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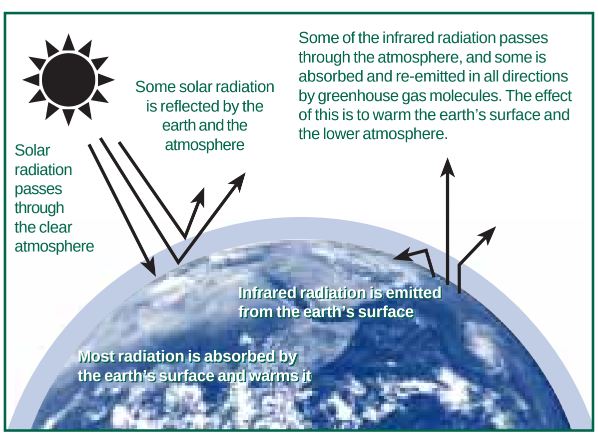
Climate Change And Ohio

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.



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.

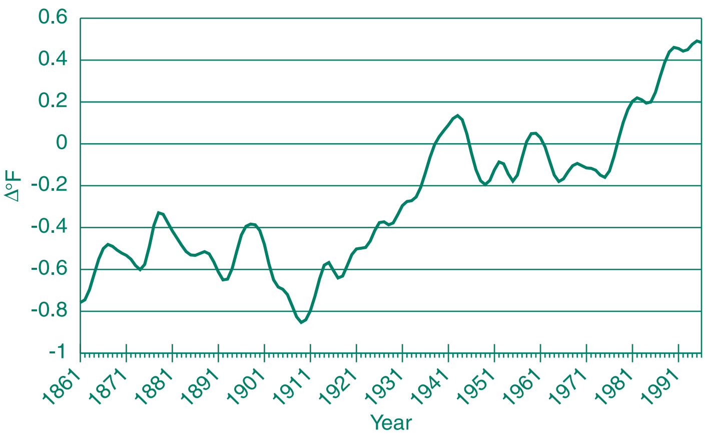
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

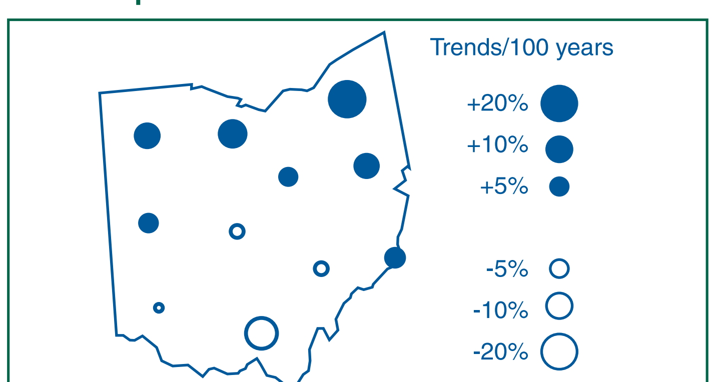
Over the last century, the average temperature near Columbus, Ohio, has increased 0.3°F, and precipitation has increased by up to 10% in this and other parts of the state, and declined by up to 10% in the southern part of the state. These past trends may or may not continue into the future.

Over the next century, climate in Ohio may 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 Ohio could increase by 3°F in winter, spring, and summer (with a range of 1-6°F) and 4°F in fall (with a range of 2-7°F). Precipitation is estimated to increase by 15% in winter and spring (with a range of 5-25%), 20% in fall (with a range of 10-35%), and 25% (with a range of 10-40%) in summer. 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. Ohio, with its irregular, intense heat waves, could be susceptible.

Precipitation Trends From 1900 To Present



Source: Karl et al. (1996)

One study projects that heat-related deaths could nearly double in both Cleveland and Columbus given a 4°F warming, from about 30 to 60 (although increased air conditioning use may not have been fully accounted for). In Cincinnati, summer deaths are estimated to nearly triple with a warming of 3°F, from 14 to 42. The elderly, especially those living alone, are at greatest risk. This study also projects little change in winter-related deaths in Cleveland, Columbus, and Cincinnati.

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%. Perhaps more important, however, is that the area exceeding national health standards for ozone could increase. Currently, Cincinnati is classified as a "moderate" nonattainment area for ozone, and increased temperatures could increase ozone concentrations further. 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 Ohio can carry California and St. Louis 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 Ohio, 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

The availability of water has helped Ohio develop a diverse economy: agriculture in the north and west, manufacturing in the northeast, and timber and mining industries in the southeast. Urban and industrial centers also have developed along Lake Erie, the Ohio River, and the navigational canals and rivers that join them. Surface water is the primary source of water for these activities. Runoff in the state is determined largely by rainfall and to a lesser degree by spring snowmelt. Earlier snowmelt would result in higher streamflows in winter and spring. Lower streamflows and lake levels in the summer could reduce water availability for municipalities and industries. The Ohio River and its major tributaries, the Muskingum, Scioto, and Great Miami rivers, are well developed with dams and reservoirs. Lower flows could adversely affect important uses such as navigation and water supply, although large storage reservoirs or changes in operations could moderate some impacts. Higher summer temperatures and lower flows also could degrade water quality by concentrating pollutants. Drinking water quality, urban and industrial discharges, and storm water overflows are important water quality issues in Ohio.

