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Climate Change And Kansas

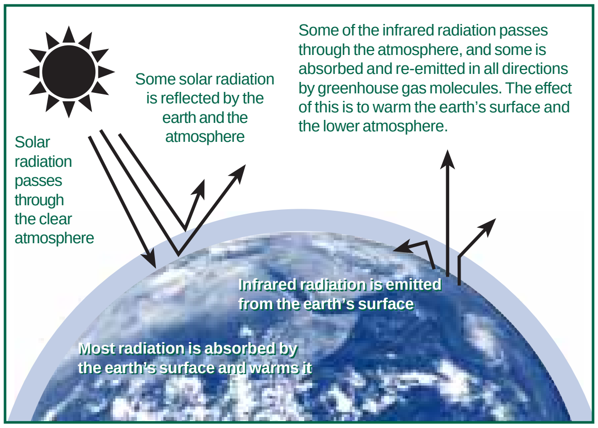
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

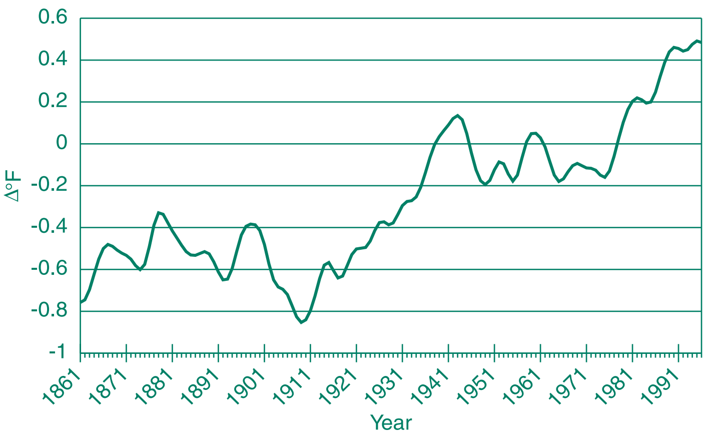
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

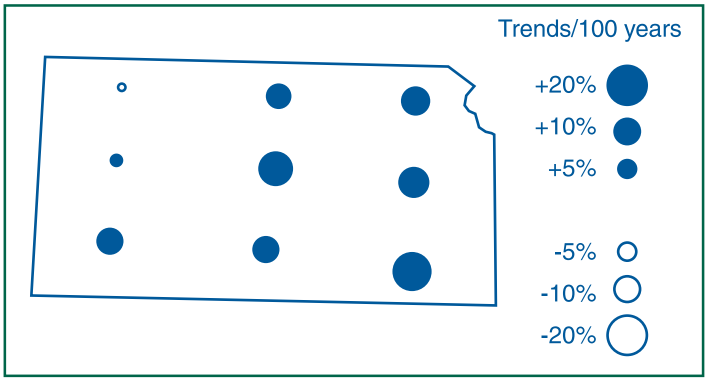
Over the last century, the average temperature in Manhattan, Kansas, has increased 1.3°F, and precipitation has increased by close to 20% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in Kansas 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 Kansas could increase by 2°F in spring (with a range of 1-4°F), 3°F in summer (with a range of 1-5°F), and 4°F (with a range of 2-7°F) in fall and winter. Precipitation is estimated to change little in winter, and increase by 15% (with a range of 5-25%) in other seasons. 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 such as tornados might be affected.

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. Kansas, with its irregular, intense heat waves, could be susceptible. One study estimates that in nearby Kansas City, summer deaths could increase by 150%, from about 50 to 75, with a warming of 4°F (although increased air

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

conditioning use may not have been fully accounted for). This study also shows that winter deaths could increase by 250% with a warming of 4-5°F. 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. 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 Kansas is in compliance with current 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 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. If conditions become warmer and wetter, mosquito populations could increase, thus increasing the risk of transmission if this and other diseases are introduced into the area. Warmer temperatures could increase the incidence of Lyme disease and other tick-borne diseases in Kansas, 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

