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EPA Climate Change And West Virginia

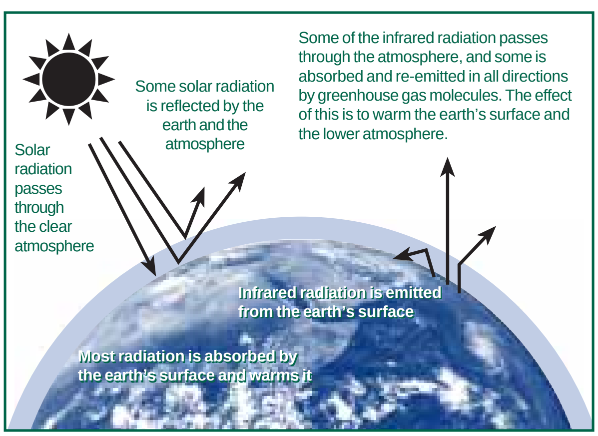
The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases — primarily carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. The heat-trapping property of these greenhouse gases is undisputed.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

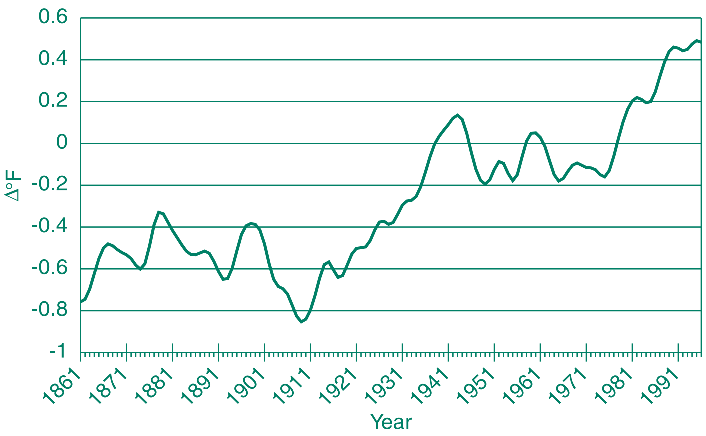
Although many greenhouse gases already are present in the atmosphere, oceans, and vegetation, their concentrations in the future will depend in part on present and future emissions. Estimating future emissions is difficult, because they will depend on demographic, economic, technological, policy, and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

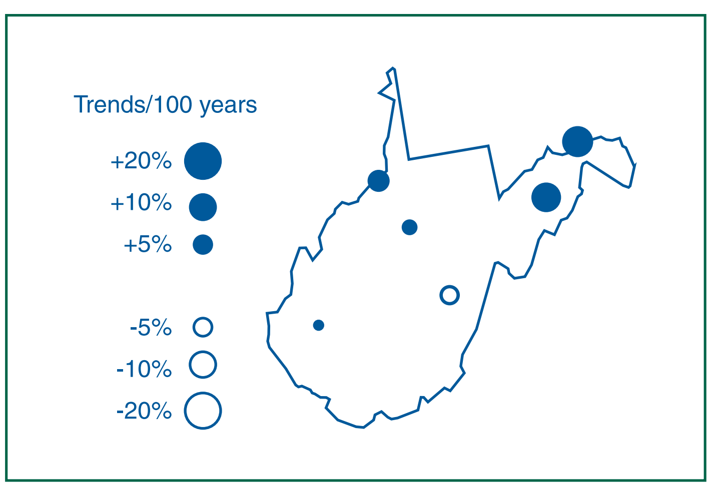
Calculations of regional climate change are much less reliable than global ones, and it is unclear whether regional climate will become more variable. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency 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 Charleston, West Virginia, has increased 1.1°F, and precipitation has increased by up to 10% in many parts of the state. These past trends may or may not continue into the future.

Over the next century, climate in West Virginia 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 West Virginia 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 20% (with a range of 10-30%) in all seasons, slightly more 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 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 summer thunderstorms 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, particularly those living alone, 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 West Virginia 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.

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. Warmer temperatures could increase the incidence of Lyme disease and other tick-borne diseases in West Virginia, because populations of ticks, and their rodent hosts, could increase under warmer temperatures and increased vegetation.

Infected individuals can bring malaria to places where it does not occur naturally. Also, some mosquitoes in West Virginia can carry malaria, and others can carry California encephalitis, which can be lethal or cause neurological damage. If conditions become warmer and wetter, mosquito populations could increase, thus increasing the potential for transmission if these diseases are introduced into the area. 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

Surface water is the principal source of water for public supply and industrial uses in West Virginia. Groundwater provides water for almost one-half of the population and nearly all the rural domestic supplies. Major rivers in the state include the Monongahela, Little Kanawha, Kanawha, Guyandotte, and Big Sandy rivers. These rivers drain into the Ohio River, which forms the boundary between Ohio and West Virginia. Rivers in the Eastern Panhandle region drain into the Potomac River. The topography of West Virginia is rugged, and many of the rivers in the state are influenced by winter snow accumulation and spring snowmelt. A warmer climate would lead to an earlier spring snowmelt, resulting in higher streamflows in winter and spring. Lower streamflows and lake levels in the summer and fall could affect the dependability of surface water supplies, particularly since many of the streams in West Virginia have low flows in the summer. The growing tourism and recreation industries such as whitewater rafting also could be affected by lower summer streamflows. Groundwater sources also could be reduced by lower spring and summer recharge. Lower summer streamflows and warmer temperatures could affect water quality by concentrating pollutant levels. This could exacerbate existing problems with acid drainage from coal mines, high concentrations of fecal coliform bacteria, and industrial pollution from the manufacturing plants along the floodplains of the Ohio and Kanawha rivers.

