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Natural Resource Issues in the Lake Tahoe Basin: An Extension Needs Assessment

by

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Lake Tahoe from Emerald Bay. Source: Lynn Wunderlich

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INTRODUCTION

This needs assessment was conducted to provide guidance for development of Cooperative Extension programs in the Lake Tahoe Basin, which lies in both the state of California and the state of Nevada. The University of Nevada Cooperative Extension (UNCE) has had an Extension office in Incline Village since 1988. The University of California Cooperative Extension (UCCE) hired an advisor to work in the basin in 2006. This assessment was conducted collaboratively to identify natural resource issues in the basin that would benefit from applied research and public outreach education by Cooperative Extension and other partner agencies.

Information was gathered during informal, face-to-face interviews with basin natural resource professionals (key informants) over a three-month period in 2006. The “key informant” approach allowed us to explore the many complex issues at Lake Tahoe with the natural resources agencies and jurisdictions working on them. The interviews began with the open-ended question: “What needs do you see for public outreach, education and applied research over the next 2 to 5 years?” Interviews were unstructured, allowing us to ask questions specific to the expertise and professional responsibilities of each interviewee. This approach elicited in-depth discussions of needs, previous outreach methods undertaken and how to improve on those methods. Agencies contacted are listed at the end of this report.

Issues identified for new and continuing involvement by UNCE and UCCE have been grouped into categories reflecting the structure of the University of California’s Division of Agriculture and Natural Resources’ core issues. They include **water quality, wildland fire, sustainable use of natural resources (science communication), air quality/climate change, invasive species, and youth development (environmental education)**. A variety of applied research, outreach and education strategies are suggested to address these natural resource management issues.

DESCRIPTION OF AREA

Lake Tahoe is one of the clearest large sub-alpine lakes in the world. Because of its clarity,

Lake Tahoe is designated as an Outstanding National Resource Water (ONRW) under the federal Clean Water Act, meaning that no further degradation of water quality should be permitted under federal law. University of California, Davis researchers have been monitoring the lake’s clarity since 1968. Since that time, the clarity has decreased about a foot a year as a result of human land use (see Figure 1). California’s Lahontan Regional Water Quality Board and the Nevada Division of Environmental Protection are developing a Total Maximum Daily Load (TMDL) limit for the lake to establish allowable levels of pollutants that will restore and maintain the lake’s high level of water quality.

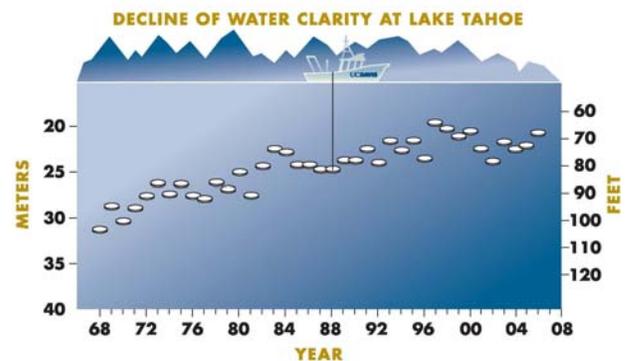


Figure 1. The Decline of Water Quality at Lake Tahoe (Secchi Depth). Courtesy of UC Davis Tahoe Environmental Research Center.

Lake Tahoe has a relatively small watershed (800 square kilometers, including the lake) for the size of the lake surface (500 square kilometers). The basin’s land area is approximately 205,000 acres, including federal, state, tribal and local government and privately owned lands. The federal ownership is approximately 80 percent of the land area in the basin (see Figure 2). Between 1870 and 1900, the forests of the basin were heavily logged for use in mine shafts at the Comstock Silver Lode in Virginia City, Nevada. Forest stands have largely been left alone to regenerate during the last 100 years, while wildland fires have been aggressively suppressed. This has led to basin forests that are overcrowded with fuels and fairly uniform in age. Urbanization of the basin has eliminated 75 percent of its marshes, 50 percent of its meadows and 35 percent of its stream zone habitats.

Most of the Lake Tahoe Basin lies in the political jurisdictions of four counties – El Dorado and Placer counties in California, and Washoe and Douglas counties in Nevada. The City of South Lake Tahoe (CSLT) is the only incorporated municipality. The Tahoe Regional Planning Agency (TRPA) oversees development at Lake Tahoe (among other responsibilities). As a result, growth in the basin in recent years has been relatively slow (less than 1 percent annually). The basin is home to about 63,000 full-time residents, plus another 30,000 or so part-time residents during the summer and winter tourist seasons. The largest concentration of people is on the southern shore of the lake, in El Dorado County and the City of South Lake Tahoe.

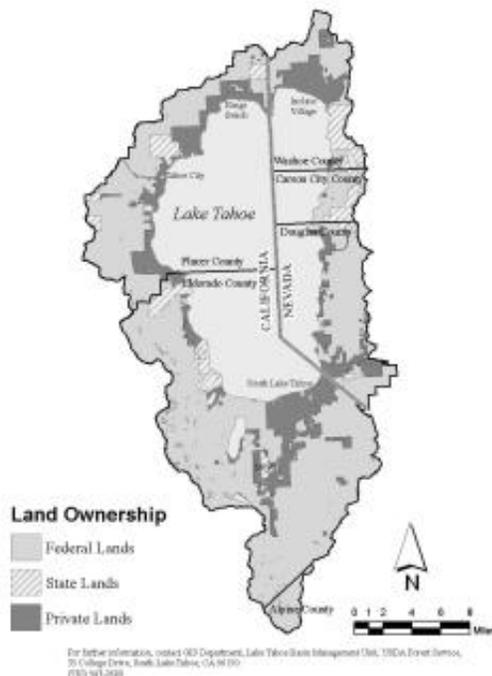


Figure 2. Tahoe Land Ownership Map. Source: Tahoe Regional Planning Agency.

