

# Tahoe Science Update Report

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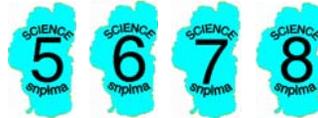
## Preface

This report provides an overview of recent science in the Tahoe Basin in support of the Environmental Improvement Program (EIP) and the Lake Tahoe Restoration Act, focusing on the Tahoe Science Program funded by the Southern Nevada Public Land Management Agreement (SNPLMA).



Readers, including potential applicants for funding, can learn more about completed and ongoing research projects, as well as management concerns as they relate to the Round 9 science themes. The report features hyperlinks to relevant publications and websites. Appendices provide more details about funded projects and publications as well as contact information for agency representatives who contributed to this report.

Tahoe science projects funded with SNPLMA funding are marked with a symbol denoting the round in which they were funded:



Round 9 subthemes approved by the Secretary of the Interior are denoted by this symbol:

Projects supported by the Nevada Tahoe License Plate Program are denoted by this symbol:



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## Introduction

The commitment to restoring and maintaining Lake Tahoe for future generations has been put into action through a multi-agency initiative known as the Environmental Improvement Program (EIP). Launched in conjunction with the 1997 Lake Tahoe Presidential Forum, the EIP provides a strategy to achieve the environmental goals for the Lake Tahoe Basin. The strategy builds on capital improvements that have been underway within the region for over two decades. This strategy is designed to accomplish, maintain, or exceed multiple environmental goals and develop a more integrated, proactive approach to environmental management. The **Lake Tahoe Restoration Act** of 2001 authorized \$300 million for the federal share of the EIP. That funding became available with the 2003 amendment of the Southern Nevada Public Lands Management Act (SNPLMA), which allocated funding from rounds 5 and 6. A complete list of projects that have been funded by the Tahoe SNPLMA funds is available at the [Lake Tahoe Basin Management Unit SNPLMA website](#).



## Role of Research in Lake Tahoe Restoration

Scientific research has played a key role at Lake Tahoe in developing environmental thresholds, identifying trends in threshold attainment, and informing policy decisions. The Lake Tahoe Restoration Act called for the best available science to prioritize and evaluate efforts to meet those environmental thresholds. Therefore, research projects funded through this program need to help land management and regulatory agencies in the Lake Tahoe basin and to promote more effective projects and policies under the EIP.

During rounds 5 and 6, science projects were supported by a variety of federal agency sponsors. One project created the Tahoe Science Consortium (TSC) to foster a greater level of collaboration between resource management agencies and research organizations. The TSC members had previously assembled less formally as the Science Advisory Group (SAG) in 1998. The primary objective of the TSC is to provide environmental managers and decision makers with comprehensive and well-synthesized scientific findings drawn from research, monitoring, and modeling. The TSC works to promote science in support of the preservation, restoration, and enhancement of the unique environmental values of the Lake Tahoe basin. The research organizations that make up the TSC include Desert Research Institute; University of California, Davis; University of Nevada, Reno; U.S. Geological Survey (USGS); and the U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station (PSW).

## Competitive Program for Tahoe Science

In 2006, PSW assumed responsibility for overseeing a science program to enhance the quality and relevance of Tahoe science being funded through SNPLMA. The shift in sponsorship to PSW was associated with several changes in the program (table 1) highlighted by the establishment of a competitive grant award program. The program continues to evolve to meet the critical management needs for science in the basin.

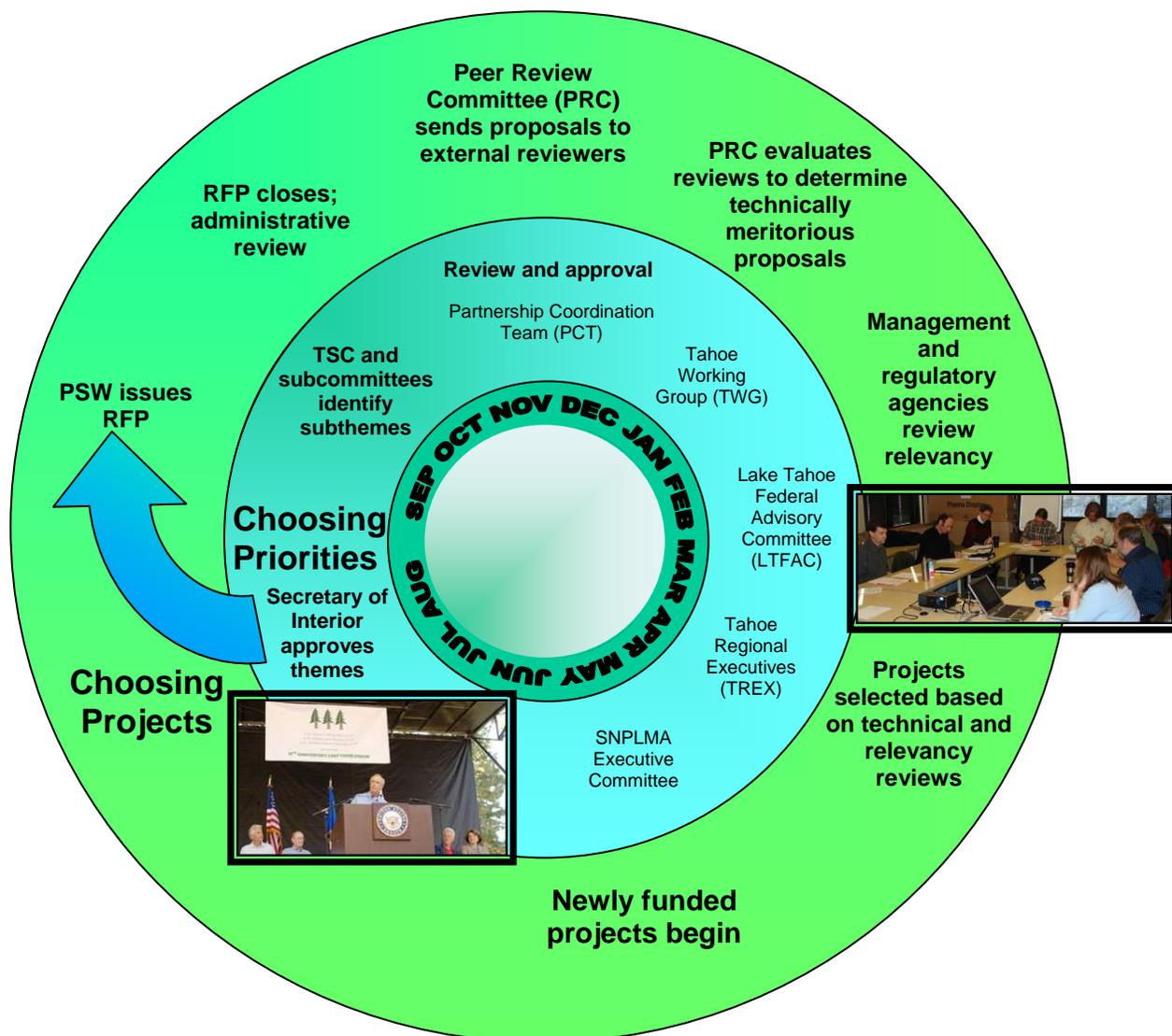
**Table 1: Changes in the Tahoe science activities funded by SNPLMA following PSW sponsorship**

	Rounds 5, 6	Rounds 7 and beyond
Federal sponsor	Various agencies	Single agency (PSW)
Funding allocation	By sponsoring agency project	By science themes
Proposal solicitation	Agency requests for proposal, (RFPs), contracts, or internal projects	Single competitive RFP covering all science themes
Review process	Varied by agency	Independent peer review for science quality and agency input for relevancy
Strategy for engagement with multiple management agencies	Varied by project	All proposals have to outline strategy for engaging with management agencies and other stakeholders
Progress reporting	Administered by individual agency sponsors	Unified reporting through PSW, updates posted on the <a href="#">PSW Tahoe Science Web site</a>

Starting in round 7, the TSC worked with agency representatives to identify priority science themes and subthemes to guide the selection of science projects. Themes are focal areas for research, which generally conform to major program areas in the EIP. Subthemes are specific topics and associated research questions within the focal areas. Appendix A provides a cross-walk of science topics and themes. In round 7, the themes were air quality, ecological communities, water quality, forest health, best management practices, and cross-cutting research. In round 8, the number of themes was reduced, but a cross-cutting climate change theme was added. In round 9, the themes were largely unchanged, but increasing funding was devoted to evaluating the impacts of fuel treatments. The process of requesting and reviewing proposals continues to be revised based on lessons learned in previous rounds.

