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Climate Change And North Dakota

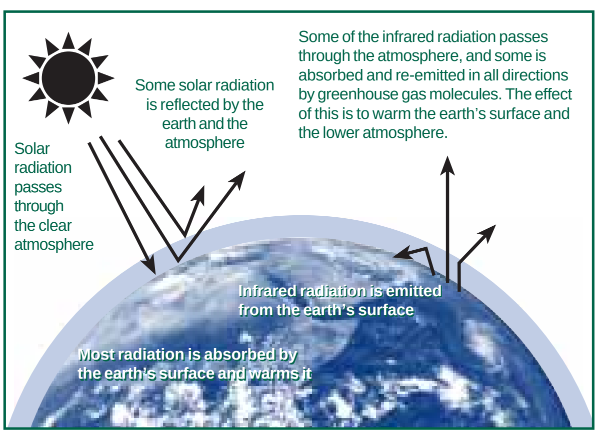
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

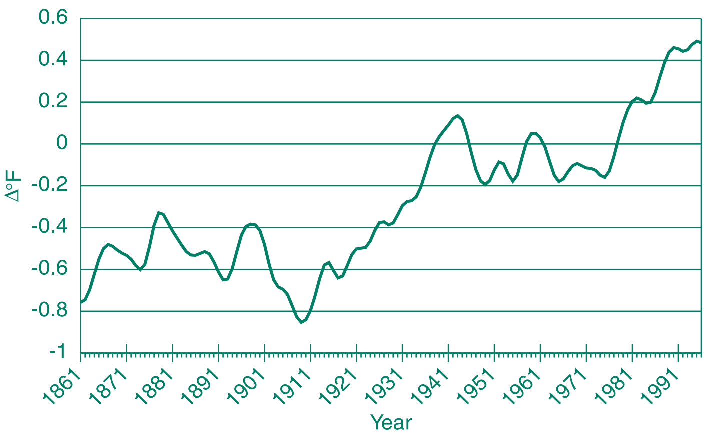
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and 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 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.

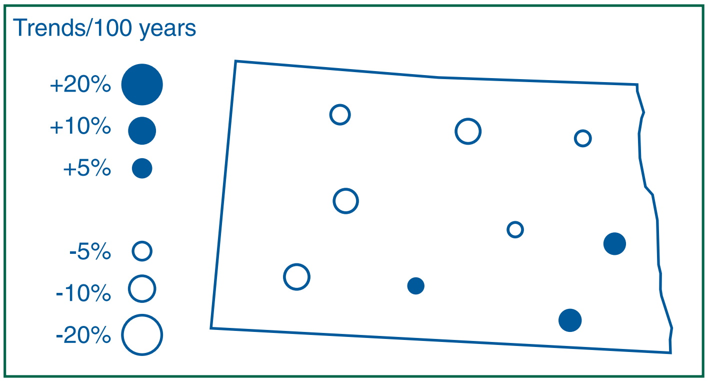
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency 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 near Bismarck, North Dakota, has increased 1.3°F, and precipitation has decreased by up to 10% in many parts of the state, except in the southeastern part of the state where precipitation has risen slightly. These past trends may or may not continue into the future.

Over the next century, climate in North Dakota 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's climate model (HadCM2), a model that accounts for both greenhouse gases and aerosols, by 2100 temperatures in North Dakota could increase by 3°F in summer (with a range of 1-5°F) and 4°F in the other seasons (with a range of 2-7°F). Precipitation is estimated to increase by 5% in spring (with a range of 0-10%), 10% in summer (with a range of 5-20%), 15% in fall (with a range of 5-25%), and 25% (with a range of 10-40%) in winter. 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. It is not clear how the severity of storms might be affected, although 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. These effects have been studied only for populations living in urban areas; however, even those in rural areas may be susceptible. North Dakota lacks large cities, which are most sensitive to heat waves; however, Minneapolis will experience similar changes in climate and could indicate how populations in North Dakota cities might be affected. One study estimates that in Minneapolis a summer warming of 5°F could increase heat-related deaths by threefold (although increased air conditioning use may not have been fully accounted for). The elderly, especially those living alone, are at greatest risk. This study also shows that winter-related deaths in North Dakota could be little changed.

