SIERRA NEVADA
CONSERVANCY

AUBURN OFFICE
11521 Blocker Drive, Ste. 205
Auburn, CA 95603
p (530)823-4670 f (530)823-4665

Dear Friend:

We are pleased to provide you a copy of "Looking to the Source: Watersheds of the Sierra Nevada." This report was prepared by the Water Education Foundation as a means to focus on the importance of the Sierra Nevada to the state's environmental and economic well-being. The report encompasses observations and information on the area contained within the Sierra Nevada Conservancy's boundary.

As the state's primary watershed, the Sierra Nevada Region provides domestic water supplies to millions of Californians, helps meet the needs of agriculture and other businesses in the state and contributes significantly to addressing environmental needs, including those in the Sacramento-San Joaquin Delta. Ongoing investment in the management of Sierra watersheds is essential in protecting and enhancing water quality and supply not only for those in the Region, but all Californians.

The Water Education Foundation maintained full editorial control of the report, receiving input from a wide range of stakeholders. The Sierra Nevada Conservancy provided partial funding of this report with the goal of increasing of the understanding of the Region's contributions and challenges.

A few of the key points from the report include the following:

- ✓ The Sierra Nevada is the point of origin for a portion of the drinking water supply for more than 23 million Californians, as well as a significant number of Nevadans.
- ✓ Many of California's urban areas are dependent upon the Sierra for their water; for example, 85% of San Francisco's water originates in the Tuolumne River Watershed of the Sierra Nevada.
- ✓ The Sierra Nevada should be a prominent element in the Delta health discussion. Approximately half of the water that flows into the Sacramento-San Joaquin Delta originates in the Sierra (Page 13).
- ✓ Restoring forest and watershed health, including reducing the risk and consequence of large, damaging fires is a critical part of protecting our state's water supply (Pages 24-27).
- ✓ Water from the Region directly supports jobs and job creation - in agriculture: farming, ranching, and dairy; in industry: energy, fuel, and construction; and in tourism and recreation (Page 15).

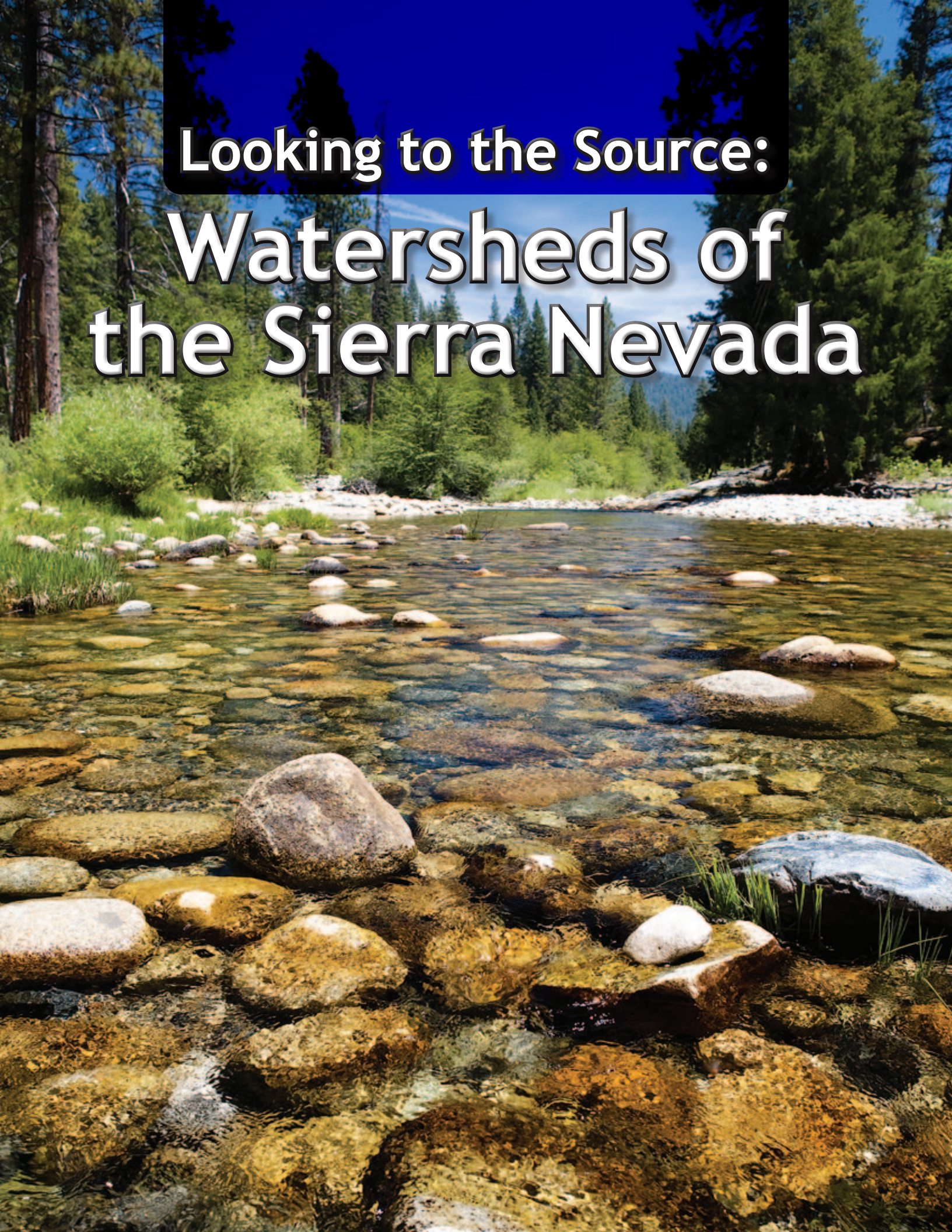
The report's description of impacts to the Region's watersheds focuses on many historic activities, perhaps leaving the reader with the impression that nothing much has changed. To be sure, legacy problems do exist, but at the same time management practices have evolved and much is being done to improve watershed health by those who work and live in these watersheds. Activities such as sustainable grazing and timber harvesting remain essential components of the economy of the Region and can contribute greatly to improving watershed health.

Likewise, while the economic contribution of recreational use is recognized, the report could lead a reader to believe that there is widespread abuse by those who visit the Region. Once again, there are certainly problematic activities, but the overwhelming majority of those who recreate are good stewards who appreciate the area's beauty and act accordingly.

We hope you find this report informative and useful.

Thank you,

Jim Branham
Executive Officer



Looking to the Source: Watersheds of the Sierra Nevada

The Sierra Nevada is a vital source of water for all of California.

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Credits

President: William R. Mills
Executive Director: Rita Schmidt Sudman
Editor: Sue McClurg
Author: Susan Lauer
Editorial Assistance: Robin Douglas
Layout Design: Curtis Leipold
Photography: Kathy Bishop
California Department of Water Resources
Jason Cannon
Elizabeth Carmel
Brien Clark
Steve Dunleavy
East Bay Municipal Utility District
El Dorado Irrigation District
Jon Klusmire, Eastern California Museum
Library of Congress
Mammoth Mountain Ski Area, LLC
Gia Martynn – The Feather River Coordinated Resource Management Group
Mono Lake Committee
Tom Rassuchine
Sierra Nevada Conservancy
U.S. Fish and Wildlife Service
U.S. Forest Service
YubaNet.com

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The mission of the Water Education Foundation, an impartial, nonprofit organization, is to create a better understanding of water resources and foster public understanding and resolution of water resource issues through facilitation, education and outreach.

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Introduction

The Sierra Nevada region is all about the water. Fed by snowmelt, California's major rivers and thousands of miles of streams flow from imposing mountain peaks through forests, alpine meadows and hundreds of lakes. Along the way are some of the most beautiful landscapes in the world, habitat for thousands of animal species and popular destinations for recreation activities. The water also is vital to timber, farm and ranch operations, as well as hydropower plants that produce energy.

On average, 60 percent of the state's total annual precipitation – in the form of rain and snow – falls in the Sierra Nevada and a portion of the southern Cascades, according to California Department of Water Resources (DWR) data. Snow serves as an enormous natural reservoir. Mountain meadows, especially in the northern Sierra, also play a critical role in the natural storage of water.

During spring and summer months, the snow melts and flows downstream into reservoirs, where it is stored until needed downstream. This water provides irrigation for farms hundreds of miles away that produce half of the nation's fruit, nuts and vegetables, and also is a vital source for dairies, which have made California the largest milk producer in the country. In addition, Sierra snowmelt provides drinking water to Sierra Nevada residents and a portion of drinking water to 23 million people living in cities stretching from the Bay Area to Southern California.

Many of California's urban centers directly depend on Sierra Nevada rivers to meet the water needs of communities and enterprise. For example, the Tuolumne River provides 85 percent of San Francisco's total water needs from the Hetch Hetchy Reservoir in the high Sierra. And Los Angeles tapped the Owens River on the eastern slope of the Sierra Nevada in the early 1900s, and still relies on the source for a supply to the city. In addition Sierra water, via the Sacramento-San Joaquin River Delta (Delta), is pumped into California's two largest water delivery projects, the State Water Project (SWP) and the federal Central Valley Project (CVP), which transport it to farms and cities throughout Central and Southern California.

"The water originating from Sierra Nevada watersheds fills many California rivers and recharges its groundwater basins; it helps meet a significant portion of urban and agricultural water uses throughout California; and it is essential for environmental stewardship – water needed for healthy watersheds and ecosystems," said Kamyar Guivetchi, manager of Statewide Integrated Water Management for DWR.