### Process for Selecting Tahoe Science Themes

The timetable for developing the science themes and subthemes is represented by the blue, inner circle in figure 1. In the fall, the TSC Committee of Scientists drafts an initial set of themes and develops these with input from agency representatives on the Partnership Coordination Team (a subcommittee of the Lake Tahoe Basin Executive Committee with representation from the Tahoe Regional Planning Agency or TRPA). The themes are intended to correlate to themes used in previous Tahoe planning efforts, including the Tahoe Regional Planning Agency (TRPA) Regional Plan, the Lake Tahoe Watershed Assessment (2000), the Pathway planning process, the EIP, and the Tahoe Science Plan (app. A). The TSC then directs subcommittees to develop subtheme questions for each of the theme areas. After refining the subthemes, the science themes and subthemes are forwarded to the Partnership Coordination Team for review and approval as part of the overall Tahoe SNPLMA package. The package then moves through several additional governing bodies, including the Tahoe Working Group, Lake Tahoe Federal Advisory Committee, Tahoe Regional Executives, and the SNPLMA Executive Committee. The Secretary of the Interior approves the SNPLMA projects during or after the annual Lake Tahoe summit.



**Figure 1: Timetable with two connected loops for selecting themes and projects.**

### Process for Selecting Tahoe Science Projects

The green, outer circle in figure 1 summarizes the process for selecting projects after the science themes have been approved by the Secretary of the Interior. In the late summer, after the annual event, PSW submits a request for proposals to address the research needs. Researchers are allotted 6 to 8 weeks to submit proposals. Proposals are evaluated based upon their technical quality and their relevancy to management agencies within the basin, using a [rigorous process](#) administered by the Tahoe Science Consortium:

- Independent scientists review the proposals for scientific merit and effectiveness in meeting the subthemes.
- Representatives of many federal and state management agencies in the basin evaluate the relevancy of the proposals to the environmental challenges that they face.
- The peer review committee recommends projects to be funded within each theme based upon scientific quality, relevancy, and funding availability.

## Highlights of the Tahoe Science Program

1. **Diverse science projects:** Thirty-one projects have been funded to date (app. B).
2. **Multi-institutional effort:** Members of the Tahoe Science Consortium (USGS; University of California, Davis; University of Nevada, Reno; Desert Research Institute; and PSW) work together to guide program activities.
3. **Collaborative planning:** To promote strategic plans to address environmental issues in the Tahoe basin, the TSC has collaborated with an array of institutions to create a science plan for the Lake Tahoe basin, conduct topical science workshops, and develop a regional stormwater monitoring plan (RSWMP).
4. **Competitive peer-reviewed process:** Proposals for science at Lake Tahoe using SNPMLA funds compete through a peer-review process that evaluates technical merit and management relevancy.
5. **Management orientation:** Themes are selected based upon management needs in the basin. The proposal review process is done in collaboration with the management community in the basin.
6. **Securing long-term knowledge systems:** Annual funding from SNPLMA has provided continuous support for the TSC in delivering science synthesis to management agencies. The program has allowed several projects to conduct multiyear research by building upon work conducted in previous rounds.

## Relevant Projects Supported by the Nevada Tahoe License Plate Program

The State of Nevada collects fees for special Lake Tahoe license plates. The fees go into a dedicated Lake Tahoe fund, which is administered by the Division of State Lands. These funds are used for projects and programs to preserve or restore the natural environment of the Lake Tahoe Basin. This program is completely separate from the Tahoe Science Program and SNPLMA funding. However, both programs use a competitive review process and help to fulfill the mission of restoring Lake Tahoe through the EIP. The program has funded several research and monitoring studies that are relevant to Round 9 subthemes. Summaries of these studies are included under relevant headings in this report.



## Science Integration

The [Tahoe Science Consortium](#) promotes integration among the many current and future scientific projects in the basin, prioritizing future research informed by a comprehensive science plan, creating an environment that promotes the contributions of the best available science, and emphasizing close cooperation with land and resource managers to facilitate the transfer of information in an effective manner.



Key accomplishments from the past year include:

- [Workshop on vegetation management in sensitive areas](#) in February 2008
- Tahoe Science Conference in March 2008
- Conceptual plan for a [Regional Stormwater Monitoring Program \(RSWMP\)](#)
- Drafting of a Tahoe Science Plan, to be published in Fall 2008. The plan provides a comprehensive review of research in the Tahoe basin, addresses key uncertainties and information gaps, identifies priority research needs, and lays out conceptual models to better understand key ecological relationships. As such, it provides an invaluable reference regarding the state of science in the Tahoe Basin.

## Forest Health

### Fuels Management

The Angora wildfire of 2007 was economically the most destructive fire to occur in the Tahoe basin to date. Prescribed burning and other forest treatments are being planned and implemented to reduce wildfire hazards. However, these activities can affect other important values, including air quality, water quality, and wildlife habitat. In recognition of its importance, the fuel management theme was allocated the single largest share of research dollars in round 9.



### Ongoing research—

- [Monitoring of fuels reduction treatments](#) <sup>5</sup>

The Lake Tahoe Basin Management Unit (LTBMU) has recently compiled numerous monitoring reports pertaining to effects of fuel treatments. Reports on the [Ward 5 Fuels Reduction project](#) and [Heavenly SEZ Fuels Reduction project](#) focus on effects of cut-to-length harvest on soil cover, soil porosity, and infiltration capacity in upland areas and riparian areas, respectively. The [Upland Fuels Treatment Effectiveness Monitoring Report by Dailey and Stanton](#) (round 5 SNPLMA project) examined pretreatment fuel conditions and forest structure across a range of vegetation types from west-shore mixed conifer to east-shore Jeffrey pine/white fir. The monitoring protocol was specifically designed to detect significant changes in plant communities and fuel loadings in response to treatments including hand thinning, mechanical thinning with chipping, and mechanical thinning with mastication.

- [Restoration and fuel treatment of riparian forests](#) <sup>7</sup>

This study is collecting data to determine the Tahoe basin's historical riparian forest fire regime and stand conditions. Data collection is underway in old-growth stands throughout the basin. The data and modeling will serve to develop guidelines for fuel treatments in riparian forests.

- [Effects of prescribed burning on vegetation and fuel loading](#) <sup>7</sup>

This project is analyzing a 10-year data set to evaluate short- and long-term effects of the prescribed burning on fuel loads and vegetation at several California state parks in the basin.



- [Effects of prescribed fire on nutrient emissions in air and water](#) <sup>7</sup>

This study is assessing impacts of prescribed fire on water and air quality. Forest managers can use the results to balance environmental impacts with fuel reduction objectives. The study will produce a basinwide inventory of potential emissions based on laboratory studies, field surveys, and geographic information system modeling.

- [Workshop on vegetation management](#) <sup>7</sup>

The TSC organized and implemented a workshop to discuss issues related to the implementation of vegetation management projects in sensitive areas of the Tahoe basin, including steep (>30 percent) slopes and streamside environment zones (SEZs). Discussions during the workshop revealed that management and regulatory agencies need standardized approaches to monitor the adverse impacts,

mitigations, and effectiveness of vegetation management projects undertaken throughout the Tahoe basin. The workshop focused heavily on impacts to soils. The workshop generated a [report from the Independent Review Panel](#) with recommendations for fuel treatments.

Specific questions identified in that report include:

**Pile burning in SEZs:** What are the potential adverse effects of pile burning in SEZs either in terms of excess nutrient mobilization or soil sterilization? What restrictions on size and placement are needed to avoid adverse impacts, and how can adverse impacts be effectively mitigated? (p. 17)

**Effects of mechanical treatments on soils and other resources:** What are the effects of different mechanical treatments on soil compaction and how should they be monitored? (p. 19)

**Environmental standards:** What are appropriate, quantifiable environmental thresholds and standards in a variety of ecological settings, and under various manipulations? (p. 24)

The TSC is following up on this workshop by convening a working group to develop standardized monitoring protocols for vegetation management projects occurring in sensitive areas.