The economy of the basin currently relies on tourism for stability. Visitors and residents are attracted to the many outdoor recreation opportunities and to the casinos on the Nevada side of the lake. Tourism amounts to 23 million visitor-days per year. Many residents are employed by the service industry, including resorts, restaurants, hotels and casinos. Hispanics make up a fairly large percentage of the workforce, numbering about 25 percent of the total population in the city of South Lake Tahoe. The Washoe Tribe, although

headquartered in Nevada, has acquired some lands on both the west and east shores of the lake in recent years.

ISSUES IDENTIFIED

Water Quality

Issue: The paramount environmental issue in the Lake Tahoe Basin for the last 25 years has been the declining quality of the lake’s water. Largely because of the water clarity monitoring begun in the late 1960s by the University of California, Davis, the public is aware that the remarkable transparency of the lake water is imperiled. The primary cause for the loss in water clarity at this time is nonpoint source (NPS) pollution, specifically fine particles from both natural and human-caused erosion. Increased amounts of algae (up about four-fold since the 1950s) also reduce the lake’s clarity. This growth of phytoplankton is stimulated by nutrient pollution, primarily nitrogen and phosphorus from streams, groundwater and direct atmospheric deposition onto the lake surface.

What’s Being Done: The TRPA has controlled urban growth and limited development in environmentally sensitive areas since the 1980s. All residences in the basin have been connected to sanitary sewers, and treated effluent is exported out of the basin. In spite of many costly efforts to reverse it, clarity continues to decline at nearly the same rate as in the 1960s (see Figure 1).

The Lake Tahoe Environmental Improvement Program (EIP) is an interagency program consisting of capital improvement projects and research funded by the states of California and Nevada, the federal government, local governments and private property owners. The EIP was projected to be a \$908 million program. Approximately \$1.2 billion has been spent to date, with more proposed through the EIP update process. The TRPA is developing a marketing campaign to inform the community about the EIP, which many agency staff consider to be the “best chance to save Lake Tahoe.” The Lake Tahoe Environmental Education Coalition, sponsored by University of California Cooperative Extension (UCCE) and University of Nevada Cooperative Extension (UNCE), participated in outreach education and research about the EIP from 2003 to 2005.



Figure 3. Stormwater retention basin installed in South Lake Tahoe as part of the Lake Tahoe Environmental Improvement Program (EIP).

The TRPA, the Lahontan Regional Water Quality Control Board (Lahontan), the Nevada Division of Environmental Protection and the USDA Forest Service (USFS) are currently involved in a multiyear, collaborative effort to update their separate regional plans, called Pathway 2007. The development of Total Maximum Daily Loads (TMDL) is a part of this process being led by Lahontan and the Nevada Division of Environmental Protection (NDEP). A private consulting firm has been hired to coordinate an extensive public involvement process.

Federal and local agencies have identified hundreds of EIP projects to be completed on public lands with public funding, and many have been implemented. These include numerous erosion-control and stormwater-runoff-control and detention projects associated with public roads and facilities (see Figure 3). Many of these projects involve effectiveness monitoring. However, monitoring is done on a project-by-project basis using different data collection protocols and contractors.

TRPA's Regional Plan requires implementation of best management practices (BMPs) on all developed properties in the Tahoe Basin to reduce NPS pollution flowing into the lake from private and public properties. All homeowners and commercial property owners are required by law to install BMPs at their own expense. This requirement is considered to be the primary private sector contribution to the EIP. New construction and remodels must also install

BMPs, as required through the building permit process.

Despite available technical assistance, implementation of "BMP retrofits" is behind schedule. Approximately 8,500 of 40,000 properties have implemented BMPs to reduce erosion and polluted runoff. The deadline for project completion is the end of 2008. Most observers think at least 5 more years will be needed for all homeowners to come into compliance. TRPA has the authority to enforce the BMP retrofit law but has received limited funding to perform enforcement to date.



Figure 4. A local Tahoe residence gets inspected for residential BMPs. Source: Tahoe Resource Conservation District.

Extension: UNCE has played an active role in the "BMP Retrofit Program" since 1999. Extension works collaboratively with other agencies to provide education and outreach to homeowners on BMP installation. UNCE produced the 160-page *Home Landscaping Guide for Lake Tahoe and Vicinity* (Cobourn, et al. 2006), now in its third printing, and the 130-page contractors' BMP manual, *How to Implement BMPs in the Lake Tahoe Basin* (Cobourn, et al. 2004). UNCE has also helped organize eight annual Contractors BMP Workshops.

Education: The Natural Resources Conservation Service (NRCS) and two local Resource Conservation Districts (RCDs) provide technical assistance to homeowners in the form of free

site evaluations on how to design and implement BMPs on their own property. Staff provides a free site evaluation to each homeowner who requests one and produces technical drawings and design specifications for each property to come into compliance (see Figure 4). The TRPA provides this technical assistance to commercial and multifamily residential property owners.

Research: The extent of water quality research at Lake Tahoe is very broad. For a summary, see the Tahoe Science Consortium's *Comprehensive Science Plan for the Lake Tahoe Basin* which is in review (see www.tahoescience.org).

What's needed: More effective outreach to homeowners is needed in order to increase the compliance rate of the BMP retrofit requirements. Also, as the BMP Retrofit Program is unique in the United States and possibly the world, better documentation of the successes and failures of the program is needed in order to communicate about it to nationwide audiences, including watershed groups that may want to consider similar policies in their areas. We also need to create better ways to learn from and communicate lessons learned during design and implementation of EIP projects.



