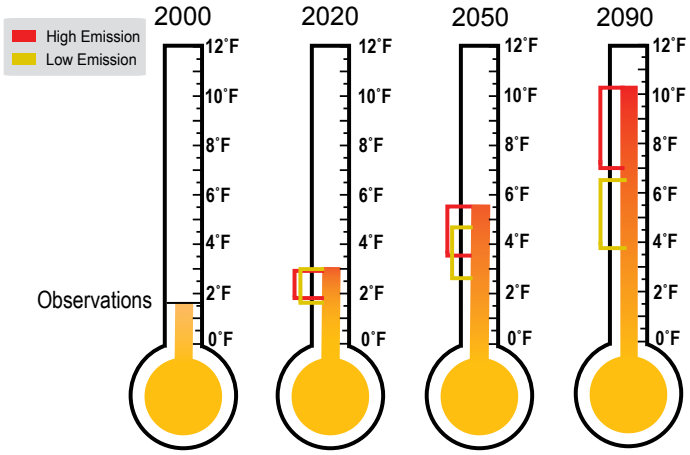
Southwest

The Southwest region stretches from the Pacific Coast to the southern Rocky Mountains. Elevations range from the lowest in the country to among the highest, with climates ranging from the driest to some of the wettest. Past climate records indicate that drought is a normal feature of the Southwest, with some of the longest documented "megadroughts" on Earth. The region has experienced the most rapid population and urban growth since the 1940s, a time with relatively few droughts until quite recently. The prospect for more severe future droughts as a result of global warming is cause for significant concern as the Southwest continues to lead the nation in population growth.



Climate change is well underway in the Southwest. Recent warming is among the most rapid in the nation, and projections suggest continued strong warming, with much larger increases under higher emissions scenarios. For example, summertime increases of up to 18°F are projected by late this century under higher emissions. Such increases will represent significant stresses to health and comfort in a region that already experiences very high summer temperatures. Rising temperatures also portend declining air quality, a particular problem for urban areas, such as those in California which already experience some of the worst air quality in the nation.

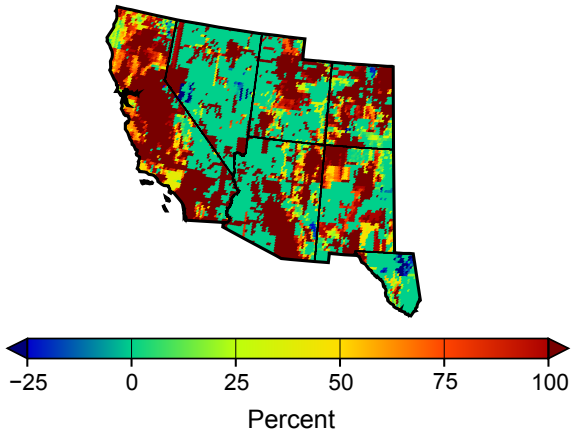
Human-induced warming is also causing a decline in spring snowpack and in Colorado River flow[1]. More hydrologic changes are projected, and combined with increasing temperatures, signal a serious drought threat for the region in the decades and centuries ahead.

Water supplies will become increasingly scarce, calling for trade-offs among competing uses and potentially leading to conflicts.

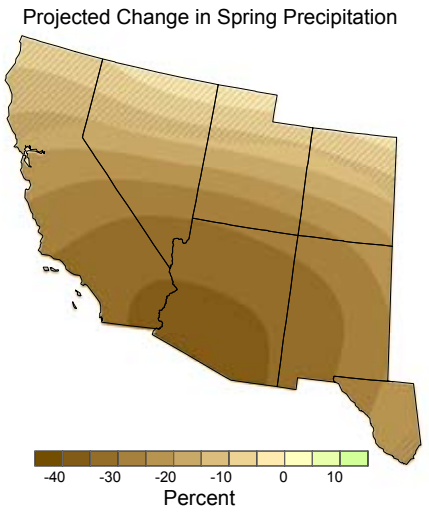
Water is needed to support the region's rapid population growth, as well as agriculture, energy, and healthy ecosystems. The largest use of water in the Southwest is associated with agriculture, including some of the nation's most important crop-producing areas in California. Water is also an important source of hydroelectric power, and water is required for the explosive population growth in the region, particularly that of major cities such as Phoenix and Las Vegas. Water also plays a critical role in supporting healthy ecosystems across the region, both on land and in rivers and lakes. Water is, quite literally, the lifeblood of the Southwest.