- [Literature review on effects of fuel treatments](#) 

The Tahoe Science Consortium has produced a literature review on effects of forest management in the Tahoe basin that highlights several key areas of needed research, including the effects of fuel treatments, particularly pile burning, understory burning, and mechanical treatments, in stream environment zones and on steep slopes. An online bibliography containing articles and reports examined in this review is available in the “Bibliographic Data Collection” Tahoe Integrated Information Management System ([TIIMS](#)).
- **Effectiveness of upland fuel reduction treatments** 

This project will extend and complete an experimental study of effects of forest fuel treatments on vegetation structure and fuel loads, small mammals, birds, and ground-dwelling invertebrates, butterflies and plants at seven sites in the Tahoe basin.
- [Developing Fuel Characteristic Classification System fuelbeds for the Angora Fire region](#) 

Researchers are developing a set of “fuelbeds” for the Angora Fire region to plan restoration projects and communicate to managers, decisionmakers, and the public the levels of fire risk and production of pollutants. A fuelbed describes the arrangement, continuity and amount of available fuels, including trees, shrubs, grasses, woody fuels, litter, and duff. A fuelbed serves to characterize potential for fire intensity, potential for crowning, and potential for consuming biomass.
- **Balancing fuel reduction, soil exposure, and erosion potential** 

Researchers from Humboldt State University and the Forest Service are starting to quantify the relationship between fuel reduction and erosion potential by characterizing the distribution and moisture of fuels at eight sites and then evaluating the response of prescribed fire and mastication treatments to simulated rainfall.

- **Identifying reference forest conditions**



Researchers from Penn State University and the Forest Service will determine how much current forest conditions have departed from presettlement forest landscapes and associated fire regimes in unlogged forest within the General Creek watershed on the west side of the lake.

- **Tree health interactions with fuel management treatments**



This project will quantify the incidence and severity of tree diseases, pathogens, and other biotic and abiotic damaging agents on the Nevada State Park and US Forest Service lands that have been treated. The project will assist land managers in evaluating the efficacy of fuel reduction treatments and quantifying tree crown mortality using remote sensing.

### Future forest fuels research—

Round 9 forest health research questions tie closely to key research questions identified in the Tahoe Science Plan.

- **Evaluating Fuel Treatment Alternatives Subtheme**



Research should evaluate and compare options for fuel treatments, including slash disposal. Evaluations should be based on economic research and/or ecological effects. Ecological effects of particular interest include quantifying the impacts of reductions in fuel loads on: a) changes in fire regime/hazard/behavior, b) water quality, c) soil quality, d) wildlife, e) air quality, or f) the spread of exotic plants or insect pests. Proposals that consider special conditions involving Stream Environment Zones (SEZs), steeply sloped areas, and urban areas are encouraged. Development of standardized monitoring protocols to evaluate effectiveness is also of special interest. Economic research should aim to quantify cost-effectiveness of alternative fuel treatment methods and biomass disposal/processing techniques. [Science subtheme approved by Secretary of Interior]

Managers are interested in tradeoffs between reduced wildfire hazard and potential impacts to water quality, wildfire, and other ecological values. The recent Tahoe [Pollutant Load Reduction Opportunity report](#) (p. 184) describes a working hypothesis that forest management BMPs for fuel control will have a neutral or beneficial effect on pollutant loading to Lake Tahoe. Monitoring and research within an adaptive management framework are required to evaluate this hypothesis, including consistent monitoring protocols under the TMDL. There is heightened interest in the basin regarding how fuel reduction treatments in riparian areas (including mechanical harvest, prescribed burning, chipping, and pile burning) could affect other resource values such as water quality and stream functions. There is also interest in better understanding how SEZ treatments will influence fire severity and spread. Insect pests of concern include bark beetles.

The [Lake Tahoe Basin Fuels Management Plan](#) lays out a 10-year strategy for multiple agencies with fuel management and fire protection responsibilities.

The [California-Nevada Tahoe Basin Fire Commission Report](#) identified important management questions that should be informed by research, including how to monitor and evaluate treatment risks and benefits.

- **Impacts of wildfire subtheme**



Research should focus on assessing, understanding and predicting the effects of wildfire on: a) forest structure/composition, b) wildlife habitat, species distribution and diversity, and/or c) soil and water quality in the Lake Tahoe Basin. Research projects can also evaluate the effectiveness of rehabilitation/restoration efforts to mitigate impacts of wildfires on soils and



water quality in Lake Tahoe. [Science subtheme approved by Secretary of Interior]

Previous research on the impacts of wildfire has been conducted by University of Nevada at Reno on the Gondola wildfire; references are available in the science plan, the TSC literature review of forest management effects, and at the [TIIMS online bibliographic database](#). Research is needed to better understand relationships between wildfire severity and environmental impacts, as well as the potential for postfire rehabilitation treatments to mitigate those impacts. The Lake Tahoe Basin Management Unit is planning [restoration treatments for the area burned by the Angora wildfire](#), and researchers are invited to participate in developing those plans.

Water quality managers are interested in research that will evaluate pollutant loading to the lake via surface runoff or infiltration through shallow groundwater in relation to existing water quality modeling efforts in the basin, including the Water Erosion Prediction Project (WEPP), the Lake Tahoe Watershed Model, and the Pollutant Load Reduction Model.

### Vegetation Management

Reducing risks from wildfire is a primary management concern in the basin, but vegetation management also must address other stressors to forests, such as diseases, insects, and climate change. Research projects are currently underway to evaluate and reduce threats to many of the large pine trees that grace the Tahoe landscape.



#### Ongoing research—

- [Restoring sugar pine in the Tahoe basin](#)

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Sugar pine (*Pinus lambertiana*), the largest pine tree in the world, has been declining owing to fire suppression, logging, and white pine blister rust (*Cronartium ribicola*—a fungal disease introduced from Europe) for the past several decades. This research will develop tools for multiaged stand management to enhance sugar pine populations and meet fuel reduction and restoration objectives.



- [Threats to white pines: an ecological and genetic assessment](#)

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Genetic resistance provides the best chance for survival of white pines under threat of white pine blister rust. This study provides an opportunity to test whitebark pine (*Pinus albicaulis*) from established locations, to develop a seedbank of genetically diverse material for the Lake Tahoe basin, and to inform strategies for conserving and restoring these trees.



### Watersheds, Habitat, and Water Quality

#### Habitat Improvement

The Tahoe basin harbors species and ecological communities of special concern because of their rarity or vulnerability to alteration by natural and human forces. Scientific research is helping us better manage and conserve these special communities and species.

#### Ongoing research—

- [Urban Biodiversity Project](#)

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Completed in 2007, this project focused on quantifying the role of undeveloped lands as it relates to the urban wildland matrix in supporting populations of plant and animal species.

- **Avian Nest-site Selection and Nesting Success in Sierra Nevada Aspen**   
Completed in 2006, this study collected five seasons of data centered on bird-habitat relationships using point counts and habitat factors related to nest site selection, nesting success, and nest predators.
- **Controlling the Proliferation of Invasive Warm Water Fishes**   
The primary goal of this ongoing project is to minimize and control the proliferation of nonnative warmwater fish species within Lake Tahoe. This project will assess the current distribution of nonnative species and their association with native species within the lake. Temperature data will be coupled with observational data to determine critical temperatures causing behavioral shifts. Fish habitat survey information and fish survey data will be used to develop a GIS layer displaying fish distributions in the littoral zone of Lake Tahoe. This project comprised year one of a three year project, and is related to ongoing [nearshore lake quality research](#).
- **Evaluating effects of ski resorts on American marten**   
This study will evaluate whether recreational activities at ski resorts have significant effects on populations of the American marten (*Martes americana*), which is a species of special concern.
- **Invertebrate Survivability Study**  
This study involves a literature and networking search to answer questions regarding survivability of quagga and zebra mussels and New Zealand mudsnails within the Tahoe Basin. The study will address issues including minimum required water calcium levels of percentile survival, how long invertebrates in various life phases can survive out of the water on a boat trainer or boat hull, how long invertebrates in various life phases can survive in a boat cooling system, and how long invertebrates in various life phases can survive a secondary treatment process for wastewater.