Figure 5. Local contractors learn to install BMPs properly at the annual BMP Workshop. Source: Tahoe Resource Conservation District.

Possible Extension Program Strategies:

Possible strategies for increasing homeowner knowledge about water quality and increasing BMP retrofit outreach effectiveness include:

- Holding classes and workshops on BMP design in Tahoe's two demonstration gardens, both of which have exhibits that show attractive implementation of small-scale BMPs (see Figure 5).
- Developing a better social marketing approach in conjunction with the TRPA's new communications plan.
- Increasing collaboration between public agencies implementing public EIP projects and local homeowners in the area. Organizing neighborhoods and offering education about their local area may increase compliance rates, because many people are interested in protecting the water and habitat in their neighborhood streams. Enhancement of the Neighborhood Leader Program could help get neighbors involved through person-to-person communication or by holding "block parties." Another model would be the Master Watershed Steward Program.
- Producing a video for the public that traces the pathways of runoff from upland private properties to Lake Tahoe.
- Increasing the ability of Spanish speakers to install BMPs. UNCE is seeking funding to translate the Contractors BMP Manual into Spanish and to offer instruction on BMP implementation in Spanish.
- Streamlining processes for BMP certification and defensible space compliance so both can be done at the same time.
- Developing BMP effectiveness information for retrofit designs through consistent, question-based monitoring of small-scale residential BMPs. Having research-based information may demonstrate to homeowners the effectiveness of their actions. It would also help RCDs and NRCS recommend the most effective treatments.
- Conducting an analysis of the BMP retrofit database maintained by the Conservation Districts and TRPA to better understand the factors and demographics that increase compliance rates.

- Involving the scientific research community in information and educational programs.
- Continuing UNCE's Lake Tahoe Report newspaper articles as needed. These articles could include descriptions of environmental issues as well as interpretations of new scientific research findings.
- Writing articles for publications in the Sacramento Valley and Bay Area, where many hard-to-reach second homeowners live.
- Producing more fact sheets about how to protect Tahoe's water quality. These could be concise, illustrated brochures on erosion control, slope stabilization, good housekeeping practices on developed properties, etc.
- Continuing UNCE's coordination of environmental education promoted by the Lake Tahoe Environmental Education Coalition (LTEEC, now unfunded). This program reached out to diverse audiences to increase the public's "environmental literacy" and inspire a sense of place. Many individuals gained a new sense of responsibility for protecting water quality through interpretive hikes, citizen monitoring events and forest stewardship workdays.
- Participating in groups looking for new solutions to nonpoint source pollution problems. One example of such a group is the Stormwater Advisory Committee being formed in Nevada to analyze the potential benefits and feasibility of creating stormwater utility districts to treat urban runoff.
- Continuing participation in citizen monitoring through Snapshot Day. Providing additional educational content to volunteers.
- Developing an outreach program on turf and lawn management to reduce nutrient-laden runoff.
- Educating property owners about threatened plants, such as the native Tahoe yellow cress.

Possible strategies for increasing information about the BMP Retrofit Program to statewide audiences include:

- Developing peer-reviewed and less formal publications about the program.

- Writing articles for news publications and magazines outside of the Tahoe Basin.
- Developing a book about the program with commissioned chapters.

Possible strategies for increasing the effectiveness of the EIP Program include:

- Participating in the Tahoe Science and Agency Coordinating Committee (TSACC) and Tahoe Science Consortium (TSC) coordination efforts to develop a comprehensive monitoring plan (described under Sustainable Use of Natural Resources below).
- Hosting annual design workshops so lessons learned can be passed on to designers.
- Producing an end-of-the-year document on EIP implementation with main conclusions about the program.
- Collaborating with local jurisdictions to provide education for maintenance crews on low-impact road maintenance and snow removal.

Sustainable Use of Natural Resources – Science Communication

Issue: Sustainable use of natural resources requires understanding natural systems and applying science-based information to improve management of those resources over time. At Lake Tahoe, there is widespread agreement that the watershed, ecosystem and economy of Lake Tahoe must be managed for sustainability. Research shows most business and property owners support environmental protection efforts, because they know the regional economy depends on the continued outstanding quality of the natural environment (Weible and Sabatier 2004).

Scientists and resource managers at Lake Tahoe have endorsed the process of adaptive management to restore the lake's water quality and to meet other environmental goals. "Adaptive management" involves conducting applied research and monitoring on the system to be managed, learning from that research and applying the lessons on the ground. Priority research is funded annually with \$3.7 million from the Southern Nevada Public Lands Management Act (SNPLMA). The EIP also allocates funding for a "comprehensive science

program” to meet the science information needs of the EIP.

Environmental scientists and researchers have a long history of conducting basic and applied research in the Tahoe Basin. Collaboration between researchers and management agencies is ongoing, as demonstrated at the Lake Tahoe Science Plan Workshop held at the new Tahoe Center for Environmental Sciences in Incline Village in October 2006. Focus groups were held with managers and scientists to identify research questions most relevant to managing basin resources, including water and air quality, soil conservation, terrestrial and aquatic habitat and human communities.

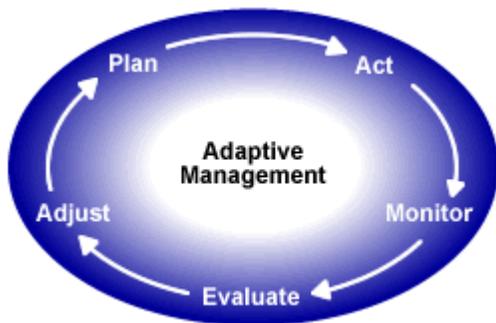


Figure 6. The Adaptive Management Loop.