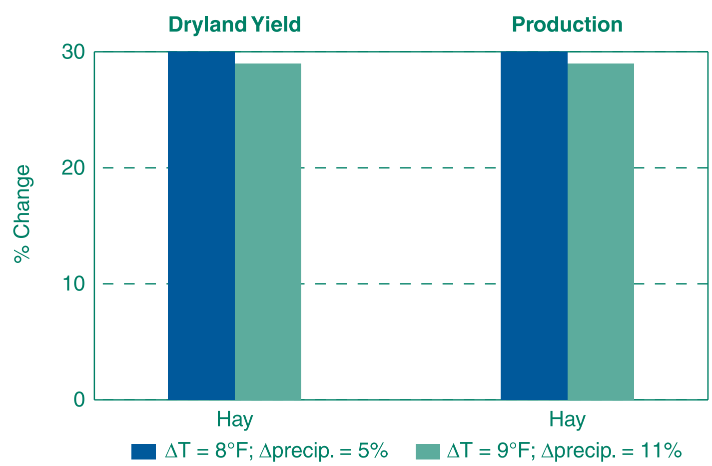
Increases in rainfall could mitigate these effects. Higher rainfall, however, could contribute to increased flooding. Most homes and businesses in West Virginia are built on flat, narrow valley floors and are susceptible to flooding. More rain also could increase erosion and exacerbate pollution in runoff areas devoted to manufacturing, coal mining, and oil and gas extraction.

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 West Virginia, production agriculture is a $400 million annual industry, three-fourths of which comes from livestock, mainly cattle and poultry. Very few of the farmed acres are irrigated. The major crop in the state is hay. Hay yields could increase by about 30% as a result of climate change, leading to changes in acres farmed and production. Farmed acres could remain constant or could decrease by as much as 30% in response to changes in prices, for example, possible decreases in hay 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 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 West Virginia could change little or decline by as much as 5-10%. However, the types of trees dominating those forests and woodlands are likely to change. Forested areas could be increasingly dominated by pine and scrub oaks, replacing many of the eastern hardwoods common throughout West Virginia. In areas where richer soils are prevalent, southern pines could increase their range and density, and in areas with poorer soils, which are more common in West Virginia's forests, scrub oaks of little commercial value (e.g., post oak and blackjack oak) could increase their range. As a result, the character of forests in West Virginia could change. Climate change also could affect the success of tree plantings to stabilize open-face mining sites.

Ecosystems

The state of West Virginia is 97% forested, and much of this cover is in high-elevation areas. These areas contain some of the last remaining stands of red spruce, which are seriously threatened by acid rain and could be further stressed by changing climate. These forests provide habitat for many plants and animals, including the varying hare, red squirrel, the endangered Virginia northern flying squirrel, and the threatened Cheat Mountain salamander. Whereas species of lower elevations at least have the potential to move upward in response to warming temperatures, those in high elevation areas do not. Given a sufficient change in climate, these spruce forests could be substantially reduced, or could disappear.

Monongahela National Forest

The Monongahela National Forest has over 900,000 acres of public land, which include the North and South Laurel Forks Wilderness, the Dolly Sods Wilderness, Otter Creek, and the Cranberry Wilderness. This scenic forest supports a rich variety of plant and animal life. The forest, a popular destination, has over one million visitor days of sightseeing and recreational use each year. The Monongahela National Forest contains maple, black cherry, birch, beech, and yellow poplar. With elevations ranging from 2,600 to over 4,000 feet, the Dolly Sods Wilderness supports unique plant communities similar to those of northern Canada. Sphagnum bogs, red spruce, yellow birch, grassy sods, azaleas, rhododendron, and mountain laurel can be found. White-tailed deer, wild turkey, bobcat, and black bear are among the wildlife found in the area. The headwaters of five river systems, which support populations of beaver and coldwater fish such as native trout, are found in the forest.

The forest's rare and unique flora and fauna could have difficulty adapting to climate change. With few natural corridors to allow species to migrate, it is possible that species unique to the area could be significantly stressed by climate and habitat changes.

West Virginia has the fourth highest number of caves (including 3,300 limestone caves) in the nation and 11 of the world's 50 longest caves. At least eight species of bats, including two that are federally endangered (Indiana bat and the Virginia big-eared bat), use caves as winter hibernation roosts or to raise young in the summer. One cave protects over 5,000 Indiana bats each winter, and another contains the largest known concentration of hibernating Virginia big-eared bats as well as the largest known maternity colony. Higher-than-normal winter temperatures could boost temperatures inside cave bat roosting sites, which has been shown to cause higher mortality due to increased winter body weight loss in endangered Indiana bats (e.g., an increase of 9°F during winter hibernation has been associated with a 42% increase in the rate of body mass loss). The south branch cave beetle is another endangered cave dweller.

Another unique West Virginia ecosystem is in the Ice Mountain Preserve. In a small slope area there are 60 small holes and openings at the base of a rock talus whose vents blow 38°F air year round. As a result, high elevation boreal plants group around the cold air vents, where ice can be seen well into May. The effects of gradually warming temperatures are already noticeable on Ice Mountain, and ice around the vents is disappearing earlier in the year. This could adversely impact the boreal plants found in this system.

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.