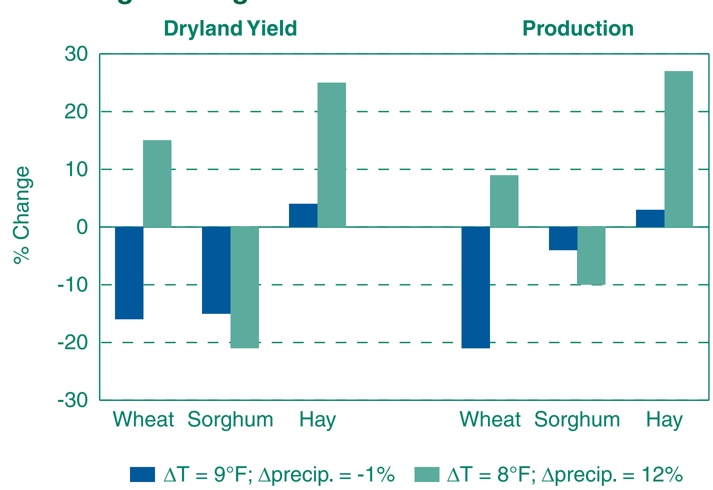
Water resources in Kansas are unevenly distributed. In western Kansas, where large-scale farming is common, surface water supplies are scarce and undependable. Groundwater is the principal supply in this region, primarily for irrigation. In eastern and south-central Kansas, where most urban centers are located and the land is better suited for livestock production, surface water is the primary source of water. Runoff in the state is largely influenced by summer rainfall and to a lesser degree by spring snowmelt. A warmer climate would lead to less snow and earlier snowmelt, resulting in higher streamflows in winter and spring. In the summer, without large increases in precipitation, higher temperatures and increased evaporation could lower streamflows and lake levels. Groundwater levels also could be reduced by lower spring and summer recharge. This could exacerbate water shortages, particularly in western Kansas, where streams unregulated by reservoirs currently suffer from long periods of negligible flow and where even the large reservoirs in the Republican and Smoky Hill river basins sometimes cannot provide sufficient water for irrigation. Streamflows in the Arkansas River, which have decreased because of irrigation demand and evaporation from reservoirs, could be diminished further in a warmer climate. Groundwater levels, which are declining because of large withdrawals, could be reduced further. In eastern Kansas, rivers such as the Kansas River have well-developed reservoir systems to store and regulate water supplies. But lower streamflows could compromise important reservoir uses, including municipal-industrial supply, fish and wildlife habitat, recreation, and irrigation. Additionally, drier conditions could complicate water allocations on the Arkansas and Missouri rivers. Lower flows and higher temperatures also could impair water quality by concentrating pollutant levels. During low flow periods, high mineral concentrations restrict uses on some streams.

More rain would ease competition for available supplies, but it also could increase flooding. Many areas adjacent to principal streams and rivers in Kansas are susceptible to flooding. According to National Flood Insurance Program designations, more than one-half of the communities and counties in Kansas have floodprone areas. Higher and more intense rainfall also could increase erosion and exacerbate levels of pollution in runoff. Storm runoff from urban areas, runoff and seepage from mining areas in southeastern Kansas, and runoff from agricultural lands are major water quality concerns in Kansas. Streambank erosion is a concern along reaches of several rivers, especially downstream of large reservoirs in the Kansas and Nemaha rivers.

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

Changes In Agricultural Yield And Production



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

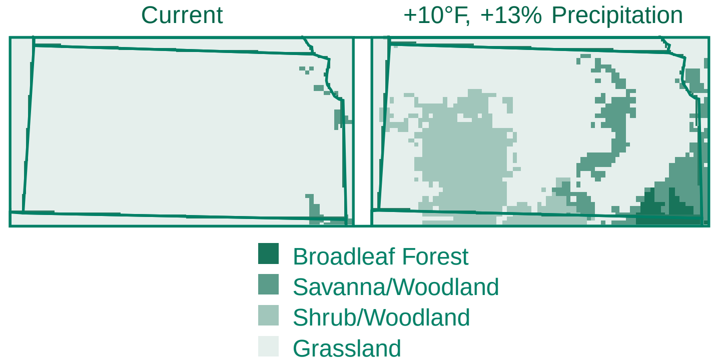
In Kansas, production agriculture is a $7.3 billion annual industry, two-thirds of which comes from livestock, mainly cattle. Almost 15% of the farmed acres are irrigated. The major crops in the state are wheat, sorghum, and hay. Climate change could reduce sorghum yields by 15-21%, and hay and pasture yields could rise by 4-25%. Wheat yields could rise by 15% or fall by 15%, depending on how climate changes and the extent to which the temperature tolerance levels of the crop are exceeded. Farmed acres could remain fairly constant. 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.

In Kansas, less than 5% of the area is forested, mostly in the southeastern part of the state and along rivers and streams. With changes in climate, the extent of forested areas in Kansas could change little or decline by as much as 10-30%. 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 Kansas. These changes would significantly affect the character of Kansas forests and woodlands.

Changes In Forest Cover



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

Ecosystems

The natural heritage of Kansas includes a transition from oak-hickory forest in the east, to bluestem prairie farther west, and finally to grama-buffalo grass prairie. Along the tributaries of the Mississippi are northern floodplain forests historically dominated by elm, ash, and cottonwood. The south-central part of the state historically was sandsage-bluestem prairie. Today, the oak savannas transition zone of the eastern part of Kansas is a globally threatened ecosystem. The wetlands of Kansas are a critically important waterfowl resource. Half the shore birds in North America are believed to stop at Quivira National Wildlife Refuge and nearby Cheyenne Bottoms National Wildlife Refuge during annual migrations. Without such habitat, shore birds, sandhill cranes, pelicans, and many waterfowl would be in jeopardy. These wetland habitats have experienced serious declines in the face of intensive agriculture. Populations of mallard, blue-winged teal, and northern pintail are at or near their lowest numbers ever recorded. Dam construction, agricultural land uses, and demand for irrigation have degraded riverine ecosystems and resulted in significantly reduced fish habitat. Populations of several prairie fishes that were once widespread and abundant in the south-central Great Plains have declined markedly.

Climate change could exacerbate the current threats to Kansas' ecosystems. A recent study showed that the health of the national wildlife refuges of the central part of the country would be threatened by projected changes in climate. Exotic species invasions, nutrient and pollutant concentrations, and sedimentation could increase in the freshwater systems of the state under climate change. Changes in water quality and quantity will also have important implications for migrant bird populations. Warmer and drier conditions would result in less open water and greater vegetative cover, which 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 productivity. 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.