However, more effort needs to be put into learning from the research already being done in order to “close the information loop” on adaptive management (see Figure 6). Natural resource managers at the Science Plan Workshop voiced frustration from not knowing what research has been done, not receiving recommendations from research, and not having easy-to-understand summaries of research results. Adaptive management would also benefit from increased effectiveness monitoring of EIP Projects and other restoration actions completed by management agencies.

What’s Being Done: Managers and researchers are participating in forums designed to help improve adaptive management. The Lake Tahoe Interagency Monitoring Program (LTIMP) meets monthly to share monitoring results and strategize on research needs and priorities. The Tahoe Science Agency Coordinating Committee (TSACC) was established in 2006 to ensure that the interests and scientific needs of management agencies

are represented in coordination and collaboration with the Tahoe Science Consortium (TSC). The TSC was formed in 2005 between University of California, Davis; University of Nevada, Reno; the Desert Research Institute; the US Geological Survey; the USDA Forest Service Pacific Southwest Research Station; Sierra Nevada College and key resource management agencies to promote a collaborative approach to research at Lake Tahoe. With the exception of some of the key management agencies, all of these entities have conducted formal research in the Lake Tahoe watershed for decades. As members of the TSC, they will collaborate to improve communication links between researchers and management as represented in Figure 7.

Projects that would benefit from collaboration include development of a science plan for the EIP, development of a comprehensive monitoring program for EIP projects, and prioritization of research to be funded through SNPLMA.

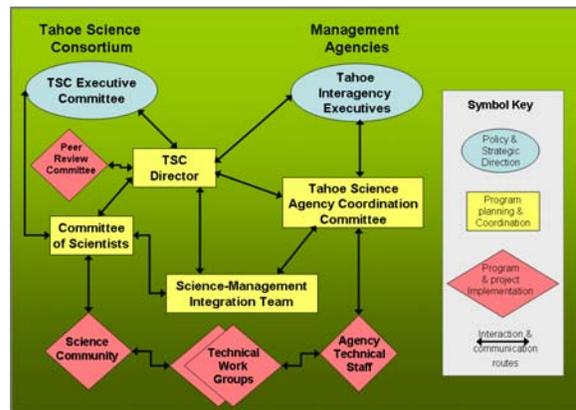


Figure 7. Collaboration process between Lake Tahoe Basin managers and researchers.

What’s Needed: The new committees and consortiums formed to increase collaboration between researchers and managers are encouraging. However, a comprehensive means of disseminating information between the two groups has not yet been developed. Meetings with upper-level managers are probably not adequate for ensuring that research results reach the on-the-ground implementers and project designers who most need the science-based information on a daily basis. Researchers would also like to learn about restoration and

water quality projects in the basin before they are constructed.

Possible Extension Program Strategies:

Strategies are needed to facilitate the information flow among researchers and agency managers, project designers and managers of private land, including:

- Requesting funds for dissemination of research results as part of all scientific research grant proposals.
- Developing fact sheets based on research for managers and the public. One current need is for easily accessible information about the TMDL process and the water clarity model.
- Continuing the Lake Tahoe Report newspaper articles for regional newspapers as needed, emphasizing interpretation of scientific research and ways citizens can reduce adverse impacts on the environment.
- Developing issue-specific workshops for managers on incorporating recent research results in management. Examples might include BMP design workshops based on results of effectiveness monitoring.
- Hosting workshops for agency representatives to formulate research questions that address the most pressing management and policy needs.
- Developing an in-depth newsletter including articles by managers who would not get their research published elsewhere.
- Developing a research catalogue or bibliography listing research projects with an abstract and contact information to request the paper.
- Developing a “state-of-the-lake” report to communicate with the public on the results of all the research in the basin.
- Developing Internet-based tools or email lists to alert managers and other scientists of the release of new research findings according to key words selected by recipients.

Wildland Fire

Situation: The 3,100-acre Angora Fire that burned in South Lake Tahoe in June 2007 illustrated that forests in the Lake Tahoe Basin are primed to burn (see Figure 8). According to

Charles Goldman, long-term researcher at Lake Tahoe, catastrophic fire poses the most significant, immediate threat to Lake Tahoe’s clarity (Goldman 2006). University of Nevada, Reno (UNR) researchers have also provided information on the potential impacts of wildfire on water quality (Miller, et al. 2006), erosion (Carroll, et al. 2007), and upper-watershed nutrient cycling (Johnson, et al. 2005). After a major fire, it is probable that large quantities of fine soil particles and ash would be deposited into the lake through water and wind erosion.

Wildfire poses a threat to basin communities as well. Recent information collected from 58 forest plots near communities showed that ignitions in 76 percent of these plots would result in destructive crown fires (Holl Consulting and Wildland Rx 2006). The draft fuel reduction plan for the basin estimates that federal, state and local agencies have reduced hazardous forest fuels on 11,200 acres since 2000. The 10-year plan calls for another 23,025 acres to be treated between 2007 and 2016, including many acres projected for prescribed burning annually.



Figure 8. Overcrowded forests in the Tahoe Basin pose a wildfire hazard to communities.

Current treatments are performed using specialized low- or no-impact equipment or by hand, and include prescribed burning and pile burning. Such treatments are very expensive. Mechanized equipment is not allowed in stream environment zones (SEZs), where fuels treatment has lagged. At least one recent wildfire in the basin started within an untreated SEZ and expanded to the surrounding forest. Barriers to treating the needed acreage include strict regulations in SEZs, a lack of mechanical contractors and lack of public acceptance of prescribed burning and conventional harvest systems. Other barriers include the short field

season and limited operational periods, strict air quality regulations, limited access by roads and steep terrain.

