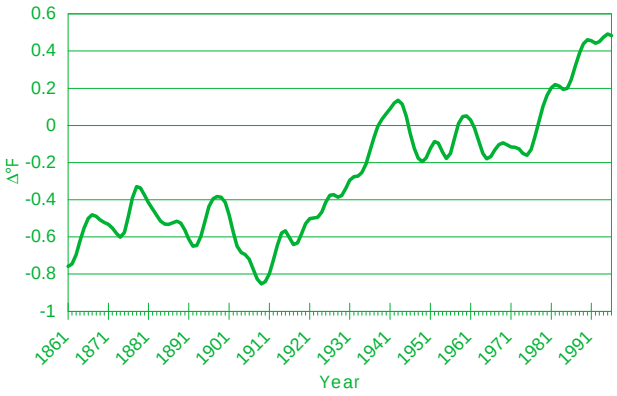
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and 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 since the late 19th century. The 9 warmest years in this century all have occurred in the last 14 years.

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 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.

Global Temperature Changes (1861–1996)



Source: IPCC (1995), updated

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 planet-wide 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. Scientists are reasonably confident 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 New Brunswick, New Jersey, has increased from 50.4°F (1889-1918 average) to 52.2°F (1966-1995 average), and precipitation in some locations in the state has increased by 5-10%.

Over the next century, New Jersey's climate may change even more. Based on projections given by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model (HadCM2), a model that accounts for both greenhouse gases and aerosols, by 2100 temperatures in New Jersey could increase about 4°F (with a range of 2-8°F) in winter and spring, and slightly more in summer and fall, if greenhouse-gas emissions are not controlled. Precipitation is projected to increase by 10-20% (with a range of 0-40%), with slightly less change in spring and slightly more in winter.

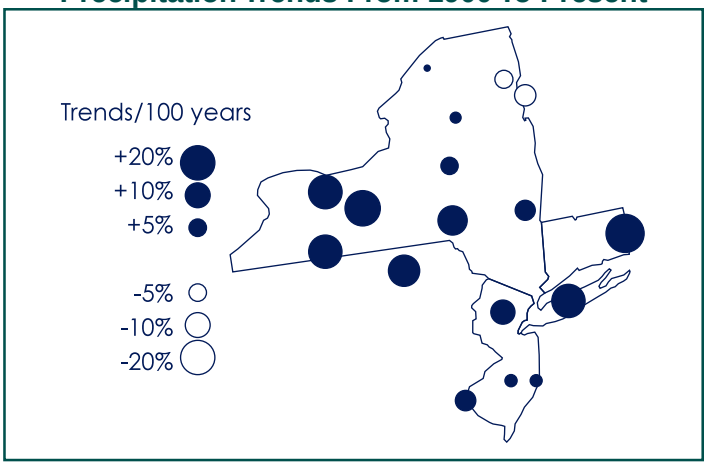
The amount of precipitation on extreme wet (or snowy) days most likely would increase, but changes in the lengths of wet or dry spells are not clear. The frequency of extreme hot days in summer is expected to increase along with the general warming trend. It is not clear how severe storms such as hurricanes would change.

Climate Change Impacts

Global climate change poses risks to human health and to terrestrial and aquatic ecosystems. Important economic resources such as agriculture, forestry, fisheries, and water resources also may be affected. Warmer temperatures, more severe droughts and floods, and sea level rise could have a wide range of impacts. All these stresses can add to existing stresses on resources caused by other influences such as population growth, land-use changes, and pollution.

Similar temperature changes have occurred in the past, but the previous changes took place over centuries or millennia instead of decades. The ability of some plants and animals to migrate and adapt appears to be much slower than the predicted rate of climate change.

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. New Jersey, with its irregular, intense heat waves, seems very susceptible.

In Newark, one study projects that a 2-3°F warming could increase heat-related deaths during a typical summer fivefold, from about 25 today to near 125 (although increased air conditioning use may not have been fully accounted for). Decreases in winter mortality probably would be less than the summer mortality increases if the climate warms. The elderly, particularly those living alone, are at greatest risk.

