Tahoe Science Update Report
August 20, 2010 Version

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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) and science projects supported by the Nevada Tahoe License Plate Program.

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 SNPLMA Round 11 science priorities. The electronic version of this 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 11 themes pending approval by the Secretary of the Interior are denoted by this symbol:

A request for proposals will be issued for these themes in Fall 2010 (expected at the start of September).

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 help attain 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 coordinated, proactive approach to environmental management. The Lake Tahoe Restoration Act of 2001 (LTRA) authorized $300 million for the federal share of the EIP. A 2003 amendment to the Southern Nevada Public Lands Management Act (SNPLMA) began to allocate funding to the support the LTRA in Round 5 of SNPLMA. The bulk of the funding has been invested in capital improvement projects, while approximately 10% of funding has been reserved for science projects. A complete list of capital and science 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 the Restoration of Lake Tahoe

Scientific research has played a key role at Lake Tahoe in quantifying targets to meet environmental goals, identifying trends towards achieving the targets, and informing policy decisions. An environmental “threshold” is defined in the Tahoe Regional Planning Compact as “an environmental standard necessary to maintain a significant scenic, recreational, educational, scientific or natural value of the region or to maintain public health and safety within the region.” 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 research organizations that currently 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). More information about the mission and background of the TSC, along with its work products, is available at www.tahoescience.org.

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 proposals, (RFPs), contracts, or internal projects | Unified, competitive RFP covering all science themes |
| Review process | Varied by agency | Independent peer review for technical quality and agency input for relevancy |
| Progress reporting | Administered by individual agency sponsors | Unified reporting through PSW, updates posted on the PSW Tahoe Science Web site |

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, while 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. Beginning in round 10, the themes conformed to major program areas in the EIP.

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 review 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.
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 attaining environmental goals for the Lake Tahoe Basin.

The peer review committee recommends projects to be funded within each theme based upon a synthesis of technical quality and relevancy, subject to funding availability.
Note that the request for proposals for new research has been issued annually in the fall (typically opening at the start of September and closing near the end of October). **This report highlights all of the subthemes that are anticipated for inclusion in the next request for proposals.**

**Highlights of the Tahoe Science Program**

1. **Diverse science projects**: Dozens of projects are underway to address a wide range of scientific challenges (app. B).
2. **Multi-institutional effort**: Members of the Tahoe Science Consortium, including research and management agencies, work collaboratively 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 comprehensive 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 rigorous 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. **Science synthesis**: Annual funding from SNPLMA has provided continuous support for the TSC to synthesize and present scientific knowledge on key topics. The approach helps to build upon research conducted in previous years.
7. **Tools for managers**: Research teams have made progress in developing a variety of tools to help managers design and evaluate environmental improvement efforts.
8. **Location-specific datasets**: Research projects are in the process of identifying locations of special ecological importance.

**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 independent from the Tahoe SNPLMA Science Program. 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 Tahoe science themes. Summaries of these studies are included under relevant headings in this report.
Science Integration

Tahoe Science Consortium

The members of the Tahoe Science Consortium promote integration among the many current and future scientific projects in the basin. They seek to create an environment that promotes the contributions of the best available science, and emphasizes close cooperation with land and resource managers to transfer information effectively. TSC accomplishments and products from previous years are available at www.tahoescience.org. Key accomplishments from the past year include:

- Hosted the 5th Biennial Lake Tahoe Basin Science Conference March 16-17, 2010 in Incline Village, NV. With 275 attendees, the conference provided a forum for individuals involved in the science and management of the Lake Tahoe Basin to learn about and discuss the latest relevant scientific information and results.
- Printed and produced CDs of the Tahoe Science Plan (also available on-line at www.tahoescience.org). 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.
- Administered a directed action peer review of the Nearshore directed action project.
- Began drafting a rapid response plans for wildfires and hazardous spills in the Tahoe basin.
- Issued a quarterly newsletter to showcase current research progress related to key science issues.

Other Science Support and Integration Projects

Tahoe Integrated Information Management System (TIIMS)

TIIMS, a bi-state, multi-agency system, provides access to key environmental data and information about the Lake Tahoe Region through the World Wide Web. This project has moved the TIIMS prototype website into production. TIIMS provide an online shopping center for a wide range of users looking for information about Lake Tahoe Basin environmental planning and restoration. Many of the SNPLMA Science Projects are posting finished products on the TIIMS platform.

Tahoe Decision Support System

The Tahoe Decision Support System (TDSS) is a tool to help resource managers use the latest scientific information to make sound management decisions that maintain environmental and socioeconomic health. The system is being developed by a team of scientists from the Science Section of the USGS Western Geographic Science Center in conjunction with the Tahoe Regional Planning Agency (TRPA). Publications resulting from this project thus far include Halsing et al. 2005 and Hessenflow and Halsing (2005).
Land-cover characterization of the Lake Tahoe Basin

This USGS project mapped the current and historical state of the land surface and conducted analysis to document patterns, rates, and trends in urbanization and land-use change. It generated a map of South Lake Tahoe (Raumann 2007), a report on historical changes in the basin (Soulard and Raumann 2008), and a journal article (Raumann and Cablk 2008).

Resource Assessments by LTBMU

In 2008, the LTBMU produced two Basin-wide assessments utilizing a combination of SNPLMA funding, as well as USFS base program funds. For the Groundwater Resources Inventory of the Lake Tahoe Basin, the USGS compiled existing hydrogeologic data and other information needed to determine the extent and characteristics of the aquifers in the Tahoe Basin. The Natural Hazards Study by the USFS provides an overview of the geologic risks as natural occurrences within the Lake Tahoe Basin.

Evaluation of Nearshore Ecology and Aesthetics

A multi-institutional synthesis project has been initiated to review and synthesize existing nearshore science, management objectives, and current conditions to develop a conceptual model that relates nearshore environmental processes with the desired conditions identified by basin management agencies, to evaluate indicators and defensible standards, and to develop a monitoring plan based on these indicators for the nearshore environment. An important facet of this project will be close collaboration with the Nearshore Agency Working Group.

Evaluation of upland ecological integrity

This project is being initiated to apply the experience and expertise of a research team to synthesize past research, monitoring, and other relevant scientific knowledge in developing products to meet management needs for a comprehensive approach to managing forest uplands in the Lake Tahoe Basin. An agency working group has been formed to guide the development of this project.

TMDL Management System

This project, sponsored by the US EPA, will define structure, operations, and tools for tracking and evaluating implementation of the TMDL and for reducing uncertainty associated with source category load allocations in the TMDL. This project will create a linked series of tools, standard procedures, and feedback loops that will allow for operation of the TMDL into the future, building on projects currently under development.

LiDAR and Multi-spectral Geospatial Data Acquisition

Sponsored by the US Geological Survey and directed by TRPA, the primary purpose of this project is to collect and make available high-resolution Light Detection and Ranging (LiDAR) and multi-spectral imagery covering the entire Lake Tahoe Basin. Expected applications for this data include fuel treatment planning, fire behavior modeling, habitat restoration planning and evaluation, hydrologic modeling, accurate mapping of vegetation height, density, size, distribution and heterogeneity, terrain visualization, landform extraction, surface feature extraction, watershed and water quality evaluations, community planning, engineering surveys and planning, and natural resource monitoring and evaluation. The project proposes to deliver: 1) current LiDAR and multi-spectral geospatial datasets, 2) an analysis of the datasets to derive estimates of impervious hard and
soft coverage for the entire basin, and 3) an analysis of the datasets to derive vegetation, terrain, and
hydrologic attributes needed as inputs for fire hazard and water quality models.

This data collection effort is expected to occur in the summer of 2010, with post-processed datasets
being made available by January 2011. Investigators are encouraged to consider how their research
could utilize these datasets when they become available. Contact Shane Romsos at TRPA (see
Appendix D) for more information.

**Round 11 Science Integration Subthemes**

**Understanding current and future resource conditions through analysis of remote sensing data**

The Round 10 Lake Tahoe SNPLMA capital program included funding to acquire high-resolution
LiDAR data and multispectral imagery for the Tahoe basin. Analyses of these datasets and images
are needed to develop information that agencies can use in the future planning of capital projects,
to characterize current natural resource conditions, and to provide a baseline for comparison of
future conditions resulting from the ongoing implementation of forest management and habitat
restoration projects. Proposed research that fuses/integrates high-resolution LiDAR and
multispectral imagery to further our understanding of landuse patterns, and current and future
natural resource conditions and management options is encouraged.

Research proposals are requested to (1) provide a spatially explicit determination of current forest
structural classes across topographic features; (2) model a range of forest structure restoration
strategies that include a range of tree density reductions and creation of openings based on (a) a
range of opening sizes, (b) frequency distributions of opening sizes on the landscape, (c) rate of
application of openings, e.g., number of openings by size per year, and (d) differences between
intensity versus extent of openings. Climate change factors and model parameters could be
included in forecasting possible forest density and structural restoration. (3) Analyze datasets to
document the location and extent of hard and soft impervious cover; (4) develop derivative
products to identify catastrophic fire risk, extent and distribution of defensible space in the urban
intermix and Wildland Urban Interface, or hydrologic networks for application to TMDL project
planning, floodplain management, or characterization of stream geomorphology; and (5) develop
spatial models and maps of habitat suitability for special status plant and wildlife species or
communities of concern.

**Discussion of remote sensing subtheme**

In addition to the topics identified in the subtheme, agencies have expressed interest in the following
applications of remote sensing data:

**Impervious surfaces**: Agencies are interested in having a map of the extent and distribution of
impervious surfaces in the Lake Tahoe basin. TRPA has developed a draft Land Coverage monitoring
plan.

**Vegetation characteristics**: TRPA is interested in having a map of vegetation characteristics
following the Healthy Vegetation monitoring plan developed for the Status and Trend Monitoring
Program.

**Riparian habitat**: Agencies are interested in having a classification and map of the distribution of
riparian habitat throughout the basin through analysis and field validation of the remote sensing
datasets.

**Drainage patterns for stormwater**: Agencies are interested in having a map of the drainage pattern
of intervening zones to support the optimal placement of stormwater BMPs.

**Aquatic invasive species habitat**: TRPA is interested in research to model the spatial distribution of
suitable habitat and or abundance of various aquatic invasive species.
Identifying environmental indicators and development of approaches for monitoring and evaluation

Land management and regulatory agencies need to evaluate whether their actions are effective at meeting environmental goals. Credible evaluations require meaningful indicators, appropriate standards, and monitoring plans to evaluate the status and trends of environmental indicators relative to established standards, as well as tools and protocols for consistent and comprehensive data analysis and reporting.