What's Being Done: The main agencies involved in wildfire prevention, education and outreach are: University of Nevada Cooperative Extension, the USFS, the California Department of Forestry and Fire Protection (CAL FIRE), the Lake Tahoe Basin Fire Safe Council and local fire departments and districts. The Conservation Districts do some defensible space education for homeowners through the Backyard Conservation Program.

Extension: University of Nevada Cooperative Extension has developed the Living With Fire Program to inform residents about how they can live more safely in high fire hazard environments (see Figure 9). Multimedia outreach materials include videos, slide shows and fact sheets available in both English and Spanish. The Lake Tahoe Basin edition of *Living with Fire* is widely distributed by local agencies. This program, for the most part, focuses on defensible space for homeowners rather than on forest fuels treatments.

University of California Cooperative Extension hosted an "Angora Fire – What Will the Future Forests Be?" workshop in November 2007 to educate residents and agency managers about forest ecology and regeneration after wildfires.

Outreach: The five fire districts and two fire departments in the basin have active outreach programs, including free curbside chipping, defensible space inspections and tree marking assistance (since most are authorized to mark trees over 14 inches for removal).

The Lake Tahoe Basin Fire Safe Council serves all of the Lake Tahoe area under the auspices of the Nevada State Fire Safe Council. Neighborhoods have formed themselves into fire safe chapters to apply for grant funding for fuel reduction projects. Fire Safe Council staff works with fire districts and crews from the California and Nevada Conservation Corps to conduct fuels reduction and defensible space projects in these neighborhoods. UCCE collaborated with the Fire Safe Council, the Nevada Tahoe Conservation District and the Tahoe Resource Conservation District in summer 2007 to conduct demonstrations of flammable home components around the basin (see Figure 10).

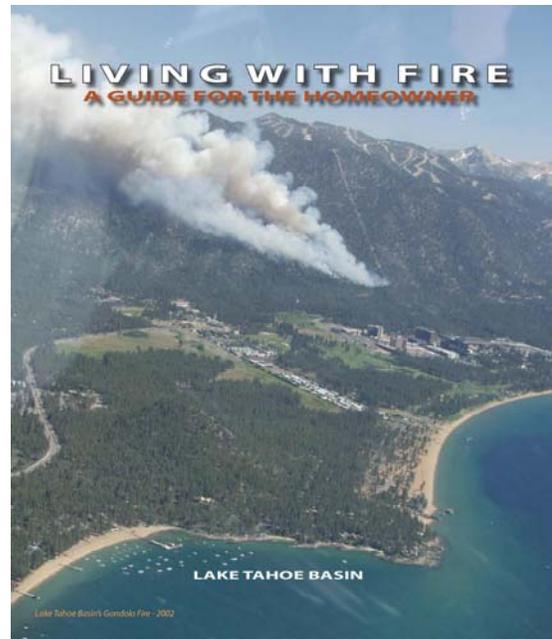


Figure 9. Outreach materials for the Living With Fire Program.

Education: Lake Tahoe Community College offers a Fire Science Program that trains local fire-fighters. In addition, the University of Nevada, Reno Fire Science Academy (FSA) offers emergency response programs and training facilities at its 426-acre campus near Carlin, Nevada.

Research: The Tahoe Science Consortium has developed a research plan for the basin on the topic of wildland fire (TSC 2006). The focus of the plan is on understanding the contribution of forest treatments and fires to nutrients reaching Lake Tahoe. For a summary, see the Tahoe Science Consortium's *Lake Tahoe Basin Science Plan: Research Strategies* (TSC 2006).

What's needed: Extension activities to help remove barriers to expanded fuels treatments are needed. The Draft Fuel Reduction Plan recommends developing a consistent and timely process for permitting of fuels reduction projects in SEZs, developing new strategies to encourage cost effective treatments of SEZs and establishing an effective public outreach program on prescribed fire.

Possible Extension Program Strategies:

Possible strategies for implementing these activities include:

- Convening a forest fuels working group made up of agency representatives to work on reducing barriers to fuels treatment and

to develop a vision for collaborative and consistent fuels management.

- Developing a literature review/synthesis of fire treatment effects on water quality.
- Developing a basin-specific manual for fuels treatment practices to facilitate communication with regulators.
- Developing a public outreach campaign on forest fuels treatment options, especially prescribed burning, including educational handouts.
- Facilitating projects promoting the utilization of treatment waste biomass for electricity generation.
- Conducting applied research on the effects of mechanical thinning in SEZs.
- Involving the scientific research community in information and educational programs.
- Conducting demonstration projects of low-impact mechanical harvest techniques, including innovative yarding techniques in SEZs.



Figure 10. A home component burn demonstration done by UCCE in Incline Village, Nevada, July 2007.

- Hosting a forest stewardship workshop series using developed UCCE curriculum.
- Collaborating to deliver the Living With Fire Program in the Tahoe Basin.

Invasive Species

Situation: Aquatic invasive species (AIS) are well-established in Lake Tahoe. Before the late 1800s, the native food web was dominated by a single predator, the Lahontan cutthroat trout that fed primarily on tui chub and zooplankton. Cutthroat trout were extirpated from the lake by 1939 because of overfishing, predation from introduced lake trout (Mackinaw), siltation of spawning habitat caused by deforestation, and

hybridization with rainbow trout in hatcheries. Several attempts to reintroduce cutthroat trout into Lake Tahoe itself have failed, due to predation by non-native lake trout, although a small population has been established at Fallen Leaf Lake. Non-native rainbow and brook trout, kokanee salmon, crayfish and the invertebrate *Mysis relicta* are also established in the basin, as are the lake whitefish, smallmouth bass, carp and arctic grayling (Murphy and Knopp, eds. 2000).

