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Climate Change And Arkansas

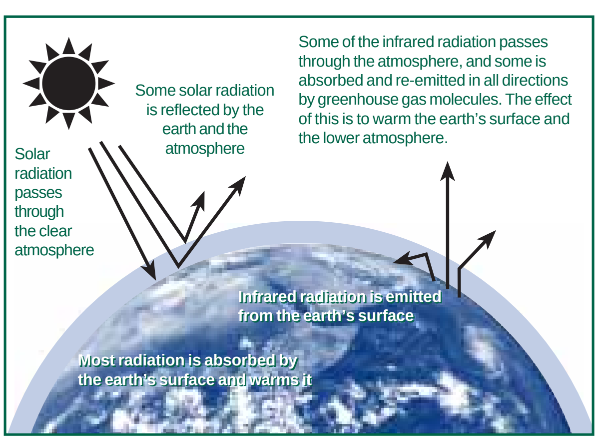
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

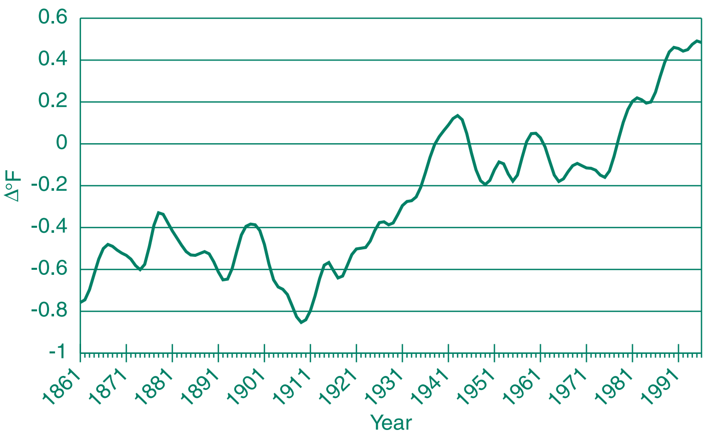
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

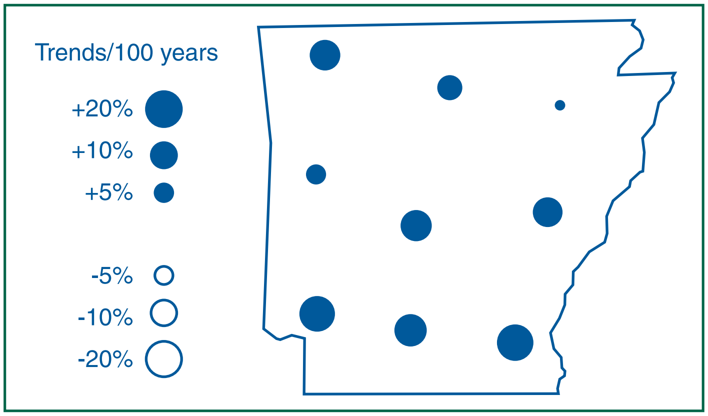
Over the last century, the average temperature in Fayetteville, Arkansas, has increased 0.4°F, and precipitation has increased by up to 20% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in Arkansas 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 Arkansas could increase by 2°F in winter and summer (with a range of 1-4°F), and 3°F in spring and fall (with a range of 1-5°F). Precipitation is estimated to change little in winter, increase by 15% in spring and fall (with a range of 5-25%), and increase by 25% in summer (with a range of 10-40%). 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 is expected to increase along with 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 summer thunderstorms is possible.

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, particularly those living alone,

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

are at greatest risk. 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. Although Arkansas 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 also are influenced by humidity. A 2°F warming and wetter conditions could increase the incidence and severity of 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, mosquitoes in Arkansas can carry malaria. If conditions become warmer and wetter, mosquito populations could increase, thus increasing the risk of transmission if this and other mosquito-borne diseases are introduced into the area. Warmer temperatures could increase the incidence of Lyme disease and other tick-borne diseases in Arkansas, 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

Arkansas has abundant surface and groundwater resources. About two-thirds of the runoff from the state flows into the Mississippi River through the Arkansas, White, and St. Francis rivers. Aquifers in the eastern part of the state are a major source of groundwater. Agriculture is the economic base of Arkansas, and the availability of water for irrigation of crops and maintenance of fish farms in the eastern part of the state is a primary concern. Because of large withdrawals, groundwater levels have declined rapidly in recent years, and saline water from underlying rocks has begun to intrude into the freshwater aquifers. Farmers have resorted to drilling deeper wells and exploring the use of surface waters from the Arkansas, White, and Little Red rivers as an alternative source.

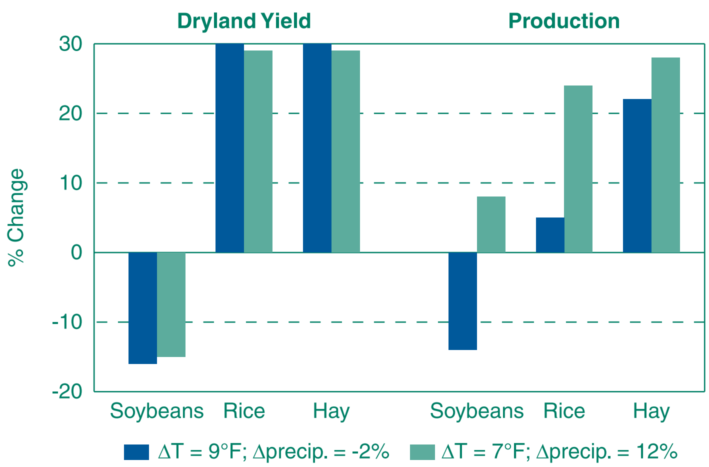
In a warmer climate, these problems could be exacerbated. Winter runoff could increase and spring and summer runoff could decrease in the northwestern Highlands and headwater areas outside the state. In other areas of the state, without increases in rainfall, higher temperatures and evaporation in the summer also could cause drier summer conditions. This could result in lower streamflows, lake levels, and groundwater levels at a time when water demand, particularly for irrigation, is often the highest. Many of the tributaries of the Arkansas River currently go dry during dry periods. Lower summer flows could also affect water-based recreation such as fishing, boating, and canoeing. Per capita boat ownership in Arkansas is one of the highest in the nation. Warmer, drier summer conditions could also increase water quality problems such as low dissolved oxygen and lake eutrophication, and could adversely affect wetlands.