The Sierra Nevada as an important water source is dependent on the condition of its watersheds – the forests and meadows that drain into waterways. The health of these watersheds is directly linked to the quality and even the amount of water that flows through the region and downstream.

The Sierra Nevada is a vital source of water for all of California.

The Sierra Nevada Ecosystem Project (SNEP), a congressionally mandated three-year study of the region released in 1996, noted that both historic – mining, logging and grazing – as well as more recent activity – poorly planned development, inappropriate recreation and catastrophic fire – have contributed to the degradation of the watersheds.

Since the SNEP report, U.S. Environmental Protection Agency (EPA) studies have noted Sierra rivers, lakes and streams and their watersheds continue to be threatened. Stretches of rivers have sometimes been closed to swimming and fishing and the habitats they provide to wildlife have been impaired.

The Sierra Nevada faces additional challenges. It is the third fastest growing region in California. Some communities already are facing the challenge of how to maintain adequate water supplies and provide wastewater treatment, while addressing pollution and runoff problems. Encroachment into wildlands also is a mounting problem.

In addition, many of the region's forests have become overgrown, and better management is needed to ensure the health of a functioning watershed. Forest fires are becoming more severe and frequent, according to the U.S. Forest Service (USFS). Although fire is a natural function of a healthy forest ecosystem, these catastrophic fires can cause extensive damage to forests and leave land susceptible to erosion. With each rainfall, the soil and nutrient-rich ash flush down the mountain towards streams and lakes, degrading water quality and diminishing the storage capacity of downstream reservoirs.

The Sierra Nevada as an important water source is dependent on the condition of its watersheds – the forests and meadows that drain into waterways.

The Sierra Nevada attracts millions of visitors during all seasons for many types of recreation. However, many activities, such as boating and trail riding on off-road vehicles, can pollute and destroy habitat.

A significant threat to the Sierra Nevada is climate change. The region already is experiencing the effects of a warming climate with increased temperatures in some areas causing snow to melt earlier in the spring. Loss of snowpack and changes in timing of snowmelt are expected to contribute to more flooding and could mean water cannot be delivered where or when it is needed.

In the face of serious challenges to Sierra watersheds, many groups and agencies at the local, regional, state and federal levels are focusing efforts on management, restoration and protection of this region. Projects that enhance and restore the upper watershed forests and meadow systems improve water quality and water supply reliability, and safeguard significant habitats and migratory corridors.

While many groups focus on specific projects, individual agencies and organizations also are teaming up to address multiple water issues and

coordinate efforts across jurisdictional boundaries. Coordinated by DWR, Integrated Regional Water Management (IRWM) has the goal to secure long-term water supply reliability by first recognizing the inter-connectivity of water supplies and the environment, and then pursuing projects that yield multiple benefits for water supplies, water quality and natural resources.

Recognizing the importance of the Sierra Nevada, in 2004 then-Gov. Schwarzenegger signed legislation authored by former Assemblymembers John Laird (D-Santa Cruz) and Tim Leslie (R-Tahoe City) establishing the Sierra Nevada Conservancy (SNC) to provide a strategic direction for the region's environmental, economic and social well-being. The SNC provides state funding for local projects and offers technical assistance and other support for collaborative projects in partnership with local governments, tribes and non-profit organizations.

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In 2004, Gov. Schwarzenegger (middle) signed AB 2600 to establish the Sierra Nevada Conservancy.

> ***"The Sierra Nevada region is the origin of approximately half of the state's water, providing habitat for fish and wildlife, and serving cities, farms and industries throughout the state."***
>
> - John Laird, California Secretary for Natural Resources

The SNC's boundaries extend beyond the geographic Sierra Nevada and include the Mono Basin, Owens Valley, the Modoc Plateau and a part of the southern Cascade Range, including the Pit River watershed. The region includes all or parts of 22 counties, from Modoc County in the north to Kern County in the south.

This publication explores the issues in Sierra Nevada watersheds that affect water quality and quantity and its beneficial uses throughout the SNC region. It describes efforts being undertaken to ensure Sierra water continues to be ample and clean for drinking, irrigation for crops and sustenance for wildlife and the environment.

Laird, who was appointed California Secretary for Natural Resources in 2011, noted: "The Sierra Nevada region is the origin of approximately half of the state's water, providing habitat for fish and wildlife and serving cities, farms and industries throughout the state. It is my goal as Secretary for Natural Resources to restore and protect clean, healthy watersheds in the Sierra Nevada, in order to secure habitat for wildlife and a safe, reliable water supply for all Californians."

What is a Watershed?

Based on the maxim "water runs downhill," a watershed is the land area through which runoff – snowmelt and rain – drains into a connected system of lakes, streams and rivers. Watersheds may be as small as a patch of land draining into a tiny pond or as large as the Sacramento River Basin, which drains an area of about 27,000 square miles. Watersheds usually are separated from one another by ridges or mountains.

A watershed has many important natural functions. It collects water from precipitation, stores groundwater in aquifers, releases water as runoff and provides habitat for plants and animals. Flowing water carries organic matter that provides food and shelter for aquatic life.

Actually, there is no "pure" water in nature. Even in the most remote watersheds, where water quality is not directly affected by humans, "natural" pollutant sources are abundant. These include sediment from stream bank erosion, bacteria and nutrients from wildlife and chemicals deposited by rainfall. Unfortunately, water also may carry pollutants like motor oil, fertilizers, and pesticides, which can mix with rain entering the soil and degrade water quality.

The combined runoff from snowpack, rain and base flow from watersheds in the SNC boundary creates many streams that run year-round. The major river systems flowing from this region are the Pit, Sacramento, Feather, Yuba, Bear, American, Cosumnes, Truckee, Carson, Walker, Owens, Mokelumne, Stanislaus,Tuolumne, Merced, Fresno, San Joaquin, Kings, Kaweah,Tule and Kern.

In addition, the Sierra Nevada region contains thousands of lakes, many of which were formed by melting glaciers. Other lakes and ponds have formed from the accumulation of rain and melting snow. These lakes vary in size from surface areas of 300 square miles to very small ponds.

Background

Geography and Geology

The Sierra Nevada is a region of superlatives. Notable landmarks include Mount Whitney, at 14,505 feet the highest point in the contiguous United States; Yosemite Valley's Yosemite Falls, the highest waterfall in North America with a 2,425-foot cascade; and Lake Tahoe, the largest alpine lake in North America and the second deepest lake in the United States at 1,645 feet.

The Sierra Nevada mountain range incorporates more than 25 percent of California's land area, stretching along the eastern edge of the state, about 450 miles long and 40 to 50 miles wide. It is one of the most diverse regions in the world because of precipitation that ranges from 10 to 90 inches depending on elevation. Towering granite cliffs give way to lush forests and alpine meadows on the westside and stark desert landscapes at the base of the eastside.

Sierra Nevada watersheds provide habitat for the majority of the bird, mammal, reptile and amphibian species found in California. Bighorn sheep nimbly navigate High Sierra peaks; mule deer, black bear and mountain lions call the forests home; hawks and eagles soar above valleys and canyons; and trout fill streams and rivers. California's state fish, the endangered Golden Trout, is native to the Sierra Nevada.

U.S. Fish and Wildlife Service

Hydrology

On average, California receives about 200 million acre-feet of precipitation per year (an acre-foot equals 325,851 gallons, or enough water to cover a football field to a depth of one foot). However, between 50 and 60 percent of the total precipitation is unavailable as a usable state supply because it evaporates, is absorbed by plants, percolates into the ground or flows to the Pacific Ocean, Oregon or Nevada.

The Sierra Nevada region provides so much of the state's water because of the mountains, which "catch" eastern-moving clouds before they reach

Groundwater

Groundwater – the portion of water beneath the land surface – plays an important role in the state's water supply and the health of watersheds. Groundwater is found in the spaces of soils and underground formations. As surface water percolates underground through sand, gravel, silt or clay, it then collects in layers called aquifers. This water can be collected with wells, or it naturally flows to the surface via seepage or springs.

The most notable Sierra Nevada groundwater basins are found in the volcanic soils of the upper portion of the Feather River watershed. Groundwater availability is more limited in the fractured rock underlying the remainder of the region.

Spring snowmelt helps recharge aquifers throughout the region. Depending on local hydrologic conditions, groundwater also provides important inflow to springs, rivers or spring-fed lakes. State hydrologists estimate that 30 percent of the water found in lakes or streams comes from groundwater.

On average, within the Sierra Nevada region, groundwater extraction is most pronounced in the northeasterly Sacramento River area, in the Bear and Battle Creek watersheds and in the South Lahontan Mono Lake/Owens Valley area where surface water supplies are limited. In the more populated areas that hold larger surface water supplies, such as the southeasterly Sacramento River area and San Joaquin-Sierra Foothills area, groundwater is relied upon less, and, as a result aquifer storage has actually increased over the eight-year period from 1998-2005. Although groundwater use within the Sierra Nevada region represents only a little over 4 percent of the total groundwater use within the state, groundwater is a significant source of supply for many communities within the region.

Nevada. Precipitation accumulates during the winter months at higher elevations as snow, and the snowpack acts as a natural reservoir that holds water until temperatures rise. During the late spring, the snowpack melts to provide significant runoff on the Sierra Nevada's west slope and, to a lesser extent, on the Sierra Nevada's eastern slopes.

