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Climate Change And Texas

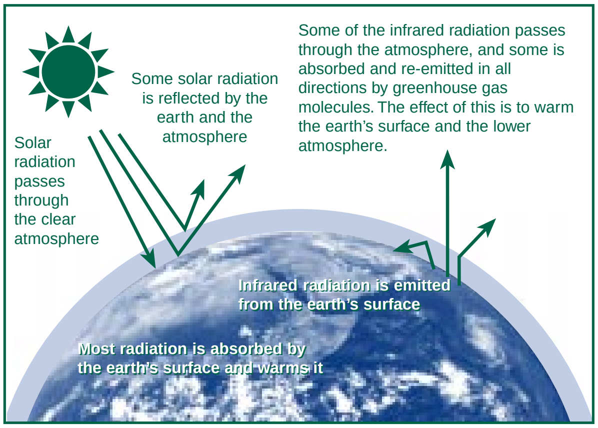
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed. 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, common air pollutants, cool the atmosphere by reflecting incoming solar radiation. However, sulfates are short-lived and vary regionally.

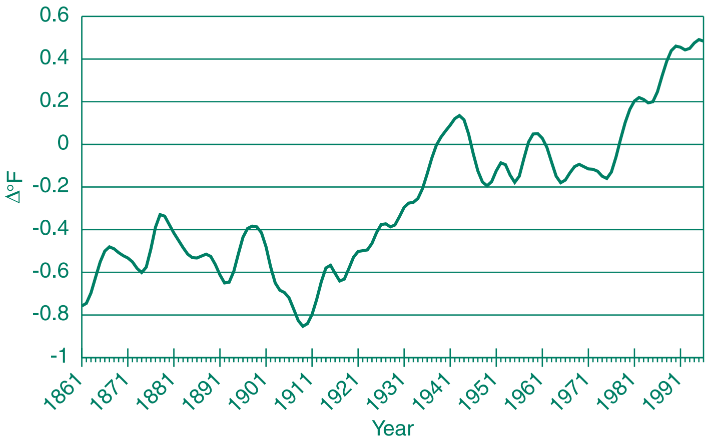
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

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 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.

Global Temperature Changes (1861–1996)



Source: IPCC (1995), updated

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. Scientists are reasonably confident 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 annual temperature in San Antonio, Texas, has decreased 0.5°F, and precipitation has decreased by up to 20% in some parts of the state.

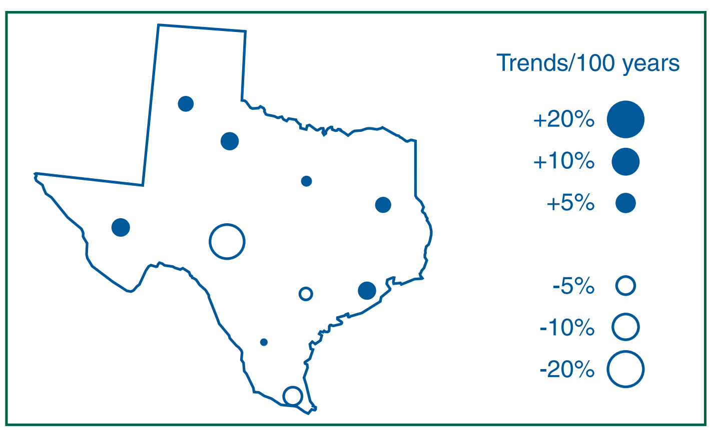
Over the next century, climate in Texas could experience additional changes. For example, based on projections made by the Intergovernmental Panel on Climate Change and results from the United Kingdom Hadley Centre's climate model (HadCM2), a model that accounts for both greenhouse gases and aerosols, by 2100 temperatures in Texas could increase by about 3°F in spring (with a range of 1-6°F) and about 4°F in other seasons (with a range of 1-9°F). Precipitation is estimated to decrease by 5-30% in winter and increase by about 10% in the other seasons. Increases in summer could be slightly larger (up to 30%) than in spring and fall. Other climate models may show different results. The amount of precipitation on extreme wet or snowy days in winter is likely to decrease, and the amount of precipitation on extreme wet days in summer 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 severe storms such as hurricanes would change.

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

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

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.

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. Texas, with its intense heat waves, could be especially susceptible.

In Dallas, one study projects that by 2050 heat-related deaths during a typical summer could triple, from about 35 heat-related deaths per summer to over 100 (although increased air conditioning use may not have been fully accounted for). Winter-related deaths are expected to change very little. The elderly, particularly those living alone, are at greatest risk.

