

# CLIMATE IMPACTS – SOUTHWEST US

From the Adaptation Workbook: [www.adaptationworkbook.org/explore-impacts](http://www.adaptationworkbook.org/explore-impacts)

This region was defined in the National Climate Assessment (2014) and includes the states of Arizona, California, Colorado, Nevada, New Mexico, and Utah. For more information, see: [National Climate Assessment \(2018\) - Southwest](#)

## **Summary of Climate Impacts (details and citations on subsequent pages):**

Temperatures in the Southwest are projected to increase by 3.5 to 8.5 degrees Fahrenheit by 2085.

By the middle of the century, the Southwest region is expected to experience 5 to 30 more days per year with a maximum temperature exceeding 95 degrees F.

The Southwest region is expected to experience between 0 and 25 fewer days per year with a minimum temperature below 10 degrees Fahrenheit by the middle of the century.

The Southwest is expected to experience more prolonged droughts under climate change.

Climate conditions may increase wildfire risks in the Southwest by the end of the century.

By the end of the century, average annual precipitation is projected to decrease substantially in the southern half of the Southwest, but may increase slightly or remain constant in the northern half of the region.

The number of days per year with more than 1 inch of precipitation will increase across the high-elevation portions of the Southwest by the middle of the century.

The freeze-free season is expected to increase by 20 to 35 days in the Southwest by the middle of the century.

Warmer temperatures, reduced snowpack, and greater water demand for agriculture may reduce available water for natural ecosystems in the Southwest.

Climate change will amplify many existing stressors to forest ecosystems in the Southwest, such as invasive species, insect pests and pathogens, and disturbance regimes.

The identity and structure of Southwest forests may change substantially under climate change.

Low-diversity systems are at greater risk from climate change.

Species in fragmented landscapes will have less opportunity to migrate in response to climate change.

Systems that are limited to particular environments will have less opportunity to migrate in response to climate change.

Systems that are more tolerant of disturbance have less risk of declining on the landscape

## **Temperatures in the Southwest are projected to increase by 3.5 to 8.5 degrees Fahrenheit by 2085.**

All climate models agree that temperatures are projected to increase over the 21st century across the Southwest, with almost uniform temperature increases across the entire region. The greatest warming is expected in the northern part of the region, especially Nevada, Utah, and Colorado. The greatest warming is expected during summer months, particularly in Utah and Colorado. Warming is generally smaller in winter, and along the Pacific coast.

*K. Kunkel, L. Stevens, and others. 2013. [Regional Climate Trends and Scenarios for the U.S. National Climate Assessment - Southwest](#). NOAA.*

**By the middle of the century, the Southwest region is expected to experience 5 to 30 more days per year with a maximum temperature exceeding 95 degrees F.**

The largest simulated increases occur in Arizona and New Mexico, with as many as 25-30 more days above 95 degrees F each year. These hot days are already common in these parts of the region. The smallest increases in hot days occur in high-elevation areas, because projected temperature increases are still not enough to increase the chance of such warm days.

K. Kunkel, L. Stevens, and others. 2013. [Regional Climate Trends and Scenarios for the U.S. National Climate Assessment - Southwest](#). NOAA.

**The Southwest region is expected to experience between 0 and 25 fewer days per year with a minimum temperature below 10 degrees Fahrenheit by the middle of the century.**

The largest decreases are expected in the northern half of the region, particularly in high-elevation areas. The smallest decrease in cold days is expected coastal and southern parts of the region, where these kinds of cold days rarely occur. Similarly, the high-elevation areas are expected to have up to 40 fewer days with a minimum temperature below 32 degrees by the middle of the century, particularly in Colorado and the mountains of northern California.

K. Kunkel, L. Stevens, and others. 2013. [Regional Climate Trends and Scenarios for the U.S. National Climate Assessment - Southwest](#). NOAA.

**The Southwest is expected to experience more prolonged droughts under climate change.**

Projections of precipitation changes are less certain than those for temperature. Under a continuation of current rising emissions trends, reduced winter and spring precipitation is consistently projected for the southern part of the Southwest by 2100 as part of the general global precipitation reduction in subtropical areas. In the northern part of the region, projected winter and spring precipitation changes are smaller than natural variations. Summer and fall changes are also smaller than natural variations throughout the region. There is mounting evidence that the combination of human-caused temperature increases and recent drought has influenced widespread tree mortality, increased fire occurrence and area burned, and forest insect outbreaks.

G. Garfin and G. Franco. 2014. [National Climate Assessment – Southwest](#). U.S. Global Change Research Program.

**Climate conditions may increase wildfire risks in in the Southwest by the end of the century.**

Between 1970 and 2003, warmer and drier conditions increased burned area in western U.S. mid-elevation conifer forests by 650%. Different modeling approaches generally conclude that future climate conditions will increase the risk of wildfire across the Southwest. Projections of annual fire probability, calculated solely with climate data and physical principles, are highly variable across the region. Dry ecosystems that are already fuel-limited may actually see a decline in wildfire risk, if warmer temperatures and moisture limitations prevent them from producing enough plant matter to carry fire. Wetter, cooler, high-elevation ecosystems in the Southwest will likely have increasing wildfire probability, however. The incidence of atmospheric conditions that contribute to large and erratic fire behavior, measured by the Haines Index, is also projected to occur more frequently (2 to 11 percent increase) by the end of the century, with the largest increases the Arizona and New Mexico. The limitation for these sorts of projections is that they do not account for changes in land use, fire suppression rates, or vegetation changes.