Water supplies across the Southwest are already becoming more limited, and this trend towards scarcity is a harbinger of future water shortages[2]. Groundwater pumping is lowering water tables and reducing perennial streamflow, just as rising temperatures are reducing the flow in some rivers, including the vital Colorado River[3]. Climate change projections for the rest of this century make it clear that rising temperatures will continue to be the norm, but also that the limitations imposed on water supply by these higher temperatures are likely to be made worse by substantial reductions in rain and snowfall in the all-important spring months[4].

Change in Population from 1970 to 2007



The map above, showing percentage changes in population, shows the very rapid growth in the Southwest. Places with increases over 100 percent growth are shown in maroon. Some of these areas had increases over 500 percent.



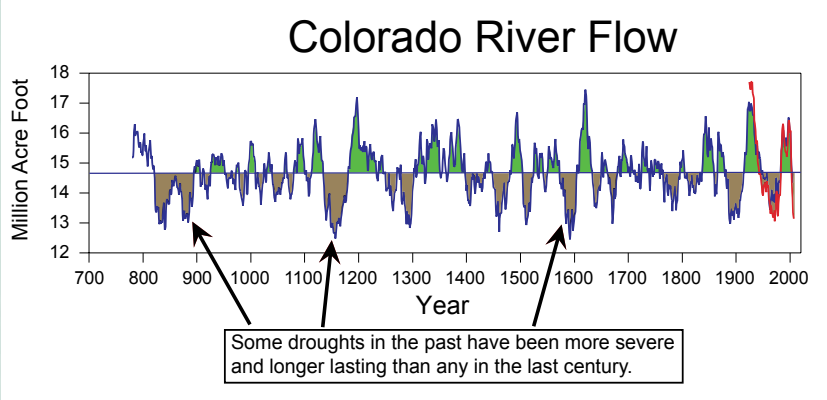
Percentage change in March-April-May precipitation for 2080-2099 compared to 1961-1979 for a higher emission scenario. Hatched areas are less certain.

A warmer and drier future means extra care will be needed in planning the allocation of water for the coming decades. The Colorado Compact, negotiated in the 1920s, allocated the Colorado River's water among the seven basin states, but was based on unrealistic assumptions about how much water was available. Even in normal decades, the Colorado doesn't have enough water to meet allocations, and during droughts, and in the future, the situation looks even bleaker. Water used in agriculture can provide a back-up supply for urban water needs during drought, and non-renewable groundwater can be tapped during dry periods. These water "buffers" are expected to become even more important in the future as climate change dries out the Southwest, yet they are at risk of disappearing as urban populations swell.

Large temperature increases along with river-flow reductions will increase the risk of interstate and bi-national water conflict. Water is already a flashpoint for conflict in the Southwest, and climate change – coupled with rapid population growth – promises to increase the likelihood of water-related conflict. In recent years, negotiations regarding existing water supplies have taken place among the seven states sharing the Colorado River and the two states (New Mexico and Texas) sharing the Rio Grande. Planned lining of major canals to prevent water loss through seepage could result in reduced water supply for those who currently use this "lost" water. Bi-national conflict potential already exists with Mexico in meeting their treaty allocations of Rio Grande and Colorado River water, just as many Native American water settlements have yet to be fully worked out. The specter of a more limited future water supply due to continued climate change and population growth will only make the potential for conflict greater.

Future of Drought in the Southwest

Much of the Southwest remains in a drought that began around 1999. It is the most severe western drought of the last 110 years, made more severe by record warming[5]. Climate projections point to an ever-increasing probability of drought for the region[6,7], and many aspects of these projections, including a northward shift in the jet stream and associated winter-spring storm tracks, are consistent with observed trends over recent decades[8,9]. Thus, the most likely future for the Southwest is a drier one.