Synthesis and review and/or conventional research proposals should address all of the following: (1) Synthesize and review previous and ongoing research efforts need to identify scientifically-supported environmental indicators for a specific topic area of agency interest. (2) Prepare a monitoring and evaluation plan that can be implemented to measure the identified indicators and report on long-term status and trends of environmental threshold area considering basin-wide needs, regulatory/programmatic requirements, statistical reliability, and agency financial constraints. (3) As appropriate, conduct pilot testing of field, analysis, data management and reporting protocols and procedures included in new or existing monitoring plans to support refinements that maximize the utility of these protocols and procedures to agencies. And (4) complete analyses to assess how the proposed new indicators compare to existing relevant indicators. Projects proposed under this subtheme should to the extent possible extract valuable information from existing datasets and provide data in accessible and useful formats to other researchers and managers seeking to evaluate changes in environmental thresholds. Researchers should plan to work collaboratively with agency representatives and other research teams to ensure the products will meet agency information and evaluation needs. Any environmental threshold area could be the focus of research proposed under this subtheme.

Discussion of environmental indicators subtheme

The “environmental indicators” subtheme is intended to solicit research to address specific management objectives such as the nine threshold categories identified by TRPA: Water Quality, Air Quality, Scenic Resources, Soil Conservation, Fish Habitat, Vegetation, Wildlife Habitat, Noise, and Recreation. The following link leads to the most recent evaluations of the threshold categories: http://www.trpa.org/default.aspx?tabid=174. Additional information is provided in TRPA Resolution 82-11, which found in Attachment C of TRPA’s Goals and Policies (http://www.trpa.org/documents/docdwnlds/goals.pdf). Interested researchers are encouraged to contact representatives of agencies (app. D), particularly TRPA given its responsibilities for the Environmental Improvement Program, to discuss specific needs.

Deepwater plant community: Several agencies have expressed interest in research to support the component of threshold V-2 (uncommon plant communities) that focuses on the deepwater plant community, which have not been systematically monitored. These are also concerns about endemic macroinvertebrates associated with deepwater communities. Reports and studies have suggested that these sensitive communities may be experiencing declines, but in general there has been insufficient information to evaluate their status and trend.

Small lakes: TRPA is also particularly interested in research to develop and pilot test a monitoring and evaluation plan for measuring the biological, physical and chemical condition of small lakes throughout the basin, which would encompass steps such as development of a conceptual model, monitoring plan, pilot testing, and development of a database.
Forest Health

Restoring forest structure and composition, particularly within and surrounding urbanized areas, is a major priority for land management agencies and other EIP partners.

Fuels Management and Wildfire Research

Prescribed burning and other forest treatments are being planned and implemented to reduce hazards from wildfires, such as the Angora wildfire of 2007, which was economically the most destructive fire to occur in the Tahoe basin to date. However, these activities can affect other important values, including air quality, water quality, and wildlife habitat.

Monitoring of fuels reduction treatments

The Lake Tahoe Basin Management Unit (LTBMU) has 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 Heavenly SEZ Fuels Reduction project is also monitoring vegetation response, with the first results reported in 2009.

Upland fuels treatment effectiveness monitoring

This 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.

Effects of fire and long-term fire suppression on Tahoe Basin water quality

This research project by the University of Nevada at Reno addressed the question of how alternative fire regimes have influenced, or have the potential to influence in the future, movement of nutrients from uplands to Lake Tahoe through surface runoff. It developed an ecological simulation model for analyzing the effects of varying fire regime, including fire suppression and prescribed fires for fuel management, on nutrient cycling for forests throughout the Tahoe Basin. The model predicts nitrogen and phosphorus fluxes and pools for soil and litter components, as well as potential nitrogen leachate. The study was completed in 2008.

Restoration and fuel treatment of riparian forests

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

This project has analyzed 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. A final report is available at the PSW website above. Results of this research were:

**Forest Structure and Composition:** Prescribed fire reduced the density of live trees (>2.5 cm DBH) an average of 46% in the year following fire. By ten years, the density was 65% lower. Significant tree mortality occurred only in pole-size (15-30 cm DBH) and sapling (2.5-15 cm DBH) sapling size classes. However, reduced tree density after fire did not shift the proportion of white fir, which still accounted for 75% of all trees ten years post-fire.

**Fuel Accumulation:** The pre-treatment surface and ground fuel load was significantly reduced an average 67% by prescribed fire. With an average rate of accumulation of 0.542 kg/m² for all fuel components combined, the surface and ground fuel load would be expected to equal the pre-fire fuel load by 2010. Prescribed fire significantly reduced the rotten component of coarse surface fuels (CWD) but did not reduce the sound component which accumulated to nearly three times pre-fire levels within ten years. The duff layer comprised the largest portion of the total pre-treatment fuel load and showed the largest response to prescribed fire with the greatest reduction in average loads following fire and the greatest accumulate rate in subsequent years.

**Understory Vegetation Response:** Prescribed fire significantly reduced understory cover by an average of 58% the year following fire, mainly due to a decline in shrub cover. Understory percent cover recovered to pre-fire levels by ten years post-burn, likely due to a significant increase in the nitrogen fixing shrub whitethorn (*Ceanothus cordulatus*).

**Monitoring Recommendations:** A re-sampling effort is being conducted in 2010 with modifications to the protocols including the addition of tree height, live crown base height, and canopy cover to determine current crown fire potential.

**Effects of prescribed fire on nutrient emissions in air and water**

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 is using laboratory studies, field surveys, and modeling to evaluate fuel loading in the basin. The researchers also plan to use the data from this study to estimate carbon losses to the atmosphere from prescribed fire treatments.

**Workshop on vegetation management**

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) Note that the new Round 9 project is focusing on this particular issue.

**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 followed up on this workshop by convening a working group to develop standardized monitoring protocols for vegetation management projects occurring in sensitive areas. Particular agencies in the basin are interested in these issues, but there remains a lack of consensus on what protocols should be followed in particular situations.

**Literature review on effects of fuel treatments**

The Pacific Southwest Research Station and the Tahoe Science Consortium have 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). The final report is available through the hyperlink above.

**Effectiveness of upland fuel reduction treatments**

This project is extending 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.

**Plant and Animal Responses to Fuel Treatments**

This project is a collaborative effort by UNR and PSW linked to the Effectiveness of upland fuel reduction treatments project above. This project will sample National Forest System land sites and four Nevada State Park sites for birds, small mammals, large mammals, ground-dwelling invertebrates, butterflies and plants. The data collected will be analyzed to assess the effects of fuel reduction activities on wildlife potential, the long-term ecological trajectory of forests and wildlife habitat. A Phase I Report has been completed for work 2006-2007, Phase II is to be completed late 2010, Phase III was initiated in 2009. Phase I Report Completed for work 2006-2007 (available at: http://lands.nv.gov/program/tahoeplate.htm), Phase II to be completed late 2010, Phase III was initiated in 2009.

**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, decision-makers, 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. A draft set of fuelbeds for the basin is available, and a GIS map of basin fuelbeds is being developed.

**Evaluating alternative fuel treatments in the South Shore wildland urban interface area**

This project links two commonly used tools, the Fire and Fuels Extension to the Forest Vegetation Simulator (FFE-FVS) and the Fuel Characteristic Classification System (FCCS), to develop a range
of management alternatives, including combinations of forest thinning and surface fuel treatments over time, for application in the wildland-urban interface. This project builds on the one above, which developed applicable fuelbeds.

**Balancing fuel reduction, soil exposure, and erosion potential**

Researchers from Humboldt State University and the Forest Service are quantifying 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 are determining how much current forest conditions have departed from pre-settlement 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**

The purpose of this UNR project is to: 1) quantify the incidence and severity of tree diseases, pathogens, and other biotic and abiotic damaging agents in the Nevada State Park and Tahoe basin US Forest Service lands within Nevada; 2) quantify changes in incidence and severity of tree diseases, pathogens, and other damaging agents in areas that have been treated by Nevada Department of Forestry and the US Forest Service; and 3) to use remote sensing technology to quantitatively tree crown damage to different fuel treatments. The project should assist land managers in evaluating the efficacy of fuel reduction treatments, determine how tree health varies with tree density, tree diameter and soil type and to provide an efficient and repeatable remote sensing protocol to quantify and monitor tree crown mortality. Expected date of completion is December 31, 2011.

**Predicting nutrient and sediment loading from prescribed fire using WEPP**

The Water Erosion Prediction Project (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 is optimizing the WEPP model to predict sediment and nutrient loadings from pile burning fire at the hillslope and subwatershed scales using simulated rainfall.

**Effects of pile burning in the Tahoe basin on soil and water quality**

This study is quantifying effects of pile burning on key soil physical, chemical, and biological properties by studying an assortment of pile sizes and conditions typical of Tahoe basin burning.

**Biodiversity response to burn intensity and post-fire restoration**

Researchers are monitoring to evaluate effects of fire intensity and post-fire treatments on birds, small mammals, and invertebrates by comparing multiple years of pre- and post-fire data.
Silvicultural prescriptions to restore forest health

This project will study how two overstory treatments (regular canopy tree spacing and clustered tree retention) and two understory treatments (mastication and pile and burn) affect measures of forest function (vegetation, soil properties, truffles), biological diversity (birds, small mammals, ants, invertebrates), and habitat and prey for key wildlife species of special concern (Northern Goshawk, California Spotted Owl, and American marten).

Integrated decision support for cost effective fuel treatments under multiple resource goals

This project will develop an integrated decision support system that combines the vegetation simulation capabilities of FVS-FFE, the fire behavior capabilities of FlamMap, the water quality prediction capabilities of FS WEPP, and the spatial scheduling and cost effectiveness analysis capabilities of MAGIS into a single system. This decision support tool will provide land managers the ability to spatially schedule fuel treatments on a landscape and to also analyze tradeoffs of different management strategies. This project builds upon two current research projects by the PIs, one of which is linking MAGIS with FVS-FFE and FlamMap, while the other is testing a method for incorporating sediment predictions from the FS WEPP model into MAGIS. Two on-going SNPLMA Round 7 research projects conducted by Co-PIs on this project (Assessing sources of fine sediment using WEPP, and Minimizing road erosion) will provide climate and soil data for predicting erosion rates.

Management options for reducing wildlife risk and maximizing carbon storage under future climate changes, ignition patterns, and forest treatments

This project is comparing and evaluating long-term impacts of fire suppression, prescribed fire, wildfire, and fuel treatments on the long-term potential for Lake Tahoe forests to sequester carbon or otherwise contribute to reducing greenhouse gas emissions in a global change context. The researchers will explicitly assess the tradeoffs among management for carbon sequestration, prescribed fires, mechanical fuel treatments, and stochastically recurring large and severe wildland fires. Predicted changes in climate and ignition patterns will be simulated along with changing fire spread behavior in response to future meteorological conditions, vegetation dynamics, and fuel treatments to examine long-term effects on carbon emissions, forest structure, and forest composition. The project will demonstrate an operational method for explicit consideration of greenhouse gases in landscape-level forest management. The project will leverage existing datasets from SNPLMA science projects, including use of the long-term dataset from the Round 7 science project “Analysis of 15 years of data from California State Parks prescribed fire monitoring program.” The investigators will build upon work to downscale global climate models for the Tahoe basin under the Round 8 SNPLMA science project, “The effects of climate change on Lake Tahoe, and implications for design of best management practices.”

