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EPA Climate Change And Nebraska

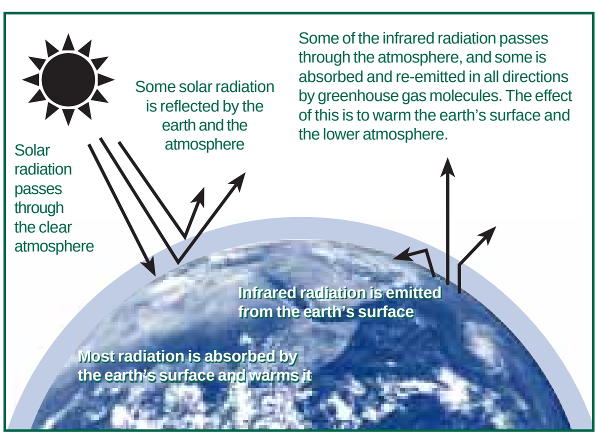
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

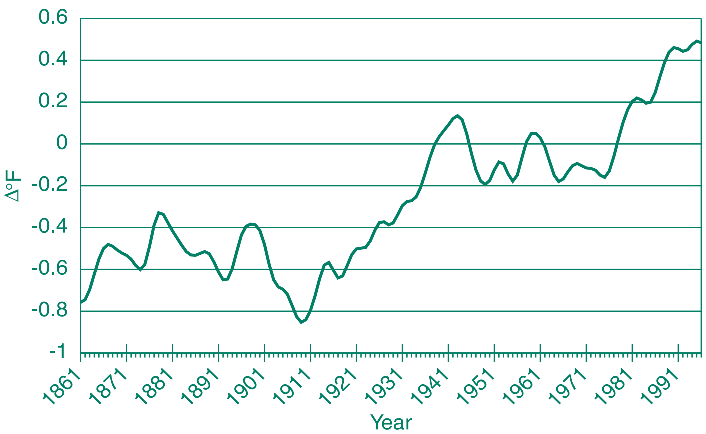
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

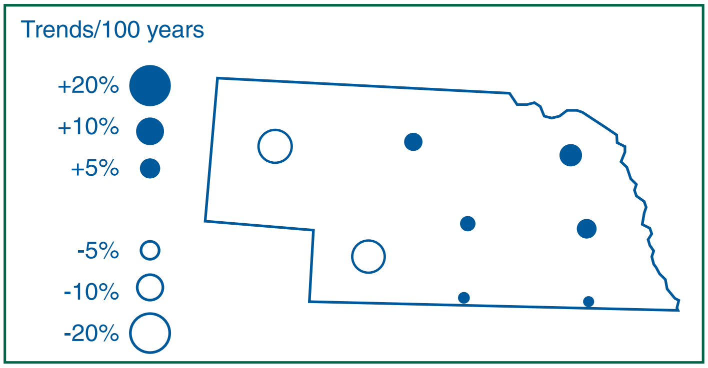
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency 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 Lincoln, Nebraska, has decreased 0.2°F, and precipitation has increased by up to 10% in many parts of the state, except in the far western areas where precipitation has fallen by nearly 20%. These past trends may or may not continue into the future.

Over the next century, climate in Nebraska could experience additional changes. 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 Nebraska could increase by 3°F in spring and summer (with a range of 1-6°F) and 4°F in fall and winter (with a range of 2-7°F). Precipitation is estimated to increase by 10% (with a range of 5-20%) in spring, summer, and fall, and 15% in winter (with a range of 5-30%). The amount of precipitation on extreme wet or snowy days in winter is likely to increase. 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 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. The elderly, especially those living alone, are at greatest risk. Nebraska, with its irregular, intense heat waves, could be susceptible. These effects have been studied only for populations living in urban areas; however, even those in rural areas may be susceptible.

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. A 2°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%. Although Nebraska is in compliance with current ozone air quality standards, increased temperatures could make remaining in compliance more difficult. 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. Upper and lower respiratory allergies also 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, thus increasing the potential for transmission of diseases such as malaria and dengue ("break bone") fever. Infected individuals can bring malaria to places where it does not occur naturally. Also, some mosquitoes in Nebraska 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 Nebraska, because populations of ticks, and their rodent hosts, could increase under warmer temperatures and increased shrub and woodland 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

Nebraska relies on both surface and groundwater to meet its water needs. Agricultural irrigation, which depends heavily on groundwater, is the largest user of water. Thick aquifer systems such as the High Plains, or Ogallala, aquifer underlie most regions of the state. The Missouri River and its major tributaries, the Platte, the Republican, and the Niobrara, drain much of the state. However, rainfall and runoff are highly variable, and water can be scarce in some regions and in some years. Runoff in the state comes primarily from spring snowmelt, much of which originates in Colorado and Wyoming, and from summer and spring thunderstorms. A warmer climate would lead to earlier spring snowmelt, resulting in high streamflows in winter and spring. In the summer, without large increases in precipitation, higher temperatures and increased evaporation would reduce streamflows and lake levels. Groundwater levels also could be reduced by lower spring and summer recharge. For a doubling in CO_2 levels, some studies show a 6-34% reduction in inflow into the Missouri River system. Drier summer conditions could severely affect the state's agricultural economic base. Under current conditions, two consecutive dry months in the summer can cause dryland crop failures. Under climate change, increased demand and reduced water availability in the summer also could increase competition between irrigation and wildlife habitat needs, such as maintaining critical habitat for migratory waterfowl in the Central flyway along the Platte River valley. Lower streamflows could compromise important uses of Missouri River reservoirs, including hydropower generation, navigation, municipal-industrial supply, fish and wildlife habitat, and recreation. Groundwater levels, which are declining in the intensively developed areas throughout the state, could be reduced further. The wetlands in Nebraska, which include shallow lakes and wet meadows in the Sand Hills region, rainwater basins in the southeast, and marshes along major rivers, also could be impaired by lower summer flows and water levels.

