September 28, 2016

To All Who Share Our Passion For Lake Tahoe

It is my privilege to present the 2015 Threshold Evaluation Report. More than 60 individuals from over 25 organizations including scientists from many disciplines contributed data, time, and analytic expertise. This is the sixth comprehensive report since the Regional Plan was adopted in 1987, and it would not have been possible without the support of partners. Thank you all.

In 1980, the states of California and Nevada had the foresight to revise and strengthen the Bi-State Compact to ensure that the "Tahoe experience" would not be lost for future generations. The findings of this report suggest that while there is still much to do, environmental conditions in the Region continue to improve in response to many decades of active management. At the same time, the report calls out areas for further focused work and some of the uncertainties we must face in the future in response to changing climatic conditions.

The 2015 report is the second consecutive threshold evaluation to be peer reviewed. Fifteen independent scientific experts examined the evidence, reviewed the analytic approach, and the conclusions reached and found that the report was technically sound. Like the peer reviewers of the 2011 evaluation, the 2015 science experts also noted many of the limitations of the current threshold standards and the need to continue to adapt and push our evaluation framework forward. In response to these peer review recommendations and the concerns of stakeholders, the TRPA Governing Board identified reviewing and updating the threshold standards, adopted more than 30 years ago, as a key strategic initiative for the agency. Today, we are actively working with the newly formed Tahoe Science Advisory Council to make that vision a reality.

The findings of this report highlight the areas where we have made the greatest strides. Progress is possible only with the partnership of myriad agencies and the coordinated implementation and investment from every sector – federal, state, local and private. Building on a foundation of scientific research, local, state and national agencies joined together to develop the Lake Tahoe Total Maximum Daily Load (TMDL) which charts a course of action to restore the historic clarity of the lake. Preventing new aquatic invasive species from entering the lake is another notable success that was only possible because of focused leadership and collective actions of a broad cross-sector collaborative partnership. Today, the partnership is focusing forward to address the Region's newly emerging challenges like forest health in a changing climate and delivering the transportation network of the future.

We are proud to present this information to residents, visitors, and others concerned with the Tahoe Region, and we look forward to working with all stakeholders to continue to protect and restore this spectacular place for generations to come.

Sincerely,

Joanne S. Marchetta, Executive Director, Tahoe Regional Planning Agency

Executive Summary

More than 35 years ago, at the direction of the states of California and Nevada, the Tahoe Regional Planning Agency (TRPA) led partners in the Region through the process of establishing a shared set of goals. They reviewed the best available science, identified key values, and developed a shared vision for Lake Tahoe. The goals ranged from specific targets for air and water quality, to broad visions for maintaining scenic beauty and enhancing the recreational experience. The goals were often ambitious and aspirational, and were formally adopted as threshold standards by the TRPA Governing Board in 1982.

Every four years, TRPA leads the development of a threshold evaluation report that assesses ecosystem health relative to the adopted standards. The report documents the progress of the partners in the Region towards achieving those shared goals. The 2015 Threshold Evaluation Report is the sixth comprehensive report since the adoption of the 1987 Regional Plan. Following the precedent established in 2011, an independent scientific peer review ensures the methods used, conclusions reached, and recommendations made are consistent with the best scientific guidance in the field. The full comments of the panel of the 15 peer reviewers can be found in Appendix C.

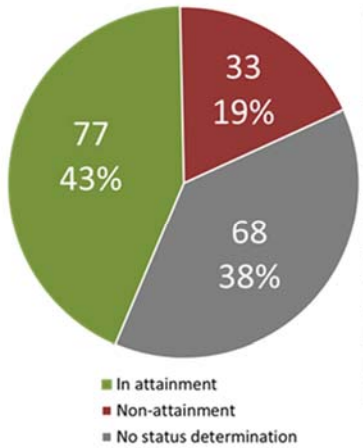
The reporting process is a collaborative endeavor that draws on the monitoring work and analytic expertise of federal, state, and local agencies, academic institutions, local businesses, and private consultants. The report provides a comprehensive overview of the environmental health of the Region as indicated by the 178 threshold standards.