G. Garfin and G. Franco. 2014. [National Climate Assessment – Southwest](#). U.S. Global Change Research Program.

Y. Tang, S. Zhong, and others. 2015. [The Potential Impact of Regional Climate Change on Fire Weather in the United States](#). *Annals of the Association of American Geographers*.

R. Guyette, F. Thompson, and others. 2014. [Future Fire Probability Modeling with Climate Change Data and Physical Chemistry](#). *Forest Science*.

**By the end of the century, average annual precipitation is projected to decrease substantially in the southern half of the Southwest, but may increase slightly or remain constant in the northern half of the region.**

There is uncertainty between different climate scenarios for future precipitation projections in the Southwest. Generally, there is a south-to-north gradient in annual precipitation projections, with decreases projected from central California, Nevada, Utah, and Colorado to the south. Decreases are largest in southern California, Arizona, and New Mexico (3-12%). The northern half of the region is projected to experience no change or a slight (0-3%) increase in annual precipitation. Precipitation decreases appear more likely for spring and summer months across the entire region, while winter months may experience slightly increased precipitation.

K. Kunkel, L. Stevens, and others. 2013. [Regional Climate Trends and Scenarios for the U.S. National Climate Assessment - Southwest](#). NOAA.

The number of days per year with more than 1 inch of precipitation will increase across the high-elevation portions of the Southwest by the middle of the century.

Nevada, northern Utah, and western Colorado are expected to experience 20 to 130% more days each year with more than an inch of precipitation by the middle of the century. For the rest of the region, projected changes in extreme rainfall are smaller than normal year-to-year variation.

K. Kunkel, L. Stevens, and others. 2013. [Regional Climate Trends and Scenarios for the U.S. National Climate Assessment - Southwest](#). NOAA.

The freeze-free season is expected to increase by 20 to 35 days in the Southwest by the middle of the century.

The freeze-free season is defined as the period of time between the last spring frost (daily minimum temperature below 32 degrees F) and the first fall frost. The length of the annual freeze-free season has been increasing since the 1980s, and all climate models agree that it will continue to increase in the future. The largest increases are projected for the interior of California.

K. Kunkel, L. Stevens, and others. 2013. [Regional Climate Trends and Scenarios for the U.S. National Climate Assessment - Southwest](#). NOAA.

Warmer temperatures, reduced snowpack, and greater water demand for agriculture may reduce available water for natural ecosystems in the Southwest.

Water is central to the region's productivity. Winter snowpack, which slowly melts and releases water in spring and summer, when both natural ecosystems and people have the greatest needs for water, is key to the Southwest's hydrology and water supplies. Over the past 50 years across most of the Southwest, there has been less late-winter precipitation falling as snow, earlier snowmelt, and earlier arrival of most of the year's streamflow. Streamflow totals in the Sacramento-San Joaquin, the Colorado, the Rio Grande, and in the Great Basin were 5% to 37% lower between 2001 and 2010 than the 20th century average flows. Projections of further reduction of late-winter and spring snowpack and subsequent reductions in runoff and soil moisture,, pose increased risks to the water supplies needed to maintain the Southwest's cities, agriculture, and ecosystems.

G. Garfin and G. Franco. 2014. [National Climate Assessment – Southwest](#). U.S. Global Change Research Program.

Climate change will amplify many existing stressors to forest ecosystems in the Southwest, such as invasive species, insect pests and pathogens, and disturbance regimes.

Invasive plants, forest pests, diseases, droughts, and floods are expected to become more damaging under climate change, and these factors may interact in unpredictable ways. Drought and increased temperatures due to climate change have caused extensive tree death across the Southwest. In addition, winter warming due to climate change has exacerbated bark beetle outbreaks by allowing more beetles, which normally die in cold weather, to survive and reproduce. Wildfire and bark beetles killed trees across 20% of Arizona and New Mexico forests from 1984 to 2008. The Mexican pine beetle, previously known only in Mexico, has been recorded in the southwestern United States and represents one of several species of Mexican bark beetles that may expand into Southwest forests with continued warming trends. Severe wildfires are also expected to become more frequent under climate change, particularly in high-elevation forests.

G. Garfin and G. Franco. 2014. [National Climate Assessment – Southwest](#). U.S. Global Change Research Program.

L. Joyce, S. Running, and others. 2014. [National Climate Assessment - Forestry](#). U.S. Global Change Research Program.

J. Vose, D. Peterson, and others. 2012. [Effects of Climate Variability and Change on Forest Ecosystems: A Comprehensive Science Synthesis for the U.S. Forest Sector.](#) USDA Forest Service Pacific Northwest Research Station.