Vegetation Management Research

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.
Restoring sugar pine in the Tahoe basin

Researchers are evaluating how burning and thinning treatments influence seedling recruitment of sugar pine, the largest pine tree in the world.

Threats to white pines: an ecological and genetic assessment

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.

Conservation, management, and responses of western white pine to environmental change

Researchers are identifying which populations of western white pines may warrant active intervention (including site preparation and planting) to sustain them under a changing climate.

Conservation, management, and restoration of sugar pine

The project objectives are: 1) determine the patterns of adaptive genetic variation across the Lake Tahoe Basin for genes controlling ecologically important plant traits (water-use efficiency, disease resistance, phenology, and growth) by genotyping individual adult sugar pines and 2) determine the underlying genes that control adaptive phenotypic traits using an association genetics approach (phenotype and determine phenotypic plasticity of sugar pine individuals for water-use efficiency, disease resistance, phenology, and growth). Identifying patterns of adaptive variation at the landscape level will constitute a valuable tool to design conservation, management (restoration or reforestation) and forest health monitoring strategies for this tree species in the Tahoe Basin. A final report is scheduled to be submitted December 31, 2011.

Conservation, management, and restoration of whitebark pine

The whitebark pine (*Pinus albicaulis*) is the highest elevation of the white pine species in the basin. This project is taking an ecological and genetic approach to better understand the interaction of landscape characteristics (geology, climatic gradients, soil properties, physiognomy) and evolutionary processes (gene flow, selection) on ecologically important plant traits (disease resistance, water use efficiency/drought adaptation, phenology, and growth). This approach will allow us to determine the adaptive genetic variation and potential, as well as to develop effective restoration and silvicultural strategies with local, diverse, and rust-resistant planting stock. This study builds upon the SNPLMA Round 7 science project, “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”, which has served to collect cones and plant seeds of all three white pine species. This project parallels the SNPLMA Round 9 science project, Conservation, management, and adaptive responses of Western white pine to environmental change and the License Plate project, Conservation, management, and restoration of sugar pine.

Stocking Guidelines for Aspen Restoration

This project will provide aspen stand data and a decision support system for Tahoe Basin land managers involved in aspen restoration. The project will quickly generate interim stocking guidelines for restorative thinning treatments in aspen stands, followed by a rigorous analysis of growth.

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regeneration, and thinning response in aspen stands. The analysis culminates in development of a transparent, user-friendly stocking assessment model that will support management decision making for restoration treatment design and scheduling of future treatments. The principal investigators are currently collaborating with LTBMU staff on two SNPLMA-supported capital projects: the Aspen Community Restoration Project and the South Shore Fuels Reduction and Healthy Forest Restoration Project. The proposed research is timed to coincide with significant restoration activities being undertaken by federal and state agencies with support from SNPLMA capital funds.

Plant community characterization and ranking of fens

The California Native Plant Society (CNPS) will monitor, map, and rank fens for their plant community diversity and quality within the Lake Tahoe Basin. The researchers will analyze data from over 100 existing fen/montane wetland surveys to refine a vegetation classification system for fens in the region. The researchers will establish a system for quantitatively ranking fens based on existing methods, and the researchers will use existing fen data and collect additional monitoring data for at least 40 stands in order to sufficiently rank fen sites. The researchers plan to focus efforts where initial reconnaissance/surveys have been undertaken by project partners, such as the US Forest Service (USFS).

Round 11 Forest Health Subthemes

Integrating the effects of forest management into the Lake Tahoe TMDL

Parallel efforts to date have collected field data and developed models for (1) effects of forest and fire management on nutrient loads in surface runoff and soil leachate in the Tahoe Basin uplands, and (2) watershed loading of sediments and nutrients to Lake Tahoe based on land use type. One model (NuCycling submodel for LANDIS-II), supported by field observations and experiments, predicts nitrogen and phosphorus leachate concentrations given forest and fuel management scenarios, but does not predict impacts to Lake Tahoe water clarity. The other model (Lake Tahoe Watershed Model - LSPC) provides input to the Lake Tahoe clarity model, but does not explicitly account for alternative forest and fuel management scenarios. Agency managers require a decision support tool for evaluating the effects of alternative forest management scenarios on nutrient and sediment loading at the watershed and basin-wide scales. TMDL Managers need to be able to link model based outputs of forest management actions to the TMDL Management System, including a comprehensive monitoring approach to validate the linkage and resulting estimates.

Proposed research should lead to increased understanding and quantification of how forest management practices (e.g., mechanical treatment, hand treatment, burning, or a combination of these activities) influence nutrient and sediment loading to Lake Tahoe and its tributaries. Research should address the question, “How do alternative forest management practices compare with regard to their short/long-term and cumulative effects on pollutant loading to tributaries and groundwater, and ultimately lake water quality?” Research proposals should address one or more of the following approaches, although proposals that integrate across these approaches are encouraged: (1) analyze, review and synthesize existing field data and incorporate results into the current models used at Lake Tahoe to simulate watershed processes (model parameterization). Where uncertainty exists, develop improved localized field data sets for incorporation into models; (2) develop modeling approaches to integrate and quantify nutrient and sediment outputs from models of vegetation dynamics in response to forest management practices; (3) develop decision support tools for evaluation of alternative upland forest management scenarios with regard to short/long-term and cumulative effects on Lake Tahoe water quality; and (4) develop a comprehensive monitoring approach to validate and calibrate model estimates.
Discussion of forest management subthemes

Managers have expressed interest in tradeoffs between reduced wildfire hazard and potential impacts to water quality. There has been 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.

The draft EIP Update states several near-term science priorities for forest health:

- Developing a Basin-wide forest monitoring program that operates in concert with fuels reduction projects to quantitatively assess at various spatial scales the effects of fuels reduction projects on the spectrum of ecosystem management objectives.
- Conducting focused studies to better understand thresholds of change in habitat loss, habitat alteration, or habitat use in urban forests.
- Conducting focused studies to evaluate alternative strategies to minimize the impacts of fuels management projects in stream environment zones.
- Conduct focused studies to objectively determine the appropriate management strategies that maximize defensible space, but at the same time function to minimize erosion and the degradation of runoff water quality.

Impact of climate change on ecological communities and evaluation of adaptation strategies

Significant changes in climate, recreational use, and air pollution are expected to affect the Sierra Nevada in coming decades. Management agencies want to understand how ecological communities within the Lake Tahoe basin, including forest communities, alpine communities, subalpine wetlands and other sensitive communities, will respond to these changing conditions over the next few decades. Current science emphasizes that adaptation strategies should be site-specific. Adaptation strategies could include thinning of forests to increase tolerance to drought and resistance to wildfire or insects, planting species or genotypes that may be more resilient to changing climate, genetic conservation of species, preservation of refugial habitats (including wetlands and riparian areas), assisted migration of species to suitable habitat, and development of wildlife corridors to facilitate migration. Such actions could be taken in anticipation of future changes or opportunistically following disturbances such as wildfires.

Proposed research projects should conduct new research and/or synthesize previous research to:
1. establish the potential range of key climate conditions relevant to ecological processes and biological communities in the Tahoe basin;
2. identify which ecological processes and biological communities in the Tahoe Basin are most vulnerable to the effects of climate change;
3. evaluate the effects of Basin-specific adaptation strategies and treatments to conserve particular ecological processes and biological communities; and/or
4. guide the temporal and spatial design of forest treatments to avoid unacceptable ecological impacts while promoting long-term desired conditions (particularly in the Jeffrey pine, mixed-conifer, and lodgepole forest community types).
Watersheds, Habitat, and Water Quality

Habitat Improvement Research
The Tahoe basin harbor 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. Numerous invasive species (both terrestrial and aquatic) now have established populations in the Lake Tahoe Basin, and the threat of additional introductions persists present. The effects of aquatic invasive species are most pronounced in the nearshore habitats of Lake Tahoe, while recently disturbed forest and urban areas are most susceptible to the invasion of terrestrial species.

Urban Biodiversity Project
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.

Multi Species Monitoring Project
This project utilizes the Multiple Species Inventory and Monitoring (MSIM) protocol, which was conceived as part of the Sierra Nevada Framework Project as a means of monitoring the large number of species of concern throughout the Sierra Nevada in an effective and cost efficient manner. The final report presents a detailed inventory of species in the Lake Tahoe Basin, along with recommendations for future monitoring.

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.

Wildlife Habitat Occupancy Models for Project and Landscape Evaluations
The goal of this project is to use existing empirical field data that was collected in a systematic manner in the Lake Tahoe basin to develop geographic range maps and habitat occupancy models for high priority forest-associated vertebrate species in the Lake Tahoe basin. The researchers propose to build habitat occupancy models because they are more robust than abundance models. These models will facilitate site and landscape-scale evaluations of management treatments, climate change, and other change agents that affect forest structure and composition today and in the future. This project utilizes significant investments previously made by local agencies and SNPLMA through the Multiple Species Indicator Monitoring (MSIM) project.

Forest management effects on woodpeckers as keystone species
This project will investigate the role of primary cavity excavators in the facilitation of colonization of secondary cavity users. Nest webs illustrate the interrelationships between species that exhibit sequential use of substrates for nesting, resting, or roosting, and they will be created to investigate how secondary cavity users utilize woodpecker cavities in burned and areas under various restoration treatments. These nest webs illustrate where interrelationships between and among species are strongest, and it will allow predictions on both direct and indirect effects of fire severity and post-fire restoration practices on woodpeckers and secondary cavity users. The Angora Wildlife Monitoring
Project (AWMP) was a 2-year multi-species investigation of the effects of fire and post-fire management practices on birds and small mammals. The Round 9 SNPLMA science project, “Biodiversity response to burn intensity and post-fire restoration” expanded this effort to include a larger number of sites (from 42 to 72), invertebrates, and nest-site selection by woodpeckers. The data obtained in this study will complement and enhance the existing study by investigating the process by which cavity excavators facilitate the recovery of bird and small mammal communities in burned areas and in what ways management activities help or hinder the restoration process.

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.

An inventory and baseline monitoring of the bird fauna of the Carson Range

This project includes the sampling of bird fauna across all vegetation and other land cover types, from lake level to summit peaks of the range, and along the eastern slopes of the range to moderate elevations. Sampling will be carried out from early spring to late autumn to capture the full range of bird use, including migration and post-breeding dispersal. Data gathered will be used to develop a pamphlet with illustrations for visitors to Nevada’s State Parks. The sampling is also intended to support a future monitoring scheme that uses breeding birds as one taxonomic group to assess environmental changes across the Nevada Tahoe basin landscape. Lastly, bird-habitat models for breeding avian species richness and abundance and key indicator bird species will be developed. The final report is available--contact Elizabeth Harrison at Nevada Division of State Lands (app. D).