#### Future research—

- **Wildlife and habitat restoration subtheme**   
How do species and/or habitats of special concern, in particular, Tahoe yellow cress, Lahontan cutthroat trout, or aspen communities, respond to restoration efforts? Research is required to determine the key activities needed to restore degraded habitats. Studies should compare alternative restoration approaches based upon ecosystem or species responses relative to appropriate reference conditions, and they should provide information to improve ongoing management efforts. [Science subtheme approved by Secretary of Interior]

Agencies are particularly interested in evaluating the effects of restoration efforts on these special biological communities and their associated thresholds within the EIP. The LTBMU has conducted [monitoring and associated research](#) to evaluate the status and trend monitoring design. The Tahoe Science Plan identifies several research questions pertaining specifically to aspen (*Populus tremuloides*), Tahoe yellow cress (*Rorippa subumbellata*), and Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*). Both Tahoe yellow cress and Lahontan cutthroat trout are being conserved under SNPLMA Round 9 capital projects. Research on aspen ecology in the Tahoe basin has been synthesized in a [technical report](#), and biologists at the University of Nevada at Reno have reported on recent research on bird nesting within aspen communities. The Tahoe Yellow Cress Technical Advisory Group has outlined key management questions in a [conservation strategy](#) to guide conservation and restoration research on Tahoe yellow cress. [Annual reports](#) by the group provide updates on how the key questions are being addressed.

• **Invasive species subtheme**

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Research should: a) evaluate approaches (including existing regulations) to control the spread of priority invasive non-native species or prevent the introduction of new invasive species, b) assess the habitat suitability of Lake Tahoe and its watershed to support the establishment of invasive mollusks, including New Zealand mud snail (*Potamopyrgus antipodarum*), quagga mussels (*Dreissena rostriformis bugensis*) or zebra mussels (*Dreissena polymorpha*), and/or c) better quantify risk assessment techniques and assumptions. [Science subtheme approved by Secretary of Interior]

Prevention and control of invasive species is a priority issue for many agencies in the basin, including the [Lake Tahoe Basin Management Unit](#), [Tahoe Regional Planning Agency](#), and the [Tahoe Resource Conservation District](#) (TRCD). The Army Corps of Engineers working with the California Tahoe Conservancy, TRPA, and the TRCD in developing an Aquatic Invasive Species Management Plan with SNPLMA capital funds and state and local matching contributions. The threat from invasive mollusks has become a particular priority for many management agencies. Accordingly, one of the plan elements is the [Invertebrate Survivability Study](#) discussed above. Researchers at the University of California Davis recently published [findings concerning the spread of the nonnative asian clam](#) (*Corbicula fluminea*), and the University of Nevada Reno recently contracted with the Scripps Institution of Oceanography to use sonar to identify clam beds in Lake Tahoe. One of the approaches to controlling these invasive aquatic species is a boat-washing program implemented by TRPA. A topic of interest is the possible relationship between asian clam beds and algal blooms in the nearshore environment. A risk assessment for mussel invasion should consider the high concentrations of calcium associated with asian clam beds. Sudeep Chandra at the University of Nevada-Reno has initiated water sampling and bench tests to determine the ability of quagga mussels to grow and reproduce in conditions found in various areas of Lake Tahoe.

In addition to the mollusks that threaten to invade the lake, several kinds of fishes, plants, and other species have already invaded the lake. [Ongoing research projects](#) are examining the spread of these species in the nearshore environment using funding from previous SNPLMA science rounds. The [Integrated Tahoe Keys Aquatic Invasive Species Eradication Project](#) is proposing to apply a variety of control methods to the Tahoe Keys. Control strategies for invasive aquatic plants currently under consideration include hand-pulling, bottom barriers and the use of aquatic herbicides.

The Lake Tahoe Basin Weed Coordinating Group has identified invasive weeds of concern as part of its [invasive weed program](#). The LTBMU noxious weed program has also identified [priority weed species](#) and has conducted effectiveness monitoring of treated infestations and status and trend monitoring of noxious weeds primarily around roads, trails, and along the wildland/urban interface within the Lake Tahoe basin.

For all of these invasive species, management agencies are interested in evaluating tradeoffs between treatment alternatives, including practical limitations and costs.

## Water Quality

“Keeping Tahoe Blue” is a primary goal within the Tahoe basin. Research on water quality focuses on measurement and modeling of conditions and trends, evaluation of data for establishing numeric water quality standards, and understanding processes that influence water quality in the main lake, nearshore environment, streams, and upland runoff.

### Ongoing research on water quality modeling—

• [Lake Tahoe total maximum daily load \(TMDL\)](#)

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The draft Lake Tahoe Total Maximum Daily Load Technical Report explains the pollutants that are causing Lake Tahoe's clarity loss and how much can be received while meeting the clarity goal for the lake. Research has shown that the number of fine-sediment particles less than 20 micrometers has

the greatest influence on Secchi depth measurement. The Pollutant Reduction Opportunity Report (PRO) is a basinwide analysis that quantifies load reductions achievable from implementing various levels of pollutant control efforts.

- **[Assessing sources of fine sediment using WEPP](#)**   
The WEPP model is a process-based model that simulates soil detachment, deposition, transport, and delivery through hillslope, channel, and structural impoundment units within a watershed. This project will refine the tool set for the Tahoe basin and train local implementers to use these new tools. The model's predictions will be evaluated using monitoring data from the Heavenly Valley Ski Resort and other cases where erosion effects of management practices have been studied.
- **[Minimizing road erosion](#)**   
Researchers are refining the [WEPP:Road modeling tool](#) to produce more accurate predictions of erosion from roads by conducting field studies and additional modeling. Products of this study will serve to predict sediment loading, identify erosion “hot spots” associated with roads, and determine an optimal road network design that minimizes sediment production through BMP application and road decommissioning.
- **[Predicting nutrient and sediment loading from prescribed fire using WEPP](#)**   
This project will optimize the WEPP model and predict sediment and nutrient loadings from prescribed fire at the hillslope and subwatershed scales using rainfall simulators and in situ sample collectors for naturally occurring events. The project will also seek to sample areas affected by wildfire.
- **[Water quality modeling toolbox for pollutant reduction](#)**   
Researchers will develop a toolbox of modeling tools and will package selected models to include user-friendly protocols, documentation, and application formats. The products will facilitate technology transfer to basin users, create conceptual and operational linkages between individual models, and update the watershed model to better address the critical issue of wildfire and pollutant runoff.

**Ongoing research on lake ecology—**

- **[Predicting and managing changes in nearshore water quality](#)**   
This research is studying establishment and spread of invasive fishes and aquatic plants, and growth of periphyton (attached algae) on rocks, piers, and other hard substrates. The results will serve to develop scientifically sound management strategies and thresholds.
- **[Using remote sensing to monitor water quality](#)**   
This study is building a system to utilize remotely sensed and field measurement data to quantify changes in water clarity measurements over the entire lake.
- **[Evaluating indicators of nearshore clarity and fish habitat](#)**   
This project will evaluate conditions of the nearshore fishery and test and develop traditional and novel metrics to determine long-term and short-term changes to the nearshore habitat of Lake Tahoe.

### Ongoing research on pollutant reduction—

Fine sediments, nutrients, and other pollutants pose major threats to the clarity of Lake Tahoe. Roads and highways can also be a substantial source and conveyance of pollutants, both through generation of road dust and through runoff into waterways. Best management practices (BMPs) are designed and implemented to prevent these pollutants from entering downstream waterways. Research projects are examining how to avoid generating pollutants at their source and how to use BMPs to effectively trap pollutants before they enter Lake Tahoe.



- **Research on BMP monitoring by LTBMU**

The LTBMU has published several [reports on recent BMP effectiveness monitoring](#). A 2006 synthesis report on [urban stormwater BMP effectiveness monitoring](#) commissioned by the LTBMU concluded that wetland/wet basin systems may provide the additional treatment capabilities to “polish” stormwater and further reduce dissolved nutrient loads when inflowing dissolved levels are moderate. The report identified a need for continuous and accurate water budgets, suggested evaluating effects of chemical treatments on pollutant retention and effects on organisms, and recommended improving and standardizing future research and monitoring communications. The latter recommendation supported the effort to develop a regional stormwater monitoring program.

- **Assessment of Seasonal Pollutant Loading and Removal Efficiency of Detention Basins**

Completed in 2003, this study provided quantitative assessments of the seasonal and annual efficiency of each of the three selected detention basins at removing biologically available nutrients, total nutrients and fine sediment by comparing influent and effluent pollutant loads observed during a variety of runoff events.