Upper and lower respiratory allergies are influenced by humidity. A 2°F warming and wetter conditions could increase respiratory allergies.

Warming and other climate changes could expand the habitat and infectivity of disease-carrying insects. Infected individuals can bring malaria to places where it does not occur naturally. Also, some mosquitoes in North Dakota can carry malaria, and others can carry western equine encephalitis, which can be lethal or cause neurological damage. If conditions become warmer and wetter, mosquito populations could increase, thus increasing the risk of transmission if these diseases are introduced into the area. Warmer temperatures could increase the incidence of Lyme disease and other tick-borne diseases in North Dakota, because populations of ticks, and their rodent hosts, could increase under warmer temperatures and increased vegetation. Increased runoff from heavy rainfall could increase water-borne diseases such as giardia, cryptosporidia, and viral and bacterial gastroenteritides. Developed countries such as the United States should be able to minimize the impacts of these diseases through existing disease prevention and control methods.

Water Resources

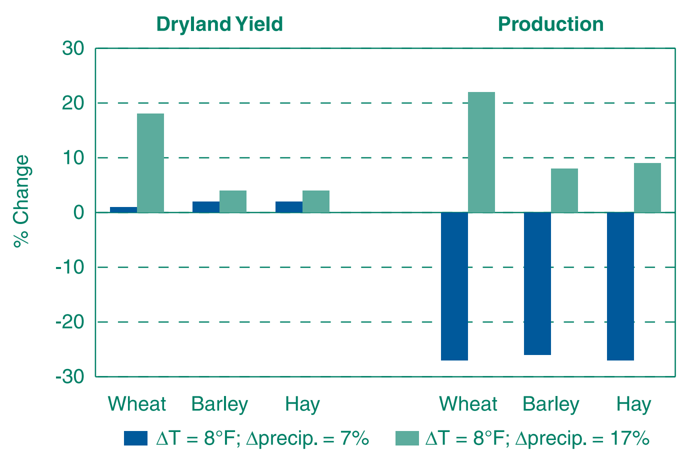
Major river basins in North Dakota include the Missouri, which drains the west-central part of the state, and those of the Souris River and Red River of the North, which drain northward into Canada. These surface waters are the primary source of water in the state, and agriculture is the dominant user of water. The mainstem of the Missouri and the lower Red River of the North are dependable sources, but other rivers are not reliable because of low flows and variable water quality. Runoff in North Dakota is influenced largely by spring-summer rainfall and spring snowmelt. Warmer temperatures would lead to earlier spring snowmelt, resulting in higher streamflows in winter and spring. In the summer, without large increases in precipitation, higher temperatures and increased evaporation would lower streamflows and lake levels. Although large storage reservoirs such as Lakes Sakakawea and Oahe might be able to moderate these impacts, the numerous smaller reservoirs throughout the state could be adversely impacted. Less water would be available to support important uses such as irrigation, hydropower production, industrial and mining operations, municipal water supplies, recreation, and fish and wildlife habitats. Evaporation often exceeds precipitation in this semiarid state, and many small rivers and streams run dry in the summer. Warmer, drier summers would exacerbate this situation. Groundwater levels also could be reduced by lower spring and summer recharge. Groundwater is an important source of water in rural areas, and a supplementary source for urban water supplies and for irrigation in areas distant from large rivers. Higher summer temperatures and lower flows also could degrade water quality by concentrating pollutants and reducing the capacity of streams to assimilate wastes from industrial, municipal, and livestock wintering areas. Wetlands and prairie potholes, which provide important waterfowl habitat, also would be impaired by declining water levels.

More rain could alleviate some of these impacts, but also could increase flooding. Floods are common along Red River of the North and the Souris River, and can be as severe as they were in 1997. The valley of the Red River of the North is the most populous area in the state and the most intensively farmed. The low gradient of the river renders it particularly susceptible to urban and agricultural flood damage. Under wet conditions, rising water levels in Devils Lake in northeastern Dakota can cause flooding in nearby areas. Increased rainfall and streamflow also could increase erosion and exacerbate levels of pollution in runoff. This could exacerbate water quality problems associated with fertilizer runoff from agricultural lands and leachate from mining and oil and gas operations.

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.

Changes In Agricultural Yield And Production



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

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.