Climate change could increase concentrations of ground-level ozone. Currently, ground-level ozone concentrations exceed national ozone health standards in some areas across the state. The Houston-Galveston area is classified as a "severe" nonattainment area, and the El Paso area is classified as in "serious" non-attainment. Ground-level ozone has been shown to aggravate respiratory illnesses such as asthma, reduce existing lung function, and induce respiratory inflammation. In addition, ambient ozone reduces crop yields and impairs ecosystem health. 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.

Warming and other climate changes may 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. Recently reported cases of malaria and dengue fever in Texas demonstrate the continued risk of these diseases. If conditions become warmer and wetter, mosquito populations could increase, thereby increasing the risk of transmission.

In addition, warmer seas could contribute to the increased intensity, duration, and extent of harmful algal blooms. These blooms damage habitat and shellfish nurseries and can be toxic to humans. About two-thirds of the Texas coastline was closed to shellfish harvesting in 1996 because of contamination by an unusually large bloom of marine algae, or "red tide." Consumption of contaminated shellfish can cause neurotoxic shellfish poisoning. Warming in the Caribbean may have contributed to this problem; future warming combined with local pollution most likely would continue to damage fish and shellfish and thus affect human health.

Coastal Areas

Sea level rise could lead to flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater contamination of drinking water, and decreased longevity of low-lying roads, causeways, and bridges. In addition, sea level rise could increase the vulnerability of coastal areas to storms and associated flooding.

The Texas coastline is over 1,400 miles long. The coastline is composed of wind tidal flats, sandy marshes, salt marshes, and beaches. The Laguna Madre has over 350 square miles of wind tidal flats that provide nesting areas or rookeries for sea birds. The sandy marsh shoreline provides critical habitat for shorebirds, wading birds, endangered brown pelicans, and other birds. About 75% of the ducks and geese found in the United States move through the Texas coastal wetlands. The salt marshes provide a home for oysters and clams, and serve as nursery grounds for young shrimp, crab, and fish. These marshes protect the shorelines from erosion and also act as a purification system by filtering out many pollutants added to the waters by human activities.

At Galveston, sea level already is rising by 25 inches per century, and it is likely to rise another 38 inches by 2100. Brown shrimp catch in the U.S. Gulf Coast could fall 25% with only a 10-inch rise in sea level. Possible responses to sea level rise include building walls to hold back the sea, allowing the sea to advance and adapting to it, and raising the land. Each of these responses will be costly, either in out-of-pocket costs or in lost land and structures. For example, the cumulative cost of sand replenishment to protect the coast of Texas from a 20-inch sea level rise by 2100 is estimated at $4.2-$12.8 billion.

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 is likely to increase with warmer climate, it could result in lower river flow and lower lake levels, particularly in the summer. If streamflow and lake levels drop, groundwater also could be reduced. In addition, more intense precipitation could increase flooding.

Several major river basins lie in part, or entirely, within Texas. Most of the state is drained by several south-flowing rivers, including the Neches, Trinity, Brazos, Colorado, San Antonio, and Nueces. Western Texas drains into the Rio Grande or its major tributary, the Pecos River. Unless increased temperatures are coupled with a strong increase in rainfall, water could become more scarce. A warmer and drier climate would lead to greater evaporation, as much as a 35% decrease in streamflow, and less water for recharging groundwater aquifers. Increased rainfall could mitigate these effects, but also could contribute to localized flooding. Additionally, climate change could give rise to more frequent and intense rainfall, resulting in flash flooding.

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 sectors.

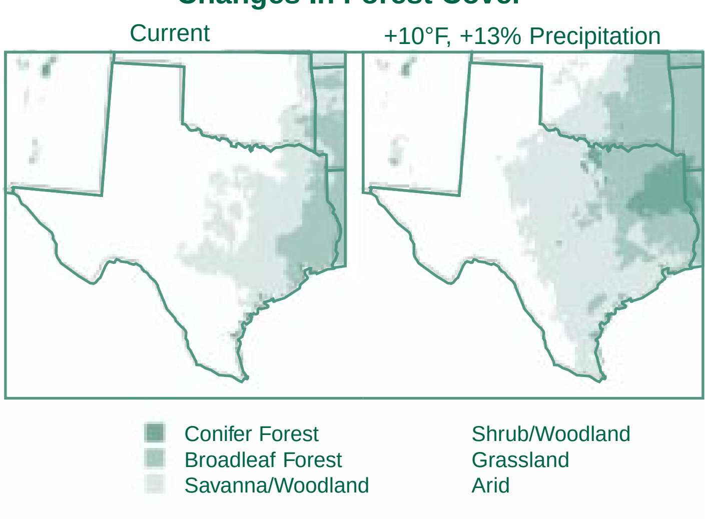
Understandably, most studies have not fully accounted for changes in climate variability, water availability, and imperfect responses by farmers to changing climate. Including these factors could change modeling results substantially. Analyses that assume changes in average climate and effective adaptation by farmers suggest that aggregate U.S. food production would not be harmed, although there may be significant regional changes.