The snowmelt in spring typically contributes half of the total annual runoff from the region. After the high risks of floods have passed during spring, water is allowed to fill reservoirs. By late summer, when natural river flows are at very low levels, water releases from the reservoirs provide much of the downstream water supply, according to the Mountain Counties section of the State Water Plan Update 2009.

Early Water Development

Humans have left footprints in the Sierra Nevada for more than 10,000 years and have been responsible for the region's development by establishing settlements and using the region's resources to sustain and enrich their lives. In all, an estimated 100,000 American Indians lived in the Sierra Nevada prior to the mid-1800s. The name "Sierra Nevada" was first noted in 1542 when the Portuguese explorer Juan Rodriguez Cabrillo landed on the coast around Santa Cruz and simply referred to the distant mountains as "sierra nevada" (snowy mountains).

Humans have left footprints in the Sierra Nevada for more than 10,000 years and have been responsible for the region's development by establishing settlements and using the region's resources to sustain and enrich their lives.

In 1848 James W. Marshall discovered gold at Sutter's Mill in Coloma on the American River, and in a few years more than 300,000 "49ers" flocked to the Sierra Nevada in hopes of striking it rich. The legacy of gold mining includes a distinctly important role as it spurred development of the Sierra Nevada region, served as a catalyst for advancements in industry and earned a place in United States history. Yet it also includes some very disturbing and lasting impacts. Early methods of panning for gold in rivers and streams soon gave way to advanced, much more productive – and very destructive – techniques. Mining was taken to new levels with hydraulic mining, using cannons and high-pressured water to blast away gravel hillsides. Rock and soil was washed through large wooden sluices to extract gold, and the debris – including mercury and arsenic – was dumped into streams and waterways and then flushed downstream.

The debris clogged rivers, destroyed fish habitat and led to flooding in downstream communities and farms. On the Yuba River alone, upwards of 685 million cubic feet of debris was deposited in the river, raising the riverbed by up to 30 feet in some places. The muck even carried to the San Francisco Bay hundreds of miles away, graphically illustrating the link between upstream watersheds and the Delta and the Bay, the state's most important estuary.

In 1884 federal Judge Lorenzo Sawyer declared hydraulic mining was "a public and private nuisance" and violated the rights of individuals downstream by destroying the landscape and damaging the watershed. The judge noted that hydraulic mining was legal; however, discharging the debris into local rivers was not. The Sawyer Decision was among the first environmental rulings introduced in the United States, and it effectively shut down hydraulic mining operations, which couldn't make a profit under the new restrictions.

The Gold Rush boom established primitive logging operations and small sawmills that expanded and flourished. The demand for lumber

John Muir

Library of Congress

skyrocketed and new technologies emerged that would change the industry significantly. In the late 1860s the Central Pacific Railroad also became a major consumer of Sierra lumber as it built its way west, crossing the Sierra Nevada at Donner Pass and becoming the nation's first transcontinental railroad.

Logging and lumber businesses thrived, but early logging practices were less than advanced. By the late 1800s, more than a third of the standing timber in the Sierra Nevada was logged and problems in the watersheds created by sedimentation and deforestation were increasing. Like timber production, livestock grazing has been a part of the Sierra landscape since the 1850s. Ranching and stock grazing were lucrative businesses. However, overgrazing began to have an adverse impact on water quality, habitat and other resource values.

In the late 1800s, the Sierra Nevada began to be valued for its natural beauty. John Muir, the most heralded early champion of the Sierra, called the mountains the "Range of Light," referring to the unique combination of sunny weather, high mountaintops and colorful alpine meadows. Muir advocated for the preservation of Sierra wilderness. Both Yosemite and Sequoia National Parks were formed by Congress in 1890.

Later Water Development

When the USFS was established in 1905, much of the Sierra Nevada was placed under federal management. In 1920 Col. Robert Marshall of the U.S. Geological Survey (USGS) proposed a statewide plan for water conveyance and storage, earmarking the Sierra water supply for use throughout the state. Downstream in the valleys and cities, California's population and economic boom brought increased demand for electricity and flood control. Local, state and federal agencies began building dams, hydropower turbines and canals to control the water, generate electricity and move the water to urban and agricultural areas.

In 1920 Col. Robert Marshall of the U.S. Geological Survey (USGS) proposed a statewide plan for water conveyance and storage, earmarking the Sierra water supply for use throughout the state.

In 1933, Congress authorized the CVP to bring water to crops and growing cities, to control flooding in the Sacramento and San Joaquin valleys, to maintain late season freshwater in the Delta and also to produce electricity through hydroelectric power plants. Most of the facilities were completed by 1951. Today the CVP includes 18 dams and reservoirs – the largest is Shasta Dam on the Sacramento River. The CVP provides water for about one-third of the state's irrigated farmland and about 1 million households in an average year.

Friant Dam construction on the San Joaquin River, circa 1945

As California's population continued to grow after World War II, state officials realized that more water was needed for cities and farms, and in 1951 the state Legislature authorized the SWP. California voters approved a $1.75 million bond in 1960 to fund construction of the facilities. The SWP is the world's largest publicly built and operated water storage and conveyance system. The project spans more than 600 miles from Northern California to Southern California, includes 34 storage facilities, 20 pumping plants, four pumping-generating plants, five hydroelectric power plants and about 700 miles of canals, tunnels, and pipelines. On the Feather River, Oroville Dam is the tallest dam in the United States at 770 feet high.

As the 20th century progressed, there was more focus on conservation and management of natural resources. In 1964, the federal Wilderness Act established 20 areas of the Sierra Nevada as primitive. This was the precursor to the eventual designation of these lands as wilderness areas.

The USFS and Bureau of Land Management (BLM) currently manage more than half of the land in the Sierra Nevada, and generally logging, mining and grazing are allowed under

federal regulations that seek to balance multiple uses, including recreation and development. However, logging and grazing are off-limits in the four national parks, two national monuments and 20 wilderness areas, nearly 15 percent of the Sierra's 24,000-plus square miles.

Free-flowing conditions of rivers with outstanding natural, cultural, and recreational values are protected under the federal Wild and Scenic Rivers Act, passed by Congress in 1968, and the California Wild and Scenic Rivers Act, passed in 1972. Today federally protected Sierra rivers include portions of the Feather, Tuolumne, Kings, American, Kern and Merced. Segments of the American, South Yuba, East Carson and West Walker rivers are protected under the state act.

In 1992, noting the importance of the Sierra Nevada and the increasing concern that the ecosystem was degrading, Congress requested an assessment of the region. The resulting SNEP report focused on a scientific review of forests, key watersheds and significant natural areas on federal lands. The report took into consideration social, economic, and ecological elements of the region.

The final SNEP report, submitted to Congress in 1996, noted that water is the most valuable commodity in the Sierra Nevada. The value of water resources in the Sierra is greater than all the other resource values (timber, grazing, mining and recreation) combined. The report also found that Sierra Nevada watersheds were under great duress from legacy pollution – toxics lingering from earlier mining, timber harvesting and grazing operations – and more recently from population growth, increased recreation and road construction.

Area of Origin

As water conveyance systems were being developed and water rights were being defined, the state Legislature recognized the need to acknowledge the importance of the needs and rights of the areas where California's water originates. This resulted in passage of legislation providing "Area of Origin" protections in state statute. In general, these statutes are intended to ensure that the beneficial use of water within these areas of origin has priority over exporting the water out of the area. These protections, which are an evolving area of law and subject to court challenges,

Sierra Nevada Conservancy

Hetch Hetchy Reservoir

are important to Sierra residents, who manage and protect the water that flows from the region not only for the benefit of the rest of the state but for the beneficial uses the water provides within their own communities. In other words, the economies and ecosystems of the region are dependent on Sierra water.

Managing and protecting water resources within the region can be challenging given the breadth of the needs, low population densities, and the need to balance water quality and supply issues with other historical, cultural, and environmental needs.

One response to these challenges has been the formulation of innovative solutions through broad collaborative processes for conservation, restoration, and protection of natural systems of the water resources and watersheds. These processes have included the local agencies and organizations, volunteers, as well as state and federal agencies and tribes.

Hydroelectricity: The Power of Water

As Sierra water flows downstream, it serves as the state's leading source of hydroelectric power generation, responsible for up to 55 percent of all hydroelectricity produced in California, according to the State Water Plan Update 2009, Mountain Counties Section. Sierra Nevada hydroelectric plants produce up to 15 percent of California's total energy every year, according to the California Energy Commission.

Simply stated, electric power is produced when water turns a turbine connected to a generator. California has nearly 400 hydroelectric plants, mostly located in the Sierra Nevada and Cascade mountain ranges at dams that also provide water supply, flood control and recreation. Altogether these plants have a total dependable capacity of about 14,000 megawatts (a megawatt is roughly equal to the amount of electricity used by 750 typical homes at any given moment). The amount of electricity produced varies each year and is largely dependent on snow, storage and rainfall in the upper watersheds – and the capacity of the reservoir where the power plant is located.

Hydroelectric facilities are divided into two categories: larger and smaller than 30 megawatts capacity. The smaller power plants are considered producers of "green energy" and are included in the state's renewable energy portfolio standards.

A Southern California Edison hydroelectric power station on Bishop Creek in the eastern Sierra.

