

In Brief

Climate Change and Water Perspectives from the Forest Service



Freshwater availability is an increasing concern across the globe and it may be the most important natural resource issue of the century. Climate change and its effects on water are expected to intensify freshwater scarcity and conflict. A forthcoming Forest Service, U.S. Department of Agriculture report will highlight the importance of managing forests to provide clean, abundant water. The report will explore likely impacts of climate change on the Nation's forested watersheds and describe how natural resource managers can incorporate a climate change perspective into watershed stewardship.

The cleanest water flows from healthy, forested watersheds.

Of the many ecosystem services provided by forests, watershed services are among the most valuable. Healthy forests capture and store water, naturally regulate streamflows and water quality, reduce flood and storm damage, control erosion, and replenish ground water. High-elevation forests protect and enhance our water supplies downstream.

Forests provide nearly two-thirds of the freshwater in the 48 conterminous States—water that fills our rivers, lakes, and streams; sustains fish, plants, and wildlife; supports food, energy, and industrial production; enables navigation; and pours from the faucets of our homes and businesses.

Forests in the United States provide drinking water to more than 180 million people.

Sixty-six million people rely on a national forest as their water source.

Climate change will impact the ability of the Nation's forests to provide water and other critical watershed services. Warming over the past several decades has fundamentally altered the hydrologic cycle, and these changes are percolating through our watersheds (see illustration below). Snowpacks are shrinking and stream temperatures will likely increase. Precipitation patterns may change, and floods, droughts, and severe weather disturbances may become more common.

Climate change is hydrologic change.

Water supplies stored as snow cover in high-elevation forests are particularly vulnerable to climate change and are projected to decline over the course of the century. Earlier spring runoff and reductions in low flows will reduce water availability downstream during the summer and fall months. Higher water temperatures, flooding, and droughts will affect water quality and exacerbate water pollution.

The Forest Service is a steward of the Nation's forested watersheds, ensuring a continued supply of high-quality water and watershed services as we adjust to a changing climate.

Projected climatic changes to the hydrologic cycle

More intense storms with more flooding and extreme winds.

Less precipitation in some areas, more in other areas. Greater interannual variability.

Glaciers are reduced or eliminated. Increased high elevation erosion.

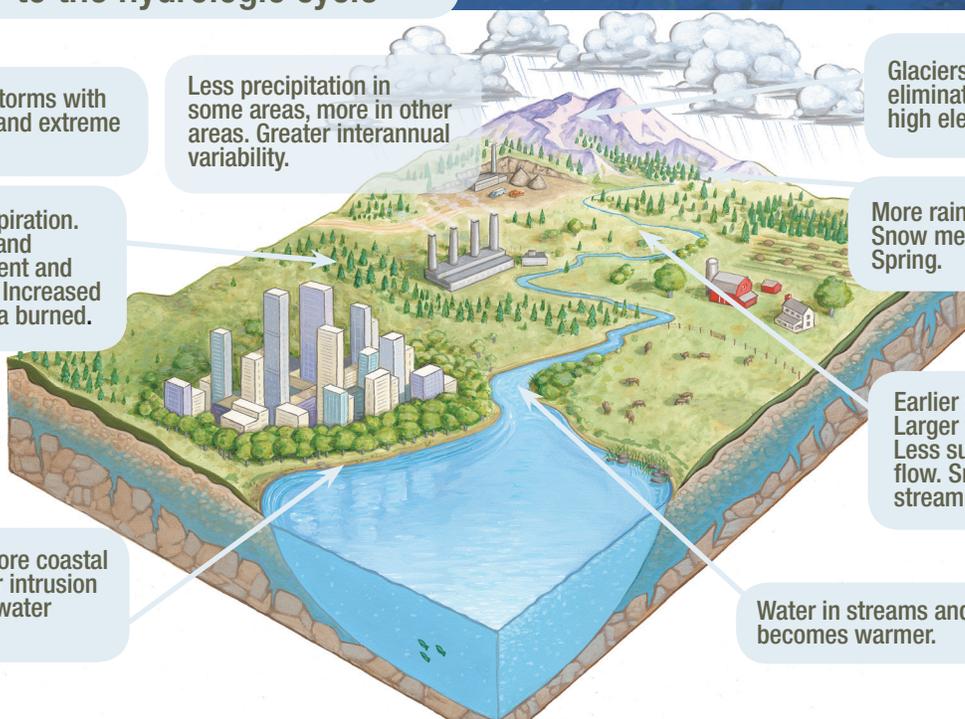
More evapotranspiration. Drier vegetation and soils. More frequent and severe droughts. Increased wildfires and area burned.