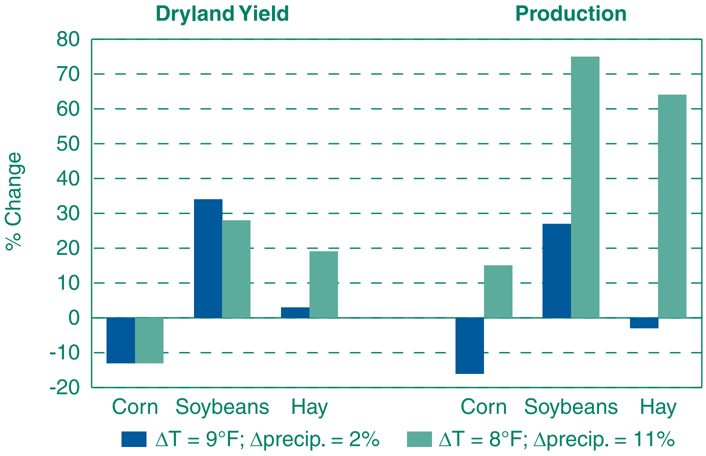
More rain would ease competition for available supplies, but it also could increase flooding. The North Platte, South Platte, and Platte rivers are vulnerable to floods from melting snow, and small streams can experience flash floods caused by intense summer thunderstorms. In a warmer climate, heavier rains are expected and flash floods could occur more frequently. Higher rainfall rates also could increase erosion and exacerbate levels of pollution from runoff. Leaching of nitrogen fertilizers into groundwater and contamination of surface waters from agricultural runoff are primary water quality concerns in Nebraska.

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 Nebraska, production agriculture is a $9 billion annual industry, 60% of which comes from livestock, mainly cattle. Almost 40% of the farmed acres are irrigated. The major crops in the state are corn, soybeans, and hay. Climate change could reduce corn yields by about 13% as temperature rises beyond the tolerance level of the crop. Hay and pasture yields could increase 2-19%, and soybean yields could increase by about 30%. Farmed acres could remain fairly constant or could increase by 28%. Livestock and dairy production may not be affected, unless summer temperatures rise significantly and conditions become significantly drier. Under these conditions, livestock tend to gain less weight and pasture yields decline, limiting forage.

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 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 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 forested areas in Nebraska could change little or decline by as much as 20-50%. 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, whereas increased rainfall could reduce their severity. In areas with richer soils, the range and density of southern pines could increase. Grasslands and savanna eventually could replace many of the forests and woodlands in eastern Nebraska. These changes would significantly affect the character of eastern Nebraska forests and woodlands.

Ecosystems

Nebraska stands at the transition between the eastern deciduous forests, the tallgrass prairie, and the shortgrass prairie. The oak-hickory forests of the eastern portion of the state also extend into the northern floodplain forests along major tributaries of the Missouri River. Important prairie ecosystems from east to west are bluestem, wheatgrass-bluestem-needlegrass, sandsage-bluestem, and grama-buffalo grass. The Nebraska Sandhills prairie in the northeastern portion of the state is one of the largest contiguous dune areas in the Western Hemisphere. Many of the native ecosystems of the state are some of the most critically endangered of the world's ecosystems. A tallying of known oak savanna sites from Missouri northward in 1985 found only 6,600 acres, some 0.02% of the estimated original coverage. Similarly, less than 1% of the original grasslands of prairie ecosystems remains undisturbed by human activities. These reductions have contributed to the state-wide endangerment of several animal and plant species, including the black-footed ferret, swift fox, and blow-out penstemon. During the last 25 years, populations of 10 endemic grassland bird species have declined, and 14 of 20 species that evolved primarily on the Great Plains declined similarly during this period.

Agricultural development and resultant nutrient, pesticide, sediment, and pollutant input levels have possibly exceeded the assimilative capacity of the Upper Missouri watershed. In recent decades, populations of fingernail clams, unionid mussels, submersed vegetation, migratory waterfowl, mink and otter have decreased along extensive reaches of the upper river. As a result, piping plover and interior least tern are endangered, and several prairie fishes that were once widespread and abundant are now threatened.

Wetlands used by the millions of waterfowl that migrate along the Mississippi corridor have also been reduced, and populations of mallard, blue-winged teal, and northern pintail are at or near their lowest numbers ever recorded. An increased number of invasive weed species, greater pest outbreaks, increased rates of aquifer use, and loss of wetlands for waterfowl could result from increased temperatures. One study of potential climate change impacts on a typical small prairie wetland showed that drier conditions resulted in less open water and greater vegetative cover. This would have significant negative implications for waterfowl populations because of the disproportionate importance of small prairie potholes and wetland extent for breeding bird density, diversity, and reproduction. As the quantity of suitable habitat declines, artificially high densities of waterfowl could lead to increased transmission of avian botulism and large-scale dieoffs.

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.