

California's Fourth Climate Change Assessment – Regional Reports

TITLE

Sierra Nevada Region Report

CITATION

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EXECUTIVE SUMMARY

The Sierra Nevada region is critical to the environment and economy of California. Its places and peoples provide essential natural resources including fresh water, clean power, working lands, and famous wilderness. The region encompasses tremendous geographical, climatological, and ecological diversity that spans majestic mountains to deep desert basins. The climate consists of cool, wet winters and warm, dry summers with large differences due to latitude (e.g., the southern Sierra is snowier than northern Sierra) and topography (e.g., the Westside is wetter than the Eastside). Variability is another notable feature of the climate with the region experiencing some of the largest year-to-year climatic fluctuations in the United States. Herein we summarize our assessment of climate-change vulnerabilities and adaptation actions in the region.

Projected climate changes: Climate change is already underway in the Sierra Nevada region, affecting heat and precipitation extremes, with long-term warming trends, declining snow packs, and changes in streamflow timing. These ongoing trends foreshadow larger changes to come. By the end of the 21st century, temperatures in the Sierra Nevada are projected to warm by 6 to 9°F on average, enough to raise the transition from rain to snow during a storm by about 1,500 to 3,000 feet. In contrast, future precipitation is predicted to vary less than temperature; long term changes may be no more than $\pm 10\text{-}15\%$ of current totals. However, precipitation extremes (both as deluge and drought) are expected to increase markedly under climate change. These climatic changes will depend on and reflect many factors, including elevation within the mountain range, with quicker warming trends and precipitation changes at highest elevations.

As a result of projected warming, Sierra Nevada snow packs will very likely be eradicated below about 6,000 feet elevation and will be much reduced by more than 60% across nearly all of the range. Notably, though, recent studies suggest that even these snowpack-loss projections may be underestimates, due to feedback loops with warming trends causing snow cover losses, and snow cover losses resulting in warmer land surfaces and thus enhanced warming trends in turn.

The loss of snowpack will combine to dry soils 15% to 40% below historical norms, depending on elevations. The result will be reduced soil and vegetation moisture; changes in rivers and lakes; and ultimately stresses on flora and fauna. Loss of snowpack and overall drying will lead to increased winter stream flows and floods, and to (largely compensating) reductions in spring and summer stream flows.

Framework for adaptation: In considering several major vulnerabilities and arenas for climate-change adaptation in the Sierra Nevada, two basic framings provided useful organizing principles. First, a recommended strategy for developing adaptation options includes (1) understanding historical trends, (2) identifying vulnerabilities, (3) developing strategies, and (4) monitoring results. This report discusses ecosystems and wildlife,

water resources, and human communities with these steps in mind. Second, not all adaptations seek to completely avoid climate-change impacts. Four categories of adaptation, in order of increasing intervention, are efforts to support (1) resistance (trying to ward off climate-change impacts), (2) resilience (increasing the capacity of systems to absorb and bounce back from climate changes), orderly response (assisting transitions to avoid at least the most undesired outcomes), and realignment (facilitating major transitions to the most desirable new conditions) to the new climate-changed environment that is coming.

Ecosystems and biodiversity: Climate is a major driver of ecosystem composition, structure, and dynamics. Even optimistic projections of warming indicate a future with more wildfire, more drought stress, and lower carbon storage in the Sierra Nevada. High elevation forests and old-growth mixed conifer forests are the most vulnerable to projected changes in climate and wildfire. Development pressures combined with warming are likely to result in oak-woodland declines, whereas meadows are particularly vulnerable to disruptions of local hydrology.

Climate variations and changes can directly impact physiological processes in sensitive species. Observed trends to date in the distributions of mammals, butterflies, and birds demonstrate that future range shifts are likely. Climate-driven shifts in species distributions will disrupt many natural communities, yielding new assemblages with unknown and challenging ecological interactions. Vulnerability to climate change is widespread among wildlife but old-growth forest species are likely the most sensitive.

A wide-ranging portfolio of adaptation options is available to reduce the vulnerability of Sierra Nevada forests, woodlands, and wildlife to climate change. Relatively low-impact means exist to improve resistance and resilience in montane meadows, while re-alignment involves more intrusive approaches. Adaptation strategies for vulnerable wildlife species should emphasize approaches that protect climate refugia and maintain migration corridors.

Water Resources: Climate-change impacts on Sierra Nevada water resources will be important for both local communities and for millions of downstream water users throughout the state. Predicted trends of temperature and precipitation will directly influence the regional water cycle, including uncertain but potentially large changes in natural and societal water demands.

Snowpack losses are already underway in the Sierra Nevada, and associated changes in snowmelt timing and streamflow availability will challenge some local to state-scale water management systems. Water resource management most often comes down to drought management in the Sierra Nevada; climate change will only aggravate the problem. Flood risks are projected to increase under climate change, stressing some existing water (and community) infrastructures. The vulnerability of groundwater supplies is less well understood but is expected to vary from area to area. For example, groundwater plays particularly important roles in the volcanic-rock aquifers of the northernmost Sierra Nevada and the Modoc Plateau. Climate change may impact the region's water quality in a large number of ways; all are still quite uncertain. Because Sierra Nevada populations are predominately rural and, in many places, disadvantaged, local water-resource management is frequently limited by lack of human and financial resources.