There is concern that climate change could increase ozone levels. For example, high temperatures, strong sunlight, and stable air masses tend to increase urban ozone levels. Furthermore, air pollution also is made worse because natural hydrocarbons emissions increase during hot weather. If a warmed climate causes increased use of air conditioners, air pollutant emissions from power plants also will increase.

A 4°F warming in New York City, with no other change in weather or emissions, could increase concentrations of ozone, a major component of smog, by 4%. Similar increases also could occur in New Jersey. Current ozone concentrations exceed the national health standards for ozone throughout the state. Virtually all of New Jersey is classified as an "extreme and severe" nonattainment area for ozone. Ground-level ozone has been shown to aggravate existing respiratory illnesses such as asthma, reduce lung function, and induce respiratory inflammation. In addition, ambient ozone reduces agricultural crop yields and impairs ecosystem health.

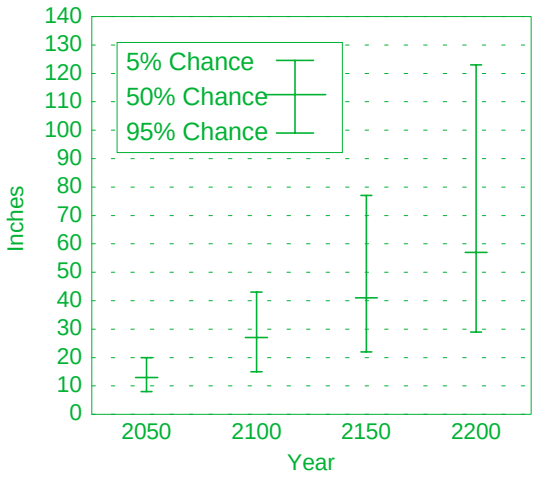
Warming and other climate changes could expand the habitat and infectivity of disease-carrying insects, thus increasing the potential for transmission of diseases such as malaria and dengue ("break bone") fever. Mosquitos flourish in some areas around New Jersey. Some can carry malaria, while others can carry Eastern equine encephalitis, which can be lethal or cause neurological damage. Lyme disease, which is carried by ticks, has increased in the Northeast. If conditions become warmer and wetter, mosquito and tick populations could increase, thereby increasing the risk of transmission of these diseases.

In addition, warmer seas could contribute to the increased intensity, duration, and extent of harmful algal blooms. These blooms can damage habitat and shellfish nurseries, can be toxic to humans, and can carry bacteria like those causing cholera. Brown algal tides and toxic algal blooms already are prevalent in the Atlantic. Warmer ocean waters could increase their occurrence and persistence.

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.

Future Sea Level Rise At Atlantic City



Source: EPA (1995)

Along much of New Jersey's coast, sea level already is rising by 15 inches per century, and it is likely to rise another 27 inches by 2100. A large portion of New Jersey's 130-mile coastline is vulnerable to extensive erosion and flooding from sea level rise and storms. The New Jersey coastline is made up primarily of long narrow barrier islands, low-lying salt marshes, and tidal flats. Because of this topography, sea level rise could inflict extensive damage on New Jersey's valuable, high-density coastal real estate and recreational beaches. Rising seas also would inundate many acres of New Jersey's remaining coastal salt marshes and tidal flats that provide flood protection, water quality benefits, and habitat for native species, as marsh plants die or recede to higher elevations.

Protecting New Jersey's coast would require significant resources and planning. For example, estimates of the cost of protecting Long Beach Island with seawalls and more sand from a 1-3 foot increase in sea level over the next century are $100-$500 million. These costs could begin to accrue soon and continue to be incurred throughout the next century.

Water Resources

Water resources are affected by changes in precipitation as well as by temperature, humidity, wind, and sunshine. Changes in streamflow tend to magnify changes in precipitation. Water resources in drier climates tend to be more sensitive to climate changes. Because evaporation from streams and lakes is likely to increase with warmer climate, it could result in lower river flow and lower lake levels, particularly in the summer. In addition, more intense precipitation could increase flooding. If streamflow and lake levels drop, groundwater also could be reduced.

