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Climate Change And Wisconsin

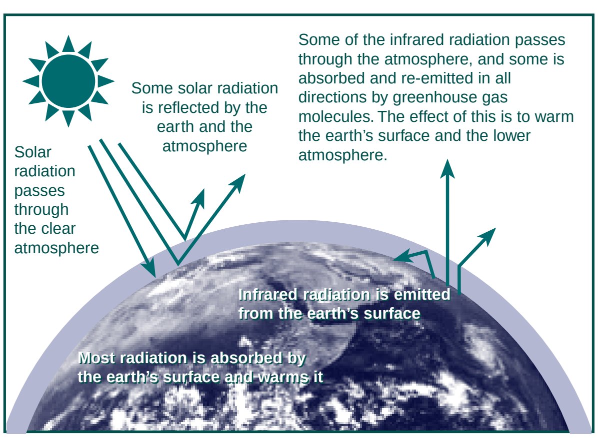
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

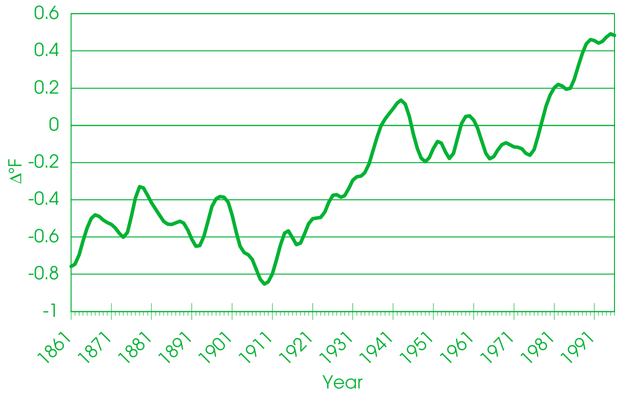
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and 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 10 warmest years in this century all have occurred in the last 15 years. Of these, 1998 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 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. 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.

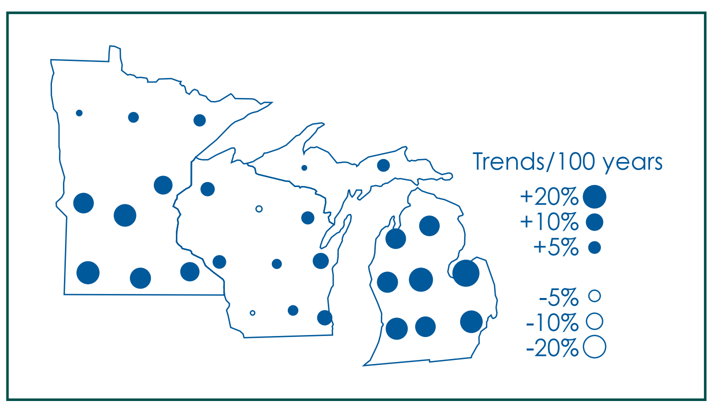
Local Climate Changes

Over the last century, the average temperature in Stanley, Wisconsin, has remained virtually unchanged, and precipitation has increased by 5-10% in some areas of the state.

Over the next century, Wisconsin's climate may change significantly. 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 has accounted for both greenhouse gases and aerosols, by 2100 temperatures in Wisconsin could increase by about 4°F (with a range of 2-7°F) in winter, spring, and fall, and by somewhat less in summer. Precipitation is projected to increase by 15-20% in winter, summer, and fall, with little change projected for spring.

The amount of precipitation on extremely wet days in summer most likely would increase. The frequency of extremely hot days in summer is expected to increase along with the general warming trend. It is not clear how severe storms would change.

Precipitation Trends From 1900 To Present



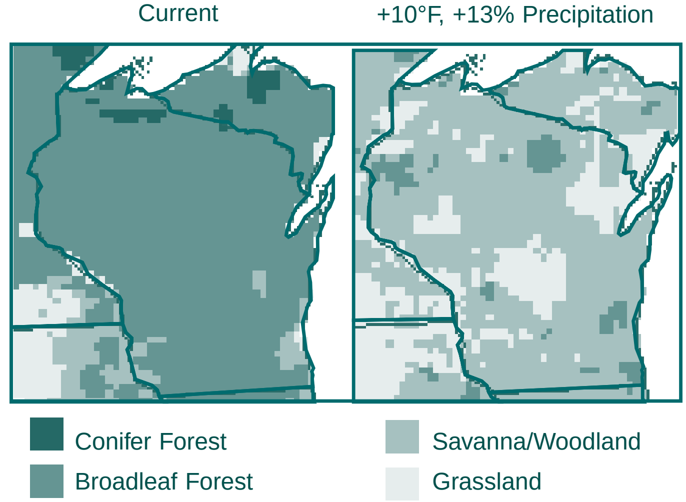
Source: Karl et al. (1996)

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.

Changes In Forest Cover



Source: VEMAP Participants (1995); Neilson (1995)

Human Health

Higher temperatures and increased frequency of heat waves could increase the number of heat-related deaths and the incidence of heat-related illnesses. Wisconsin, with its irregular, intense heat waves, seems somewhat susceptible.

In Milwaukee, one study projects that a 3°F warming could almost double heat-related deaths during a typical summer from 30 per summer to about 55 (although increased air conditioning use may not have been fully accounted for). The elderly, particularly those living alone, are at greatest risk.

There is concern that 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. Air pollution also is made worse by increases in natural hydrocarbon emissions 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 the Midwest, with no other change in weather or emissions, could increase concentrations of ozone, a major component of smog, by as much as 8%. Perhaps more important, however, is that the area exceeding national health standards for ozone could almost triple. Currently, Door, Marathon, and Oneida counties do not meet national standards 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 crop yields and impairs ecosystem health.