- **Efficiency Assessment of Stormwater Treatment Vaults**

Completed in 2005, this report examined effectiveness of stormwater treatment vaults in reducing nutrient and sediment loads of stormwater runoff from a residential development in the Round Hill General Improvement District, located on the southeast side of the Lake Tahoe Basin.

- **Effectiveness of Highway Alignment BMPs for Sediment and Nutrient Control**

Completed in 2004, this research evaluated the nutrient and suspended sediment removal efficiency of three types of highway alignment BMPs: a sediment trap, a sediment basin and a Stormceptor®.

- **Evaluation and Enhancement of Sediment Retention & Trapping Devices**

Completed in 2007, this project was a laboratory evaluation of sediment retention and trapping devices currently utilized by NDOT in the Lake Tahoe Basin, as well as modification to these devices to increase sediment trapping and retention.

- **Regional Stormwater Monitoring Program (RSWMP)**

A [conceptual plan for regional stormwater monitoring](#) was recently completed, and the implementation phase has begun. The overall goals of the Tahoe Basin RSWMP are to develop a long-term program of stormwater monitoring, assessment, and management recommendations to inform effective and efficient reduction of pollutant loads required by National Pollutant Discharge Permit Elimination System permits and TMDL requirements. The next phase of the program will develop a quality assurance project plan (QAPP) to serve as the technical manual to be used by all participants in monitoring stormwater.

- **Minimizing road erosion** 

Researchers are refining the [WEPP:Road modeling tool](#) to produce more accurate predictions of erosion from roads by conducting field studies and additional modeling. Products of this study will serve to predict sediment loading, identify erosion “hot spots” associated with roads, and determine an optimal road network design that minimizes sediment production through BMP application and road decommissioning.
- **Assessing performance of BMPs** 

This study will develop recommended standardized protocols for monitoring, reporting, and evaluating the performance of erosion control projects in the Lake Tahoe basin. Results will be used to develop a database system to be housed on the Tahoe Integrated Information Management System ([TIIMS](#)).
- **Particle size analysis and protocol development** 

Researchers are developing guidance to standardize collection and reporting of particle size data, and creating a consistent database that includes all available data on particle size distribution and composition for Lake Tahoe, streams, urban runoff, and the atmosphere.
- **Using fingerprinting to determine sources of highway sediment** 

This study will use chemical fingerprinting to identify and map highway and road sources of fine sediment that is entering and has historically entered Lake Tahoe through stormwater runoff and streams.
- **Potential of flood plains to retain fine sediments** 

This research will quantify the potential for the Upper Truckee River and other flood plains to retain fine sediments by linking, calibrating, and validating an urban hydrology model (SWMM) and a floodplain sediment model (SIFT2D-WQ).

#### **Upcoming water quality research—**

The TMDL has identified very fine (<20 µm) particles from urban areas as one of the primary contributors of decreased lake clarity. The subthemes call for monitoring of both fine particle weights and numbers.

- **Fine particles subtheme** 

Sources, characterization and transport of fine particles from urban land uses. Primary questions under this sub-theme are:

- 1) How does fine particle generation relate to urban land uses/features (including, but not limited to, impervious coverage, single family/multiple family residences, commercial development, parking lots, construction sites, roads and shoulders, driveways, curbs and gutters);
- 2) How do natural processes and human activities contribute to fine particle formation; and
- 3) How are fine particles transported to the lake through the urban drainage network?

Research should a) quantify loads in terms of weight and numbers of fine (<63 µm) and very fine (<20 µm) particles; b) calculate the probability of particle delivery from urban stormwater to the lake; c) evaluate effects of snowmelt and snow management on particle movement; d) examine how geology, soil types, and natural erosion processes relate to fine particle generation; and/or e)

examine contributions from road sand abrasion and soil along road shoulders. Field monitoring should be conducted year-round across hydrologic seasons, using accepted methodologies for the basin and a statistical design to minimize uncertainty. Results should help refine, calibrate and validate the PLRM and prioritize projects to meet regulatory targets. [Science subtheme approved by Secretary of Interior]

Managers have stated a need for guidelines on estimating the relative levels of pollutants within catchments and consistently reporting event mean concentration (EMC). In addition to understanding the sources of fine-particle loads, they are interested in potential sinks and other factors that may inhibit particle loads from reaching the lake.

- **Urban and roadway BMP effectiveness**



What is the effectiveness of current and proposed BMPs in removing fine sediments from urban stormwater drainage? To the extent possible, research should: a) focus on all BMPs that treat urban runoff, including those on primary and secondary roads; b) evaluate removal effectiveness for particles <math><63\ \mu\text{m}</math> in diameter while focusing on those <math><20\ \mu\text{m}</math>; c) express load measurements as both weight and particle numbers; d) emphasize direct monitoring using accepted methodologies applied in the Tahoe basin; e) monitor year-round across the major hydrologic seasons; f) select BMPs that are representative of the Tahoe basin as a whole (i.e. not compliance monitoring for individual projects); g) generate results for development, calibration and validation of PLRM; h) use a statistical design to minimize uncertainty; and i) integrate results into agency efforts to track progress towards meeting regulatory targets for pollutant reduction. [Science subtheme approved by Secretary of Interior]

Agencies are interested in the suitability of surrogates for fine particle number, such as total suspended solids and turbidity, to design and evaluate BMPs. The recent [RSWMP](#) effort compiled a summary of BMP monitoring projects. Key questions relate to the potential for retrofitting, improving and innovating pollutant controls, as called for by the [TMDL](#) implementation plan. A variety of practices can be considered, including porous pavements, deicing agents, sweeping/vacuuming, and other methods to deal with winter road conditions. Efforts are needed to optimize maintenance schedules across a range of settings in the basin.

- **Treating runoff with large vegetated areas subtheme**



What is the feasibility of using large, naturally vegetated areas to remove fine sediments and nutrients from urban runoff and stream flow? Studies can address the following topics or others as determined appropriate by the respondent, a) development of statistical and modeling approaches to quantify pollutant removal, b) evaluate ability of soils and natural vegetation to treat storm water and retain pollutants over many decades, c) evaluate the regional potential for implementation of engineered storm water treatment systems and quantify load reductions for nitrogen, phosphorus and fine particles, and d) evaluate environmental impacts to community ecology and biodiversity if natural vegetated areas were used for stormwater treatment. [Science subtheme approved by Secretary of Interior]

Managers want to evaluate the effectiveness of routing or pumping runoff from urban areas and roadways into vegetated areas (considering different kinds of vegetation) in treating pollutant loads. The evaluations should consider potential risks and cost-effectiveness of such treatments relative to conventional BMPs.

### Stream Restoration

Stream restoration has been an important activity in the Tahoe basin, with numerous projects planned and implemented to restore geomorphic and ecological functions, including retention of fine sediments and enhancement of habitat for plants and



animals. We need to know how well these efforts have worked to achieve goals. Additional research is needed to help resource managers evaluate and improve the effectiveness of stream restoration efforts for producing a variety of benefits.

#### Ongoing research—

- [Applying modeling tools for stream restoration](#)   
This project is developing modeling tools to manage Lake Tahoe streams by conducting field experiments of erosion resistance of bioengineered treatments and by simulating channel response.
- [Predicting sediment load reductions from channel restoration](#)   
Through in-channel and flood-plain monitoring, this project is comparing sediment transport and retention between entrenched and unentrenched stream reaches on the Upper Truckee River. The results will help to predict how much fine sediment loads could be reduced by reconnecting stream channels to wide flood plains.
- [Tools to evaluate and track benefits of stream restoration](#)   
This project will inventory and evaluate current and completed stream restoration projects in the Tahoe Basin to determine consistent ways to define and evaluate project benefits and lessons, develop conceptual models, and refine rapid assessment tools.