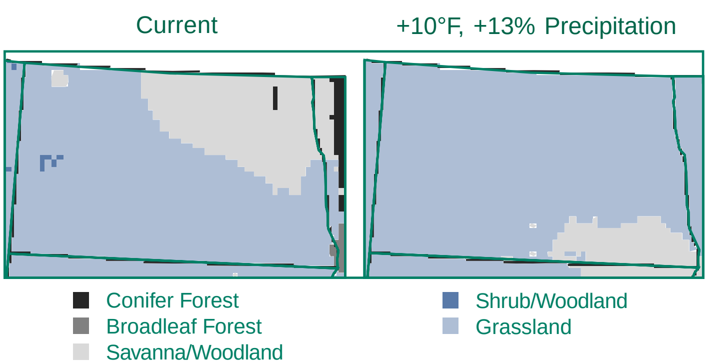
In North Dakota, production agriculture is a $3 billion annual industry, two-thirds of which comes from crops. Very few of the farmed acres are irrigated. The major crops in the state are wheat, barley, and hay. Climate change could marginally increase yields of all of these crops, with wheat rising by 2-18% and the other crops by 2-4%. Farmed acres could remain fairly constant or could decrease by as much as 28%.

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 warmer conditions, such as oaks and pines, would prevail. 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.

With changes in climate, the extent of the few forested areas in North Dakota could change little or decline almost entirely. The uncertainties depend on many factors, including whether soils become drier and, if so, how much drier. Hotter, drier weather could increase the frequency and intensity of wildfires, decreasing the range and density of ponderosa pines and northern aspen-birch forests. Grasslands and savanna eventually could replace many of the forests and riparian woodlands in North Dakota. Increases in rainfall could, however, reduce the severity of these changes. These changes would significantly affect the character of forests and woodlands in North Dakota.

Changes In Forest Cover



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

Ecosystems

In North Dakota, eastern forests are found along with tallgrass, midgrass, and shortgrass prairies. An ecological transition zone, the state boasts Great Plains riverine forests, hardwood ravines, and a range of aquatic habitats. The Prairie Pothole Region, so crucial for waterfowl populations, covers large portions of the eastern and central parts of the state. More than half of North America's waterfowl production occurs in the Prairie Pothole Region. Many notable wildlife refuges are home to an incredible wealth of wildlife species. At Des Lacs National Wildlife Refuge, flocks of 250,000 snow geese are sometimes present. Up to 200,000 franklins and ring-billed gulls visit Tewaukon National Wildlife Refuge. Drainage of wetlands, agricultural encroachment, and increased fragmentation of native prairie are suspected in the recent declines of wetland and open grassland bird species. Since the 1970s, mallard, blue-winged teals, and northern pintails have been close to their lowest recorded populations. At same time, fire suppression and less grazing have resulted in encroachment by woody vegetation, and species associated with woody vegetation have increased dramatically. Increased nest predation by red fox, striped skunk, and raccoon has reduced nesting success of five species of ducks to levels that appear to be too low to support stable numbers of breeding ducks in the Prairie Pothole Region. Climate change could further stress and endanger many of these ecosystems.

The state's wildlife refuges and prairie pothole systems appear to be especially sensitive to changes in precipitation and temperature. Sixty percent of the annual variation in the number of these wetlands can be explained by year-to-year changes in temperature and precipitation. Smaller wetlands may be particularly vulnerable. Model projections show that warmer annual temperatures could result in reduced open water and greater vegetation cover, independent of precipitation changes. Rising temperatures, if continued for several years, could decrease breeding bird density and diversity in this critically important waterfowl habitat. Major threats to other ecosystems include habitat loss and species extinction, increased fire frequency, and increased vulnerability to invasive plant and insect species. Many species have already suffered significant declines because of loss of habitat, including bison, white tailed prairie dog, Arkansas River shiner, speckled chub, and numerous grassland and migratory birds. Species of the upland prairie may face additional problems in a changing climate. Under projected climate changes, all 23 grassland bird species could move north into regions that at the moment are mostly forest and are not expected to convert to grassland within the time frame of the projected warming. Hence, the size and fragmented nature of the existing grassland patches in the north would place an additional burden on bird populations.

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.