The larger hydroelectric plants on dams, such as Shasta, Folsom and Oroville, are operated by the federal Bureau of Reclamation and DWR. Smaller hydropower plants are operated by utilities, mainly Pacific Gas and Electric Company, Sacramento Municipal Utility District and Southern California Edison.

Benefits of hydroelectric plants are: their ability to generate power during periods when demand is high and energy is more valuable, such as hot summer afternoon hours; relative low cost; and near-zero emissions, according to the California Energy Commission. But hydroelectric power plants have a significant impact on the health of Sierra aquatic ecosystems. They can alter stream flows, water temperature, turbidity – the amount of sediment in the water – and oxygen content.

Eighty percent of California's hydropower dams are regulated through 30- to 50-year licenses issued by the Federal Energy Regulatory Commission. Nearly half the state's facilities are scheduled to be relicensed in the next 15 years. Regulations developed during the relicensing process for the operation of these hydroelectric facilities include an elaborate amalgam of requirements for the protection of the various beneficial uses, including flood control, water supply, recreation, fisheries and environment. Yet critics say relicensing efforts typically focus on river and stream reaches adjacent to hydropower facilities and fall short in recognizing watershed and bioregional impacts of project operations.

The Journey of Sierra Water

It all begins with rain and snow falling on a watershed. The precipitation is absorbed into the ground or flows into creeks, streams and rivers. Water flowing downstream either joins with larger rivers and contributes to urban, agricultural or environmental uses, or it is captured and stored in reservoirs until needed. When released the water is used for multiple purposes, including the maintenance of fisheries and recreation. It also is a water source that flows through aqueducts, large pipes and canals to a distribution system made up of a vast network of pipes that connect to exact addresses – to homes and businesses. In some areas, gravity is all that is needed to convey water downstream. When needed, booster pumping stations maintain adequate pressure to move the water.

In a drinking water distribution system, chemists take samples to ensure the water meets federal and state standards and does not contain organisms that can transmit disease. Water treatment plants operate around the clock to ensure that the water is safe and it tastes, smells and looks good.

Many water districts rely on water from Sierra rivers as a direct source. For example, to meet the growing needs of its population at the turn of the 20th century, the city of San Francisco began examining the potential of damming the Tuolumne River for more water. The city proposed building a large hydroelectric dam and filling the Hetch Hetchy Valley, located near Yosemite Valley. A heated political struggle ensued, with opposition to the dam led by John Muir, until Congress passed the Raker Act in 1913 and allowed the dam to proceed. O'Shaughnessy Dam was completed in 1923.

Farmers also depend on the Tuolumne River as a direct supply. For example, today the Turlock Irrigation District serves more than 4,900 irrigation customers working 150,000 acres of farmland.

In the East Bay, across from San Francisco, residents of Alameda and Contra Costa counties voted in 1923 to form the East Bay Municipal Utility District (EBMUD) to meet the region's growing water needs. Today the district serves 1.4 million customers. Almost all of EBMUD's water supply originates in the 577-mile watershed of the Mokelumne River.

"Ninety percent of our district's water comes from the Mokelumne

Pardee Dam

East Bay Municipal Utilities District

River; it's our drinking water source. Needless to say, it is vital to us," said Michael Wallis, director of Operations and Maintenance for EBMUD.

"One of the most important factors in water quality is the source: the purer the source, the better the water," Wallis said. "Watershed health is crucial. Without that high quality water, there would be a fundamental, profound effect including additional costs to treat the water for our customers."

In Southern California, the Los Angeles Department of Water and Power (LADWP) recognized the need to augment local water supplies for a rapidly growing city at the turn of the 20th century. It found the source 250 miles away on the eastern slope of the Sierra Nevada in the Owens Valley. In 1913 the Los Angeles Aqueduct began deliveries from Owens Lake to Los Angeles. The acquisition of land and water rights for the Los Angeles Aqueduct, begun in 1905 by William Mulholland, superintendent of the LADWP, was highly controversial and led to violence and sabotage of the aqueduct by local residents in the 1920s. A second aqueduct added capacity in 1970.

After years of legal battles, Inyo County and the city of Los Angeles came to an agreement to jointly manage the valley's water resources and regulate the amount of exported water based on environmental effects. Restoration projects have included restoring Mono Lake, controlling dust pollution by re-watering portions of Owens Lake, enhancing valley ecosystems and recreational opportunities and re-watering of the Lower Owens River. Until the court decisions and agreements reduced the amounts of water exported to Los Angeles, the Owens Valley provided up to 75 percent of the city's annual water supply via the two aqueducts. Even in recent years, when the supply has been reduced, the Los Angeles Aqueduct has provided about half of the city's water needs, according to the LADWP.

Sacramento-San Joaquin Delta

> ***"The Sierra Nevada is as important as the Delta, just in a different way."***
>
> – Professor Roger Bales, Director , Sierra Nevada Research Institute, University of California, Merced

The Delta Connection

From the Sierra Nevada and the southern Cascades, runoff from snowmelt and rain flows through watersheds via creeks and streams and into larger rivers, including California's two longest rivers, the Sacramento (447 miles) and the San Joaquin (330 miles), which come together just south of Sacramento. Here the two rivers mingle with smaller tributaries and tidal flows to form a 700-mile maze of sloughs and waterways surrounding more than 60 leveed tracts and islands that make up the Delta.

In general, outflow from the primary rivers of the Sierra Nevada region accounts for 40 to 50 percent of total water into the Delta, depending on the type of water year, according to DWR. For example, during an average year, 13 million acre-feet of water flows from the primary rivers of the Sierra Nevada region into the Central Valley. In the wettest years, Sierra river flows into the Central Valley can exceed 20 million acre-feet.

"The Sierra Nevada is as important as the Delta, just in a different way. It's not a trade-off between the watersheds of the Sierra Nevada and the Delta; we need them both," said Professor Roger Bales, director of Sierra Nevada Research Institute, University of California, Merced.

Water Quality

Sierra Nevada streams and rivers run clear and cool. However, looks are deceiving; 79 percent of the rivers in the Sierra Nevada region have had stretches periodically closed or public health warnings issued for fishing, according to the CalEPA's Environmental Health Hazard Assessment (OEHHA), and 75 percent have had stretches at one time listed as impacted for drinking, according to EPA.

While natural events, climate and geology factor into overall watershed health and water quality, it is human activity that largely threatens the degradation of Sierra Nevada water. Early development – mining, logging and railroads – created "legacy" impacts. More recent development – large dams, roads and water diversions – without healthy forest management practices has created significant erosion and altered the shape, flow temperature and water quality of rivers and streams. Additionally, added contaminants, such as oil and nitrates (from fertilizers, septic tanks and wastewater systems) have increased water quality degradation in some areas.

El Dorado Irrigation District

Water quality sampling by El Dorado Irrigation District

Malakoff Diggins

Sue McClurg

Today, EPA estimates that pollution from random, diffuse sources – known as non-point sources – accounts for 65 percent of pollution in U.S. rivers. These include pollutants that get into the watershed from everyday activities that we all do, such as walking the dog or driving a car. As water moves through a watershed, it picks up bacteria and chemicals and carries them to streams, rivers, lakes and coasts.

As water quality deteriorates, costs increase – costs associated with treatment and storage for drinking water, reduced crop yields, higher handling costs and damage to fish and wildlife. Since its 1993 update, the State Water Plan has continued to note, "avoiding these costs by protecting water sources from degradation in the first place is one of California's more pressing water management problems."

While there is agreement on the connection between land use and water quality, the challenges are complex and opinions differ about how to measure and address the impacts.

In compliance with the federal Clean Water Act, the State Water Resources Control Board – through its Regional Water Quality Control boards (Regional Boards) – lists impaired water bodies every two years. After the EPA reviews and approves the list, either the EPA or the respective Regional Board works with stakeholders to prepare a plan to reduce pollutants in the impaired waterways. In the Sierra region, 11 of 24 major watersheds have at least one river, lake or reservoir listed as impaired equating to a total of 535 impaired river miles and 252,044 impaired acres of reservoirs or lakes. Abandoned roads and mines are the most widespread "legacy" problems on forest lands. Dams and diversions, overgrazing, roads, logging, recreation activities and physical alterations also have caused significant water quality degradation. Air pollution, primarily coming from the Central Valley, also is taking a toll.

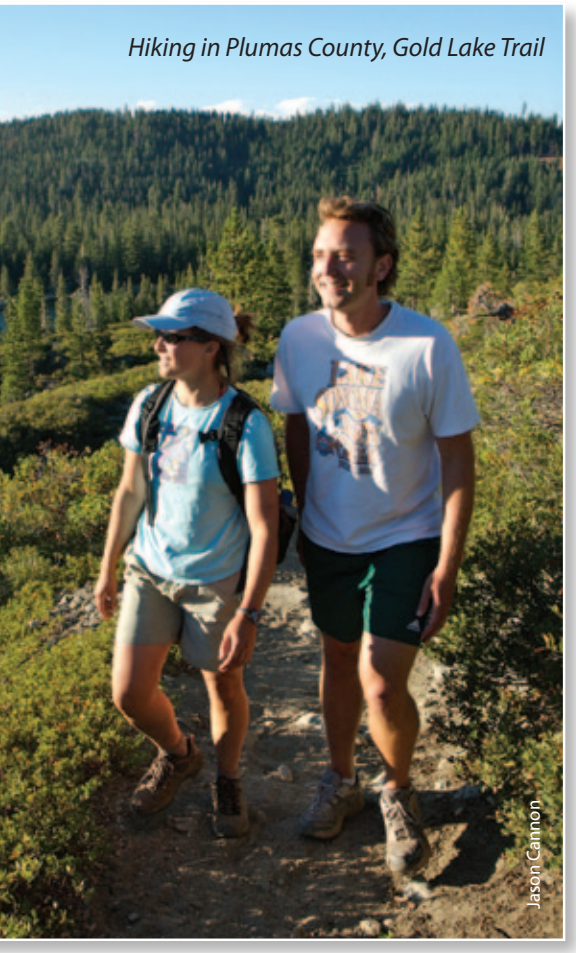
Economic Benefits of Watersheds

Ecosystem Services

Functioning watersheds with healthy forests provide products and services that are essential to human health and livelihood. These include basics like fresh water and clean air, as well as services that are difficult to measure, such as a watershed's ability to hold back eroding soils to protect downstream property from floods, carbon storage and the value of beautiful natural landscapes.