Characterizing mountain lion distribution, abundance, and interactions with prey populations

The purpose of this project is to obtain essential data to make informed management decisions regarding mountain lions and their prey while providing land-use planners with information to preserve critical habitat and travel corridors in Nevada. This project will: 1) model the genetic structure of mountain lions within Nevada and across state lines to identify distinct sub-populations and determine whether they interact as a metapopulation; 2) examine prey species selection and kill rates of collared lions in select populations; 3) refine and validate the NDOW mountain lion population model through extensive ground truthing of model parameters; and 4) determine the relative influence of environmental variables, human impact, immigration and other potentially relevant factors in regulating mountain lion distribution and abundance in different areas of Nevada including the Lake Tahoe Basin. The final report is to be delivered May 2012.

Controlling the Proliferation of Invasive Warm Water Fishes

The primary goal of this project is to minimize and control the proliferation of nonnative warmwater fish species within Lake Tahoe. This project includes the assessment of 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. In addition, 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 comprises year one of a three year project, it is related to ongoing nearshore lake quality research. Final report is available at http://lands.nv.gov/program/tahoeplate.htm
Invertebrate survivability study (USACE)

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 is examining the minimum required water calcium levels for 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. A presentation on the study is available, as is a summary report on Asian clam in Lake Tahoe.

Development of a risk model to determine expansion and impacts of Asian clams in Lake Tahoe

This new project will study the spread of Asian clams in the lake, help agencies to develop control methods, predict likely future locations for clam colonization, and assess the impact of clams on both a local and lake-wide scale.

Expansion of Asian Clams in Lake Tahoe: A Risk Assessment of Spread, Habitat Choice, and Potential Impact

This project will develop a risk analysis of Asian clam distribution and its environmental impact by examining structure, transport, life history, and energetics of existing populations discovered in Lake Tahoe. The specific objectives are to 1) determine the environmental parameters that contribute to the establishment and expansion of clam beds; 2) develop a life history-growth model to determine potential growth and reproduction; 3) create a transport model that estimate the most favored pathways of young life stages of Asian clams; and 4) develop a preliminary understanding of clam impact on particle size distribution of phytoplankton and fine sediments. The project is set to complete by August 31, 2011.

Asian Clam Pilot Removal and Monitoring Project

The TRPA is leading a pilot project for Asian clam removal in Lake Tahoe. It will explore the effects of diver-assisted suction removal, bottom barriers and a combination of both treatments on clam survival and reproduction. Also, monitoring and laboratory experiments will be completed to track changes in growth and biomass of algal blooms. Lastly, sediment hand cores will be taken during the pre-installation baseline establishment period and at the time of barrier removal. The final report is due November 30, 2010.

Inventory and Monitoring of Butterflies

This project includes sampling of butterfly fauna in the Lake Tahoe Basin (Nevada State Park lands in particular) and the Carson Range, in all vegetation types. This information will provide baseline data for the support of a future monitoring scheme that uses butterflies as a taxonomic group to assess environmental change across the Nevada Tahoe landscape. In addition, a comprehensive, annotated list of butterfly fauna for the Carson Range and the Nevada side of the Tahoe basin will be developed for future adaptation into an information brochure for distribution to the public. A report was completed in August 2008--contact Elizabeth Harrison at Nevada Division of State Lands (app. D).

Lake Tahoe Basin Invasive Weed Management Project

This project will maintain and improve the health of the Lake Tahoe Basin by preventing and controlling the rapid expansion of invasive weeds and non-native, aggressive, foreign plant species. This project will include the treatment of high priority historical infestations and new populations of
surveyed, mapped and monitored noxious weeds on the Nevada side of the Lake Tahoe Basin within public rights-of-way and on NV State Park lands. Treatments will be completed on individual infestations by a contracted, certified pesticide applicator, and will utilize an Integrated Pest Management approach, including hand pulling, digging, and herbicide treatments. Basin-wide weed surveying, mapping and monitoring as well as research, education and outreach efforts will be completed using separate funding sources. The project is set to complete by December 31, 2010.

Natural and human limitations to Asian clam distribution and recolonization

The major objectives of this project are to (1) understand the life history (including reproduction and growth) of deepwater clam populations and their relationship with associated benthic macroinvertebrate communities, chlorophyll concentrations, temperature, water currents and nearshore clam populations as a potential source or sink of recruits, (2) develop the relationship between treatment site selection (i.e., low population density site versus high density population center site) and rate of Asian clam recolonization, and (3) perform a cost efficiency analysis of rubber bottom barrier application that is dependent on recolonization rate and site selection. This project builds upon the Round 9 SNPLMA science project, “Development of a risk model to determine the expansion and potential environmental impacts of Asian clams in Lake Tahoe.” A final report is scheduled to be submitted May 31, 2012.

Potential for Pathogen Growth, Fecal Indicator Growth and Phosphorus Release under Clam Removal Barriers

The project seeks to measure the impact of clam barriers – rubber sheets that are spread on the bottom of Lake Tahoe to create anaerobic conditions to kill Asian clams – on the survival and re-growth of fecal indicator bacteria (FIB) and potential bacterial pathogens, and the release of soluble reactive phosphorus (SRP) from the anaerobic sediments that are produced through the treatment. The goals of the project are to (1) establish if FIB can re-grow under low oxygen conditions underneath clam barriers positioned in the lake, (2) perform spiking experiments with fecal material to track the fate of FIB and two relevant bacterial pathogens, *Campylobacter jejuni* and *Salmonella enterica*, and (3) quantify the release rates of phosphorus from the sediments associated with Asian clam growth in Lake Tahoe.

Round 11 Aquatic Habitat Improvement Subtheme

Understanding the impacts of aquatic invasive species

The prevention of new introductions and the control of established invasive species is a high priority for Tahoe basin land management and regulatory agencies. Agencies have a need for ongoing quantitative information to manage established species and minimize their impacts. Information related to prevention is required to assess risks from individual species and to track environmental conditions that may facilitate new invasions. Information related to control of invasive species is needed to assess the effectiveness and potential environmental effects of various control strategies. Long-term status and trend monitoring of priority invasive species in near shore habitats and streams in the Tahoe basin and their environmental effects is needed for strategic planning efforts and assessment of impacts to environmental thresholds.

Synthesis and review and/or conventional research should be conducted in collaboration with agency representatives and other research teams to ensure products will meet agency information and evaluation needs. Proposals are requested to: (1) Synthesize existing data and develop new strategies to prepare a regional and sub-regional monitoring plan for priority aquatic invasive species (AIS). The monitoring plan should assess the long-term status and trends of established
AIS, aid the early detection of new invasions, and provide insight into the effectiveness of control and prevention strategies in Lake Tahoe’s near shore environment, tributary streams, and other lakes of the region. (2) Determine the effectiveness of various control strategies for priority species, such as treatment of satellite populations vs. source populations, re-colonization rates, and the effects of control measures on near shore water quality and aesthetic indicators (biological, chemical, and physical). (3) Develop a predictive model to assess the risk of introduction of priority invasive species based on life history, habitat requirements, current and predicted environmental conditions of the region, and vectors, such as motorized boats, non-motorized watercraft (e.g., kayaks, canoes, or paddle boards), aquatic accessories (e.g., beach toys or power boat toys), and boating appurtenances (e.g., anchors, lines, or fenders).

Discussion of habitat improvement subtheme: invasive species emphasis

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). An Aquatic Invasive Species Management Plan has been approved by the Aquatic Nuisance Species Task Force and endorsed by the Governors of Nevada and California and the TRPA executive director. The plan identifies the Lake Tahoe Aquatic Invasive Species Interagency Working Group as the body to recommend research priorities. Some of the current research priorities identified in the plan include interactions of native and non-native species, effects of climate change on AIS establishment, and evaluating potential sites for invasion. The plan identifies a variety of research questions that should be considered as part of AIS management efforts, including:

Environmental

- Are calcium levels in Lake Tahoe adequate to support all life stages of quagga/zebra mussels (this work in currently underway at UNR)?
- How do seasonal changes in calcium concentration affect mussel survivability (question being addressed by UNR)?
- Are concrete structures substantial sources of calcium to facilitate dreissenid mussel establishment?
- What are other substantial sources of calcium to Lake Tahoe that could support dreissenid mussel establishment?
- What are the spawning cycles of largemouth bass and other warm water fishes in Lake Tahoe?
- Are there unique microhabitats in the Region that would allow otherwise unpredictable invasions, e.g., geothermal springs?
- Is the algal assemblage in Lake Tahoe sufficient to support invertebrate growth and reproduction?
- Will physical habitat in the Lake Tahoe be limiting to quagga and zebra mussels?
- What causes the massive die-offs of signal crayfish along the west shore of Lake Tahoe?
- What are the impacts of signal crayfish on sedimentation and water clarity?
- Which waterbodies in the Tahoe Region are at risk for New Zealand mudsnail invasion?
- What other areas of Lake Tahoe physically resemble those currently inhabited by Asian clams? And, are chemical conditions limiting to survival of Asian clams in these areas?

Management

- Will management strategies for existing AIS alter Lake Tahoe water quality, food web structure, and benthic ecology?
How can IPM be better incorporated into AIS control/eradication efforts?

Interaction with Other Existing AIS

- Can nearshore habitats currently infested with AIS (e.g., Eurasian watermilfoil, Asian clams) facilitate the establishment of other AIS (e.g., quagga/zebra mussels, New Zealand mudsnails, and hydrilla)?
- How does competition with other invasive species (bivalves and macrophytes) affect ability to colonize or to maintain established colonies of Asian clams?
- What is the energetic contribution of signal crayfish to predatory warm water fishes such as largemouth bass?
- Will Asian clam removal facilitate recolonization by Asian clams or other invasive species (e.g., aquatic weeds, dreissenid mussels)?
- Are there potential predators of the New Zealand mudsnail currently in Lake Tahoe?
- How do established colonies of New Zealand mudsnails affect potential colonization for other invasive species?

Surveys

- Survey tributaries to Lake Tahoe and other waterbodies in the Region for AIS such as New Zealand mudsnails, Asian clams, and non-native submersed aquatic plants.
- What is the level of *Batrachochytrium dendrobatidis* (Bd) infection in native amphibian populations and their habitats?

Vector Pathways

- Examine new vector pathways for existing species of concern.
- What are the primary pathways of AIS introduction to Lake Tahoe in addition to motorized watercraft?
- What are the likely pathways of New Zealand mudsnail introduction to Lake Tahoe?

Climate Change

- What is the response of warm-water fishes and bullfrog in Lake Tahoe to regional/local climate change (UCD 2008)?
- Will physicochemical factors resulting from climate change enhance potential for successful colonization of new AIS?

The threat posed by three invasive mollusks (quagga mussel, zebra mussel, and New Zealand mud snail) has become a particular priority for many management agencies. The Invertebrate Survivability Study and other projects have sought to evaluate the risk that these invasive species may become established. Researchers have recently reported initial results from water sampling and bench tests that indicate that quagga mussels can grow and reproduce in conditions found in various areas of Lake Tahoe.