In a warmer climate, rainfall could increase. Higher rainfall could alleviate water supply problems and recharge groundwater aquifers, but also could increase flooding. Intense rainfalls currently cause localized flooding problems throughout the state. Much of the farmland in eastern Arkansas is in the floodplains of major streams, and widespread flooding in low-lying areas is a continuing concern. Higher rainfall and streamflow also could increase erosion and levels of pesticides and fertilizers in runoff from farming areas. It also could increase pollution in runoff from urban and mining areas. The pollution of water and the accumulation of pesticides in bottom sediments of streams, lakes, and ponds in agricultural areas have been important water quality issues in the state.

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)

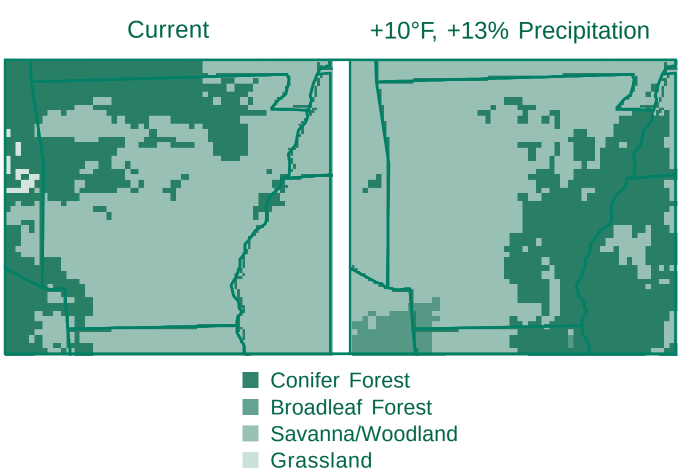
Understandably, most studies have not fully accounted for changes in climate variability, water availability, crop pests, changes in air pollution such as ozone, and adaptation by farmers to changing climate. Including these factors could change modeling results substantially. Analyses that assume changes 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 Arkansas, production agriculture is a $4 billion annual industry, three-fourths of which comes from livestock, mainly poultry. Almost one-half of the farmed acres are irrigated. The major crops in the state are soybeans, rice, and hay. Soybean yields could rise by 11% with adequate irrigation or fall by 16%, depending on how climate changes. In contrast, rice, hay, and pasture yields are projected to increase by about 30%. Farmed acres are projected to remain fairly constant in response to offsetting changes in estimated farm production and prices. 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 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 subtropical evergreens, would prevail over time. 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.

Changes In Forest Cover



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

In Arkansas, longleaf and slash pine forests could expand northward and replace loblolly and shortleaf pine forests. Wetter conditions would favor expansion of southern pine, oak, and hickory forests. In contrast, under drier conditions, scrub and other noncommercial oaks and shrubs could increase their range, and 40-60% of the forests in the state could be replaced by grasslands and pasture. Warmer and drier conditions could increase the frequency and intensity of fires, which could result in increased losses to important commercial timber areas. Even warmer and wetter conditions could stress forests by increasing the winter survival of insect pests.

Ecosystems

The Arkansas landscape is divided between highland ecosystems in the north and lowland habitats in the south. The Ozark and Ouachita plateaus are covered by oak, hickory, maple, and beech forests and host several endemic animal species, including fish and salamanders. The Mississippi alluvial plain region, the delta, contains the remnants of a once-extensive bottomland hardwood forests and meandering flatland rivers. The floodplains of the White and Cache rivers contain the most important breeding areas for mallard ducks in the world — as much as 10% of the continent's population may winter in this area. Loess ridges are found within the delta region, and they contain several plant species that are uncommon elsewhere in the state. The sandy soils of the Gulf coastal plain are dominated by pine woods, including loblolly, longleaf, and shortleaf, and provide old-growth habitat for endangered red-cockaded woodpeckers and other animals.

Scientists working in the Cache River have already documented a steady decline in magnitude and predictability of base flow during low flow periods since the 1920s, which they have attributed largely to intensive agriculture. Direct and indirect effects of climate change would exacerbate these and other threats to riparian ecosystems, including exotic species invasions, excess nutrient and toxin loading, and sedimentation. Habitat for warm water fish could also be reduced by hotter temperatures. The physical impacts on stream channels in the Ozarks could be significant. Because of extensive land use changes, coarse gravel (with low water retention capacity) has been accumulating along riparian shores at the expense of fine sediment. Research has demonstrated that changes in hydrology, which could be exacerbated by climate change in the future, affect the ability of willows and sycamores to germinate, which in turn is expected to affect sediment transport processes and habitat availability in these riparian systems. A warming climate with less midcontinental rainfall would increase pressure on aquifers such as the Ogallala, which in turn could affect the Arkansas river basin. Increased air temperatures could have an adverse effect on the hydrology and productivity of loblolly pine stands, which in western Arkansas are at the limit of their range.

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.