Water resources management for a highly variable climate is not new in California, but managers now face rates and magnitudes of change not seen in the history of the state. Increased surface-water storage in new or expanded reservoirs is frequently discussed as an adaptation option, but remains a source of friction between water purveyors (and flood managers), local communities, and conservation organizations. Better

coordination of surface-water and groundwater supplies should be important considerations in discussions of new storage options. Integrated Regional Water Management and the Sustainable Groundwater Management Act provide two avenues for developing and implementing needed adaptations. Successful water-resource adaptations in the Sierra Nevada region are in the interests of the entire state.

Communities: Climate change threatens to exceed the capacity of some communities in the Sierra Nevada region to respond given the current availability of physical, social, financial, human, and cultural capital. Many communities in the Sierra Nevada region are identified as disadvantaged and thus may be particularly limited in terms of climate change adaptation.

The economies of most Sierra Nevada communities are dependent on the natural resources (forests, agriculture, and tourism) that surround them. The many communities that rely on the forest products industry were hit particularly hard by the Great Recession of 2008-2009. Some of the region's communities are economically and culturally tied to agriculture and thus need stable water supplies and reliable weather. The fates of tourism-dependent communities are linked to the snowpack, stream and lake conditions, and forest health.

Water uses and sources differ from community to community. Thus, the climate related threats to water quantity and quality will vary. Capacities to address these challenges also differ from community to community, and are limited in many of the more disadvantaged rural communities.

Combined effects of drought, decline in forest health, and wildfire—all of which climate change will exacerbate—threaten the life and property of communities, especially in the wildland-urban interface throughout the region. Inadequate capacity to restore forest health (including more natural wildfire intensities and extents) limits land-management options for preparing for climate change. Inadequate capacity (e.g., at remaining mills) to safely and economically remove and use byproducts (wood and other biomaterials) of forest restoration is a primary challenge to restoration effort throughout the region.

Increased heat and precipitation extremes are expected to impact the region's transportation and other infrastructures. Hydroelectric generation may be reduced by climate change, but electricity demands within the region may be more shielded (by overall cool climates) in the mountainous parts of the region.

Climate change imperils the public health and well-being. Age, disability, and geographic/social isolation may aggravate climate-change challenges and limit responses by the region's population. Health impacts from heat waves and poor air quality are especially likely to be enhanced by climate change.

Among the most encouraging signs regarding adaptation to a changing climate are the rise of collaborative groups and, more recently, a new openness to these groups from land management agencies. New policy and programmatic innovations are providing tools and authorities to accelerate forest-management efforts, including stewardship authorities and community-responsive contracts. Stakeholder collaborations and community-based organizations are developing in the region to improve the capacity for landscape-scale forest management and restoration that crosses land ownerships. Communities are speaking up to agencies for triple-bottom line prioritization that balances social, economic, and ecological goals. Ultimately, ecosystem health, economic health, community health, and human health are interlinked in the context of climate change. Thus, integrated strategies (like IRWM programs) and the rebuilding of community adaptation capacities are critical to climate change adaptation in the region.

Adaptation in the Region: Agencies, communities, and other organizations throughout the region are already at work on a wide variety of adaptive measures that are improving the condition of present-day landscapes and communities as well as providing improved prospects in the face of coming climate changes. Current examples of efforts to adapt include:

ECOSYSTEMS AND BIODIVERSITY:

- The Sierra Nevada Watershed Improvement Program led by the Sierra Nevada Conservancy and U.S. Forest Service, aiming to restore the health of primary Sierra Nevada watersheds through increased investment and needed policy changes
- A growing number of teams working to improve forest health and to reestablish wildfire to its proper place in the region's ecosystems, including the Fire MOU Partnership, several major activities in the Lake Tahoe Basin, several Collaborative Forest Landscape Restoration Projects, and local programs like the French Meadows Forest Resilience Project.
- Meadow-restoration efforts, including those of the Sierra Meadows Partnership and the Native Youth Conservation Corps.

WATER RESOURCES:

- Fifteen Integrated Regional Water Management regions, and planning efforts spawned by the Sustainable Groundwater Management Act.
- More local initiatives like the Lake Almanor Watershed Group and South Lassen Watersheds Group that are addressing water quality and quantity, and forest health issues, in their areas.

COMMUNITIES:

- Tribal efforts to enhance water, wildfire, and food security, and to prepare for climate change on their lands and surroundings.
- Community collaborative efforts by coalitions like Amador-Calaveras Consensus Group and California Healthy Impact Product Solutions groups.
- Climate-smart land-preservation activities like those promoted by Point Blue Conservation Science and the California Council of Land Trusts.
- Climate-smart development activities like those recommended by the Sierra Nevada Alliance and Sierra Green Building Association.

Climate change is going to bring major changes to the region's and state's living and water resources and communities. These kinds of adaptation initiatives are needed to put the region on the firmer footing it will need to forestall or avoid the most deleterious of the coming changes.

ACCESS

For access to the full report, please email Research@sgc.ca.gov

DISCLAIMER

This report summarizes recent climate research, including work sponsored by the California Natural Resources Agency and California Energy Commission. The information presented here does not necessarily represent the views of the coordinating agencies of the State of California.