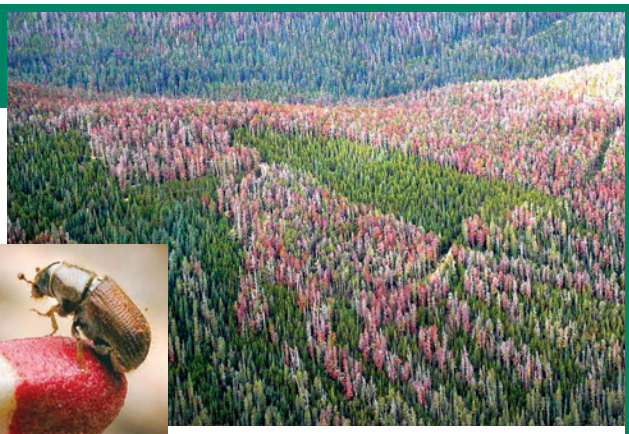
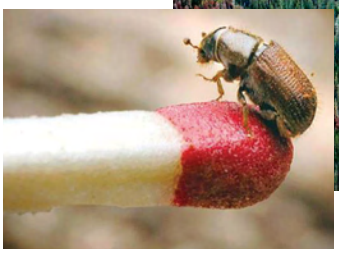
The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States

(U.S. Climate Change Science Program Synthesis and Assessment Product 4.3)

There is a robust scientific consensus that the Earth's climate has changed and will continue to change as human activities increase the concentrations of greenhouse gases in the atmosphere. This global scale change is affecting North America, which is very likely to experience significant warming and changes to temporal and spatial patterns of precipitation over the next several decades. In order to examine the implications of these changes for our nation, the U.S. Climate Change Science Program (CCSP) requested a group of experts to assess the ways that climate change is affecting U.S. agriculture, land resources, water resources, and biodiversity. This brochure summarizes the major findings and conclusions from their report.

Overarching Conclusions

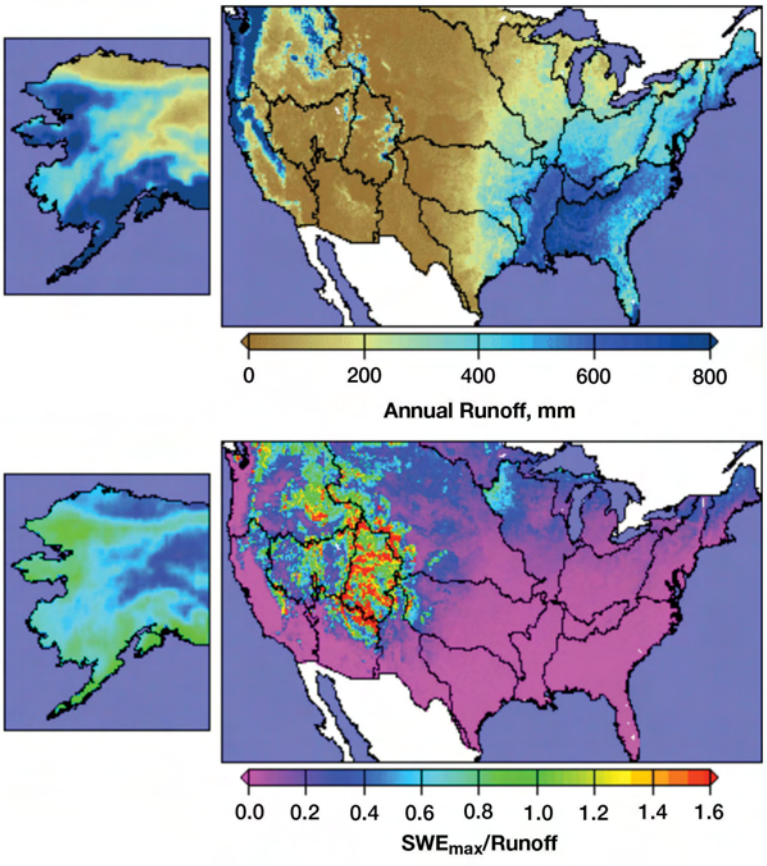




The CCSP study found it very likely that the United States has been and will continue to be affected by climate change, as expressed in the following overarching conclusions.

- Climate changes – temperature increases, increasing CO_2 levels, and altered patterns of precipitation – are already affecting U.S. water resources, agriculture, land resources, and biodiversity.
- Climate change will continue to have significant effects on these resources over the next few decades and beyond.
- Many other stresses and disturbances are also affecting these resources.
- Climate change impacts on ecosystems will affect the services that ecosystems provide, such as cleaning water and removing carbon from the atmosphere, but we do not yet possess sufficient understanding to project the timing, magnitude, and consequences of many of these effects.
- Existing monitoring systems, while useful for many purposes, are not optimized for detecting the impacts of climate change on ecosystems.

The maps below show average annual runoff and the ratio of maximum snow accumulation to average annual runoff in the continental U.S. and Alaska (data replotted from Maurer et al. (2002)).