Droughts are a long-standing feature of the Southwest's climate, and the droughts of the last 110 years, including the current on-going drought, pale in comparison to some of the decades-long "megadroughts" that the region has experienced over the last 2000 years[10]. The closing decades of the 1500s were very dry, and during medieval times, even longer – many decades long – droughts gripped parts of the Southwest multiple times[11]. These droughts had clear impacts on the flow of the Colorado River[12,13], the all-important Sierra Nevada headwaters for California[14], and elsewhere. Droughts happen routinely in the Southwest, but what causes a drought to last years, and sometimes decades, is not well understood. This means the Southwest must be prepared for drought, potentially from multiple causes, and that combined effects of natural climate variability and human-induced climate change could turn out to be a "one-two punch" for the region.

Increasing temperature, drought, wildfire, and invasive species will continue to accelerate landscape transformations, and lead to threats to ranching, biodiversity, and protected areas.

Climate change already appears to be influencing natural and managed ecosystems of the Southwest, and future landscape impacts could be substantial. Temperature increases have made the current drought in the region more severe than the more natural droughts of the last several centuries, with implications for natural ecosystems. For example, about 4600 square miles of piñon-juniper woodland in the Four Corners region of the Southwest have witnessed substantial die-offs of piñon pine trees[15]. Record wildfires are also being driven by rising temperatures and related reductions in spring snowpack and soil moisture[16].

Reduced water levels on the Lake Powell reservoir leave a "bath tub ring" that shows the previous water level.

Climate change, coupled with invasive plant species, have the potential to greatly alter iconic landscapes of the Southwest by making fire a more frequent event in these ecosystems that are not adapted to fire, and thus have no natural defenses against it. For example, the Sonoran Desert, famous for the saguaro cactus, is being invaded by red brome and buffle grasses that do well in high temperatures and are native to Africa and the Mediterranean. Not only do these noxious weeds out-compete some native species in the Sonoran Desert, they also fuel hot cactus-killing fires. Climate warming will also impact the look and feel of the Sonoran Desert in other ways, such as if more woody species spread northward from Mexico into areas currently dominated by native grasses[17]. Both Saguaro and Joshua Tree National Parks, for example, could end up with far fewer of their namesake plants[18].

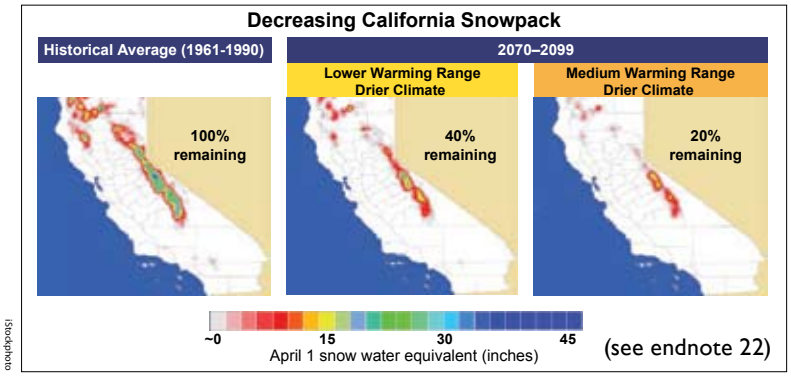
Joshua Tree

The Southwest region is also home to two of the world's biodiversity "hotspots" – at-risk regions that hold large numbers of plant and animal species found only in those regions[19,20]. Riparian and wetland ecosystems are home to much of this biodiversity and are already severely compromised by dams and reservoirs, water withdrawals, and invasive species – a situation that will likely worsen as climate change stresses water supply.

Given the mountainous nature of the Southwest, and the great diversity of plants and animals, there are undoubtedly other species that are at risk in the face of climate change combined with other regional threats including human-caused fragmentation of the landscape, invasive species, groundwater and streamflow reductions, and pollution. As plant and animal species change, ranchers, foresters, and others in the Southwest will have to adjust to the rapidly changing landscapes.