Since the 1970s, nonnative, warm-water fish species, including bluegill and largemouth bass have been found in half the 16 University of California (UC) and University of Nevada, Reno sampling locations around the lake (Chandra and Allen 2006). Bass found near shore are often found near non-native Eurasian water milfoil (*Myriophyllum spicatum*), which produces favorable habitat for these fish. Milfoil became established in Lake Tahoe by the late 1970s. Surveys done since 1995 show continued expansion and spread of the non-native milfoil and curlyleafed pondweed, *Potamogeton crispus* (see Figure 11). Milfoil is now found in over 30 locations around the lake, as well as downstream in the Truckee River, and pondweed is spreading rapidly along the southern shoreline.



Figure 11. The invasive aquatic weed, Eurasian watermilfoil, has spread throughout the Tahoe Keys Marina since its introduction to Lake Tahoe in the late 1970s. Source: Lars Anderson.

A potential new threat is the quagga mussel, which was discovered recently in Lake Mead at the Las Vegas Boat Harbor, as well as at Lakes Mohave and Havasu. Like its infamous cousin, the zebra mussel, quagga mussels are biofoulers that can obstruct pipes in municipal

and industrial raw-water systems, costing millions of dollars annually to treat. Their presence can also have serious impacts on native wildlife, fisheries and the local ecosystem.

For terrestrial weeds, the Tahoe Basin is in the relatively early stages of infestation. Weeds are found in relatively isolated areas with small populations, many of which have been eradicated entirely. Populations occur along transportation routes; areas associated with firefighting activities; and in other areas that have experienced land disturbance or where materials, including straw bales, fill dirt or gravel have been imported. Some of the invasive weeds have been brought into the area for use as ornamental plants (e.g. Dalmatian toadflax, Scotch broom). These species were later identified as invasive and have escaped cultivation to infest wildland areas.

What's Being Done: UNCE and UCCE have collaborated on invasive weed programs in the Lake Tahoe Basin. In collaboration with land management agencies, they formed the Lake Tahoe Basin Weed Coordinating Group (LTBWCG), a bistate, basinwide coalition. Along with the Tahoe Resource Conservation District and the USDA Agricultural Research Service, they hosted a three-day workshop on the biology and management of invasive aquatic species for the public, management agency staff and marina managers. One result was the securing of funding for a full-time coordinator to work on AIS issues in the Lake Tahoe Basin.

Weed Management: For terrestrial weeds, the emphasis has been on early detection and rapid response. Since 2003, the entire basin has been surveyed, with prioritized invasive weeds treated under the terms of an agreement with Lahontan Regional Water Quality Control Board. Grant funding has enabled the basin-wide surveys and control efforts to continue. LTBWCG partners annually review weed survey and control "coverage" for the entire basin to continue early detection efforts.

Outreach: Past efforts have focused on materials generation, workshops and events, broad public education, public relations and focused weed identification campaigns. In 2006, the group presented educational materials at 12 events and workshops reaching over 700 people. They distributed 3,800 copies of a weed identification booklet, a brochure for homeowners on control of weeds, and a *Don't*

Plant a Pest brochure to homeowners and agencies. They also distributed over 1,000 signs, boater cards and posters to marinas and local governments on identification and prevention of the spread of Eurasian watermilfoil (see Figure 12).

UNCE added five new pages on weed identification to the 2006 edition of the *Home Landscaping Guide for Lake Tahoe and Vicinity*. Two of these pages contained full-color photographs of Tahoe's terrestrial invasive weeds. Programs include training of volunteer Weed Warriors by UNCE to identify and eradicate weeds on public lands and working with contractors and nurseries to promote planting of native and noninvasive alternatives. Weed group members have also pursued and secured funding to hire contractors for eradication activities. One of these grants funds a full-time weed outreach coordinator at the Tahoe Resource Conservation District. Funding has also been obtained to integrate invasive weed education into the Backyard Conservation Program.

Demonstration projects: In 2005, the California State Lands Commission began a demonstration project to remove Eurasian watermilfoil in Lake Tahoe's Emerald Bay using diver-assisted hand suction methods. Additional removal methods, including bottom barriers, will be piloted next summer. Development of a feasibility plan of management options for invasive aquatic weeds in Lake Tahoe is also scheduled for next year.



Figure 12. Outreach materials developed by the Tahoe Basin Weed Coordinating Group.

Community residents installed a boat-washing station at Fallen Leaf Lake to prevent the spread of milfoil to that uninfested lake in 2006. A

temporary 2-year permit was issued by TRPA for a high-pressure hose to remove any vegetation on boats before being launched in the lake. Also at Fallen Leaf Lake, UC Davis has conducted experiments on the reintroduction of Lahontan cutthroat trout, and volunteers conduct water quality sampling and clarity measurements.

What's Needed: For terrestrial weeds, continued funding, coordination and ongoing outreach and education are needed to keep the focus on identifying and eradicating initial populations of invasive weeds before they spread. Prevention strategies focusing on primary routes of transportation are needed. For aquatic weeds, coordinating approaches and strategies among management agencies is needed, as well as additional public education. Continued research into environmentally acceptable, effective means to control aquatic weeds is also essential.