The non-native Asian clam (*Corbicula fluminea*) has already become established and may be creating habitat that favors invasion by other mollusks. Researchers at the University of California Davis have published findings concerning the spread of the clam, and the University of Nevada Reno has contracted with the Scripps Institution of Oceanography to use sonar to identify clam beds in Lake Tahoe. A topic of interest is the possible relationship between Asian clam beds and algal blooms in the nearshore environment.

In addition to the mollusks threatening the lake, several kinds of fishes and plants have 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.

Several near-term science priorities for invasive species are included in the draft EIP Update:

- Using carefully designed pilot projects, complete science-based evaluations of the effectiveness of alternative strategies to control and manage invasive and noxious species that are now established in the Tahoe Basin.
- Developing and maintaining a basin-wide monitoring program of both aquatic and terrestrial habitats to assess the distribution and abundance of invasive species now established in the Tahoe Basin. This monitoring program should also serve as one component of an early warning system to detect new invasions.
- Examining the factors affecting nearshore water quality and ecology.
- Conducting focused studies to develop invasive species threshold carrying capacities for terrestrial and aquatic habitats.

**Water Quality Research**

“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.

**Lake Tahoe total maximum daily load (TMDL)**

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 Water Erosion Prediction Project (WEPP) modeling tool is being refined to predict baseflow, runoff, and sediment from watersheds in the basin. 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.

Water quality modeling toolbox for pollutant reduction

Researchers are developing and packaging modeling tools that will better evaluate pollutant loads from wildfire and stormwater. The products will facilitate technology transfer to basin users, create conceptual and operational linkages between individual models, and update the Lake Tahoe Watershed Model to better address pollutant runoff from wildfire.

Development and Validation of the Tahoe Project Sediment Model

This project will develop an upland decision support tool to assist managers in the selection and assessment of site-specific management options to reduce forest fuel loads and to evaluate effectiveness of sediment mitigation practices. The proposed online model will be a flexible web-interface tool which will assess the effects of site specific management practices on sediment transport and delivery from a treated hillslope to a channel and will be developed such that new information can be incorporated into the tool as it becomes available from on-going research in or near the basin. The project will utilize results from several previous and current SNPLMA research projects and monitoring data to develop, parameterize, and validate the online decision support system.

Lake Ecology Research

Pelagic zone water quality and modeling of fine sediment source, transport and fate

This EPA-sponsored project was intended to (1) establish a monitoring program to evaluate trends in lake particle composition, (2) gain a better understanding of the sources of fine sediments entering the lake, (3) evaluate other physical, chemical and biological processes that effect algal growth, particle distribution and clarity, and (4) further refine the Lake Clarity Model. A final report, “Sources, distribution and dynamics of fine particles in Lake Tahoe: linkage to restoration of lake clarity” by UC Davis is available from EPA. Many of the work products from this project were required for the refinement of the Lake Clarity Model and incorporated into the development of the TMDL.

Predicting and managing changes in nearshore water quality

This project is studying the establishment and spread of invasive fishes and aquatic plants, and growth of periphyton (attached algae) on rocks, piers, and other hard substrates.

Researchers are testing models that predict how water clarity varies across and within the lake (in three dimensions) during wind-driven
upwelling, during phytoplankton blooms, and in relation to stream inflows.

**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**

In conjunction with the Nevada License Plate funded project below, this project is evaluating conditions of the nearshore fishery and testing metrics to evaluate long-term and short-term changes to the nearshore habitat of Lake Tahoe. A final report is expected September 30, 2010.

**Development of nearshore fish indicators for Lake Tahoe**

This project will develop new metrics that will assess short, mid, and long-term changes to the nearshore fishery in Lake Tahoe. This information will support evaluation and planning efforts associated with the Tahoe Regional Planning Agency’s fisheries threshold which is currently in non-attainment. The investigator will evaluate whether traditional indicators such as density, growth and body condition commonly used to assess impacts in other ecosystems can be used to determine fishery changes in Lake Tahoe. Also experiments and field sampling will be conducted to explore the development of novel indicators such as ultra violet light and trophic niche to measure short term changes in the fishery. The development of these metrics will allow managers to select which indicators are appropriate to monitor changes to the nearshore fishery at Lake Tahoe. Data collection is still in process, and a final report is expected September 30, 2010.

**Linking on-shore and nearshore processes**

This project was designed to demonstrate the utility of establishing a near-shore monitoring program using data collection buoys to track changes in localized shorezone characteristics. A buoy was deployed near the mouth of Third Creek to collect near-continuous data on turbidity, light attenuation, chlorophyll and temperature. An attempt was made to develop relationships between near-shore water clarity and specific on-shore events within the Third Creek watershed. In addition, near-shore water quality was evaluated by conducting lake perimeter surveys of turbidity and chlorophyll on a seasonal basis in conjunction with air quality monitoring and sampling associated with a separately funded project. A final report is available-contact Elizabeth Harrison at the Nevada Division of State Lands (app. D).

**Nearshore Water Quality Monitoring at Lake Tahoe**

This project is designed to build off of previous research (above) which tested the feasibility of using buoys to measure near-shore water quality conditions. This work will address and solve operational issues previously discovered during the initial study. Specifically, the project will include: 1) a continuous one-year long buoy deployment to assess seasonal operations; 2) to test a new anti-biofouling design for the light transmissivity and chlorophyll fluorescence sensors and; 3) the addition of a temperature string and multi-level sampling to assess depth-dependent changes in temperature, transmissivity, and relative chlorophyll. The final report is scheduled to be submitted November 30, 2011.
Use of thermal tracing techniques to identify groundwater influences on aquatic plant distribution in the nearshore zone of Lake Tahoe (Nevada Division of Environmental Protection)

This study will evaluate the relationship between groundwater discharge and the distribution of aquatic plants utilizing a fiber optic distributed temperature sensing (DTS) system to measure temperature along several 100 m of the shallow near-shore zone at Lake Tahoe. The analysis will examine relationships among groundwater flux rates, water chemistry, and the spatial coverage of periphyton-macrophyte biomass.

Stormwater Pollutant Reduction Research

Fine sediments, nutrients, and other pollutants from stormwater 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 publishes annual reports on Forest BMP effectiveness monitoring. This BMP monitoring is supported through various projects funded through SNPLMA, along with USFS base program funds. In addition, as part of the LTMBU Urban Erosion Control Grants program, the LTBMU commissioned a 2006 synthesis report on urban stormwater BMP effectiveness monitoring. This report 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, which is currently being supported by the LTBMU Urban Erosion Control Grants program funded through SNPLMA.

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 commercial stormwater treatment system.
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.

Groundwater receiving stormwater runoff and potential contaminant transport

This USGS study, reported by Green et al. (2008), documents hydrogeologic conditions in a shallow aquifer and associated interactions between a stormwater control system with nearby Lake Tahoe from 2005-2007. Selected chemical qualities of stormwater, bottom sediment from a stormwater detention basin, ground water, and nearshore lake and interstitial water are characterized and coupled with results of a three-dimensional, finite-difference, mathematical model to evaluate responses of ground-water flow to runoff accumulation in the stormwater control system.

Integrated BMP modeling: Application to Tahoe TMDL

This project is customizing a basin-scale BMP model / module and incorporating it into the Load Simulation Program (LSPC) watershed, land-use based, pollutant loading model (Load Simulation Program in C++) that is currently being used in the Lake Tahoe TMDL. This is necessary for effective water quality planning, determination of BMP priorities, evaluating progress towards meeting the TMDL and, providing a quantitative and science-based focus to the Environmental Improvement Plan (EIP). The project is sponsored by the USGS under the direction of the Nevada Department of Environmental Protection.

Direct runoff monitoring and load modeling (Regional Stormwater Monitoring Program)

The overall goals of this joint DRI-UCD project were 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. A conceptual plan for regional stormwater monitoring was completed and posted on the TSC website. That report was modified into a final report (available from EPA), which also includes the results of continuous monitoring from Water Year 2003 through Water Year 2008 at selected stormwater monitoring sites within the Tahoe Basin. The next phase of the program (funded through the LTBMU Erosion Control Program) is developing a quality assurance project plan (QAPP) to serve as the technical manual to be used by all participants in monitoring stormwater.

Integrating private parcel water quality and fire defensible space information into SWQIC’s existing conditions analysis and its pilot application to the Phase 3 portion of the Crystal Bay II Project Area

This TRPA-led project is developing an option to employ a more focused and refined existing conditions analysis memorandum procedure that focuses and retrieves more specific and useful project area information. This information will serve the effort to incorporate private parcel storm water and fire defensible space measures into the Environmental Improvement Program (EIP) water quality project planning and permitting process. This approach to conducting Existing Conditions Analysis will assist implementers and regulators in determining and evaluating the feasibility of more optimal storm water project designs. Additionally, this project strives to balance costs and benefits to achieve the highest pollutant load reductions through a more comprehensive approach to neighborhood storm water projects. The project is set to complete by December 31, 2010.
Quantification of changes in water quality due to enhanced source control

This project, led by the Nevada Tahoe Conservation District, will monitor matched roadway catchments in Washoe County to determine the water quality benefits of street sweeping (in terms of pollutant removal). Estimates of particulate matter on roadways before and after road sweeping will be determined using a “true HEPA” vacuum. Material captured in the “true HEPA” vacuum will be analyzed to determine the bulk size distribution of particulate matter. In addition vehicular traffic will be counted periodically to evaluate impacts of traffic on fine sediment generation from road abrasives. Also atmospheric monitoring equipment will be installed to determine atmospheric deposition of particles to the project sites. Lastly, multiple water quality samples will be collected automatically and analyzed for each runoff event. The final report is due August 31, 2010.

Cultured periphyton process for nutrient and fine sediment removal

This DRI project has evaluated the effectiveness and applicability of cultured periphyton as an ecologically-based advanced treatment technology to reduce stormwater pollutant loadings in a real world setting located on the Nevada side of the Tahoe Basin. The effectiveness of this system will be based on the water quality of the influent and effluent of this system in addition to the analysis of harvested biomass. Key design, operation and maintenance guidelines will be identified for possible future deployment of this stormwater treatment system throughout the Tahoe Basin. A final report can be downloaded at http://lands.nv.gov/program/tahoeplate.htm

Rosewood Creek monitoring

This DRI project continued a long-term monitoring effort on Rosewood Creek which is a major tributary to Third Creek. Monitoring data will help support restoration designs of the middle reach of Rosewood Creek and post-construction data will provide understanding of how stream restoration projects can reduce the delivery of nutrients and suspended sediments to Lake Tahoe. This project will also supplement previous monitoring on the lower reach restoration project in an effort to identify the efficiency of this project reducing suspended sediment loads. In addition, this data may be used for future calibrations of the CONCEPTS model which was developed as part of the Tahoe Total Maximum Daily Load (TMDL). The final report is scheduled to be delivered August 31, 2010.