Together, these benefits are called "ecosystem services" and are available to everyone. Yet because these services are generally free, their critical contribution to society often has been overlooked in decision making. That is beginning to change, according to Bales: "'Ecosystem services' is gaining currency as a term. We are using it more often as a way of describing the multiple benefits of watersheds in economic terms," he said. "There is an increasing emphasis on maintaining, as a broader basis for understanding, the importance of the watersheds.

Kayakers on Mono Lake



Hiking in Plumas County, Gold Lake Trail

"We need to recognize watersheds and forest ecosystems as assets with economic and social value. There is great importance in providing ecosystem services that include water for the welfare of all of California," Bales added.

The SNEP report estimated that Sierra Nevada ecosystems produce about $2.2 billion worth of commodities and services annually, including water resources, agriculture, timber products, ranching, mining, tourism and recreation. More than 60 percent of that – $1.3 billion a year – is the direct value of water for irrigation, municipal and hydroelectric use, based solely on the value of the actual water rights.

In addition to establishing the worth of products and services, the economic value of watersheds becomes apparent when the costs of restoration and protection are compared with investments in new or improved infrastructure. For example, what would it cost to maintain and restore a degraded watershed compared to constructing and operating a new water filtration plant? In many cases it is cheaper and more efficient to invest in ecosystem management and protection.

In its *Sierra Nevada Wealth Index* (2006), the Sierra Business Council (SBC), a nonprofit organization whose mission is to bolster the economics, environment and community well-being throughout the region, calls the Sierra Nevada's natural capital "the life support system that makes our very existence as a society possible." Healthy natural systems provide, free of charge, a variety of services essential to life – air purification, soil formation, nitrogen fixation, water filtration and storage, natural pest control and plant pollination. The global value of these ecosystem services was estimated at $33 trillion a year – close to the gross world product – by a team of researchers from the United States, Argentina and the Netherlands in 1998.

"Ecological services are an important way to quantify the region's importance," said Steve Frisch, executive director of the SBC. "Markets for ecosystem services are an important element of the new restoration or conservation-based forest economy in the Sierra Nevada."

Socioeconomics in the Region

Attracted to natural beauty and a small-town lifestyle, people increasingly have been drawn to the Sierra Nevada, and the region has experienced a population boom as well as a shift in socio-economic character.

Historically, the Sierra Nevada's natural resources, such as timber and mining, drove the region's economy. Yet times have changed. Restrictions on harvesting public lands have had a major impact on the local communities that relied on the timber industry for jobs and livelihood. Pockets of poverty are present throughout the region. At the same time, more people have moved into the Sierra from metropolitan areas, and jobs tied to recreation, education, health and land development are on the increase. In addition a large fraction of the "new" residents are retirees.

The SBC's *Sierra Nevada Wealth Index* noted one-third of the region's residents commute out of their home county for work; second homes make up 15 percent of all housing units; and local wages provide only half of residents' income while retirement funds and investments make up a "disproportionate amount of income" in the Sierra Nevada.

The challenge for the Sierra's communities is good planning to accommodate the growth while preserving natural resources. The SNEP Report noted "population growth and its accompanying effects are causing significant impacts on resources," including habitat conversions and fragmentation, changes in stream flow and groundwater due to land clearing and paving.

Perhaps because of the growth, the region has become much more aware of the value of its natural resources and importance of the ecosystem to the welfare of the region and the rest of the state. Efforts to acknowledge, invest in and promote the importance of watersheds can be found in business endeavors. For example, Sugar Bowl Ski Resort, atop Donner Summit near Lake Tahoe, is working to reduce impacts on its watersheds by seeding ski slope areas prone to runoff and re-vegetating the base area with native wild flowers in attempts to prevent erosion and retain water quality. Also, SBC has teamed up with the National Geographic Society and the SNC to promote geotourism – tourism that sustains or enhances the geographical character of a place, its environment, culture, aesthetics, heritage and the well-being of its residents.

CHIPS

One example of how a community can rally to restore a watershed and also create jobs is a project called the Calaveras Healthy Impact Products Solutions or CHIPS. In the Blue Mountain area of Calaveras County, a handful of small, isolated towns have faced mounting challenges. Eight local lumber mills – the main industry – have closed within the last 20 years with significant impact on the local economy. Meanwhile, forest overgrowth of small trees and brush has dramatically increased the fire danger.

In 2005 a diverse coalition formed to address local fire threat and economic deterioration. The CHIPS project trains local residents to chip brush and small trees to reduce forest fuel and teaches job skills participants can use to start their own businesses in the vegetation control industry. Loggers, landowners, homeowners, the Miwok Tribe and environmental groups came together to develop the project. A $96,500 grant by the U.S. Department of Agriculture funded equipment and helped develop a chipping crew training program.

In the first stages, small-diameter wood and underbrush from private and public lands are chipped and distributed for use as landscape mulch. Plans for the future include manufacturing wood pellets, posts and poles, pressed logs and woodworking products.

"The CHIPS Project is a best-case example of the new forest economy, where ecological, economic, and social issues are blended into a successful outcome for the environment, the community and the economy," said Calaveras County Supervisor Steve Wilensky, a key coordinator of the project.

Ongoing Challenges

Healthy Forests are Key

Simply put, forests are water factories. In healthy forests the canopy – tree branches, needles and leaves – intercepts rainfall and absorbs its erosive energy before it hits the ground. A forest floor with a covering of dropped needles and leaves further reduces the potential for erosion.

"Healthy forests act like a filter and a sponge, helping to remove impurities and control runoff," said Bob Mion, Communications Director at the California Forestry Association, which advocates for forestry professionals and responsible forestry practices.

Well-managed forests protect streamside riparian zones. A continuous cover of trees and shade near streams helps reduce water temperature, and more importantly, prevents sudden temperature fluctuations. This benefits fish and wildlife dependent on the stream and forest habitat. Healthy forests also add an important level of predictability for water managers through controlled peak flows and reduced flood risks as the forests are able to absorb water and slowly release it over time.

In the State Water Plan Update 2009, forest management was addressed as a specific component of the state's strategy for water resources for the first time. "We must manage our watersheds from the headwaters to the sea. The source of much of our water lies in forested watersheds from which roughly three-quarters of California's water originates," said Lester Snow, then-secretary of the California Natural Resources Agency.

Overall, forests are managed, regulated and owned by a vast array of federal, state and local agencies, tribes, private companies and individuals and non-governmental organizations. Each has a different forest management strategy with different goals and challenges.

The largest forest landowner is the USFS; when it was established in 1897 the agency was given the charge to "secure favorable conditions of water flow." Secretary of Agriculture Tom Vilsack emphasized the role of the USFS in protecting water sources in a 2009 address: "We must work and must be committed to a shared vision, a vision that conserves our forests and the vital resources important to our survival while wisely respecting the need for a forest economy that creates jobs and vibrant rural communities. Our shared vision must begin with a complete commitment to restoration. Restoration, for me, means managing forest lands first and foremost to protect our water sources while making our forests far more resilient to climate change."

U.S. Forest Service

Forest land after thinning, Tahoe National Forest

Forest Service scientists believe the quality of riparian and meadow ecosystems is directly related to the healthy condition of nearby uplands in their watershed: "These ecosystems are the most altered and impaired habitats of the Sierra Nevada," said Carolyn Hunsaker, research ecologist and principal scientist with the Pacific Southwest Research Station, which is part of the USFS.

In the southern Sierra on the headwaters of the Kings River, a 15-year

study is ongoing to evaluate the effects of forest management for ecological restoration, including prescribed fire, mechanical thinning, and tree harvesting. The goal is to determine the best practices to manage a forest. The Kings River Experimental Watershed Forest Health and Research Project (KREW Project), which includes 15,000 acres, began in 2000 on eight sub-watersheds. Each sub-watershed has been carefully monitored for six years to collect precise data. Fire and mechanical thinning treatments are scheduled to begin in 2011. Each site has a control watershed that receives no treatments, a watershed that is burned, a watershed that is thinned, and a watershed that is both burned and thinned. After the treatments, the watersheds will be monitored for five years to determine changes.

Scientists are hoping to answer important questions that will guide future forest management actions: What is the effect of fire and fuel reduction treatments, such as tree thinning, on riparian and stream conditions? Does the use of prescribed fire increase or decrease the rate of soil erosion and affect soil health and productivity? How adequate and effective are current stream buffers (areas on both sides of a stream with restricted uses) at protecting aquatic ecosystems?

