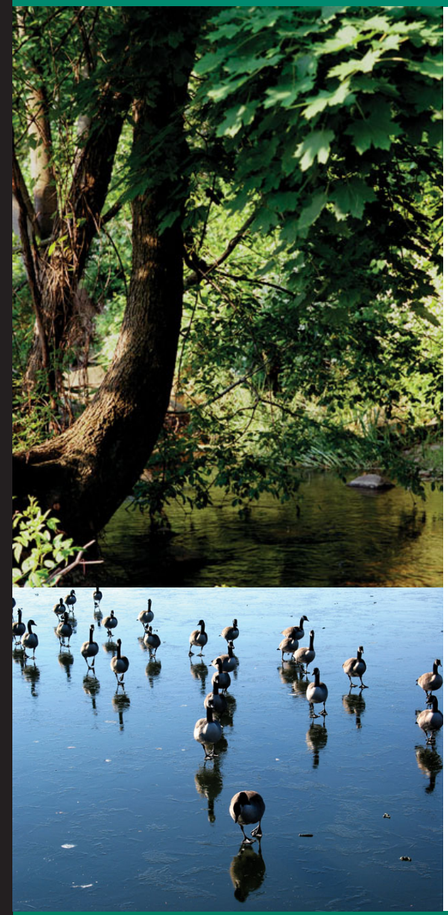
U.S. Climate Change Science Program

Climate Change and Ecosystems

Summary of Recent Findings



An ecosystem can be described as a community of organisms and its relationship with a particular environment. A forest is an ecosystem, as is a pond or a desert. Climate is a key driver of changes in ecosystems, and strategies for protecting climate-sensitive ecosystems will be increasingly important for management, because impacts resulting from a changing climate system are already evident and will persist into the future.[1]

This factsheet summarizes information from a recent assessment of possible adaptation options to protect climate-sensitive ecosystems in the United States.

Adaptation Approaches

Protecting key ecosystem features	Focusing management protections on structural characteristics, organisms, or areas that represent important "underpinnings" or "keystones" of the overall system.
Reducing human stresses	Minimizing localized human stressors (e.g., pollution, fragmentation) that hinder the ability of species or ecosystems to withstand climatic events.
Representation	Protecting a portfolio of variant forms of a species or ecosystem so that, regardless of the climatic changes that occur, there will be areas that survive and provide a sources for recovery.
Replication	Maintaining more than one example of each ecosystem or population such that if one area is affected by a disturbance, replicates in another area provide insurance against extinction and a source for recolonization of affected areas.
Restoration	Rehabilitating ecosystems that have been lost or compromised.
Refugia	Using areas that are less affected by climate change as sources of "seed" for recovery or as destinations for climate-sensitive migrants.
Relocation	Transplanting organisms from one location to another in order to bypass a barrier (e.g., urban area).

One essential element of any adaptation approach will be identifying thresholds in ecosystems. Climate changes may cause ecological thresholds to be exceeded, leading to abrupt shifts in the structure of ecosystems. Threshold changes in ecosystems have profound implications for management because such changes may be unexpected, large, and difficult to reverse. If these ecosystems cannot then be restored, actions to increase their resilience will no longer be viable. Understanding where thresholds have been exceeded in the past and where (and how likely) they may be exceeded in the future allows managers to plan accordingly and avoid tipping points where possible

Increasing the Nation's Ability to Act

Over time, our ability to "manage for resilience" of current systems in the face of climate change will be limited as temperature thresholds are exceeded, climate impacts become severe and irreversible, and socioeconomic costs of maintaining existing ecosystem structures, functions, and services become excessive. It will then be necessary to "manage for change," with a re-examination of priorities and a shift to adaptation options incorporating information on projected ecosystem changes. We will need to continuously refine and add to our current body of knowledge in order to preserve the Nation's lands and waters in a rapidly changing world.[1]

US Climate Change Science Program
www.climatescience.gov

[1] SAP 4.4
[2] Scientific Assessment
[3] SAP 4.3

For further information on this report and to access other CCSP information, go to <www.climatescience.gov>

Information from the Synthesis and Assessment Product 4.4

Also including information from SAP 4.3 and the Scientific Assessment of the Effect of Global Change on the United States

Climate is a dominant factor influencing the distributions, structures, functions, and services of ecosystems. Changes in climate can interact with other environmental changes to affect biodiversity and the future condition of ecosystems.

