Aquatic Ecosystems

Climate Change Vulnerability, Adaptation Strategies, and Management Implications

General Information:

The Sierra Nevada has 24 major watersheds; 16 watersheds drain to the west and 8 drain the Sierra's eastern slopes. Aquatic ecosystems within these watersheds – including streams, rivers, and lakes – support 40 native fish species, 30 native amphibian species/subspecies, 321 aquatic insect species, and many different riparian plant communities. Aquatic ecosystems and water are also used by human communities for drinking water, irrigation, tourism, and recreation. As a result of water management activities (i.e., dams, reservoirs & water withdrawals), land use changes, and species introductions, aquatic ecosystems in the Sierra Nevada are experiencing altered hydrology, temperature, connectivity, and species assemblages.

Ecosystem Vulnerability: Moderate

Aquatic ecosystems are sensitive to climate and climate-driven changes that affect water supply and quality, including increased temperatures, changes in hydrology (i.e., due to shifts in precipitation volume or timing, snowpack volume, and snowmelt runoff and timing), and altered wildfire regimes. Aquatic systems are also sensitive to a variety of non-climate stressors that can exacerbate climate impacts, including fish stocking, water diversions and hydropower production, residential and commercial development, timber harvest, grazing and agricultural practices. For example, roads and timber harvest may increase erosion and overland flow, processes that will likely be exacerbated by more frequent extreme precipitation events. Water withdrawals can exacerbate climate-induced shifts in water supply, and will likely be an important factor as the population of California continues to grow. In addition, introduced stocked non-native trout have many negative impacts on native fish and amphibian species that are also facing habitat fragmentation as a result of dams, low flows, and shifting temperature regimes.

Projected Climate and Climate-Driven Changes	Impacts on Aquatic Ecosystems
Increased air temperature (+2.4 to +3.4˚C), with largest increases during summer	• Increased stream and lake temperatures – Temperature increases can be buffered by shade (topographic or vegetative), lake turnover, snowmelt input, groundwater input, reservoir release, and other factors • Altered habitat conditions (i.e., reduced dissolved oxygen, altered nutrient cycling) • Increased evaporation and climatic water deficit

Changes in precipitation and snowpack
– Decreased snowpack (-64% to -87%), especially in northern range
– Earlier snowmelt and runoff
– Increased frequency (+18% to +55%) of extreme precipitation events
	• Altered flows:
	  – Reduced mean annual flow (most critical for northern Sierra Nevada)
	  – Altered runoff timing and advanced runoff center of mass (most critical for south-central Sierra Nevada)
	  – Decreased summer flow and prolonged duration of low- or zero-flow periods (most critical for central Sierra Nevada)
	  – Flashier runoff and higher flow magnitudes (e.g., floods)
	• Reduced habitat availability due to substrate homogenization and shifts in sediment delivery, distribution, and deposition
	• Reduced volume and duration of cold water inputs, exacerbating higher stream temperatures and reducing groundwater recharge

More frequent and severe fires	• Altered sediment loads, large woody debris delivery, stream temperature, and pH

Aquatic ecosystems likely have a limited ability to adapt to changing climate conditions due to their dependence on high elevation, cold water inputs and lack of habitat connectivity as a result of human development. However, some aquatic species may exhibit some phenotypic or behavioral adaptability.

Thermal refugia for aquatic species may exist in areas with riparian vegetation or topographic shading

Adaptation Strategies for Aquatic Ecosystems

Generated by the Southern Sierra Change Adaptation Workshop

Adaptation Categories	Potential Management Actions
Manage for persistence (i.e., resist change and build resilience)	• Forest management: – Manage vegetation along lotic waterways to shade streams and promote resilience – Improve natural water storage in meadow wetland complexes – Manage for snowsheds and evapotranspiration (i.e., through thinning, structuring, and fire) to build resilience • Manipulate dam discharge: – License agreements – Joint issuance of licenses – Shorten licensing period under the Federal Energy Regulatory Commission • Public education and outreach: – Explain what hydrographs are and emphasize their importance in natural systems – Include stakeholder participation in planning efforts – Develop a constituency for ecosystem services (i.e., preserve upstream functionality)
Manage for change (i.e., anticipate and plan reaction to extreme events)	• Monitoring: – Practice and improve monitoring – Rebuild monitoring infrastructure – Use modern data structuring • Public education and outreach (see above)

Prioritizing ecosystem-scale management and influencing resource use (e.g., through public education) could help increase the overall resilience of aquatic ecosystems to climate and climate-driven changes

Management Implications

This information can be used in a variety of ways:

- ✔ Forest Plan Revisions
- ✔ U.S. Forest Service Climate Change Performance Scorecard: Element 6 - "Assessing Vulnerability" and Element 7 - "Adaptation Actions"
- ✔ National Park Service Resource Stewardship Strategies, Fire and Fuel Management Plans, General Management Plans, Strategic Plans, and Wilderness Stewardship Plans
- ✔ To evaluate and inform dam licensing agreements

Further information and citations can be found in source reports, *A Climate Change Vulnerability Assessment for Focal Resources of the Sierra*, available online at the EcoAdapt Library: http://ecoadapt.org/library, and *Southern Sierra Change Adaptation Workshop – Final Report* available online at the California Climate Commons: http://climate.calcommons.org/aux/sscaw/index.htm.

EcoAdapt™
Meeting the challenges of climate change