"There is a disconnect. When people think about where water comes from, they think pipes and pumps. But it's the forests that are the source. And with 50 percent of the Sierra forests under federal land management, we are the keepers of the quality of water," Hunsaker said. "To effectively manage the forests, we need complete understanding."

The KREW Project began as a joint effort among federal and state agencies, as well as universities. Funding was initially provided by the CALFED Watershed Program and more recently the National Science Foundation provided research funding to the University of California.

A key component of such a vision is a willingness and commitment for federal forest supervisors to view the state agencies as well as local governments and agencies within and outside the region as potential partners in managing the landscape.

Fire

Fire is a natural process, and much of the Sierra Nevada vegetation evolved with and as a result of fire. Before the region was settled, lightning strikes sparked low-intensity fires that cleared forests of debris and prevented the build-up of underbrush and smaller trees, which can also fuel a wildfire.

Into the 20th century, as the Sierra Nevada began to develop, fire suppression policies dictated that low-intensity fires were to be put out to avoid damage to property. After an especially devastating fire that charred much of the Northwest in 1910, the thinking changed; forest fires were a destructive force that must be suppressed. USDA Forest Service action followed in what was known as the "10 a.m. Fire Control Policy," which dictated that all fires

needed to put out by 10 a.m. the day after they were discovered. No matter how well intended, this policy made forests more susceptible to catastrophic fire by quenching low-intensity fires that would clear the extra growth.

As a result, forests that at one time featured open space and large trees now are overgrown with many more, smaller trees and underbrush. For example, prior to the 1850s, the typical forest area included 50-70 trees per acre; today many Sierra Nevada forests average 400-1,000 trees per acre. This leads to a build-up of fuels, an invitation for more severe, even catastrophic fires, which are occurring more frequently.

"Sampling of fire-scarred trees has indicated that historically fires have occurred between seven to 15 years. But this consistent cycle has been broken during the past 100 years or so as a result of society's attempt to exclude fire from the environment. We are reaping now the unintended consequences of our past choices," said Jerry Hurley, a wildland fire management expert retired from the USFS and presently coordinator of the Plumas County Fire Safe Council. "The principle is simple: Increased fuel loadings equals increased fire intensity equaling increased resource damage."

Besides the century-long practice of suppression policy, the SNEP report pointed to many factors that add to the potential for high-intensity wildfires, including variation in climate, timber harvest, mining, grazing, human settlement patterns and land-use practices. Development and heightened land use in the Sierra Nevada especially have added to the ignition risk.

Hurley noted that lightning strikes are particularly troublesome. There often are dozens to hundreds of lightning strikes occurring in less than 24 hours, and the resultant acres burned can be "mind numbing," Hurley said. "There are not enough resources immediately available to handle the volume during a lighting burst, so consequently fires are prioritized for resource assignment. Usually the resources go to the urban interface where humans and homes are first priority and the forests – the watersheds – are left for later or to fend for themselves."

YubaNet.com

The devastation of intense wildfires destroys forest habitat and also impacts water quality. High-intensity fires race through from the ground to the treetops with towering flames and scorching heat that destroys organic material in soils, consumes seed-sources and transform forests into shrub fields. When fire burns vegetation that holds soils in place, erosion becomes a problem.

With each rainfall, surface runoff laden with soil and ash – loaded with nitrogen and phosphorous – moves down mountainsides into streams, lakes and reservoirs. The sediment can significantly alter in-stream habitat, burying and suffocating organisms and fish. It can pollute drinking water, impact recreational use and clog intake systems at water treatment plants and power plants. Public land management agencies spend millions of dollars each year following large wildfires, to perform emergency burned area rehabilitation in order to retain soils and protect streams and lakes.

In Nevada County, east of Truckee, the Martis Fire broke out from an escaped campfire on Father's Day 2001. The fire eventually burned about 15,000 acres. The substantial vegetation loss created a significant risk for erosion into the Truckee River, which provides drinking water for Reno and Sparks in Nevada.

Efforts are underway to revegetate the watershed on both public and private lands to stop the erosion and safeguard the drinking water supply. The SBC is now managing the Martis Fire Ecosystem Restoration Project in coordination with the Washoe County Department of Regional Parks and Open Space. The purpose of the project is to restore the ecology within the headwaters of the Truckee River. Part of the effort involves replacing flammable noxious weeds with native plants to reduce the burn cycle. The project also includes treatments to control weeds and ladder fuels and revegetate areas burned by the 2001 fire. In particular, after the fire, musk thistle invaded significant portions of the denuded riparian floodplain, affecting water clarity and quality, wildlife habitat and the recreational experience along the Truckee River banks and reservoir shorelines.

After catastrophic fires, many agencies and groups get involved to clean up and restore damaged watersheds. But reducing fuel loads – undergrowth and crowded trees – to avoid such devastation in the first place through sustainable forest management is an important part of the solution.

After catastrophic fires, many agencies and groups get involved to clean up and restore damaged watersheds. But reducing fuel loads – undergrowth and crowded trees – to avoid such devastation in the first place through sustainable forest management is an important part of the solution. Prescribed burns to remove fuel can offer a relatively low cost means, but many forests are too overgrown to safely introduce any degree of fire. When prescribed burns are too dangerous, forest managers must mechanically remove brush and trees. The cost of fuel treatments ranges from $100 to $1,500 per acre. By comparison, fire suppression costs $1,000 to $10,000 per acre: "One million dollars a day is common on large fires," according to Hurley.

Black's Forest vs the Cone Fire: Proving Fuel Treatments Work

In 2002, a wildfire from a logging operation to the west burned into the Blacks Mountain Experimental Forest (BMEF) in the southern Cascades where a fuel treatment study had begun in 1991. Treatments before the fire included mechanical thinning with and without fuel reduction through prescribed fire.

When the Cone Fire burned more than 2,000 acres, including the BMEF, scientists got a first-hand look at how a high-intensity wildfire reacts to treated areas where fuel is reduced.

In areas where there was no thinning or prescribed burning before the Cone Fire, the devastation was severe. Areas where trees had been thinned without a follow-up prescribed burn experienced more damage than those where thinning was followed by a prescribed burn. However, both types of treatment caused the intense wildfire to drop quickly out of the crowns of the trees to become either a surface fire or die out.

Bottom line: thinning and prescribed burning was most effective in fighting off wildfire effects. "The rapidity of apparent change from a high-intensity crown fire to a much lower-intensity surface fire may have significant implications for management of wildland/urban interface zones as well as wildlands in general," said Carl Skinner, USFS Geographer of the Pacific Southwest Research Station Silviculture Laboratory.

Recreation

The Sierra Nevada has been called California's outdoor playground, given its accessible and scenic lands and waterways. The region's diversity draws visitors to the top of mountain peaks and to the bottom of river canyons. Yosemite Valley, Lake Tahoe, Mono

Jon Klusmire, Eastern California Museum

Lake and the Sequoia Big Trees attract tens of millions of visitors each year. In total, recreational activities on public lands account for between 50 and 60 million visitor-days per year, and nearly two-thirds of the visits occur on public lands managed by the USFS.

"Region-wide, tourism – heavily dependent on the natural beauty and landscape of the Sierra – now accounts for 15 percent of the region's total payroll. In a number of counties, it is the single most important economic activity," noted the SBC's *Sierra Nevada Wealth Index*.

Popular activities include camping and hiking, backpacking, skiing, fishing, hunting, boating, off-road vehicle use, mountaineering, wildlife watching and much more. Many recreation opportunities center on water, be that reservoirs and lakes, or streams and rivers. USFS data shows in National Forests camping, picnicking and swimming are the most popular activities with fishing and hiking close behind. At higher elevations with resorts, winter sports are a tremendous draw.

Recreational fishing and whitewater rafting are the two most significant recreational uses of Sierra Nevada water. Fishing accounts for close to $200 million a year, according to the USFS's travel cost method of accounting (estimates the value of a day of fishing at $18.96 – multiplied by the total number of fishing days in a year). Whitewater rafting is estimated to generate $50 million a year.

The problem with recreation is its popularity; people's recreational actions and the facilities built to support their activities can have impacts. Recreationists must have roads to get to the Sierra destinations. In many instances, this means travelling over roads that were originally constructed for other purposes: mining, logging, ranching and hydropower facilities. These roads exist in the foothills, in the national forests and the national parks. Once recreationists get there they use the landscape for a plethora of uses. With this use, it is not surprising that damage is being done to watersheds, such as vegetation removal and impacts to water quality from pollutants used and left by those enjoying the outdoors.

For example, the heavily used Rubicon Trail near Lake Tahoe has had restrictions placed on use until a management plan can control the damage by off-highway vehicles (OHVs) each year. The trail, which has been heralded as the world's most famous four-wheel-drive trail, draws 20,000 to 30,000 off-road drivers a year. In 2009 the Central Valley Regional Water Quality Control Board issued a cleanup-and-abatement order to El Dorado County and El Dorado National Forest to stop the damage being caused by OHV use. Problems included trail erosion, excessive silt, automotive fluids and bacteria pollution from human waste that have impacted lakes and streams. This is a complicated, contentious issue, and efforts are ongoing to resolve the matter so recreationists can enjoy the trail and the watershed is protected.