Threshold Standard Status

This report considers conditions relative to 178 standards in nine threshold categories (Figure ES-1)[1]. (Resolution 82-11 (TRPA 2012). Status determinations relative to the standard were made for 110 (68 percent) standards. Of the 110, 70 percent (77) were found to be "at or better than target" or "considerably better than target."

Evaluators qualitatively assessed the implementation status of 25 management standards and policy statements. Consistent with the findings of prior threshold evaluation reports, it was found that all had been implemented through TRPA, state, and/or federal regulatory controls and/or are addressed as a component of on-the-ground environmental improvement projects and programs.

[1] *Note: There are 869 separate scenic assessment units, each with a specific target standard in five separate scenic standard categories enumerated here. Because of the volume of standards associated with the scenic resource threshold category, the indicator results were aggregated for this summary.*

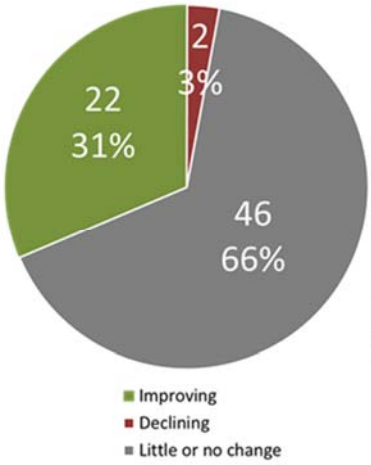


Category	Standards (#)	Status		
		Attainment	Non-attainment	No status determination
Air Quality	20	16	2	2
Water Quality	54	5	4	45
Soil Conservation	13	9	3	1
Vegetation	28	11	12	5
Fisheries	7	5	2	0
Wildlife	16	13	1	2
Scenic Resources	6	6	0	0
Noise	32	10	9	13
Recreation	2	2	0	0
Total	178	77	33	68

Figure ES-1. 2015 status determination summary by threshold category for the 178 threshold standards addressed in this report. Standards were placed into one of three categories: Attainment – where conditions are at or better than the standard; Non-attainment – where conditions are worse than the standard; and No status determination - where ambiguity in the standard, reference to an unknown historic baseline, or insufficient data precluded a determination of status.

Threshold Indicator Trends

Trend determinations were possible for 70 of the 178 standards evaluated in this report, and the vast majority where trend could be assessed (68 or 97 percent) are either improving or show little or no change. Improving trends outnumbered declining trends by over 10 to one. Conditions were declining for only two standards (Figure ES-2). For the majority of standards where no trend determination was possible, reasons include feasibility, standard ambiguity, funding gaps, and data issues. These findings represent a small improvement, but are generally consistent, with the findings of the 2011 Threshold Evaluation Report.



Category	Standards (#)	Trend				
		Improving	Little or no change	Declining	No determination	N/A
Air Quality	20	10	6	0	2	2
Water Quality	54	2	8	1	42	1
Soil Conservation	13	3	9	0	1	0
Vegetation	28	1	10	1	11	5
Fisheries	7	0	0	0	4	3
Wildlife	16	3	2	0	2	9
Scenic Resources	6	2	3	0	0	1
Noise	32	1	8	0	22	1
Recreation	2	0	0	0	0	2
Total	178	22	46	2	84	24

Figure ES-2. A trend determination was made for 70 of the 178 indicators. Standards were placed into one of four trend categories: Improving – where status was improving relative to the trend; little or no change – where status change was less than 0.5 percent; declining – where status relative to trend increased by more than 0.5 percent; and no determination – where insufficient data exists to assess trend or where status determination was qualitative.