#### Upcoming research—

- [Stream restoration subtheme](#)   
Research should evaluate the effectiveness of SEZ, stream and/or meadow restoration projects in minimizing downstream delivery of important pollutants (e.g., fine sediment or nutrients) and other ecological services. Of particular interest are projects that: a) evaluate the ecological and/or economic costs and benefits of stream/meadow restoration in urban areas or other areas facing special constraints due to infrastructure, and/or b) evaluate which indicators and thresholds of riparian function are most important for monitoring and evaluating project success. [Science subtheme approved by Secretary of Interior]

Research is underway to evaluate the effects of restoring incised stream channels to flood plains in terms of attenuating water flows and fine sediments. However, agencies are interested in extending that research to more streams, across a variety of pollutants, and for longer periods (to better evaluate effects of large flood events). Managers want to be able to quantify benefits of stream and meadow restoration in terms of nutrient and fine sediment removal within particular hydrologic units. Agencies are interested in the effects of stream restoration projects on other ecological values including wildlife. Additional research is desired to evaluate restoration in forested streamside environment zones (SEZs). An example of monitoring such restoration is the [Lonely Gulch Restoration Project](#).

## Air Quality and Transportation

The Tahoe Regional Planning Agency [2006 Threshold Evaluation Report](#) found that the Tahoe basin was not attaining standards for carbon monoxide, ozone, and particulates. These pollutants pose threats to human health. Air deposition of nitrogen, phosphorous, and fine sediment contributes to pollution of Lake Tahoe. Research under this topic includes sampling, modeling, and demonstration projects to control airborne particulate matter and other pollutants that may reduce clarity of Lake Tahoe or otherwise affect ecological values and human health within the basin. Research on air quality has a strong focus on transportation, as vehicles and roadway management are an important source



of pollutants. The TRPA is planning to develop basin-scale monitoring plans for particulate matter, ozone and its precursors, and vehicle congestion and distances traveled.

## Air Quality

### Ongoing research—

- **Cost-effectiveness of different road dust control strategies**   
This study will assess the impact of BMPs designed to reduce the contribution from road dust resuspended by vehicles.
- **Source of particulate matter**   
Researchers are analyzing ambient particle data to distinguish chemical species and to identify the sources of particular matter within the basin.

### Upcoming research—

- **Visibility Impairment Source Apportionment Analysis**  
The TRPA Air Quality Program has issued a request for services to analyze the visibility data collected at the South Lake Tahoe and Bliss State Park monitoring sites and other available data and reports to identify the sources of aerosol emissions that cause visibility degradation in the Lake Tahoe. The RFP opened on August 20, 2008 and will close on September 30, 2008.
- **Gaseous Pollutants Subtheme**   
Research is needed in the following areas: a) assessment of the causes of elevated ozone, b) ambient concentrations and sources of ozone forming precursors, (c) determination of the sources of ozone forming precursors (e.g., various kinds of mobile sources and biogenic emissions), or d) strategies to reduce ambient ozone levels. [Science subtheme approved by Secretary of Interior]

With regard to management strategies, air quality managers are interested in comparisons of alternative transportation policies and programs in reducing ozone levels as well as evaluations of the attainability of current ozone standards.

- **Particle Deposition Subtheme**   
Building upon previous and current studies of soil resuspension emission factors and particulate matter (PM) source apportionment, research is needed to quantify the relationships of Vehicle Miles Traveled (VMT) and vehicle class to PM loading to the lake. [Science subtheme approved by Secretary of Interior]

Atmospheric deposition of particulate matter is a major source of uncertainty in the Tahoe TMDL plan. Managers are interested in research that will serve to evaluate and optimize strategies to reduce fine particle impacts to air and lake quality, including alternative transportation programs and policies as well as roadway management practices such as deicing, sweeping, and vacuuming. Such strategies may also consider how potential changes in management practices would affect other values such as public safety.

## Cross-Cutting Science

### Climate Change

Numerous challenges to restoring Lake Tahoe are expected to occur as a result of climate change, as summarized in a [recent report by the State of Nevada](#):

- Warming and decreasing clarity of Lake Tahoe owing to changes in temperature and precipitation

- Likelihood of increased wildfires
- Spread of invasive species and insect pests such as bark beetles
- Reduced summer streamflows and threats to native fishes
- Increased ozone and particulate matter

#### Ongoing research—

The Pacific Southwest Research Station has prepared a [Web site on climate change research](#) in the Sierra Nevada.

- **Implications of climate change for design of best management practices**   
This research will examine how climate change will affect the future clarity of Lake Tahoe and BMP effectiveness by applying a climate-change model, a watershed hydrologic model, a project-scale BMP model, and a lake hydrodynamic water quality model.
- **Modeling influence of management on wildfire under future climatic conditions**   
Researchers are developing a process-based model of tree and stand growth for the Tahoe basin, which they will then use to model fire risk and fire spread for current stand conditions and the structural treatments under different carbon dioxide scenarios. The results will determine which fuel treatments reduce the risk of catastrophic fire and best meet location-specific goals.
- **Modeling cheatgrass invasion risk**   
Researchers will develop and apply a spatially explicit model of cheatgrass (*Bromus tectorum*) invasion risk in montane meadows of the Tahoe basin by examining regional and local moisture gradients and other factors that affect plant invasion in meadows. The research will predict future impacts and suggest management solutions to cheatgrass invasion under projected climate scenarios.



#### Upcoming research—

- **Managing for climate change subtheme**   
Research should aim to better inform managers of the implications of climate change for: a) forest management activities including fuel treatments, habitat restoration, revegetation, and control of invasive species; b) fire behavior and wildfire potential, c) requirements for effective defensible space, or d) the ability of stormwater management practices such as BMP, drainage control, and erosion control to diminish sediment and nutrient transport to Lake Tahoe. [Science subtheme approved by Secretary of Interior]

In addition to wanting to better understand the likely impacts of climate change in terms of changes to disturbance regimes (e.g., wildfires, droughts), managers are interested in how to modify environmental improvement strategies to ameliorate those impacts.

## Appendices

### Appendix A: Cross-Table of Resource Areas in Tahoe Plans

TRPA Regional Plan threshold categories 1987	Lake Tahoe watershed assessment 2000	Pathway planning process	Environmental Improvement Program–Phase II	Lake Tahoe Science Plan theme areas	Tahoe Science Program Update Report (this document)
Air quality	Air quality	Air quality	Improving air quality and transportation	Air quality	Air quality
--	--	Transportation			
Soil Conservation/ Stream Environment Zone (SEZ)	Upland water quality/ sediment and nutrient discharge	Soil conservation and SEZ habitats	Habitat and vegetation	Soil conservation	Stream restoration
Water quality	Water quality	Water quality	Storm water management	Water quality	Water quality
Vegetation	Biological integrity and aquatic resources	Vegetation and forest fuels	1) Forest health and fuels management; 2) Habitat and vegetation	Ecology and biodiversity	Forest health (fuels management and vegetation management)
Wildlife		Wildlife and fisheries	1) Habitat and vegetation; 2) Watershed management 3) Threatened, endangered, and sensitive species		Habitat improvement
Fisheries					
--	Socioeconomics	Socioeconomics	--	Social Sciences	
Recreation		Recreation	Enhancing recreation and scenic resources		Recreation*
Scenic Resources		Scenic quality and resources			
--	--	--	--	--	Climate change
--	Adaptive management strategy	Adaptive management system	Science and reporting	Science plan framework and overview conceptual model	Science integration

TRPA = Tahoe Regional Planning Agency, SNPLMA = Southern Nevada Public Land Management Act.

\*Recreation is not highlighted in this report since it was not included in the Round 9 subthemes. However, the Round 8 [project on the American marten](#) addresses an important recreation issue (effects of ski resorts).