Hybrid BMP Retrofit of a Primary Roadway

This project includes the design, construction and monitoring of multiple stormwater treatment best management practices (BMPs) based on low impact development concepts for a Washoe County public right-of-way. The LID improvements will allow stormwater to infiltrate in off-line systems to sequester fine sediment and other pollutants and will ensure that future events will not flush out captured pollutants. The monitoring design and data collection efforts will be completed to ensure effectiveness data can be input into the Pollutant Load Reduction Model (PLRM). The final report is scheduled to be submitted March 31, 2013.

Assessing performance of BMPs

This study is developing 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).
Analysis of particle size data

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. They are developing cost-effective methods to better monitor the fine particle pollution that threatens lake clarity.

Water quality modeling toolbox for pollutant reduction

Researchers are developing and packaging modeling tools that will better evaluate pollutant loads from wildfire and stormwater.

Using fingerprinting to determine sources of highway sediment

This study is using chemical fingerprinting to identify and map highway and road sources of fine sediment delivered to Lake Tahoe via stormwater runoff and streams.

Potential of floodplains to retain fine sediments

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

Urban stormwater fine sediment filtration using granular perlite

This project will test the effectiveness of granular perlite as a practice for treating urban stormwater in an existing system that currently discharges directly to Trout Creek.

Stormwater treatment practices

This US Army Corps of Engineers project sponsored the three projects listed below using funds from Rounds 5 and 6 of SNPLMA.

Development of hydraulic design criteria

This US Army Corps of Engineers project established hydraulic design criteria for BMPs based on hydrologic characteristics in the basin.

Development of pollutant load reduction model

The project, led by Northwest Hydraulic Consultants, focused on creating stormwater loading evaluation tools. The model has been completed but is frequently being updated.

Refinement of pollutant event mean concentrations for various land types

This project, led by 2ndNature LLC, developed a data collection strategy to improve the scientific basis of the Pollutant Load Reduction Model (PLRM). The goal of this data collection is to provide improved scientific basis to: 1) validate and refine the relative role of specific geographic, physical, anthropogenic and source control factors on the likely urban roadway condition, 2) estimate fine sediment particle (<16μm) CRCs and variability relative to different road conditions, and 3) estimate fine sediment particle CECs for two typical Lake Tahoe stormwater treatment BMPs types: detention
basins and media filters. The project was completed and a report is available from 2ndNature. The next project has picked up from where this project has left off.

**Priority urban stormwater monitoring to directly inform the Pollutant Load Reduction Model (PLRM)**

This project will estimate pollutant loads (focusing on very fine sediments) in runoff from specific urban land uses and from typical stormwater treatments in the basin. The project will build upon the monitoring plan and the data analysis conducted through the project above to refine the PLRM database.

**Development of a road cut and fill land use category for the Pollutant Load Reduction Model (PLRM)**

This project will examine directly measured erosion data and conduct targeted rainfall simulation to evaluate pollutant loading from road cut and fill slopes.

**Measuring the ability of floodplains to treat urban runoff in the Lake Tahoe basin**

This project will quantify how gravitational settling and biofilm processes remove very fine (<20 micron) particles from urban stormwater and determine the composition of the stormwater and particles to assess the potential for negative impacts to floodplain biota and their food webs.

**Tahoe Stormwater Particle Assessment and Management for Urban and Roadway Runoff**

The intent of this project is to add to our current, yet incomplete knowledge concerning fine particles. Specifically, this project will (1) provide information to help establish reliable, calibrated relationship(s) between turbidity, the mass of size-fractionated suspended solids, and the number of <16 micron particles in stormwater runoff; (2) provide details on mechanisms involved in the removal of fine particles in vegetated BMP treatment basins; and (3) provide data on the efficiency of this commonly used BMP type, while also giving recommendations for design characteristics to increase fine particle removal. This project also will build upon information developed from the projects listed above.

**Defensible Space-Erosion Protection Tools Development**

This research will identify, study and quantify defensible space practices around homes that are capable of reducing or eliminating fire risk, while minimizing erosion, protecting water quality, infiltrating stormwater and snowmelt, reducing runoff and gaining acceptance from fire agencies and homeowners. The researchers propose to evaluate eight promising soil protection Best Management Practices (BMPs) for both flammability and erosion control parameters. The researchers will directly measure both variables and, in coordination with BMP implementation staff, fire districts and homeowners, will implement the most mutually-effective BMPs at three residences to showcase defensible space practices that achieve both fire protection and erosion control-water quality objectives. This project will build upon information from the forested upland chapter of the Lake Tahoe TMDL Pollutant Reduction Opportunities Report.
Round 11 Stormwater Quality Subtheme

Quantifying the benefits of urban stormwater management

Research associated with the Lake Tahoe total maximum daily load (TMDL) indicates that stormwater from urban land uses is the largest contributor and presents the greatest opportunity to reduce fine sediment particle (< 16 µm) and total phosphorous loads to streams and Lake Tahoe. However, pollutant loading and reduction estimates are based upon limited information, particularly with respect to fine sediment particle size class distribution. Improved characterization of urban stormwater is needed for the purposes of load reduction modeling, BMP design and TMDL crediting. A better understanding of the factors and processes related to the generation, mobilization, transport and fate of pollutants is needed. Furthermore, a better understanding of innovative treatment and control/recovery mechanisms to reduce fine sediment particles is needed to inform feasibility and cost-effectiveness evaluations and refine implementation plans and strategies. Roadways are a land use of primary concern, as these have the greatest pollutant yield potential. There is a need to evaluate roadway operations and maintenance practices and optimize them to ensure cost effective fine sediment particle load reductions.

Research proposals should address one or more of the following. (1) Source characterization: What are the factors controlling particle size distribution and turbidity of urban stormwater? How do these factors vary geographically, seasonally, and over the hydrograph? How does impervious area connectivity and hydrologic routing affect pollutant concentrations and loadings? What is the correlation between suspended sediment size classes and phosphorous (total and dissolved) concentrations? (2) Improving existing tools: How can existing tools and methods to estimate, track and report urban stormwater load reductions be improved? (3) Pollutant control/treatment: What is the effectiveness of controls to reduce pollutant concentrations and loadings? What are the key BMP design features that influence load reductions and what are the associated ranges? What are the optimal O&M practices in terms of cost and effectiveness and under various pollutant loading scenarios? How should BMPs be designed to maximize pollutant removal? How does BMP effectiveness vary over time? Research on innovative control strategies (e.g., pump and infiltrate) is especially encouraged. Research should examine the full range of particle size classes (total, < 63µm, < 16µm), and express suspended sediment measurements in terms of both mass and particle numbers.

Discussion of urban stormwater management subtheme

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.

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.

Several near-term science priorities for water quality are included in the draft EIP Update:

- Developing a better understanding of how watershed restoration projects reduce sediment loadings and improve lake clarity.
Assessing the effectiveness of stormwater management projects to treat and reduce polluted runoff in urban areas as well as understand their effects on riparian habitat condition and species of concern.

**Development of robust methods for evaluating fine sediment concentrations and loads**

This project has been designated as a “directed action” sponsored by PSW and is expected to be initiated in 2011.

The control of fine sediment particles is a high priority for achieving the Lake Tahoe TMDL clarity challenge. Reliable, low-cost methods are needed for evaluating fine sediment concentrations on a regional basis and for improving estimates of fine particle loading from various sources.

The measurement and assessment of fine particle concentrations and loads is required for effective water quality management in the Tahoe Basin. Low-cost methods for quantifying fine sediment concentrations must be developed that are reliable, repeatable, and applicable on a regional basis for monitoring the benefits from implementation of water quality improvement projects. Additional analyses should evaluate the extent to which data produced by proposed methods are dependent upon site conditions or other characteristics. Direct consultation with the Regional Stormwater Monitoring Program development staff is required to ensure that methods are complete and standardized. This research also should examine the relations between fine sediment particle numbers and other important water quality characteristics, such as turbidity, total suspended solids, and phosphorus loading. Research should build on past monitoring data, methods and studies conducted in the Tahoe basin.

**Stream Restoration Research**

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. The researchers 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.

**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.
Quantification and characterization of Trout Creek restoration effectiveness

This research will develop a simple methodology to predict total and fine sediment load reductions resulting from restoration efforts at Trout Creek and the Upper Truckee River.

Sierra Nevada Test of California Wetland and Riparian Area Monitoring Program (WRAMP)

The US EPA has awarded a 104(b)(3) Wetland Program Development Grant to test the California Wetland and Riparian Area Monitoring Program (WRAMP) for the Sierra Nevada in a watershed of the Tahoe Basin, and to initiate development of a montane wet meadow module of the California Rapid Assessment Method for wetland and riparian areas (CRAM). For more information, contact Jacques Landy at EPA or Shane Romsos at TRPA (contact information in app. D).

Round 11 Stream Restoration/Water Quality Subtheme

Quantifying the effects of actions to reduce sediment loads using SEZs

Management and regulatory agencies need tools and methodologies to quantify the direct effects of stream environment zone (SEZ) restoration projects in achieving pollutant load reductions targets for the Lake Tahoe TMDL. Quantifications of benefits and impacts are important in demonstrating the fulfillment of basin-wide planning and environmental improvement efforts such as the Lake Tahoe TMDL and the Environmental Improvement Program. Specifically, estimates of the direct effects of SEZ restoration projects to achieve TMDL reduction goals are needed. Development of a protocol similar to the Lake Clarity Crediting Program is also needed for tracking and reporting purposes.

Research proposals should aim to develop methods that quantify the direct effects (both benefits and impacts) of SEZ restoration projects to reduce pollutant loads relative to the Lake Tahoe TMDL targets. Research projects should build upon existing datasets, methodologies, and models to the extent feasible and appropriate. Research proposals should address the following: (1) Development of tools and methodologies to quantify the direct effects of SEZ restoration projects in achieving pollutant load reductions targets for the Lake Tahoe TMDL. (2) Identify the capacity of SEZ and stream restoration activities to treat polluted urban stormwater runoff. (3) Identify the origin (i.e., anthropogenic or natural) and quantify the volume of stormwater that directly and indirectly drains into streams. (4) Identify the sources and anthropogenic origin of fine sediment and nutrients that are carried in the stream load and deposited on the floodplain. Research may focus on a particular site, but efforts are encouraged to develop and test methodologies for application at appropriately broad spatial and temporal scales.

Discussion of reducing sediment loads using SEZs subtheme

Agencies are interested in research that will support the TMDL program and help to quantify benefits of SEZ restoration to treat urban runoff. Proposals that utilize the forthcoming remote sensing datasets are especially encouraged.
Air Quality and Transportation

EIP partners have identified an urgent need for improved air quality monitoring infrastructure and evaluation tools to measure and mitigate the impacts of air pollutant levels on human health and lake clarity. 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 Research

Source characterization of particulate matter depositing to Lake Tahoe

This study examined the mechanisms leading to road dust deposition to the lake and the sources of the road dust through both measurement and modeling. This project is sponsored by the EPA and implemented by the Desert Research Institute.