Comparison 2011 to 2015
In general, compared to 2011, more standards showed improvement with attainment moving from 63 percent (58 standards) to 70 percent (77 standards). Status continued to improve for water clarity, air quality, scenic and soil conservation. Areas needing continued focus include removal of land coverage on sensitive lands, new threats to forest vegetation, deepwater plant communities, and the need for continued emphasis on water quality conditions (macroinvertebrates, periphyton (algae) and AIS control).

Summary of Findings by Threshold Category

The following section summarizes the findings and conclusions of the 2015 Threshold Evaluation Report by each threshold category. It also provides an outlook section that summarizes recommendations or future actions.

Air Quality

The Tahoe Region enjoys healthy air quality. Threshold standards are designed to ensure air quality in the Region continues to protect human health, scenic values, and environmental quality, and reduce nitrate deposition.

Findings and Conclusions: The majority of air quality standards are in attainment and observed change suggests that conditions are improving or stable. These observations are consistent with past threshold evaluation reports. Actions implemented to improve air quality in the Lake Tahoe Region occur at the national, state, and regional scale. The U.S. Environmental Protection Agency and state agencies, such as the California Air Resources Board, have established vehicle tail-pipe emission standards and industrial air pollution standards. These actions have resulted in substantial reductions in the emissions of harmful pollutants at state-wide and national scales and likely have contributed to improvement in air quality at Lake Tahoe. At a regional scale, TRPA has established ordinances and policies to encourage alternative modes of transportation and to reduce vehicle idling by prohibiting the creation of new drive-through window establishments.

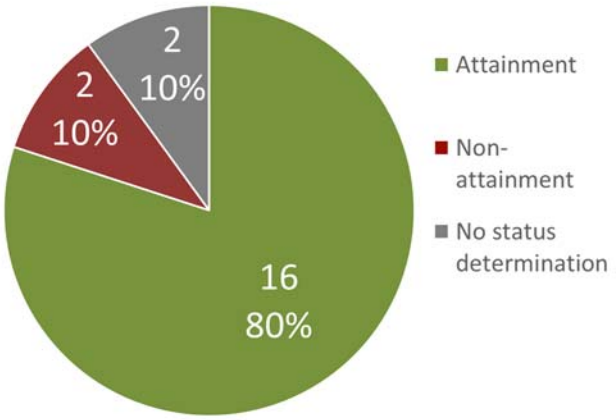


Figure ES-3: *Summary of the status of air quality standards*

Outlook: Since 2010, partners in the Region have built more than 30 miles of bicycles and pedestrian facilities, constructed 18 bus-shelters, revitalized street corridors, and created new public spaces. The 2012 Regional Plan incentives cluster population and employment in relatively compact town centers that are well served by transit and pedestrian and bicycle infrastructure. One hundred projects on the Regional Transportation Plan project list are designed to reduce vehicle miles travelled (VMT), improve air quality, and promote other threshold gains (TMPO & TRPA 2012). Thoughtful land-use planning is a central element of TRPA's growth management system and an important strategy to maintain and improve the Region's air quality. The Transfer of

Development Rights (TDR) program provides incentives to transfer development rights from sensitive lands and remote areas into less sensitive lands located in town centers. As part of the 2015 strategic initiative to review the development rights system and the TDR program, TRPA is working with stakeholders to improve the program and accelerate transfers and implementation of the Regional Plan.

TRPA and partners continue to work to improve air quality monitoring in the Region. Working with the Placer County Air Pollution Control District (APCD), TRPA initiated monitoring on the North Shore in 2013 by contracting the APCD to monitor both ozone and particulate matter 2.5 (PM 2.5) at the district's monitoring station in Tahoe City. In 2013, TRPA worked with the Lake Tahoe Community College to install an air quality monitor to collect information on meteorology (eg. temperature, relative humidity, wind speed, and wind direction), ozone, and particulate matter ($PM_{2.5}$ and PM_{10}). Improved monitoring will enable more accurate assessment of current conditions to protect public and environmental health.