Key Questions and Answers

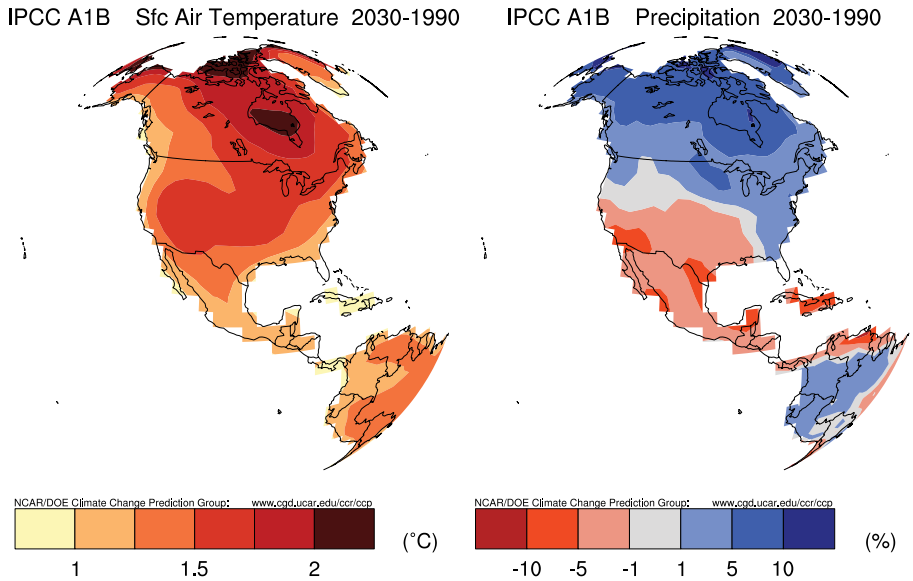
What factors influencing agriculture, land resources, water resources, and biodiversity in the United States are sensitive to climate and climate change? Climate change affects average temperatures and temperature extremes; timing and geographical patterns of precipitation; snowmelt, runoff, evaporation, and soil moisture; the frequency of disturbances such as drought, insect and disease outbreaks, severe storms and forest fires; atmospheric composition and air quality; and patterns of human settlement and land use change.

How could changes in climate exacerbate or ameliorate stresses on agriculture, land resources, water resources, and biodiversity? Ecosystems and their services (land and water resources, agriculture, biodiversity) experience a wide range of stresses, including pests and pathogens, invasive species, air pollution, extreme events, wildfires and floods. Climate change can cause or exacerbate direct stress through high temperatures, reduced water availability, and altered frequency of extreme events and severe storms.

What current and potential observation systems could be used to monitor stress indicators? Understanding climate impacts on each of these sectors requires monitoring many aspects of climate and a wide range of biological and physical responses. In general, the current suite of observing systems is reasonably able overall to monitor ecosystem change and health in the United States, but neither the observing systems nor the current state of scientific understanding is adequate to rigorously quantify climate contributions to ecological change and separate climate effects from other influences.

Can observation systems detect changes in agriculture, land and water resources, and biodiversity that are caused by climate change, as opposed to change driven by other causes? The current suite of observing systems, in general, is reasonably able to monitor ecosystem change and health in the United States, but neither the observing systems nor the current state of scientific understanding is adequate to rigorously quantify climate contributions to ecological change and separate these from other influences.

This figure shows how U.S. temperatures and precipitation would change by 2030 under an emissions scenario that would have atmospheric concentrations of greenhouse gases at about 700 parts per million by 2100 (this is roughly double the pre-industrial level). The changes are shown as the difference between two 20-year averages (2020-2040 minus 1980-1999). These results are based on simulations from nine different climate models from the IPCC AR4 multi-model ensemble. Courtesy Lawrence Buja and Julie Arblaster, National Center for Atmospheric Research.



Sector Highlights

Agriculture

- Life cycle of grain and oilseed crops will likely progress more rapidly; but with rising temperatures and variable rainfall, crops will begin to experience failure, especially if precipitation lessens or becomes more variable.
- Climate change is leading to a northward migration of cropland weeds, and range and pasture plant species, which affects crops, grazing land, and livestock operations.
- Higher temperatures will very likely reduce livestock production during the summer season; ruminants may be particularly affected because generally shelter is not provided to buffer the adverse effects of changing climate.

Land Resources

- Climate change has likely increased the size and number of forest fires, insect outbreaks and tree mortality in the Interior West (Colorado, the Great Basin), Southwest and Alaska.
- In arid lands, changes in temperature and precipitation will very likely decrease the vegetation cover that protects the ground surface from wind and erosion.
- Rising CO_2 will very likely increase photosynthesis for forests, but this increase will likely only enhance wood production in young forests on fertile soils.

Water Resources

- A suite of climate simulations shows that the United States may experience increased runoff in eastern regions, gradually transitioning to little change in the Missouri and lower Mississippi, to substantial decreases in annual runoff in the interior of the west (Colorado and Great Basin).
- Stream temperatures are likely to increase as the climate warms, which will impact aquatic ecosystems both directly and indirectly.
- There is a trend toward reduced mountain snowpack and earlier spring snowmelt runoff peaks across much of the western United States.

Biodiversity

- Earlier spring onset, lengthening of the growing season, and net primary productivity increase are noticeable in the higher latitudes of North America.
- The rapid rate of warming in the Arctic observed in recent decades – and projected to continue for at least the next century – is dramatically reducing snow and ice cover that provide denning and forage habitat for polar bears.
- Corals in many tropical regions are experiencing substantial mortality from increasing water temperatures, increasing storm intensity, and a reduction in pH.

US Climate Change Science Program
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