Development of an air pollutant emissions inventory

This DRI project developed a baseline emissions inventory that can be used to quantify and evaluate the contribution of various sources to ambient pollutant levels. In addition to the pollutants commonly included in an inventory (i.e., CO, NOx, VOCs, PM10, PM2.5, and SO2) estimates of ammonia (NH3), phosphorous (P), and phosphate (PO4) were also developed due to their contribution to the declining water clarity of the lake. A further aspect of this project was to develop a GIS-based tool to update the baseline inventory to account for future development and changes in infrastructure. A final report for this project is available from the EPA.

Sources of particulate matter

Researchers have analyzed ambient particle data to distinguish chemical species and to identify the sources of particular matter within the basin. They have prepared a draft report, finding support for the hypothesis that re-suspended paved road dust is the major source of PM10 in the basin, and that the most important sources to control are road dust, followed by wood smoke and mobile sources.

Mobile emissions monitoring

This study by DRI used the TRAKER measurement system to measure seasonal and spatial changes in road dust emissions. The US EPA sponsored the project. The final report, Measurement and modeling of fugitive dust emissions from paved road travel in the Lake Tahoe Basin, recommended the use of PM10 compliant sweepers, anti-icing pretreatment, and avoidance of loose gravel for road surfaces.
Cost-effectiveness of different road dust control strategies
This study is assessing the impact of BMPs designed to reduce the contribution from road dust resuspended by vehicles.

Impacts of vehicle activity on airborne particle deposition to Lake Tahoe
This project is estimating the impact of vehicle miles traveled (VMT) on particulate matter (PM) loading to the lake.

Visibility Monitoring and Standards: Assessment of Current and Alternative Approaches
This project will evaluate current visibility measurements and indicators available for tracking haze in the Lake Tahoe Basin and the nearby Desolation Wilderness, which is a mandatory Class I area. The project will provide recommendations for future monitoring, data analysis, and threshold development. The project consists of four tasks: 1) Critical review of guidance documents and previous studies; 2) Compilation of relevant visibility and particulate matter databases; 3) Examination of alternative monitoring technologies; and 4) Synthesis, reporting, and recommendations. This effort will build upon the recently completed SNPLMA Round 7 science project, “Lake Tahoe source attribution study: receptor modeling study to determine the sources of observed ambient particulate matter in the Lake Tahoe basin,” which performed multivariate source apportionment using monitoring data from the Lake Tahoe Atmospheric Deposition Study (LTADS).

Lake Tahoe Visibility Impairment Source Apportionment Analysis
The project will provide a comprehensive analysis of causes of visibility impairment in the Lake Tahoe Basin. The researchers will gather and review existing aerosol, optical, emissions, and meteorological data and summarize past source apportionment analyses as well as conducting new source apportionment receptor modeling. The researchers will review source and receptor modeling results for the area from the Western Regional Air Partnership (WRAP) and conduct additional receptor modeling using Chemical Mass Balance (CMB) and Positive Matrix Factorization (PMF). The researchers will compare WRAP haze source apportionment with results from the CMB and PMF analyses. The researchers will also compare study results with the Causes of Haze Assessment (COHA) results and conclusions from the Lake Tahoe Atmospheric Deposition Study (LTADS). The project will be coordinated with the above project.

Particulate Emissions from Biomass Burning: Quantification of the Contributions from Residential Wood Combustion, Forest Fires, and Prescribed Fires
The goal of this study is to develop and use a specific characterization method to differentiate between particulate matter (PM) contributions in the Lake Tahoe basin from residential wood combustion, wildfires, and prescribed fires. The researchers propose to develop a method to specifically characterize PM emissions from domestic wood combustion, wildfires, and prescribed fire emissions by combining two of the most commonly used biomass combustion tracers, soluble potassium (K+) and levoglucosan, with detailed characterization of organic compounds (i.e., carbohydrates, anhydrosugars, lignin), and particulate-bound mercury (Hg). The SNPLMA Round 6 science project, “Development of an Air Pollutant Emissions Inventory for the Lake Tahoe Basin that Incorporates Current and Future Land Use Scenarios” prepared a more comprehensive and spatially distributed emissions inventory, which attributed similar PM10 and PM2.5 contributions to wood smoke from domestic heating, and attributed 12% and 16% of the PM10 and PM2.5 emissions to
wildfires. The completed SNPLMA Round 7 science project, “Lake Tahoe source attribution study: receptor modeling study to determine the sources of observed ambient particulate matter in the Lake Tahoe basin,” further analyzed the LTADS data to conclude that wood smoke is a major contributor to ambient PM2.5 levels, although that analysis was unable to separate contributions from the different sources of wood smoke. Collaboration and coordination with the current SNPLMA Round 9 science project, “Effects of burning in the Tahoe Basin on soil and water quality,” will allow us to assess how various pile sizes, configuration, and combustion properties (e.g., fire intensity as measured by underlying soil temperature) may impact PM emissions and help to develop strategies to reduce impacts of prescribed fires on PM related air quality issues and deposition.

Distribution of ozone, ozone precursors and gaseous components of atmospheric nitrogen deposition

The proposed study will characterize ozone, precursors of ozone (O3) formation, and gaseous pollutants that are important contributors to atmospheric nitrogen (N) deposition in the Lake Tahoe Basin. The researchers will use passive samplers for monitoring of O3, nitric oxide (NO), nitrogen dioxide (NO2), ammonia (NH3), nitric acid (HNO3) and volatile organic compounds (VOCs) on a network of 32 sites inside and outside of the Basin. Using statistical and geostatistical models the researchers will create distribution maps of the measured compounds for the entire Basin. The researchers are hoping to utilize meteorological data that may be collected as part of SNPLMA Round 10 science projects below.

Meteorology Research

Tahoe Climate Information Management System (TahoeClim)

A joint collaboration between the Western Regional Climate Center at DRI in Reno and the UC Davis Tahoe Environmental Research Center (TERC) will develop an accessible archive of historical and current meteorological and climatological data for the Tahoe Basin. The Tahoe Climate Information Management System (TahoeClim) will include all past and present observations from the principal weather and climate networks operating in the basin and NASA space-born thermal infrared imagery. The data flow and management system will be established to allow the continued assimilation and archiving of real-time data in the future. This project will link with the California Climate Tracker, with the NOAA Westmap Project, and with the NOAA-WRCC West-Wide Drought Tracker. This project will be coordinated with the Round 10 science project below.

Improving meteorological data and forecasts for prescribed fire burn day decisions

The products and deliverables from this project will include for the Lake Tahoe Basin: 1) a 100-m gridded climatology of surface wind; 2) a 4-km mixing height climatology with associated transport wind; 3) a 100-m surface and upper level climatology; 4) 100-m resolution gridded operational forecasts of surface wind; 4) new weather station observations during the project period for an elevation transect within the Tahoe Basin; and 5) a customized smoke prediction website tool. These deliverables are developed from a suite of existing tools including the operational CANSAC forecast system at the Desert Research Institute, the Bluesky smoke prediction framework, WindNinja and field weather instruments. The project will be coordinated to inform related SNPLMA Round 10 air quality science projects.
Round 11 Air Quality Subthemes

Secondary pollutant formation and the impacts of TMDL-related primary and secondary atmospheric pollutants

Secondary pollutants are not directly emitted from sources but are instead formed by chemical reactions in the atmosphere. Examples include ammonium sulfate and ammonium nitrate, which are major contributors to visibility degradation in the Tahoe basin and ozone concentrations, which now exceed air quality standards. Due to the secondary nature of these pollutants, the development of effective control strategies requires detailed knowledge of the chemical and physical processes leading to their formation. A related need is to model the transport and deposition of atmospheric pollutants into Lake Tahoe considered important in the Lake Tahoe Total Maximum Daily Load: particles, nitrogen, and phosphorus.

Proposals under this subtheme should yield results that inform issues related to the processes leading to gaseous and particulate secondary pollutants in the Lake Tahoe basin, lead to the development of an air quality model, estimate primary pollutant carrying capacities, or increase our understanding of TMDL pollutant transport and deposition. Potential modeling and measurement studies must relate to: (1) the development and validation of an air quality model to: (i) predict secondary pollutant formation, and as feasible, (ii) estimate the transport and deposition of TMDL-related primary and secondary pollutants to the lake; (2) conducting focused studies to quantify the precursor sources and pathways leading to the formation of these secondary species; (3) the development of “carrying capacity” estimates for the primary and secondary pollutant precursors (i.e., hydrocarbons, nitrous oxides, ammonia, etc.), which can be used by agencies to develop acceptable level of emissions (i.e., carrying capacities) to help ensure the Tahoe Basin meets the most stringent pollution standards. Research to develop carrying capacities also should include an assessment of how much of each pollutant needs to be removed in order to attain and maintain standards. Research proposals for the development of TMDL pollutant transport and deposition estimates also should include the development of protocols to estimate, track, and report on the effectiveness of atmospheric pollutant load reduction actions.

Assessing the impacts of fire on air quality

Emissions from burning impact human health, ambient air quality, atmospheric visibility, and lake water quality. Information available to managers for predicting and mitigating these impacts is inadequate to quantify tradeoffs among various alternatives. The Tahoe Fire Commission found that there was "a lack of comprehensive air quality and meteorological information within the Lake Tahoe Basin to analyze air quality conditions to optimize burn windows for prescribed fire activities," and also that "low emission fuel reduction techniques are part of the necessary tools needed to minimize health-based air quality issues and visibility impacts when reducing the fuel load." Therefore, information is needed to increase our understanding of the effects of alternative fuel treatments, wildfires, and residential wood burning on air quality and pollutant deposition; and the development of best management practices to reduce these impacts.

Research should address one or more of the following issues: (1) evaluating local and regional impacts on air quality and/or particle deposition of various alternatives in the basin for reducing forest fuels (e.g., underburning, broadcast burning, pile burning, thinning, mastication, removing biomass for burning in the basin, and removing biomass out-of-basin), considering short-term impacts and long-term effects given the likelihood of wildfires; (2) evaluating the impacts of residential wood burning to air quality and pollutant deposition; and (3) evaluating the ability of alternative BMPs or control measures to mitigate the air quality impacts of various practices.

Discussion of air quality subthemes

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.

The draft EIP Update includes several near-term science priorities for air quality and transportation:

- Developing a comprehensive, basin-wide air quality monitoring program to better assess the long-term status and trends of air pollutants under a range of meteorological conditions.
- Developing a greenhouse gas emissions inventory to measure and evaluate the effectiveness of transit programs, forest management activities, and other strategies to reduce greenhouse gas emissions in the basin and meet new Federal and State regulations.
- Conducting focused studies to quantify the sources and pathways of airborne pollutants (especially particle deposition) to Lake Tahoe.
- Developing an air quality model that utilizes the full suite of meteorological, chemical, and particulate data. The model should provide predictive capabilities to aid in the development of strategies for air pollution reduction and climate change response.
- Conducting a synthesis analyses to document and predict the synergistic/antagonistic effects of atmospheric pollution and climate change on Lake Tahoe Basin resources and management activities.
- Increasing the region’s capacity to monitor the status and trends of transportation characteristics in order to improve transportation management strategies.
Recreation

**Evaluating effects of ski resorts on American marten**

This study is evaluating whether recreational activities at ski resorts have significant effects on populations of the American marten (*Martes americana*), which is a species of special concern.