Saguaro cactus

Increased frequency and altered timing of flooding, in some cases coupled with landscape transformation, will increase risks to people, ecosystems, and reservoirs.



Paradoxically, future climate change means not only a greater likelihood of drought for the Southwest, but also an increased risk of flooding. Precipitation patterns are already observed to be shifting, with more rain falling in heavy downpours, the kinds of events that can lead to flooding[21]. Rapid landscape transformation due to vegetation die-off, wildfire, and loss of wetlands along rivers is also likely to reduce the flood-buffering capacity of the region.

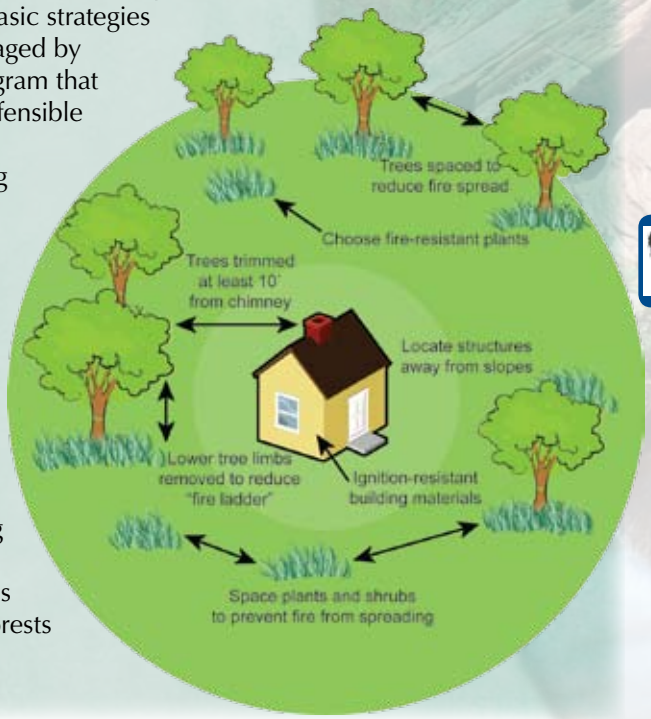
Potential impacts of greater flooding obviously include greater risk to humans and human infrastructure, but there are likely to be other impacts as well. Flooding causes reservoirs to fill with sediment at a faster rate, thus reducing their water-storage capacities. The Sacramento-San Joaquin River Delta system is already at substantial risk of flooding, and climate change-related increases in river flooding, coupled with sea level rise, would make the situation worse.

Tourism and recreation are projected to suffer from the impacts of climate change.

Tourism and recreation are important aspects of the region's economy. Winter recreation, notably skiing, is already seeing the affects of warming. The future viability of some ski resorts is threatened by continued climate change, especially under higher emissions scenarios. Ecosystem degradation will affect the quality of the experience for hikers, bikers, birders, and others who enjoy the Southwest's natural beauty. Water sports that depend on the flows of rivers and sufficient water in lakes and reservoirs are already being affected, and much larger changes are expected.

Adaptation Strategies: Fire

Living with the observed and projected increase in fire risk involves actions by residents as well as fire and land management officials. Some basic strategies for reducing damage to structures due to fires are being encouraged by groups like National Firewise Communities, an interagency program that encourages wildfire preparedness measures such as creating defensible space around residential structures by thinning trees and brush, choosing fire-resistant plants, selecting ignition-resistant building materials, positioning structures away from slopes, and working with firefighters to develop emergency plans.



Additional strategies for responding to the increased risk of fire as climate continues to change could include improving evacuation procedures and communications infrastructure. Also important would be regularly updated insights into what the latest climate science implies for changes in types, locations, timing, and potential severity of fire risks over seasons to decades and beyond; implications for related political, legal, economic, and social institutions; and improving prognostications for regeneration of burnt-over areas and the implications for subsequent fire risks. Reconsideration of policies that encourage growth of residential developments in or near forests is another potential avenue for adaptive strategies.