Water Quality

Lake Tahoe's extraordinary water clarity and quality are world-renowned. TRPA and state agencies have adopted strict water quality standards to protect and restore the lake for current and future generations.

Findings and Conclusions: Between 1968 and 2000, a third of the lake's iconic clarity was lost. Had the trend continued, Secchi depth in 2015 would have reached a new low of 16 meters (52.6 feet). Instead today in 2015, the observed Secchi depth was 22.3 meters (73.2 feet). Annual clarity measurements typically vary widely, so we look to longer term trends, which are encouraging. The five-year running average from 2010 to 2015 was 22.3 meters (73.2 feet), 18 feet better than forecasted in 2000. The continued improvement is a strong indication that the actions of partners in the Region are contributing to improved clarity and helping TRPA attain one of its signature goals.

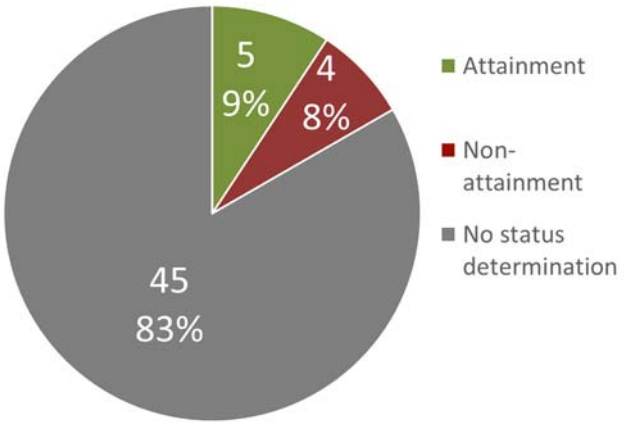


Figure ES-4: Summary of the status of water quality standards

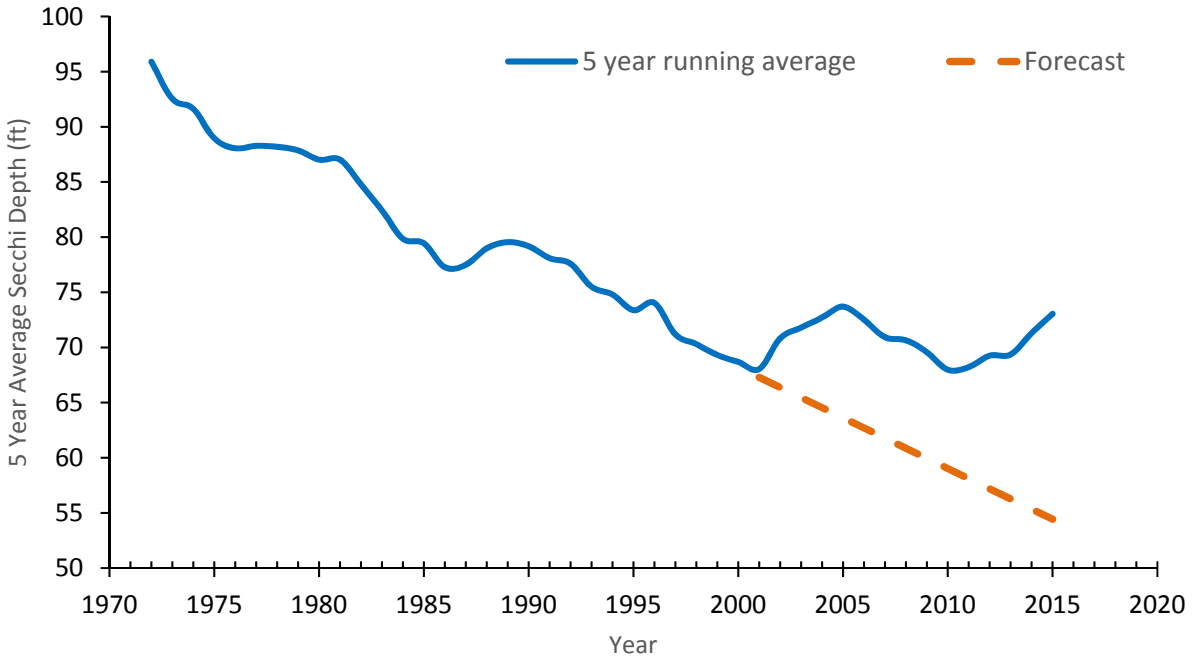


Figure ES-5. *Five-year average Secchi depth between 1970-2015. In 2000, forecasts based on observed trends between 1968 and 2000 suggested that by 2030 the lake's clarity could drop to less than 40 feet (Murphy & Knopp 2000). Today, the 2015 five-year average Secchi Depth (73 feet) is 18 feet better than the year 2000 forecast.*

The success of the aquatic invasive species (AIS) prevention program is another notable achievement. Thanks to the inspection of more than 200,000 watercraft prior to launch and the decontamination of more than 44,000 boats, no new AIS have been discovered in Lake Tahoe since the program's inception in 2007.

Signals of improving environmental health are also visible in other water quality parameters. This report improves our knowledge about tributary runoff. It contains the first flow-weighted pollutant load analysis for Tahoe's tributary streams and the results are encouraging. The amount of pollutants carried in tributaries (loads) are highly dependent on flow, or the amount of water in the streams. In wetter years, when streamflow is greater, heavy pollutant loads reach the lake. In drier years, fewer pollutants reach the lake via tributaries. A flow-weighted load analysis adjusts for annual wetness and explores whether the same atmospheric conditions deliver more or less nutrients to the lake. This report shows for the first time that pollutant loads from the non-urban uplands are likely decreasing as the watersheds recover from past disturbance.

Phytoplankton primary productivity in the deep waters of the lake continue to increase which is a concern because it could signal a shift away from the lake's historic oligotrophic state. It was the lone indicator that worsened in both the 2011 and 2015 threshold evaluation reports. Understanding the drivers of increasing productivity remains a priority for partners in the Region.