**Sand Harbor Carrying Capacity Study**

This project includes the gathering of new and existing data related to social carrying capacity (completion of surveys evaluating visitor use, visitor experience and values) and environmental carrying capacity (water quality, habitat, vegetation, etc.) to evaluate the potential impacts of current use patterns at the Sand Harbor management unit of Lake Tahoe Nevada State Park (“Sand Harbor”). This data will be coupled with economic modeling to provide management recommendations for Sand Harbor and set carrying capacities. The study will be focused on the main beach, boat parking area and associated facilities, Diver’s Cove and group use area and picnic areas. The final report is scheduled to be submitted December 31, 2011.
Cross-Cutting Science: Climate Change

Numerous challenges to restoring Lake Tahoe are expected to occur as a result of climate change, as summarized in recent reports by the State of California and the State of Nevada:

- Increased likelihood of wildfires during longer fire seasons and at higher elevations
- Increased risk of uncharacteristically large and severe forest fires
- Spread of non-native aquatic invasive species and terrestrial pests such as bark beetles
- Reduced summer streamflows, warmer stream temperatures, and increased threats to native fishes
- Increased ozone and particulate matter
- Increased likelihood of severe floods and erosion
- Warming and decreasing clarity of Lake Tahoe owing to changes in temperature and precipitation

Climate Change Research

The Pacific Southwest Research Station has prepared a web site on climate change research in the Sierra Nevada, including a case study on the neighboring Tahoe National Forest.

Modeling cheatgrass invasion risk

Researchers have developed and applied 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. This research is demonstrating that the current climate supports continued spread of cheatgrass within the drier, low elevation areas near the south and east shores of the lake; however, large increases in winter minimum temperatures in the basin, which are predicted in several future climate models, could render higher elevation areas more vulnerable to invasion. A final report is available through the link above.

Modeling influence of management on wildfire under future climatic conditions

Field studies and modeling will evaluate which fuel treatments reduce the risk of catastrophic fire under different future climate scenarios.

Implications of climate change for design of best management practices

Researchers have produced a suite of reports evaluating how future climate may affect hydrology in the Tahoe basin and used the results to predict effects on lake clarity. This compilation of reports is available through the PSW website. Some of the key results of the modeling efforts were:

1) Upward trends in maximum and minimum temperatures;
2) No strong trends in annual precipitation amount, except for declining precipitation for one of the modeled scenarios (GFDL A2) toward the end of the century;
3) A continuing shift from snowfall to rain, toward earlier snowmelt and runoff during the water year, for both scenarios;
4) A downward shift in the hydrologic flow-duration curve for the A2 scenario in the last third of the century;
5) Some increases in drought severity, especially toward the end of the century;
6) Dramatic increases in flood magnitude in the middle third of the century, especially with the B1 scenario;
7) Sediment and nutrient loading to Lake Tahoe should not increase, to any meaningful level, as a result of climate change and may actually decrease due to the estimated decline in water yield;
8) That while climate change will result in a modest decline in BMP performance for fine sediment particle load reductions (i.e. increase in average pollutant load), any diminished performance will be relatively small and load reduction should still be significant;
9) That by the middle of the 21st Century (after about 2050) Lake Tahoe could cease to mix to the bottom. This will in turn result in complete oxygen depletion in the deep waters and an increase in sediment release of nitrogen and phosphorus;
10) That annual loading of soluble reactive phosphorus under sustained conditions of lake stratification (no deep mixing) and anoxic sediments could be twice the current load from all other sources. Loading of ammonium under these conditions could increase the amount of biological available nitrogen that enters the lake by 25 percent. This effect on the Lake Tahoe’s nutrient budgets could have a dramatic and long-lasting impact on the food web and trophic status of Lake Tahoe;
11) That the resulting annual Secchi depth in the later portion of the 21st Century could be in the range of 15-20 m as compared measured values of 21-22 m since 2000 and;
12) Climate change will drive the lake surface level down below the natural rim after 2086 for the GFDL A2 but not the GFDL B1 scenario.

Conservation, management, and responses of western white pine to environmental change

Researchers are identifying which populations of western white pines may warrant active intervention (including site preparation and planting) to sustain them under a changing climate.

Hydrologic response of sub-alpine wetlands to climate change

Researchers are developing hydrologic models of fens, a rare type of wetland, to understand how to sustain them under a changing climate.

Round 11 Climate Change Research

The Forest Health subtheme, Impact of climate change on ecological communities and the evaluation of adaptation strategies, addresses climate change issues in Round 11.
### Appendices

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

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<td>Air quality</td>
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<td>Upland water quality/sediment and nutrient discharge</td>
<td>Soil conservation and SEZ habitats</td>
<td>Habitat and vegetation</td>
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<td>Vegetation and forest fuels</td>
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<td>Ecology and biodiversity</td>
<td>Forest health (fuels management and vegetation management)</td>
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<td>Wildlife and fisheries</td>
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<td>Adaptive management strategy</td>
<td>Adaptive management system</td>
<td>Science and reporting</td>
<td>Science plan framework and overview conceptual model</td>
<td>Science integration</td>
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</table>

TRPA = Tahoe Regional Planning Agency, SNPLMA = Southern Nevada Public Land Management Act.
## Appendix B: Table of SNPLMA Science Projects by Rounds

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<th>Subtheme</th>
<th>Title</th>
<th>Federal Sponsor</th>
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<td>Air quality</td>
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<td>Mobile emissions measurement and modeling in the Lake Tahoe basin</td>
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<td>Forest fuel management</td>
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<tr>
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<td>Forest Fuel management</td>
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<tr>
<td>5</td>
<td>Biological communities</td>
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<td>Lake Tahoe urban lot biodiversity study data collection</td>
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<td>Lake quality</td>
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<td>Pelagic zone water quality and modeling of fine-sediment source, transport, and fate</td>
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<td>Water quality modeling</td>
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<tr>
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<td>Biological communities</td>
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<td>Biological resource monitoring</td>
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<tr>
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<td>Air quality</td>
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<td>Development of an air pollutant emissions inventory for the Lake Tahoe basin that incorporates future land use scenarios</td>
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<tr>
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<td>Cross cutting</td>
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<td>Forest and fuels reduction</td>
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<td>8</td>
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<tr>
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<td>Forest management, fuels reduction, and stream and meadow restoration</td>
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<td>Evaluating alternative fuel treatments in the South Shore wildland urban interface area</td>
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<td>fine sediment from storm water runoff</td>
<td>圭urewater fine sediment filtration using granular perlite</td>
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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 Relevant Publications

Science Integration, Decision Making, and Remote Sensing


http://www.nvwra.org/docs/journal/vol_2_no_1/jnwra_2_article2_halsing.pdf


Forest Fuels, Fire, and Soils


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.


Terrestrial Habitat


Lake Habitat and Invasive Species


Stormwater Quality and Erosion


Please note that publications from the LTBMU have been moved to a new publications webpage.

Streams

http://www.ingentaconnect.com/content/bpl/jawr/2008/00000044/00000003/art00007


Air Quality


Climate Change and Meteorology


http://oak.ucc.nau.edu/mdh22/Publications/Hurteau%20and%20North%202009%20carbon.pdf


### Appendix D: Contact Information for Key Agency Representatives

<table>
<thead>
<tr>
<th>Organization</th>
<th>Name and Title</th>
<th>E-mail</th>
<th>Phone</th>
<th>Topics</th>
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<tbody>
<tr>
<td>Tahoe Science Consortium (TSC)</td>
<td>Zach Hymanson, TSC Director</td>
<td><a href="mailto:redfir@sbcglobal.net">redfir@sbcglobal.net</a></td>
<td>775-881-7561</td>
<td>All</td>
</tr>
<tr>
<td>Nevada Division of Environmental Protection (NDEP)</td>
<td>Jason Kuchnicki, Lake Tahoe Watershed Unit Supervisor</td>
<td><a href="mailto:jkuchnic@ndep.nv.gov">jkuchnic@ndep.nv.gov</a></td>
<td>775-687-9450</td>
<td>All</td>
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<tr>
<td>Nevada Division of State Lands</td>
<td>Elizabeth Harrison, Water Quality Program Manager</td>
<td><a href="mailto:eharrison@lands.nv.gov">eharrison@lands.nv.gov</a></td>
<td>(775) 684-2736</td>
<td>Nevada License Plate Projects</td>
</tr>
<tr>
<td>USDA Forest Service, LTBMU</td>
<td>Susan Norman, Physical Sciences Group Leader</td>
<td><a href="mailto:snorman@fs.fed.us">snorman@fs.fed.us</a></td>
<td>530-543-2662</td>
<td>Watershed restoration, climate change</td>
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<td></td>
<td>David Fournier, Vegetation Program Manager</td>
<td><a href="mailto:dfournier@fs.fed.us">dfournier@fs.fed.us</a></td>
<td>530-543-2626</td>
<td>Wildfirefuels</td>
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<tr>
<td></td>
<td>Holly Eddinger, Life Sciences Program Leader</td>
<td><a href="mailto:heddinger@fs.fed.us">heddinger@fs.fed.us</a></td>
<td>530-543-2633</td>
<td>Sensitive species and invasive species</td>
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<tr>
<td>US Fish and Wildlife Service</td>
<td>Steve Chilton, Aquatic Nuisance Species Coordinator</td>
<td><a href="mailto:steve_chilton@fws.gov">steve_chilton@fws.gov</a></td>
<td>775-589-5265</td>
<td>Sensitive species and invasive species</td>
</tr>
<tr>
<td>Lahontan Water Quality Board</td>
<td>Hannah Schembri, Water Resource Control Engineer</td>
<td><a href="mailto:hschembri@waterboards.ca.gov">hschembri@waterboards.ca.gov</a></td>
<td>530-542-5423</td>
<td>Wildfire and fuels, water quality, climate change, particle deposition, stream restoration</td>
</tr>
<tr>
<td>US Environmental Protection Agency</td>
<td>Jacques Landy, EPA Tahoe Representative</td>
<td><a href="mailto:Landy.Jacques@epamail.epa.gov">Landy.Jacques@epamail.epa.gov</a></td>
<td>775-589-5248</td>
<td>Water quality, air quality, climate change, particle deposition, stream restoration</td>
</tr>
<tr>
<td>Tahoe Regional Planning Agency (TRPA)</td>
<td>Shane Romsos, Science, Monitoring and Evaluation Program Manager</td>
<td><a href="mailto:sromsos@trpa.org">sromsos@trpa.org</a></td>
<td>775-589-5201</td>
<td>All</td>
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