More rain and less snow. Snow melts sooner in Spring.

Sea level rises. More coastal erosion. Saltwater intrusion into coastal freshwater aquifers.

Earlier spring runoff. Larger flood peaks. Less summer stream flow. Smaller headwater stream networks.

Water in streams and lakes becomes warmer.



Climate change will affect water availability—quantity, quality, timing, and distribution—and other watershed services. It will affect the people who rely on water for everyday use (see table below).

At least 36 States anticipate water shortages within the next 10 years.

U.S. Government Accountability Office, 2003

Forty percent of the world's population will be living in water-scarce regions by 2025.

World Resources Institute, United Nations Environment Programme, and World Business Council for Sustainable Development, 2002

Availability of clean drinking water is a critical issue for most people in the world. Seventy percent of the Earth's surface is covered by water, but less than 1 percent of this amount is freshwater, present on the land surface, in the atmosphere, or in the ground. A small fraction of the world's freshwater is renewable and available for human use, and this water supply is unequally distributed across the continents. Seasonal differences in precipitation, waterflows, and demand mean that freshwater is not always available when and where it's needed.

As populations, incomes, and consumption levels increase, people put more pressure on our forested watersheds to deliver the services they want and need. Declining water quantity and quality are becoming common issues, especially where our demands exceed supply. Growing water demands, in turn, put aquatic resources and other services at risk because less water is available to sustain them. Many municipalities, businesses, farmers, and citizens already face difficult decisions about how—and where—to get their water. Future changes in the timing, magnitude, and quality of waterflows resulting from climate change will compound these water challenges.

Caring for the Nation's forests will help protect watershed services into the future.

We may not be able to precisely predict the extent, location, or timing of climate change impacts, but we can recognize ecosystem changes and respond with flexible and adaptive watershed management strategies. **The following actions will help resource professionals and landowners incorporate a climate change perspective into their work.**

Prepare for change

Preparing now to face future challenges is essential.

- Managers, planners, and conservation groups can use existing information to identify watersheds and services that are most vulnerable to adverse changes. Planning for change and priority-setting will need to begin with the most vulnerable and highest value watersheds.

Adaptive management is an approach that promotes learning through doing. This approach involves actively making decisions and monitoring results to improve our understanding about the complex systems we manage.

Three examples of current and projected climatic changes, their effects on ecosystems, and potential consequences to the supply and delivery of watershed services. Climatic changes are based on current trends and projections from the Intergovernmental Panel on Climate Change Fourth Assessment Report (2007). For all changes, uncertainty is substantial and the geographic variability is expected to be high.

↑ = probable increase, ↓ = probable decrease, ▲ = change

Climatic Changes	Location	Ecosystem Effects	Consequences for Watershed Services
Warmer air temperatures	Widespread Greatest change in mountains and northern latitudes	↓ Precipitation as snow; faster and earlier snowmelt ↑ Evapotranspiration and primary productivity ↑ Water temperatures ↑ Sea level; coastal erosion and saltwater intrusion into freshwater supplies	▲ Amount, type, quality, and distribution of aquatic habitat and biota ▲ Water availability and recreational and cultural experiences ↓ Water quality and timing ↓ Function and operation of existing water infrastructure in coastal areas
Changes in precipitation patterns (projected changes vary by location and have substantial uncertainty)	Less winter precipitation at lower latitudes (Southwest, Intermountain West)	↓ Snow; changes in streamflow timing ↑ Risk of disturbance, e.g., drought, wildfires, insects, disease ↓ Vegetation growth; changes in composition	↓ Water supplies for people, agriculture, energy, and other uses ↑ Water demand, ground water withdrawals, and consumptive use of surface waters ↓ Fisheries and water-based tourism
	More precipitation at higher latitudes (Pacific Northwest, New England)	↑ Streamflow ▲ Vegetation growth and composition ↑ Soil erosion and landslides	↑ Freshwater supplies ↑ Improvements in warm water fisheries
Greater variability in precipitation from year to year	Everywhere	↑ Variability in stream, lake, and riparian habitats ↑ Risk of aquatic and riparian species extirpation ↑ Soil erosion, stream and lake sedimentation, and landslides	↑ Uncertainty in water supply ↑ Uncertainty for reservoir operations ↑ Risk to aquatic habitat and water supply infrastructure
More extreme floods and droughts			

- Broad-scale inventories, assessments, and early-warning monitoring can help managers identify trends, anticipate effects, and act quickly to limit loss or reduction in critical watershed services.
- Ensuring that land managers, landowners, and decisionmakers can access people with skills and training in water resources will be important as climate change further complicates issues.