Outlook: The 2015 Threshold Evaluation Report highlighted a disconnect between what the monitoring programs of scientific partners are documenting in the lake's nearshore and the public's perception. A UC Davis analysis of periphyton (attached algae) data collected between 1982 and 2015 found that that there had been little or no change in nearshore attached algae over the last 30 years. A Desert Research Institute analysis of nearshore water clarity measurements between 2001 and 2015 found similar results and concluded that clarity levels measured in 2015

were about the same as measured in 2001. These findings run counter to the anecdotal reports from visitors and residents about more slimy rocks. Targeted studies are looking at causes of variability and high incidence in some lakeshore areas, and an interagency working group is currently exploring monitoring protocols along with issues like how to better communicate research findings to the public.

The number of water quality standards for which no status determination could be reached relative to the standard is a cause for concern. Many of these standards when adopted in the 1980s lacked an established baseline or a defined target endpoint, which precludes status determination. As the initiative to review the threshold standards proceeds, addressing this issue will help clarify the full status of the Region's water quality.

Soil Conservation

Soils support the Region's vegetation and provide natural filtration that prevents pollutants from negatively impacting water quality. The threshold standards for soil conservation direct development towards less sensitive lands and establish restoration goals to reverse the impacts of legacy development in stream environment zones (wetlands).

Findings and Conclusions:

There has been negligible change in the total impervious cover in the Region in the last five years. Between August 2010 and July 2015, 19 acres of hard impervious cover were permitted through TRPA permit approvals. This represents a 0.2 percent change and brings the total impervious cover within the Region to 7,974 acres, or 3.9 percent of the Region. The permitting process of partners has been effective in focusing development on less sensitive lands and encouraging removal of impervious cover from sensitive areas. Since 2010, 10.4 acres of cover in land capability class 1b (environmentally sensitive) has been removed. All land capability classes are in attainment except for class 1b and class 2. Development rights (commodity) transfers by private parties as part of the Transfer of Development Rights Program accounted for 8.08 acres of cover removed from class 1b and 2.45 acres were removed by the California Tahoe Conservancy and the Nevada Division of State Lands.