Is Climate Change Already Affecting Some Ecosystems?

Ecosystems and their services (land and water resources, agriculture, and biodiversity) experience a wide range of stresses, including pests and pathogens, invasive species, air pollution, and extreme events. Climate change can not only cause or exacerbate stress through high temperatures, reduced water availability, and altered frequency of extreme events and severe storms, but also ameliorate stress through warmer springs and longer growing seasons. Additionally, climate change can modify the frequency and severity of stresses. For example, increased minimum temperatures and warmer springs extend the range and lifetime of many pests that stress trees and crops.[3]

A growing body of literature indicates that over the past three decades, the changes in the climate system described above have caused physical and biological changes in a variety of ecosystems on the global scale, including evolutionary responses, shifts in species' ranges, and changes in phenological patterns, such as migration, and life cycles.[1]

These changes are being observed in the United States today. Climate change has very likely increased the size and number of forest fires, insect outbreaks, and tree mortality in the interior West, the Southwest, and Alaska, and will continue to do so. In the higher latitudes of North America, an earlier spring onset, lengthening of the growing season, and net increase in primary productivity are noticeable. In addition, the migration of plant and animal species is changing the composition and structure of arid, polar, aquatic, coastal, and other ecosystems.[3]

Will Future Climate Change Have An Even Greater Impact On Ecosystems?

> Continued greenhouse gas emissions at or above current rates are expected to cause further warming and to induce many climate changes this century that will very likely be larger than those of last century.[2]

Findings from the Intergovernmental Panel on Climate Change as well as the CCSP Synthesis and Assessment Reports indicate that all of North America is very likely to warm during this century, and to warm more than the global average increase in most areas. Nearly all the models used in the United Nations' IPCC assessment project that the average warming in the United States will exceed 3.6 °F; five out of 21 models projecting that average warming will exceed 7.2 °F.[2]

In the 21st century, precipitation over North America is projected to be less frequent but more intense. For the North Atlantic, it is likely that hurricane rainfall and wind speeds will increase in response to human-caused warming. The IPCC projects that global sea level will rise between 7 and 23 inches by the end of the century without considering the currently observed accelerating ice melt.[2]

As a consequence, the resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g., land use change, pollution). Additionally, in North America, warming has generally resulted in and is expected to continue to result in shifts of species' ranges poleward and to higher altitudes.[2]

What Ecosystems Are Most Likely To Be Affected?

Major changes in ecosystem structure, composition, and function, are very likely to occur where temperature increases exceed 1.5–2.5°C - well within the projections for most parts of the U.S. this century.[1] Some examples of ecosystems likely to be affected include:

Streams: Temperatures are likely to increase as the climate warms and are very likely to have effects on aquatic ecosystems and water quality.

Rivers: Decreased streamflow, increased water removal, and greater competition from nonnative species will very likely negatively impact rivers in arid lands.

Subtropical and tropical corals: Major bleaching events that are clearly driven by increases in sea surface temperatures have already affected corals in shallow waters. Increases in ocean acidity, which are a direct consequence of increases in atmospheric carbon dioxide, are calculated to have the potential for serious negative consequences for corals.

The Arctic: Rapid rates of warming in the Arctic observed in recent decades, and projected for at least the next century, are dramatically reducing the snow and ice covers that provide denning and foraging habitat for polar bears.

What Are Some Options For Protecting Our Ecosystems?

Strategies for protecting climate-sensitive ecosystems will be increasingly important for management because impacts resulting from a changing climate system are already evident and will persist into the future. While there will always be uncertainties associated with the future path of climate change, the response of ecosystems to climate impacts, and the effects of management, it is both possible and essential for adaptation to proceed using the best available science. Adaptation options for enhancing ecosystem resilience include changes in management processes, practices, or structures to reduce anticipated damages or enhance beneficial responses associated with climate variability and change.

Changes in temperature, precipitation, sea level, and other climate-related factors can often exacerbate problems that are already of concern to managers. For example, increased intensity of precipitation events can further increase delivery of non-point source pollution and sediments to rivers, estuaries, and coasts. Fortunately, many management practices that exist to address such "traditional" stressors can also address climate change impacts. For example, the construction of a buffer strip along watercourses (such as rivers) both manage pollution loadings from agricultural lands into rivers today and establish protective barriers against increases in both pollution and sediment loadings due to climate changes in the future.