Advance and share knowledge about water and climate change

Together, scientists and managers can provide new information and tools for the management toolbox.

- New information will be needed to track and evaluate changing watershed conditions, understand the effects of management practices, and forecast quality, quantity, and timing of water supplies. New technologies will be needed to improve data collection. Dynamic, process-based models will be needed to improve climate change projections and evaluate management options.
- National forests and experimental research sites will continue to serve as learning laboratories to help land managers understand interactions between climate and ecosystems, evaluate management options, and test solutions.
- Intensive cooperation between scientists and land managers in both natural and social sciences will promote adaptive management and learning.

Manage for watershed resilience and enhance ecosystem adaptability

Healthy, resilient watersheds are the best insurance policy for a changing climate.

- Managing wildland and urban forests for a set of watershed services—like high water quality, flood control, and fish habitat—ensures that management and land use decisions are designed to maintain and protect healthy watersheds.
- Public forests will continue to serve as natural reservoirs for high-quality water and as refuges for biodiversity.
- Current management practices applied broadly, more strategically, and in new ways can help watersheds adapt to change. Best management practices protect watersheds that are actively managed, and restoration activities reestablish processes or services that have been lost or are at risk.

Active management will need to...

- Restore meadows, wetlands, and floodplains to improve natural storage, reduce flood hazards, and prolong seasonal flows
- Protect and restore riparian forests to moderate changes in stream temperature
- Remove migration barriers and reestablish habitat connectivity to help species adapt to changing conditions
- Reduce flood and wildfire risks in vulnerable watersheds to prevent erosion and maintain clean water supplies
- Improve or decommission roads to reduce adverse impacts during large storms

Support entrepreneurial projects and leaders

New approaches to watershed management will help us meet future challenges.

- Management approaches will need to be flexible and forward-thinking, with a focus on desired processes and benefits rather than individual species and specific, static conditions.
- Demonstration projects that integrate science and management will foster innovation and provide new information for land managers and the public.
- Emerging ecosystem markets can align economic interests with conservation objectives, and new market opportunities can provide incentives for private landowners to maintain and improve watershed services.

Vital signs of a healthy, resilient watershed

Resilient ecosystems are those that rebound after disturbance and continue to provide ecosystem services. A healthy, resilient watershed has the capacity to:

- Capture and store rainfall
- Recharge ground water reservoirs
- Minimize erosion losses and protect soil quality
- Sustain and regulate streamflows
- Store and recycle nutrients
- Support natural riparian and floodplain functions
- Provide habitat for native aquatic species
- Resist and recover quickly from floods, fire, insect outbreaks, and other extreme events

Adapted from: Sprague et al. [eds]. 2006. *The State of Chesapeake Forests. The Conservation Fund and the Forest Service.*

Connect with partners and the public

We will need to step across boundaries to expand our reach.

- Creating and cultivating effective partnerships will promote collaborative action across larger landscapes. Reaching out to new partners, such as developers, health and environmental organizations, private businesses, municipal water managers, and city planners, will increase awareness about the critical role of healthy forested watersheds.
- Conserving water will keep water in streams and help to sustain healthy watersheds. We can all lead by example and reduce our water footprint, encouraging others to make similar commitments.
- Connecting people to their water source will have a lasting effect on watershed stewardship.

Climate change is a formidable challenge and there is much we can do to respond. Actions taken now can minimize potential negative impacts and unlock new opportunities—they must include a focus on water.



The mission of the Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. This mission rests on a tradition of managing forests to protect the Nation's clean water supplies. Today, our commitment to watershed stewardship is even more critical as we respond to new challenges like climate change. Through research, partnerships, and mindful, meaningful management, we will enhance the ability of the Nation's watersheds to adapt to change and continue to support the health and well-being of people and ecosystems.



The Forest Service

The National Forest System was established with the purpose of “securing favorable conditions of waterflows” in the Nation’s headwaters. For over a century, the Forest Service has protected water and managed public forests to provide the goods and services that people want and need.

State and Private Forestry extends the Forest Service mission to urban and community forests and to more than 400 million acres of private land. Nearly 60 percent of the Nation’s forests are privately owned—the people who own and manage these lands serve as stewards of the Nation’s water supply and other ecosystem services that benefit society.

In 1910, Forest Service Research established its first experimental watershed to conduct research that informed management and policy on public and private lands. This tradition continues today with a wide array of partners.

International Programs works with agencies, countries, and nonprofit partners to assist others around the world in protecting and managing natural areas.

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FS-908

June 2008

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