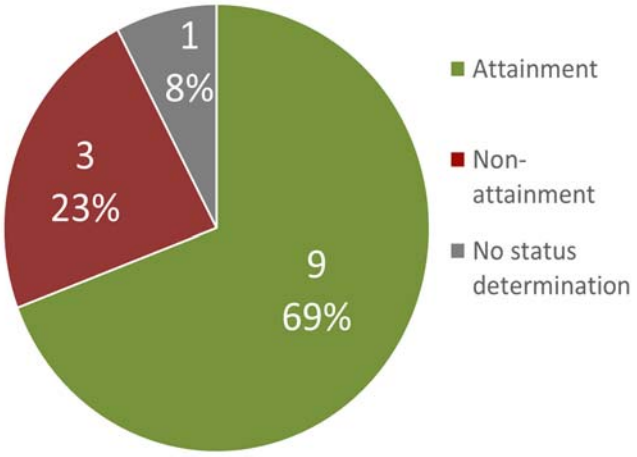


Figure ES-6: Summary of the status of soil conservation standards

With approved plans for the restoration of more than 500 acres of the Upper Truckee Marsh, the Region is nearing attainment of the stream environment zone (SEZ) restoration target established in 1982. This is an historic milestone and one that provides an opportunity to collectively celebrate our accomplishments, reflect on work completed to date, and chart a path forward. The outlook for our Region's SEZs are significantly brighter today than when the standard was adopted. Development forecasts produced around the time of the standard's adoption suggested that absent regulation, between 1,550 and 1,770 additional acres of SEZ could have been lost by 1995

(DMDC Inc. 1978). Fortunately, that did not occur. The U.S. Forest Service and the California Tahoe Conservancy have acquired and protected over 900 acres of SEZ (TRPA 1988), and the permit review process and development restrictions prevented any new degradation of non-protected SEZs. To date, 924 acres of SEZ have been restored. TRPA accounting of SEZ restoration projects has historically not included restoration projects completed by the U.S. Forest service in the 1980s, which included restoration of 680 acres between 1984 and 1987 (TRPA 1988). Looking comprehensively, partners have restored 1,604 acres of SEZ and restored/acquired nearly 2,500 acres.

Outlook: The attainment of a core restoration goal is within our sights and continued work and coordination between partners can ensure that it is completed. However, it should not be the end point for SEZ restoration in the Region. It is also time to pause and collectively reflect on the important roles SEZs play and consider establishing a new goal for SEZ restoration. Restoration of SEZs remains a cost-effective tool to improve water quality, improve recreational opportunities, and enhance habitat for native species. SEZs provide significant benefits for water quality, wildlife, wildfire protection, and flood control. A robust discussion about the ultimate goals for SEZ restoration would benefit all restoration project implementers.

Since the adoption of the 1987 Regional Plan, progress toward attainment of the impervious cover standard for the 1b land capability class remains challenging. Attainment would require the removal and/or relocation of 659 acres of impervious cover, roughly 8.3 percent of all impervious cover in the Region. It would also likely require removal and buyout (with transfers or retirement) of large portions of existing private development (residential, tourist, commercial) in the Region's communities. Removal or relocation of this magnitude may be infeasible in a reasonable time-frame.

Vegetation Preservation

The Region's vegetation is central to the "Tahoe experience" and plays an important role in providing wildlife habitat, stabilizing soils, and cleansing the air. The threshold standards for vegetation are intended to maintain the community richness and diversity, increase the extent of old growth conifer forests, and provide special protection for uncommon communities and sensitive species.

Findings and Conclusions:

The vegetation in the Region is recovering from the impacts of legacy land use. The majority of vegetation standards that are currently not in attainment relate to common vegetation in the Region. This finding is consistent with those of past threshold evaluations. As the landscape naturally recovers from the impacts of historic logging, grazing, and ground disturbance activities over the course of this century, many of the standards are expected to be attained.