Possible Extension Program Strategies:

Education on the impacts of aquatic weeds is needed to allow a comprehensive aquatic weed management strategy to develop at Lake Tahoe. Possible education methods include:

- Involving the scientific research community in information and educational programs.
- Facilitating dialogue on aquatic weeds and possible management strategies leading to boat-wash stations at marinas and other spread prevention techniques.
- Conducting broad public education, including billboards on major transportation routes, placing educational materials in boater launch fee packets, etc.
- Continuing participation in the LTBWCG.
- Coordinating or assisting with education and outreach about new biological invasive threats to the basin, such as the quagga mussel.

Air Quality and the Effects of Climate Change

Situation: Poor air quality in the Tahoe Basin has been implicated in decreasing water quality in Lake Tahoe. Airborne nitrogen and phosphorus falling into the lake spur the growth of algae. Deposited nutrients, together with the fine particles in air pollution, decrease the clarity of Lake Tahoe's water. Poor air quality also

affects the scenic qualities of the basin and contributes to the cumulative impacts causing global climate change (see Figure 13). Most air pollution originates within the basin from vehicle emissions, wood-burning stoves, prescribed fires and wind-blown dust.

Climate change poses a particular threat to the Lake Tahoe Basin. The California Department of Water Resources predicts that the snow line in the Sierra will move up in elevation by 500 feet for every 1-degree Celsius rise in temperature in the atmosphere. National Oceanic and Atmospheric Administration (NOAA) climate models now predict a 2-degree increase in the next 25 years. This could have a dramatic effect on Tahoe Basin ecosystems and a devastating effect on its resort-based economy.

Climate change could also lead to serious impacts on water quality. It will likely affect nutrient-cycling parameters in the upper watersheds of the Tahoe Basin. University of Nevada, Reno researchers are currently pursuing this aspect.



Figure 13. Smog over Lake Tahoe. Source: Tahoe Regional Planning Agency.

University of California scientists (Coats, et al. 2006) found that Lake Tahoe has become more thermally stable since the late 1960s and that its water mixes to the bottom less frequently than in the early 1970s. This affects the dispersal of fine sediments and oxygen throughout the lake. With less frequent mixing, less oxygen will be carried to the bottom of the lake. This could trigger the release of nutrients currently trapped on the bottom of the lake by oxygenated compounds. The next deep mixing of the lake could bring greatly increased concentrations of nutrients to the surface, stimulating algal blooms and decreasing clarity.

What's Being Done: Most efforts to improve air quality at Lake Tahoe are based on attempts to increase use of public transportation and decrease the number of miles traveled each year by privately owned vehicles. The TRPA has also passed an ordinance requiring old wood-burning stoves to be replaced by more efficient, lower-emission models when real estate is sold or transferred. Studies show that the number of vehicle miles traveled each year in the Tahoe Basin continues to increase, not decrease. While "green building" is an interesting new option for builders, the actual number of solar, energy-efficient structures in the Tahoe Basin is very low.

Sierra Watershed Education Partnership (SWEP) held a Youth Global Climate Change Symposium attracting 275 students in spring 2006. Science fair presentations and citizen policy recommendations were made, and solar car races were held.

University of Nevada Cooperative Extension assisted the Tahoe Environmental Research Center on the campus of Sierra Nevada College in creating a docent training program for educating the public about the Green Building features of the new Tahoe Center for Environmental Sciences.

What's Needed: Increased public outreach and education is needed about the impacts of fossil fuel use on air quality, lake clarity and global climate.

Possible Extension Program Strategies:

Possible strategies to increase education about air quality and climate change include:

- Writing articles in newspapers about the predicted impacts of climate change on the region, and how local residents can become part of the air quality solution.
- Organizing more public tours of energy-efficient and solar buildings that meet the "Leadership in Environmental and Energy Design" (LEED) criteria of the U.S. Green Building Council (see Figure 14).
- Creating a program or publications for the public on reducing air pollution by using alternate forms of transportation.
- Collaborating with jurisdictions implementing EIP transportation projects to help educate citizens on their air quality benefits.

- Involving the scientific research community in information and educational programs.



Figure 14. Tahoe Center for Environmental Sciences opening in October 2006. The center was designed using LEED principles. Source: UC Davis Tahoe Environmental Research Center.

Youth Development – Environmental Education

Situation: Youth at Lake Tahoe are growing up in a unique location, rich in beauty, outdoor recreation opportunities and available scientific knowledge about the environment. Research has shown that education that includes experiencing local ecosystems and working on local environmental issues, called "place-based learning," improves school achievement (Lieberman and Hoody 1998), because youth can relate better to lessons about a place that they know. Place-based education promotes youth citizenship through participation in community-monitoring and restoration projects. Local youth are also uniquely positioned to influence their families on sustainable living practices.

What's Being Done: UNCE and UCCE collaborated on development of the Lake Tahoe Environmental Education Coalition (LTEEC). One major focus of LTEEC was to work with the Sierra Watershed Education Partnership (SWEP) to bring together environmental educators from around the basin to collaborate on delivering place-based education to local youth. In 2003, SWEP received a two year grant from Adopt-A-Watershed to fund "K-12 coordinators" to help teachers offer environmental education within their own classrooms. SWEP has taken the lead since Adopt-A-Watershed funding expired by

organizing several teacher trainings each year using Project WET curriculum. SWEP is also continuing coordination of Adopt-A-Watershed with the Tahoe-Truckee Unified School District. LTEEC partner organizations also collaborate to offer educational activities to children and their families, including Earth Day, Snapshot Day (citizen monitoring), Forest Stewardship Day and Children's Environmental Science Day (see Figure 15).