Sierra Nevada rivers attract thousands of visitors every year, resulting in enormous amounts of litter. While local organizations and governmental agencies have increased efforts to educate visitors about how to better enjoy the Sierra Nevada experience, volunteers have pitched in to improve

Mammoth Mountain Ski Area, LLC

the health of the streams and rivers. For example, the South Yuba River Citizens League has sponsored a clean-up day for the past 13 years on its local watersheds. Two years ago, the SNC began sponsoring a regional event, the Great Sierra River Cleanup. Already the event has attracted more than 7,500 volunteers who removed over 270 tons of garbage along 700 miles of stream and river frontage, ranging from the Pit River in Modoc County to the banks of the Tule River in Tulare County.

Development and Land Use

The appeal of the scenic landscapes, recreational opportunities and a rural lifestyle has made the Sierra Nevada an attractive place to live. Today, the population throughout the region has grown to more than 650,000 people. By 2040, that number could triple, according to the SNEP report, primarily as urban areas of the San Joaquin Valley expand into the foothills.

Population growth has significant impacts on resources, including fragmented and damaged habitats, invasion of non-native plants and animals, altered stream flows and increased extraction of groundwater.

Communities and organizations have begun to address effects of development. Better planning and programs to help mitigate impacts are being incorporated in most areas of the Sierra.

From an ecological perspective, development has effects on both the conditions and functions of watersheds. Stormwater runoff is a growing concern. Usually, increased rates of runoff and intensity of local flood events are linked to paving in new developments and roads. Like their urban counterparts, some rural areas are experiencing high intensity runoff over short periods. This creates greater flood risk and reduces the ability to capture water for use during dry summer periods.

"Few things are more important to water than how and where we accommodate future growth," said Joan Clayburgh, executive director of the Sierra Nevada Alliance. "The good news is that there are proven tools and strategies to meet our water challenges while also preserving our unique rural communities and landscapes."

To that end, the Sierra Nevada Alliance – made up of more than 80 grassroots member groups – has launched its Regional Climate Change Program to work with local groups to encourage regional plans like county general plans to address climate change issues, including components to protect water and watersheds, wildlands and agriculture. Key strategies include promoting good county general plan policies, supporting the model IRWM process, assisting efforts to shape smart growth, improving the understanding of important regional issues like climate change and building networks and collaborations among Alliance member groups, IRWM efforts, and other issue based organizations.

> ***"Few things are more important to water than how and where we accommodate future growth."***
>
> – Joan Clayburgh, Executive Director, Sierra Nevada Alliance

Development also puts an added burden on water districts, many of which were formed more than half-a-century ago to meet increasing demands. For example El Dorado Irrigation District (EID) was formally organized in 1925 to provide domestic water to the city of Placerville and irrigation water to local farmers. El Dorado County's population has grown from 6,000 in the 1920s to 188,000 today. EID's service area has grown from 31,567 acres to 140,800 acres. The number and types of services the district provides have also expanded to meet the many needs of our customers. "Like all water agencies in California, we need to think creatively about how to sustain a reliable water supply," said Jim Abercrombie, general manager of EID.

Programs to stretch water supply include an irrigation management program for agriculture that saves up to 2,000 acre-feet of water each year, and residential and commercial water efficiency programs that save hundreds more acre-feet of water. The district's recycled water program alleviates the need to use drinking water to irrigate many commercial and public landscapes, as well as yards at more than 3,500 residences.

Climate Change

Climate change has global implications and poses a significant threat to the Sierra Nevada watersheds and overall state water quality and supply. A long-term increase in temperature and a shift in precipitation patterns are expected to trigger earlier melting of snowpack and have effects on habitat, according to the California Climate Change Adaptation Strategy. Scientists attribute these changes to greenhouse gases, particularly those generated from the human production and use of fossil fuels.

In the Sierra Nevada, rising temperatures and other climatic changes have begun to alter the water cycle, upon which the state's water system relies. The state water delivery system is a snow-fed system in which snowpack provides "storage" and the gradual runoff in the late spring and early summer replenishes downstream reservoirs to meet water demands in the summer and fall. More water is falling as rain rather than snow, and spring runoff is coming earlier, resulting in stresses to the water supply and flood control system. During the past 100 years, the fraction of the annual runoff that occurs during April to July has decreased by 23 percent for the Sacramento basin and 19 percent for the San Joaquin basin, according to state climate statistics.

The change in the water cycle poses challenges for water managers who depend on the proper timing and quantity of the spring melt in order to provide a reliable water source. With warmer temperatures, rather than a solid snowpack during the winter and a prolonged spring snowmelt that flows into reservoirs, runoff water will arrive early in the spring – still during the wet rainy season – in concentrated, short deluges. This will fill reservoirs at a time when space is needed for lower-elevation local rainfall dumped by wet season storms. To prevent flooding, water managers would likely need to release water from reservoirs more frequently to protect downstream communities. Water supply shortages could then develop from an inability to store water when it is available, not only from a lack of water during a drought.

EBMUD has taken a proactive approach incorporating climate change into its management strategy in 2007. One of the focus areas is water conservation. The district's aim is to reduce potable water demand and save 39 million gallons a day (MGD) by the year 2040. In 2009 alone, conservation efforts by customers saved 1.2 MGD. In addition, the district's recycling program to reduce potable water demand strives to achieve an 11 MGD savings from additional recycling projects by the year 2040.

At the state level, in 2008 then-Gov. Schwarzenegger signed an Executive Order calling on state agencies to develop California's first strategy to identify and prepare for these expected climate impacts. Since then, California has undertaken a number of initiatives to reduce greenhouse gas emissions in the state, including implementation of the Global Warming Solutions Act (AB 32), the Renewable Energy Portfolio Standard and the Low Carbon Fuel Standard.

Yet, even if all greenhouse gas emissions were stopped today, temperatures are expected to continue to rise throughout the world, and the effects of climate change are already being seen.

Facing reductions in the amount of water flowing from the Sierra Nevada, "We will need to actively manage watersheds much more than we have in the past to meet our needs," Bales said. "In order to maintain the water use we have now, we need more storage. There is no silver bullet, and I am not saying build more dams. But we do need to look for ways to store water."

Restoration of meadows is one way to enhance water supply, according to the Feather River Coordinated Resource Management Group: "We are only going to have the limited supply of fresh water on the earth that Mother Nature currently provides, but projects like meadow restoration help deliver melting snow water later in the summer season to users downstream. This may be a way to adapt to climate change if needed, because less snow means less water, especially in the summer when it's needed most. Slow release of water from meadows may alleviate some of that pressure," said Gia Martynn, watershed coordinator for the organization.

Restoring and Protecting the Sierra

Restoration projects are ongoing throughout the Sierra Nevada by local governments and agencies, non-governmental agencies and private enterprises. Project sizes vary from stream cleanups by community volunteers to multi-million-dollar efforts funded by several sources and involving years of planning and work.

In the past, many restoration efforts were done on a project-by-project basis outside of the context of a regional plan. Facing challenges today, the push is toward IRWM planning where issues are addressed on a regional level and restoration projects are coordinated among many parties. The primary impetus for this has been the state's IRWM program, providing local funding for local projects through Propositions 50, 84 and 1E.

In the northern Sierra Nevada in the Upper Feather River Watershed, 24 public and private sector groups formed the Feather River Coordinated Resource Management Group in 1985 with the goal to improve watershed health. "The group recognizes that restoring watershed function is a major priority in reversing erosional trends and improving environmental and economic resources. Stable, well-vegetated streams with functioning meadows, aquifers and uplands are critical in maintaining good watershed condition," Martynn said.

Today, more than 115 watershed projects have been completed, including studies and assessments, stream restoration, monitoring, resource management plans, strategic planning, community outreach and educational activities. That includes 66 on-the-ground restoration projects that have treated approximately 44 miles of stream, directly restoring approximately 3,900 acres of meadow and floodplains within the watershed.

"We are re-establishing stability and proper hydrologic function in headwater meadows by reconnecting channels with historic floodplains. Overall, restoration activities play an important role in accelerating improvement in watershed function, the local economy and downstream uses," Martynn said.

Gia Martynn, The Feather River Coordinated Resource Management Group

Left, Clark's Creek in the Upper Feather River watershed in July 2001 before restoration. Right, same area in July 2006 after restoration.

Integrated Regional Water Management

Central to efforts to reduce emissions and adapt to climate change is IRWM planning, a strategy designed to bridge local, regional and state needs in order to best address the many demands on the state's water resources. Coordinated by DWR, water managers use IRWM planning to examine water supply management, conservation, habitat, ecosystem services and flood management in a holistic and interconnected manner. In addition, the state is now requiring that IRWM efforts address reducing emissions and adapting to climate change in their plans. Some of the strategies being included in plans to combat climate change stress diversification of water resources. These include, for example, water conservation, restoration, recycling, groundwater recovery, as well as continued monitoring and analyzing climate change impacts.

"Integrated planning is transforming the state's water plan from a source of information on water supply and demand into a strategic blueprint for managing water resources," noted then-Natural Resource Secretary Snow. "That blueprint includes exploring investments in water use efficiencies, supply management including desalination, managing groundwater and surface water together, preserving water

quality and engaging in environmental stewardship."

In the Sierra Nevada region, 15 IRWM plans are underway, incorporating watersheds from north to south. While not all are fully completed, some received funding from Prop 50 to finalize the plan. That includes $25 million to Sacramento Regional Water Authority, $7 million to Upper Feather River Watershed and $12.5 million to the Sacramento Valley.