**Appendix B: Science Projects Funded by Southern Nevada Public Lands Management Act**

Round	General category or theme	Subtheme	Title	Federal Sponsor
5	Air quality	N/A	<a href="#">Mobile emissions measurement and modeling in the Lake Tahoe basin</a>	EPA
5	Forest fuel management	N/A	<a href="#">Riparian fuels reduction monitoring</a>	USFS
5	Forest fuel management	N/A	<a href="#">Upland fuels reduction monitoring program</a>	USFS
5	Forest Fuel management	N/A	<a href="#">Effects of fire and long-term fire suppression on Tahoe basin water quality and biodiversity</a>	USFS
5	Biological communities	N/A	<a href="#">Lake Tahoe urban lot biodiversity study data collection</a>	USFS
5	Lake quality	N/A	<a href="#">Pelagic zone water quality and modeling of fine-sediment source, transport, and fate</a>	EPA
5	Water quality modeling	N/A	<a href="#">Groundwater monitoring and modeling</a>	USGS
5	Water quality modeling	N/A	<a href="#">Lake Tahoe total maximum daily load (TMDL)</a>	EPA
5	Pollution reduction	N/A	<a href="#">Direct runoff monitoring and load modeling</a>	EPA
5	Pollution reduction	N/A	<a href="#">Land-cover characterization of the Lake Tahoe basin</a>	USGS
5	Science integration	N/A	<a href="#">Tahoe environmental science system</a>	EPA
5	Science integration	N/A	<a href="#">Tahoe decision-support system</a>	USGS
5	Science integration	N/A	<a href="#">Lake Tahoe adaptive management framework</a>	USFS
6	Science integration	N/A	<a href="#">Adaptive management--Forest Service participation</a>	USFS
6	Science integration	N/A	<a href="#">Adaptive management framework--phase III</a>	USFS
6	Air quality	N/A	<a href="#">Air deposition studies in the Lake Tahoe basin</a>	EPA
6	Biological communities	N/A	<a href="#">Biological resource monitoring</a>	USFS
6	Air quality	N/A	<a href="#">Development of an air pollutant emissions inventory for the Lake Tahoe basin that incorporates future land use scenarios</a>	EPA
6	Pollution reduction	N/A	<a href="#">Integrated BMP modeling: application to Tahoe TMDL</a>	USGS
6	Pollution reduction	N/A	<a href="#">Stormwater treatment practices</a>	USACE
6	Science integration	N/A	<a href="#">Tahoe decision-support system</a>	USGS
6	Science integration	N/A	<a href="#">Tahoe environmental science system</a>	EPA
7	Air quality	Dust and airborne sediment control demonstration projects	<a href="#">Examination of dust and airborne sediment control demonstration projects</a>	PSW
7	Water quality	Nearshore water quality	<a href="#">Predicting and managing changes in nearshore water quality</a>	PSW
7	Water quality	Stream channel	<a href="#">Application of enhanced stream-corridor modeling tools for adaptive management of Tahoe basin streams</a>	PSW
7	Water quality	Stream channel	<a href="#">Methodology to predict total and fine-sediment load reductions as a</a>	PSW

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Round	General category or theme	Subtheme	Title	Federal Sponsor
			<a href="#">result of channel restoration in Lake Tahoe streams</a>	
7	Water quality	Fine sediments	<a href="#">Assessing sources and transport of fine sediment in responses to management practices in the Tahoe basin using the WEPP model</a>	PSW
7	Forest management	Fuel treatments	<a href="#">Potential nutrient emissions from prescribed fire in the Lake Tahoe basin</a>	PSW
7	Forest management	Fuel treatments	<a href="#">Restoration and fuel treatment of Lake Tahoe's riparian forests</a>	PSW
7	Ecological community	Conservation of ecological communities	<a href="#">Restoring sugar pine in the Tahoe Basin: regeneration ecology and recruitment dynamics of sugar pine under various stand structures</a>	PSW
7	Ecological community	Conservation of ecological communities	<a href="#">Natural and anthropogenic threats to white pines from lower montane forests to subalpine woodlands of the Lake Tahoe basin: an ecological and genetic assessment for conservation, monitoring, and management</a>	PSW
7	Best management practices	Road management practices	<a href="#">Improving road erosion modeling for the Lake Tahoe basin and evaluating BMP strategies for fine-sediment reduction at watershed scales</a>	PSW
7	Best management practices	Best management practices effectiveness	<a href="#">Development of a BMP performance assessment and data analysis system for the Tahoe Integrated Information Management System (TIIMS)</a>	PSW
7	Cross cutting	Analysis, evaluation, synthesis of existing data	<a href="#">Analysis of 15 years of data from the California State Parks Prescribed Fire Effects Monitoring Program</a>	PSW
7	Cross cutting	Analysis, evaluation, synthesis of existing data	<a href="#">Receptor modeling study to determine the sources of observed ambient particulate matter (PM) in the Lake Tahoe basin</a>	PSW
7	Cross cutting	Evaluation of basin monitoring and networks	Tahoe basin <a href="#">particle size analysis and protocol development</a>	PSW
7	Cross cutting	Evaluation of basin monitoring and networks	<a href="#">Monitoring past, present, and future water quality using remote sensing</a>	PSW
7	Science integration	N/A	Tahoe Science Consortium	PSW
8	Forest management, fuels reduction, and stream and meadow restoration	Forest and fuels reduction	Upland fuel reduction treatments in the Lake Tahoe basin: forest restoration effectiveness	PSW
8	Forest management, fuels	Forest and fuels	<a href="#">Developing FCCS fuelbeds for the Angora Fire region</a>	PSW

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Round	General category or theme	Subtheme	Title	Federal Sponsor
	reduction, and stream and meadow restoration	reduction		
8	Forest management, fuels reduction, and stream and meadow restoration	Forest and fuels reduction	Developing fuels treatments for balancing fuel reduction, soil exposure, and potential for erosion in the Tahoe basin	PSW
8	Forest management, fuels reduction, and stream and meadow restoration	Forest and fuels reduction	Identifying spatially explicit reference conditions for forest landscapes in the Lake Tahoe basin, USA	PSW
8	Forest management, fuels reduction, and stream and meadow restoration	Stream and meadow restoration	A comprehensive integration of past stream restoration efforts and future tools to evaluate and track the multitude of benefits to streams and meadows in the Lake Tahoe basin	PSW
8	Forest management, fuels reduction, and stream and meadow restoration	Recreation	The effects of ski resorts in the Lake Tahoe region of California on population dynamics of the American marten	PSW
8	Water quality	Water quality modeling	Development of a water quality modeling toolbox to inform pollutant reduction planning, implementation planning, and adaptive management	PSW
8	Water quality	Water quality modeling	Nutrient and sediment loading predictions for prescribed fire using optimized WEPP model	PSW
8	Water quality	Best management practices	Potential of engineered flood plains and wetlands as fine-particle BMPs: case study of Trout Creek and the Upper Truckee River	PSW
8	Water quality	Roadway pollutants	Determining sources of highway runoff fine sediment in stormwater, streams, and Lake Tahoe using fingerprinting techniques	PSW
8	Water quality	Nearshore	NICHES: nearshore indicators for clarity, habitat, and ecological sustainability	PSW
8	Climate change	Application of predictive models	Predictive modeling of cheatgrass invasion risk for the Lake Tahoe basin	PSW
8	Climate change	Application of predictive models	Modeling the influence of management actions on fire risk and spread under future climatic conditions	PSW
8	Climate change	Application of predictive models	The effects of climate change on Lake Tahoe, and implications for design of best management practices	PSW
8	Science integration	N/A	Tahoe Science Consortium	PSW

EPA = Environmental Protection Agency; USFS = U.S. Department of Agriculture, Forest Service; USGS = U.S. Geological Survey; USACE = U.S. Army Corps of Engineers; PSW = Pacific Southwest Research Station.

## Appendix C: Recent Publications Relevant to Round 9 Subthemes

Science as a tool in Lake Tahoe basin management (conference proceedings). Lake Tahoe science plan special workshop, October 18-20, 2006, Tahoe Center for Environmental Sciences, Incline Village, Nevada. Journal of Nevada Water Resources Association 4(1).  
<http://www.tahoescience.org/EventImage.aspx?sa=1&id=108>

### Fuels Management and Wildfire

**Beaty, R.M.; Taylor, A.H. 2008.** Fire history and the structure and dynamics of a mixed conifer forest landscape in the northern Sierra Nevada, Lake Tahoe Basin, California, USA. Forest Ecology and Management. 255:707-719.  
[http://www.geog.psu.edu/vegdyn/Publications/Beaty\\_and\\_Taylor2008.pdf](http://www.geog.psu.edu/vegdyn/Publications/Beaty_and_Taylor2008.pdf)

**California-Nevada Tahoe Basin Fire Commission. 2008.** The Emergency California-Nevada Tahoe Basin Fire Commission report. Sacramento, CA: California Office of State Publishing. <http://resources.ca.gov/TahoeFireCommission/>

**Carroll, E.M.; Miller, W.W.; Johnson, D.W.; Saito, L.; Qualls, R.G.; Walker, R.F.. 2007.** Spatial analysis of a large magnitude erosion event following a Sierran wildfire. Journal of Environmental Quality. 36:1105-1111. <http://jeq.scijournals.org/cgi/content/abstract/joenq;36/4/1105>

**Miller, W.; Elliot, W.; Hartsough, B.; Stephens, S.L. 2008.** Vegetation management in sensitive areas of the Lake Tahoe basin: a workshop to evaluate risks and advance existing strategies and practices. Expert panel report, Tahoe Science Consortium, Incline Village, NV.  
<http://www.tahoescience.org/Document.aspx?id=47>

**Murphy, J.; Johnson, D.; Miller, W.; Walker, R.; Blank, R. 2006.** Prescribed fire effects on forest floor and soil nutrients in a Sierra Nevada forest. 171: 181-199.