In Texas, agriculture is a $12.6 billion annual industry, two-thirds of which comes from livestock, especially cattle. About 25% of the crop acreage is irrigated. The major crops in the state are cotton, wheat, and sorghum. Climate change could reduce cotton and sorghum yields by 2-15% and wheat yields by 43-68%, leading to changes in acres farmed and production. For example, cotton yields could fall while production rises because of an increase in cotton acres farmed. Irrigated acreage could decline slightly because of decreased water availability.

Forests

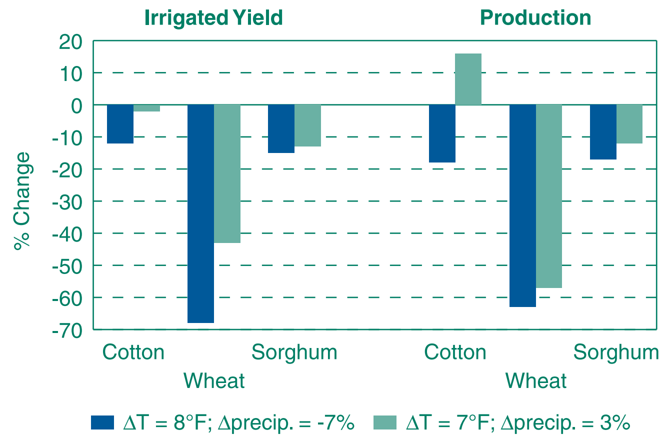
Trees and forests are adapted to specific climate conditions, and as climate warms, forests will change. These changes could include changes in species, geographic range, and health and productivity. If conditions also become drier, the current range of forests could be reduced and replaced by grasslands and pasture. Even a warmer and wetter climate could lead to changes; trees that are better adapted to warmer conditions, such as southern pines, would spread. Under these conditions, forests could become more dense. These changes could occur during the lifetimes of today's children, particularly if 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



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

Changes In Agricultural Yield And Production



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

With changes in climate, the extent and density of forested areas in east Texas could change little or decline by 50-70%. Hotter, drier weather could increase wildfires and the susceptibility of pine forests to pine bark beetles and other pests, which would reduce forests and expand grasslands and arid shrublands. With increased rainfall, however, these effects could be less severe. In some areas, the types of trees dominating Texas forests would change; for example, longleaf and slash pine densities could increase in the deciduous forests of east Texas.

Ecosystems

The vast area within Texas includes a great diversity of ecosystems, from forests to grasslands to semiarid shrublands to extensive coastal and inland wetlands. In Texas, climate change could weaken and stress trees, making them more susceptible to pine bark beetle outbreaks. Semi-arid grasslands and shrublands are very sensitive to changes in rainfall season and in the amount of rainfall, and could be affected adversely by warmer, drier conditions.

The Balcones Canyonlands National Wildlife Refuge in central Texas provides nesting grounds for the golden-cheeked warbler and the black-capped vireo, two endangered songbirds. Warmer and drier conditions could reduce critical habitat in the refuge and further stress sensitive plant and animal populations. The coastal wetlands, which support important fisheries and provide vital wildlife habitat, are also vulnerable to climate change. For example, Brazoria National Wildlife Refuge, a 43,388 acre coastal estuarine and coastal prairie habitat on the Gulf Coast, provides winter habitat for 30,000-40,000 ducks and 40,000 snow geese. The refuge also contains about 4,000 acres of native coastal bluestem prairie. Changes in rainfall and runoff from upland regions could adversely affect sensitive coastal systems, and sea level rise would accelerate loss of wetlands and estuaries, eliminating breeding and foraging habitat for commercial, game, and threatened and endangered species.

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.