Warming and other climate changes could expand the habitat of disease-carrying insects or alter the life-cycle dynamics of the infective parasites they may carry, thus increasing the potential for transmission of diseases such as malaria and dengue ("break bone") fever. Mosquitoes flourish in Wisconsin, and some carry LaCrosse encephalitis. The number of mosquitoes that carry this disease could increase with climate change. Also, the mosquitoes that carry yellow fever, dengue fever, and Eastern equine encephalitis recently have spread as far north as Chicago. Global warming could shift the region where these mosquitoes breed and overwinter farther north. If conditions become warmer and wetter, mosquito populations could increase, increasing the risk of transmission of these diseases.

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 and density 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 these conditions, such as oaks and southern pines, would thrive. 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 of forested areas in Wisconsin could change little or decline by 55-75%. The uncertainties depend on many factors, including whether soils become drier and, if so, by how much drier. Significant summer droughts with increased tree loss and wildfire frequency could be expected with hotter and drier weather. The mixed aspen, birch, beech, maple, and pine forests found in the north would shrink in range and would be replaced by a combination of grasslands and hardwood forests consisting of more oak, elm, ash, and pines. Grasslands and savanna eventually could replace much of the forest and woodland in the state. These changes would affect the character of Wisconsin forests and the activities that depend on them.

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.

About one-third of Wisconsin lies within the headwaters of the Mississippi River basin. The remainder contains numerous small rivers and streams, most of which drain to either Lake Michigan or Lake Superior. Earlier spring snowmelt under climate change could cause seasonal flows to peak sooner in most streams. Increased summer evaporation probably would reduce summer streamflows.

In the northern part of the state, as much as one-third of precipitation currently goes to groundwater. This groundwater recharge would almost certainly decrease in a warmer climate because of increased evaporation. This would reduce the amount of water in many, if not most, of the state's aquifers. In addition, unless the evaporation were counteracted by increased precipitation, the reduction in groundwater could harm the health of Wisconsin's lakes and streams.

The water temperatures of the Great Lakes could increase because of the warmer summer air temperatures and longer ice-free season. This could increase evaporation and degrade water quality through decreases in dissolved oxygen and increases in the growth of algae. Perhaps more importantly, increased lake evaporation could decrease lake levels by a foot or more for a 4°F warming. This could increase shore erosion from wind and rain, increase water pollutant concentrations, and result in increased dredging and other problems for Great Lakes shipping. Flood damages, however, could be lessened.

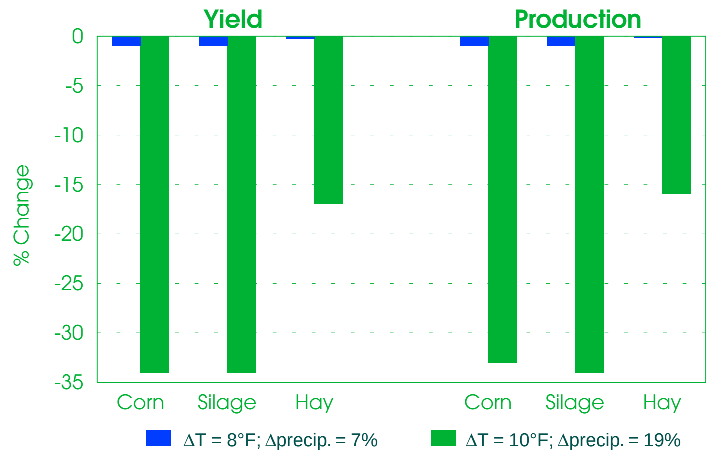
Agriculture

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 Wisconsin, agriculture is about a $6 billion annual industry, of which three-quarters comes from livestock. The principal crops are corn, silage, and hay. About 3% of the state's farmed acres is irrigated. The effects of climate change are difficult to predict, however, potential impacts for Wisconsin might include: corn and silage yields unchanged, or they could decrease by up to 34%. Hay yields could remain unchanged or could decrease by 17%. Acreage use could remain largely unchanged, and farm income could remain unchanged or could increase up to 100%. Irrigated acreage could increase. This could further stress water supplies, and water quality could be further degraded.

Changes In Agricultural Yield And Production



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

Ecosystems

Wisconsin has diverse ecosystems that support a variety of wildlife. Wisconsin's aquatic wildlife includes brown trout, walleye, musky, largemouth bass, crayfish, snails, mussels, and freshwater sponges. These species rely on the state's vast water resources, which include more than 43,000 miles of flowing waters, 15,000 inland lakes, 800 miles of coastline, and wetlands covering approximately 5 million acres. Wisconsin is also home to a variety of birds and animals, including the bald eagle, osprey, deer, black bear, and gray wolf. One of the largest populations of Karner blue butterfly, an endangered species, is found in Wisconsin.

Climate change could influence many of Wisconsin's ecosystems. Brown trout could lose a majority of their habitat as a result of climate change. Prolonged drought from climate change could decrease the number of lakes with suitable habitat for organisms such as crayfish and snails. Drought also could decrease groundwater supplies of silica, an essential nutrient for freshwater sponges and diatoms. Climate change could affect the habitat and population of many endemic species, and cause the disappearance of some endangered species. Because of the fragmentation of ecosystems from natural and human-caused barriers, many of Wisconsin's animals could have difficulty migrating in response to the effects of climate change.

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.