A good example of IRWM planning in action is the Cosumnes, American, Bear and Yuba watersheds (CABY), a collaborative planning effort that adopted an IRWM plan in late 2006. The group's success has been the result of involving diverse interests, said Katie Burdick, executive director of CABY, which is comprised of more than 30 organizations, representing water supply, environmental, recreation, agriculture, and community interests, as well as federal and local government.

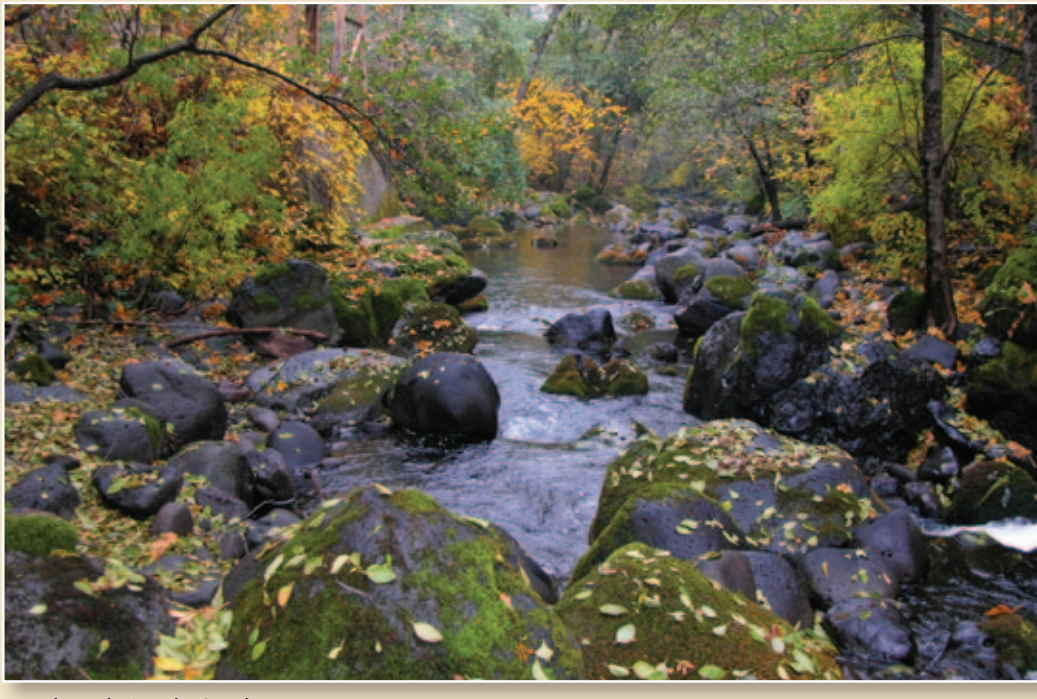
A current effort focuses on water conservation, drought relief

> ***"Integrated planning is transforming the state's water plan from a source of information on water supply and demand into a strategic blueprint for managing water resources."***
>
> - Lester Snow , then-California Secretary for Natural Resources

Battle Creek Restoration

In Tehama County, an ambitious project will restore about 42 miles of habitat on Battle Creek plus six miles of habitat on the creek's tributaries while maintaining the continued production of hydroelectric power. In all, five dams will be removed and fish screens or ladders will be put in or modified at the remaining dams to allow fish to travel unimpeded. The project cost is $80 million and is scheduled to be completed by 2014. Battle Creek is included in the SNC boundaries.

The restoration project is among one of the largest anadromous fish restoration efforts in North America. Battle Creek, which is a major tributary of the Sacramento River, features important habitat for threatened and endangered Chinook salmon and Central Valley steelhead trout.



North Fork, Battle Creek

The project has been 12 years in the making and includes the Bureau of Reclamation (Reclamation), Pacific Gas and Electric Co., USFS, National Marine Fisheries Service and California Department of Fish and Game.

"Reclamation and its partners and contributors are embarking on a historic restoration of valuable habitat in Battle Creek. And by improving fish populations, the reliability in state and federal water operations as well as the salmon harvest will also be improved," said Reclamation Commissioner Michael Connor at the groundbreaking ceremony in 2010.

and system efficiency in small Sierra Nevada water districts. "Our philosophy is whether you serve 2,000 or 200,000 people, conservation matters. We have worked with small, disadvantaged districts to put together conservation strategies," Burdick said.

The program is aimed at drought and water use efficiency, "so we have the capacity to respond to uncertain water quantity and quality challenges," Burdick said. "This IRWM group is taking on the issue of conservation and making sure the smallest districts get a shot at doing the right thing. The group is committed, and collaboration has been very powerful."

The trend of IRWM will continue as an important tool. The U.S. Army Corps of Engineers stressed in a 2010 report: "As important as water is to life, livelihood, and leisure, water is a resource that is often taken for granted until too much of it appears or too little is available to satisfy basic societal needs. Managing water resources as a collaborative endeavor is becoming increasingly crucial as society faces demographic, economic, institutional and climate changes manifesting across the U.S. and around the globe. "These changes portend a different understanding of the risks associated with the occurrence, location, intensity and impacts of extreme events - including floods and droughts," wrote Steven Stockton, director of Civil Works Headquarters, U.S. Army Corps of Engineers. "To succeed we must act with a sense of urgency to improve the management of critical water resources – especially in an era where the variety of changes threatens the sustainability of all natural resources. The time to act is now."

"As important as water is to life, livelihood, and leisure, water is a resource that is often taken for granted until too much of it appears or too little is available to satisfy basic societal needs."

- Steven Stockton, Director of Civil Works Headquarters, U.S. Army Corps of Engineers

Red Clover Meadow Restoration

The Red Clover/McReynolds Creek Restoration Project in the northern Sierra Nevada is a good example of how local, state and federal agencies can work together with private landowners to restore watersheds. The project covers 715 acres of privately owned land and 60 acres of public land in Plumas National Forest (PNF). This portion of Red Clover Creek drains a watershed area of 84 square miles, and is a tributary to Indian Creek and ultimately, the East Branch North Fork Feather River.

The watershed has been historically used for grazing and logging with an extensive road and historic logging railroad system. These land uses, along with a 1950s-era beaver eradication effort, created moderate to severe incision of stream channels throughout the valley, resulting in extensive gully networks that have lowered the shallow groundwater tables in the valley meadow. This has changed plant communities and greatly increased sediment. As a result the Red Clover meadow lost productivity, experienced diminished summer flows and had severe bank erosion.

The Feather River Coordinated Resource Management Group completed its first demonstration project in this area in 1985. The project consisted of check dams to raise the water level in the gully so it could access the floodplain. The goal of the most recent project was to improve the water and sediment retention functions of the watershed and restore functionality of 400 acres of effected floodplain.

Stream flows were returned to the original meadow and channel elevations through a "pond and plug" technique along 3.3 miles of eroding stream channels on both private and public lands. The pond and plug technique sets floodplain function as the fundamental precursor to all other project objectives, such as reduced bank erosion, improved water quality, improved fish and wildlife habitat, reduced flood flows and increased base flows.

"We've completed 60 restoration projects, and it has been the experience that once full floodplain function has been restored, other project objectives are more effectively achieved, because in a riparian ecosystem, they are inextricably linked," said Brian Morris, general manager of Plumas County's Flood Control and Water Conservation District.

As a result, expectations are to restore vegetation that was once native to the valley and expose compacted soils so wet meadow species can return. Plant root systems and the restored function of the floodplain are expected to increase absorption rates, thereby attenuating flood flows and increasing summer base flows. In addition, benefits to wildlife and fisheries are expected due to restored habitat and reduction in water temperatures.

Summary

The importance of Sierra Nevada watersheds to the state's overall water picture cannot be overstated. The rain and snowmelt captured in the upper elevations flow to fill rivers and recharge groundwater basins. The precipitation provides irrigation for food crops, water to keep business and industry thriving, hydropower to light homes and quality drinking water to residents throughout California. Yet the Sierra source faces mounting threats, including unhealthy forests and catastrophic fire risk, poorly planned development, unauthorized recreation and legacy impacts, such as lingering toxics from mining.

Looming in the background is the prospect that climate change may alter the precipitation patterns on which the state's water delivery system is based. Scientists note that climate change is likely to reduce the Sierra snowpack in many areas, which could cause more spring flooding and heighten the effects of droughts. Planners and managers are keeping a keen eye on the climate and adjusting operations as necessary. Adaptive management is key, they say.

Committed organizations, federal and state agencies and citizen groups are involved in addressing the problems to maintain and improve the function of watersheds throughout the Sierra Nevada. Restoration efforts, ranging from small meadows to large forests, are having considerable, positive results. Yet, education, investment and support need to continue so that Sierra Nevada watersheds can function and thrive for the sake of those who live in the region and also for those outside the area who depend on water deliveries.

When he was California Natural Resources Agency Secretary, Snow noted, "The health of Sierra Nevada watersheds is vital to the state's overall water quality and water supply. Healthy watersheds, including forests and meadows, contribute to safely managing floods and protecting California's environment. Comprehensive investment in our natural resources on a watershed scale will pay big dividends for Californians in ensuring our water needs and sustaining our communities."

Tom Rassuchine

For More Information

WATER EDUCATION FOUNDATION

717 K Street, Suite 317
Sacramento, CA 95814
916-444-6240
www.watereducation.org