**Reuter, J.; Allen, B.C.; Liston, A.; Hackley, S.; Cahill, T.; Schladow, G.; Paytan, A. 2008.** Immediate environmental impacts of the Angora Fire: air quality, atmospheric deposition and Lake Tahoe water quality: 4th biennial Tahoe basin science conference.  
<http://www.nvwra.org/docs/2008/Tahoe%20Presentations/Reuter.pdf>

**U.S. Department of Agriculture, Forest Service. 2007.** [2006 Ward Unit 5 Soil Monitoring Report](#). South Lake Tahoe, CA: Lake Tahoe Basin Management Unit.

**U.S. Department of Agriculture, Forest Service. 2007.** Lake Tahoe basin multi-jurisdictional fuel reduction and wildfire prevention strategy. South Lake Tahoe, CA: Lake Tahoe Basin Management Unit. 80 p. [http://www.fs.fed.us/r5/ltbmu/documents/fuel-reduction-projects/10-year-plan/LTB\\_FUELS\\_PLAN\\_12\\_13\\_2007.pdf](http://www.fs.fed.us/r5/ltbmu/documents/fuel-reduction-projects/10-year-plan/LTB_FUELS_PLAN_12_13_2007.pdf)

**U.S. Department of Agriculture, Forest Service. 2007.** [Pre-treatment and partial-treatment forest structure and fuel loads in the LTBMU August 2007](#). South Lake Tahoe, CA: Lake Tahoe Basin Management Unit.

**U.S. Department of Agriculture, Forest Service. 2008.** [2006/2007 LTBMU monitoring program annual report](#). South Lake Tahoe, CA: Lake Tahoe Basin Management Unit.

**U.S. Department of Agriculture, Forest Service. 2008.** [Angora Fire hydrophobicity monitoring—2007 field report](#). South Lake Tahoe, CA: Lake Tahoe Basin Management Unit.

**U.S. Department of Agriculture, Forest Service. 2008.** [Heavenly SEZ Fuels Reduction Project monitoring report—March 2008](#). South Lake Tahoe, CA: Lake Tahoe Basin Management Unit.

### **Vegetation Management**

**Scholl, A.E.; Taylor, A.H. 2006.** Regeneration patterns in old-growth red fir-western white pine forests in the northern Sierra Nevada, Lake Tahoe, USA. *Forest Ecology and Management*. 235: 143-154.

### **Habitat Improvement**

**Heckmann, K.E.; Manley, P.N.; Schlesinger, M.D. 2008.** Ecological integrity of remnant montane forests along an urban gradient in the Sierra Nevada. *Forest Ecology and Management*. 255:2453-2466. <http://www.sciencedirect.com/science/article/B6T6X-4RWBCWD-1/2/7f1b4cd105eabfb98c03c916701e78b4>

**Kamerath, M.; Chandra, S.; Allen, B.C. 2008.** Distribution and impacts of warm water invasive fish in Lake Tahoe, USA. *Aquatic Invasions*. 3(1): 35-41.

**Manley, P.N.; Murphy, D.D.; Campbell, L.A.; Heckmann, K.E.; Merideth, S.; Sanford, M.; Schlesinger, M.D. 2005.** Biotic diversity interfaces with urbanization in the Lake Tahoe basin. *California Agriculture*. 60(2):59-64. [http://calag.ucop.edu/0602AMJ/pdfs/2\\_HabitatFragmentation.pdf](http://calag.ucop.edu/0602AMJ/pdfs/2_HabitatFragmentation.pdf)

**Stanton, A.E.; Pavlik, B.M. 2007.** Implementation of the Conservation Strategy for Tahoe yellow cress (*Rorippa subumbellata*). 2006 annual report. BMP Ecosciences, San Francisco, CA, prepared for Tahoe Yellow Cress Adaptive Management Working Group and Executive Committee, January 2007. [http://heritage.nv.gov/reports/rosu\\_annrep\\_2006.pdf](http://heritage.nv.gov/reports/rosu_annrep_2006.pdf).

### **Water Quality**

**2NDNATURE. 2006.** Lake Tahoe BMP monitoring evaluation process, synthesis of existing research. Prepared for U.S. Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe, CA. <ftp://2ndnatureinc.com/2ndnature/Tahoe%20References/>

**Bachand, P.; Reuter, J.; Heyvaert, A.; Fujii, R. 2006.** Chemical treatment methods pilot (CTMP) for treatment of urban runoff. Phase I. Feasibility and design. Davis, CA: University of California Davis. 165 p.

**Bachand, P.; Trejo-Gaytan, J.; Darby, J.; Reuter, J. 2006.** Small-scale studies on low intensity chemical dosing (LICD) for treatment of highway runoff. P. Bachand and Associates and University of California, Davis, Department of Civil and Environmental Engineering. 120 p. <http://www.dot.ca.gov/hq/env/stormwater/pdf/CTSW-RT-06-073-13-1.pdf>.

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**Coats, R.; Larsen, M.; Heyvaert, A.; Thomas, J.; Luck, M.; Reuter, J. 2008.** Nutrient and sediment production, watershed characteristics and land use in the Tahoe basin, California-Nevada. *Journal of the American Water Resources Association*. 44(3): 754-770.  
<http://www.hydroikos.com/PDFs/Nutrient%20&%20Sediment%20Transport.pdf>

**Heyvaert, A.C.; Reuter, J.E.; Goldman, C.R. 2006.** Subalpine storm water treatment with a constructed surface flow wetland. *Journal of the American Water Resources Association*. 42 (1): 45-54. <http://www.blackwell-synergy.com/doi/abs/10.1111/j.1752-1688.2006.tb03822.x>

**Heyvaert, A.C.; Reuter, J.E.; Thomas, J.; Miller, W.; Hymanson, Z. 2008.** Lake Tahoe Basin Regional Stormwater Monitoring Program conceptual development plan. Prepared in partnership with the Tahoe Science Consortium. [www.tahoescience.org](http://www.tahoescience.org). 48 p.

**Lahontan Water Board; Nevada Division of Environmental Protection [NDEP]. 2008.** v. 2.0. Lake Tahoe TMDL pollutant reduction opportunity report. South Lake Tahoe, CA; Carson City, NV. 279 p.  
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**Roberts, D.M.; Reuter, J.E. 2007.** Draft Lake Tahoe total maximum daily load technical report. South Lake Tahoe, CA: Lahontan Water Board; Carson City, NV: Nevada Division of Environmental Protection. 337 p.  
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**Appendix D: Contact Information for Report Contributors**

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USDA Forest Service, LTBMU	Susan Norman, Acting Ecosystem Department Staff Officer	<a href="mailto:snorman@fs.fed.us">snorman@fs.fed.us</a>	530-543-2662	Watershed restoration, climate change
	David Fournier, Vegetation Program Manager	<a href="mailto:dfournier@fs.fed.us">dfournier@fs.fed.us</a>	530-543-2626	Wildfire and fuels
	Holly Eddinger, Life Sciences Program Leader	<a href="mailto:heddinger@fs.fed.us">heddinger@fs.fed.us</a>	530-543-2633	Wildlife and invasive species
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Lahontan Water Quality Board	Hannah Schembri, Water Resource Control Engineer	<a href="mailto:hschembri@waterboards.ca.gov">hschembri@waterboards.ca.gov</a>	530-542-5423	Wildfire and fuels, water quality, climate change, particle deposition, stream restoration
US Environmental Protection Agency	Jacques Landy, EPA Tahoe Representative	<a href="mailto:Landy.Jacques@epamail.epa.gov">Landy.Jacques@epamail.epa.gov</a>	775-589-5248	Water quality, air quality, climate change, particle deposition, stream restoration
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