Ensuring the supply of high quality municipal and industrial water is the most critical water resource issue in New Jersey. About half the state's potable water comes from streams and rivers, primarily the Delaware, Raritan, and Passaic rivers, and numerous small streams. The other half comes from groundwater. Except

for that part of the Delaware River that flows from upper New York State, winter snow accumulation has only a modest effect on New Jersey streams. However, streamflow could decrease because of the increased evaporation that would accompany warmer temperatures. The mean annual flow of the Delaware River at Trenton could decrease about 15% if average temperatures warm 4.5°F and precipitation remains unchanged. Urbanization has lowered water quality and increased flooding in many small New Jersey rivers and streams, especially in the northern part of the state. Reduced flows, especially in summer, would exacerbate the decline in water quality. Many New Jersey aquifers also have been contaminated because of industrial and urban development. In the absence of increased precipitation, the amount of groundwater available to refill the aquifers could decrease.

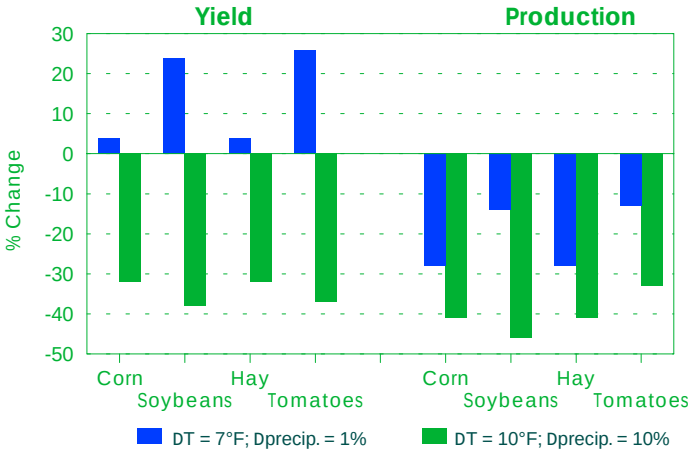
Agriculture

The mix of crop and livestock production in a state is influenced by climatic conditions and water availability. As climate warms, production patterns will 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, and other economic sectors.

Understandably, most studies have not fully accounted for changes in climate variability, water availability, and imperfect responses by farmers to changing climate. Including these factors could substantially change modeling results. Analyses based on changes in average climate and which assume farmers effectively adapt suggest that aggregate U.S. food production will not be harmed, although there may be significant regional changes.

In New Jersey, agriculture is about a $0.7 billion annual industry, two-thirds of which comes from crops. About 6% of New Jersey's agricultural land is irrigated. The principal crops are hay, corn, soybeans, and some vegetables. Projections of changes in New Jersey yield are mixed; they could range from up by 25% to down by 38%. Climate change could lower total acres farmed and production, as well as farm income.

Changes In Agricultural Yield And Production



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

Forests

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

With changes in climate, the extent and density of forested areas in New Jersey could change little or could decline by as much as 10-20%. However, wildfire frequency almost certainly would change with hotter and drier conditions. The types of trees dominating New Jersey forests are likely to change. The mixed forests, dominated by southern pines and oaks, would spread northward throughout the state. These forests would replace the predominantly hardwood forests currently found in the northern half of the state.

Ecosystems

The most important ecosystems of New Jersey that would be vulnerable to climate change are the coastal wetlands and the forested Pine Barrens. The Pine Barrens cover approximately 1 million acres of the Outer Coastal Plain in southern and central New Jersey. The Pine Barrens provide the habitat for rare and unusual species, including the pine barrens treefrog, which is protected by the Endangered Species Act. Because there are few natural corridors that would allow migration of species, their ability to adapt and migrate in response to climate change could be limited.

Plant and animal species near the borders of their ranges are likely to be most affected by climate change. Species better adapted for cool conditions would need to migrate northward, while southern species of plants and animals (including noxious weeds such as kudzu and insect pests such as fire ants) could spread into the state.

New Jersey's coastal wetlands are among the largest and most diverse in the mid-Atlantic region. Sea level rise would alter flooding and salinity, with substantial impacts on wildlife and fisheries. Losses of tidal freshwater wetlands would be especially harmful to foraging grounds for wading birds.

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.