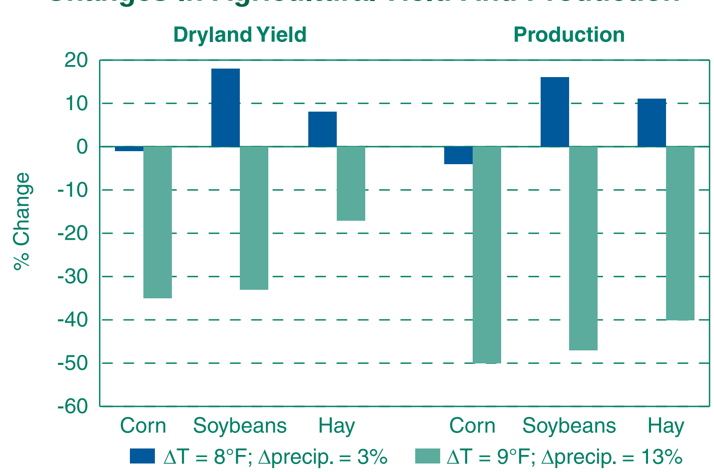
Floods occur in Ohio nearly every year. In a warmer climate, rainfall could be higher and storms could be more intense. Wetter conditions would increase water availability, but could increase flooding. Areas such as the Maumee and Blanchard river basins and the lowlands south of Columbus are susceptible to flooding. In the northern and western parts of the state, erosion of farmland can be severe. Increased rains could exacerbate levels of pesticides and fertilizers in runoff from agricultural lands and sedimentation of navigation channels. It also could increase acid drainage from mining activities in eastern and southeastern Ohio.

In a warmer climate, increased temperature and higher evaporation could reduce inflows into the Great Lakes and lower lake levels. Shorelines could be vulnerable to erosion damage from wind and rain, but flood damage could be reduced. Harbors and channels could require more dredging. Although lower water levels in channels connecting the lakes could hamper shipping, reduced ice cover would lengthen the shipping season. Warmer temperatures could degrade lake water quality.

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 Ohio, production agriculture is a $4.4 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 corn, soybeans, and hay. Corn yields could fall by as much as 35% under severe conditions where temperatures rise beyond the tolerance levels of the crop and are combined with increased stress from decreased soil moisture. Depending on how climate changes, hay and pasture yields could fall by 16% or rise by 8%, and soybeans yields could rise by 18% or fall by 33%. Farmed acres could remain fairly constant, or they could decrease by as much as 20%. Nursery and horticulture crops are also important to Ohio agriculture and could be affected by climate change. However, these impacts have not been well studied, and because inputs such as water are tightly managed for many of these crops, their exposure to climate change may be limited.

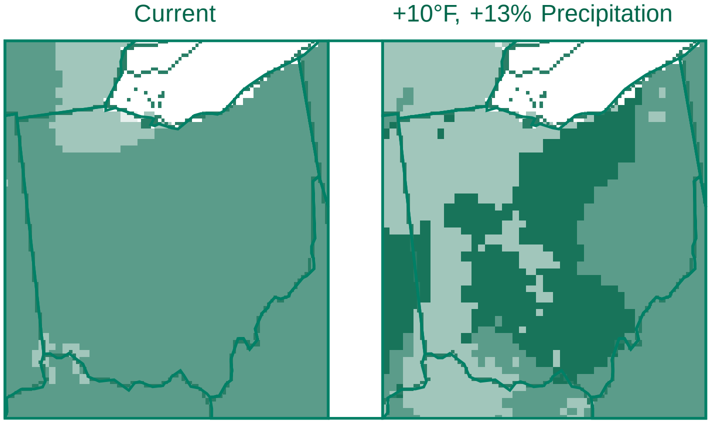
Forests

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 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 forested areas in Ohio could change little or decline by as much as 30-50%. Even if there is no decline in forested area, the types of trees dominating those forests and woodlands are likely to change. In a warmer climate, forested areas could be increasingly dominated by pine and scrub oaks, replacing many of the eastern hardwoods common throughout Ohio forests. In areas where richer soils are prevalent or if precipitation increases significantly, southern pines could increase their range and density. In contrast, under drier conditions or in areas with poorer soils (which are more common in Ohio's forests), scrub oaks of little commercial value (e.g., post oak and blackjack oak) could increase their range.

Changes In Forest Cover

Current | +10°F, +13% Precipitation



Conifer Forest | Savanna/Woodland | Broadleaf Forest | Grassland

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

Ecosystems

Much of Ohio's landscape has been transformed by logging, agricultural, urban, and industrial development, increasing the importance of the few, high quality, natural communities that remain today. The northern third of the state, which drains into Lake Erie, contains plant communities ranging from deciduous and hemlock forests to prairies, sand barrens, savannas, bogs, fens, marshes, and sandy beaches. Oak savanna and wet prairie habitats mark where eastern forests meet western prairie ecosystems, and these are threatened communities. Less than 2% of the original oak savannas in the Midwest exists today. This habitat contains more than one-third of the rare plants and animals in Ohio. Over 65 species of birds and many butterfly species nest within the region, including the less than 20 nesting pairs of endangered lark sparrow that survive in the state.

Ohio is in one of the nation's most highly industrialized regions. It had already lost 90% of its wetlands between 1700 and 1980. Changes in climate could further threaten remaining wetlands, particularly ecosystems within the Lake Erie drainage. If the level of Lake Erie falls, the wetland habitats that depend on inundation of freshwater from the lake would be adversely affected. Warming could change the temperature structure of lakes, availability of dissolved oxygen, and cycling of nutrients, all of which will affect aquatic flora and fauna. If temperatures in Lake Erie rise as projected, cold water refuges for certain fishes may disappear and areas of warm water could increase, thus altering the types and ranges of fish species and communities. Lower dissolved oxygen levels in Ohio ponds during warmer years have reduced cool-water bottom habitat for northern pike, summer weight, and development. Warmer water temperatures in rivers and streams of the state could enhance invasion of white perch, which exhibits higher winter survival of young during warm winters.

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.