UNCE operates the Nevada State 4-H Camp in Stateline, Nevada, but actual 4-H membership in the basin is limited. A UNCE effort to develop 4-H after school clubs was not successful because not enough people were recruited. A UNCE collaboration with the King's Beach Boys and Girls Club was very successful. UNCE developed environmental education activities for club youth on an overnight backpacking trip. REI and the Tahoe Rim Trail Foundation provided funding and equipment.

The new UC Davis Tahoe Environmental Research Center (TERC) in Incline Village is also focusing on delivering place-based learning to local youth. TERC offers interactive exhibits on the science of water quality and limnology at the Thomas J. Long Education Center on the first floor of the TERC center. The initial focus for the interpretive center has been giving tours to sixth-grade classes.

What's Needed: Offering place-based education can be more challenging for classroom teachers than using more traditional teaching styles, because of the need to make connections with local environmental issues. With the pressure on schools to meet the testing requirements of the No Child Left Behind Act, school administrators have not rushed to embrace these new methods. Ongoing collaboration between educators and environmental education, science, restoration and service organizations is needed to maintain and expand place-based education opportunities for youth.

Possible Extension Program Strategies: The primary strategy for place-based environmental education programming is to collaborate with other organizations already serving youth. Extension activities could include:

- Participating in an environmental education summit at Lake Tahoe to offer teachers instruction on place-based

learning and other experiential teaching methods.

- Working with TERC and SWEP to hold other teacher trainings.



Figure 15. Young people learn about water quality at Children's Environmental Science Day. Source: UC Davis Tahoe Environmental Research Center.

- Offering presentations to youth about water quality using Project Wet materials and other experiential means.
- Offering presentations to youth about forests and fuels management using Project Learning Tree materials and other experiential means.
- Offering presentations to youth about wildlife issues, including bears in Tahoe neighborhoods, using Project Wild and locally developed materials.
- Coordinating with existing after-school programs (including Boys and Girls Clubs) to offer 4-H and environmental education activities. These could include guided hikes and backpack trips in coordination with the Tahoe Rim Trail Association.
- Targeting youth for education as part of the outreach for the BMP Retrofit Program.
- The University of Nevada Academy for the Environment (UNAE) has expressed interest in the development of a joint UNCE/UNAE science and education program for youth and agency participants that could be conducted at

the Nevada State 4-H Camp. The UNAE, established in 2004, is an interdisciplinary institute at the University of Nevada, Reno whose mission is to develop, enhance and coordinate environmental teaching, research and service at the University of Nevada, Reno.

- Offering a week-long institute for teachers from California and Nevada, based on UCCE's Forestry Institute for Teachers and taught by faculty from University of Nevada and University of California.

CONCLUSION

The purpose of this needs assessment was to identify issues of critical importance to improving natural resource management in the Lake Tahoe Basin. Through interviews with more than 35 scientists, agency staff and natural resources managers, we gathered ideas for needed public outreach, education and applied research in six subject matter areas, from air and water quality to wildfire and invasive species.

University of California Cooperative Extension and University of Nevada Cooperative Extension plan to work together to develop programs to address educational needs in these subject matter areas. We will share the lead for development of Cooperative Extension programs for some issue areas, and we will each focus on some individual issue areas as well. We also seek to include other agencies and individuals in planning for future programs and products. At times, we will try to act as a catalyst to stimulate collaborative work by various stakeholders to address critical needs. At other times, we will support others who take the lead.

Partnership with others is a consistent goal. We will continue to work with the BMP Retrofit Partners to improve the effectiveness of small-scale BMPs and to educate the public and building contractors about them. We will collaborate with Fire Safe Councils and fire districts on fuels reduction and defensible space programs. We will also work with partners in the Tahoe Science Consortium to develop methods for the dissemination of research findings to natural resource managers and the public. As scientists monitor the watershed and seek new ways to solve environmental problems, their

discoveries need to be shared in order for adaptive management and continuous improvement in environmental restoration design to result.

We invite members of the Lake Tahoe community to share their ideas about how to address the needs identified in this assessment. Susie Kocher can be reached at skocher@nature.berkeley.edu, and John Cobourn can be reached at cobournj@unce.unr.edu. We welcome your suggestions and involvement to improve our effectiveness in working with agencies and the public. At Lake Tahoe, a better-educated and motivated public must play a crucial role in restoration of our beautiful lake and its watershed. It is up to all those who live, work and play here to improve our stewardship of our air, water, forests and home sites. If we do so, we will be able to pass the legacy of Tahoe's beauty on to future generations.

AGENCIES CONTACTED FOR INTERVIEWS

Individuals from the following agencies were interviewed:

Academy for the Environment, University of Nevada, Reno
California Department of Parks and Recreation
California Tahoe Conservancy (5)
El Dorado County Board of Supervisors staff member
El Dorado County Department of Transportation
El Dorado County Supervisor
Incline Village General Improvement District
Lahontan Regional Water Quality Control Board (2)
Lake Valley Fire Protection District
Meeks Bay Fire Protection District
Natural Resources Conservation Service
Nevada Division of Environmental Protection
Nevada Fire Safe Council
Nevada State Lands
Nevada Tahoe Conservation District
South Lake Tahoe Family Resource Center
Tahoe Environmental Research Center (3)
Tahoe Regional Planning Agency (3)
Tahoe Resource Conservation District (2)
Tahoe Science Consortium
University of California Cooperative Extension (2)
University of Nevada Cooperative Extension (3)
University of Nevada, Reno (2)
U.S. Army Corps of Engineers
USDA Agricultural Research Service
U.S. Environmental Protection Agency
U.S.F.S. Lake Tahoe Basin Management Unit
Washoe Tribe Environmental Department
Washoe County Public Works Department

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