### The identity and structure of Southwest forests may change substantially under climate change.

Historical and projected climate change makes two-fifths (40%) of the region vulnerable to these shifts of major vegetation types or biomes; notably threatened are the conifer forests of southern California and sky islands of Arizona. Douglas-fir, ponderosa pine, and pinyon pine may be most negatively affected in Arizona, Colorado, and New Mexico. Following more frequent fires, forest systems may shift to more early-successional species, open canopy forests, and possibly invasive species. In California, mixed evergreen forest may replace evergreen conifer forest, as Douglas-fir and white fir forests are replaced by Douglas fir and tanoak forests. White fir–ponderosa pine forest may be replaced by ponderosa pine–California black oak forest in the Sierra Nevada. Tanoak–Pacific madrone–canyon live oak woodland may replace blue oak woodlands, chaparral, and perennial grassland. In general, shrubland will replace oak woodland, and grassland may replace shrubland throughout California.

G. Garfin and G. Franco. 2014. [National Climate Assessment – Southwest](#). U.S. Global Change Research Program.

J. Vose, D. Peterson, and others. 2012. [Effects of Climate Variability and Change on Forest Ecosystems: A Comprehensive Science Synthesis for the U.S. Forest Sector](#). USDA Forest Service Pacific Northwest Research Station.

### Low-diversity systems are at greater risk from climate change.

Studies have consistently shown that diverse systems have exhibited greater resilience to extreme environmental conditions and greater potential to recover from disturbance than less diverse communities. This relationship makes less diverse communities inherently more susceptible to future changes and stressors. The diversity of potential responses of a system to environmental change (response diversity), is a critical component of ecosystem resilience. Response diversity is generally reduced in less diverse ecological systems. Genetic diversity within species is also critical for the ability of populations to adapt to climate change, because species with high genetic variation have better odds of producing individuals that can withstand extreme events and adapt to changes over time.

T. Elmqvist, C. Folke, and others. 2003. [Response diversity, ecosystem change, and resilience](#). *Frontiers in Ecology and the Environment*.

A. Hoffman and C. Sgrò. 2011. [Climate change and evolutionary adaptation](#). *Nature*.

### Species in fragmented landscapes will have less opportunity to migrate in response to climate change.

Habitat fragmentation can hinder the ability of tree species to migrate to more suitable habitat on the landscape, especially if the surrounding area is nonforested. Modeling results indicate that mean centers of suitable habitat for tree species will migrate between 60 and 350 miles by the year 2100 under a high emissions scenario and between 30 and 250 miles under milder climate change scenarios. Based on data gathered for seedling distributions, it has been estimated that many northern tree species could possibly migrate northward at a rate of 60 miles per century. Fragmentation makes this disparity even more challenging, because the landscape is essentially less permeable to migration.

L. Iverson, M. Schwartz, and others. 2004. [How fast and far might tree species migrate in the eastern United States due to climate change?](#) *Global Ecology and Biogeography*.

C. Woodall, C. Oswald, and others. 2009. [An indicator of tree migration in forests of the eastern United States](#). *Forest Ecology and Management*.

### Systems that are limited to particular environments will have less opportunity to migrate in response to climate change.

Some species and forest types are confined to particular habitats on the landscape, whether through requirements for hydrologic regimes, soil types, or other reasons. Similar to species occurring in fragmented landscapes, isolated species and systems face additional barriers to migration. Widespread species may also have particular habitat requirements. For example, sugar maple is often limited to soils that are rich in nutrients like calcium, so this species may actually have less available suitable habitat than might be projected solely from temperature and precipitation patterns. Riparian forests are not expected to be able to migrate to upland areas because many species depend on seasonal flood dynamics for regeneration and a competitive advantage. Similarly, lowland conifer swamps contain a unique mix of species that are adapted to low pH values, peat soils, and particular water table regimes. These species face additional challenges in migration compared to more-widespread species with broad ecological tolerances.

A. Jump and J. Peñuelas. 2005. [Running to stand still: adaptation and the response of plants to rapid climate change](#). *Ecology Letters*.

## Systems that are more tolerant of disturbance have less risk of declining on the landscape

Disturbances such as wildfire, flooding, and pest outbreaks are expected to increase in the future. Forests that are adapted to gap-phase disturbances, with stand-replacing events occurring over hundreds or thousands of years, may be less tolerant of more frequent widespread disturbances. Mesic hardwood forests can create conditions that could buffer against fire and drought to some extent, but these systems are not expected to do well if soil moisture declines significantly. Forest systems that are more tolerant of drought, flooding, or fire are expected to be better able to withstand climate-driven disturbances. This principle holds true only to a given point, because it is also possible for disturbance-adapted systems to experience too much disruption. For example, dry pine forests and woodlands might benefit from drier conditions with more frequent fire, but these systems might also convert to savannas or open grasslands if fire becomes too frequent or drought becomes too severe.

G. Nowacki and M. Abrams. 2008. [\*The Demise of Fire and "Mesophication" of Forests in the Eastern United States.\*](#) *BioScience*.  
E. Gustafson and B. Sturtevant. 2013. [\*Modeling Forest Mortality Caused by Drought Stress: Implications for Climate Change.\*](#) *Ecosystems*.