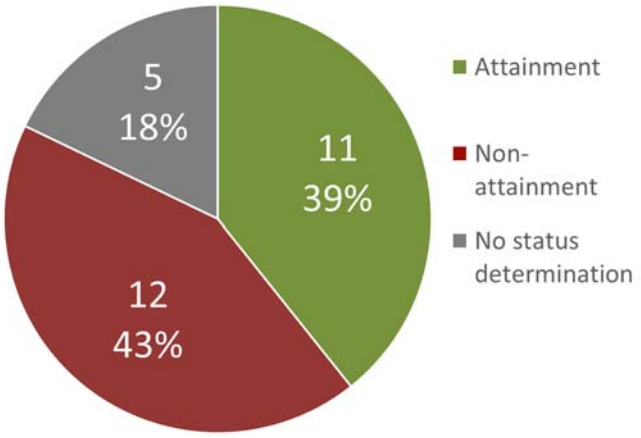


Figure ES-7: Summary of the status of vegetation preservation standards

We are aligning with partners to improve on the number of standards for which insufficient data were available to assess status. The U.S. Forest Service monitors and is currently completing its analysis of status and trend for the five uncommon plant communities reported as "no status determination." As we move to more frequent and real-time reporting intervals, this data and its findings will be supplied as soon as it is available.

One area of concern is the status of deep water plant communities. Recent surveys suggest that the populations may have declined by as much as 80 percent since they were surveyed in the early 1960s. A decline was also observed in the cushion plant community on Freel peak that was likely the result of changing climate. Sensitive vegetation species are generally doing quite well in the Region. Population status of four of the five sensitive species are considerably better than the standard, with Tahoe Yellow Cress having been removed recently from the federal endangered species candidate list based on active conservation work. Galena creek rockcress is the lone sensitive plant species not in attainment. However, U.S. Forest Service botanists question the identification of the desired number of plant populations as ever actually being accurately observed in the Region.

Outlook: Global climate change poses a threat to the integrity of Region's vegetation communities and plant species and could exacerbate existing stressors. The southern Sierra is experiencing a bark beetle epidemic due to the prolonged drought that has left more than 66 million dead trees on the landscape. The Tahoe Region is also experiencing increased beetle activity but has not yet experienced infestations on the scale observed in the south. Drought and overcrowding reduce trees' ability to fend off beetle attacks and increase the risk of largescale infestations and tree die-offs. Regional partners have been working for over a decade on fuels reduction and forest health projects in the wildland urban interface (WUI) to reduce the risk of catastrophic wildfire for communities and the environment.

In the face of multiple threats, the science of forest management has begun to focus on landscape-level forest resilience or "the capacity of the system to resist damage and recover quickly when challenged by environmental pressures" (Fuller and Quine 2016). Regional partners are actively exploring forest health treatments beyond the WUI to increase the resilience of Tahoe's forests. The TRPA strategic initiative to promote forest health supports the U.S. Forest Service and other land management agencies as they address these issues and consider multi-benefit restoration and management through a collaborative, multi-agency process.

Fisheries

Fisheries standards are intended to improve and maintain lake and stream habitat and support efforts to reintroduce the native Lahontan cutthroat trout to the Region.

Findings and Conclusions: The Region is meeting most of the threshold standards for fisheries. The reintroduction of Lahontan cutthroat trout in Fallen Leaf Lake is one of the more successful reintroduction projects for this native fish species.

Outlook: While the standards were found to generally be in attainment, the standards focus on physical habitat requirements that may not reflect the status of native fish populations. Recent population surveys in Lake Tahoe suggest significant declines in native fish species in parts of the nearshore. Declines are likely the result of impacts from the presence of aquatic invasive species in the lake. While efforts to prevent new invasive species from entering the lake have been successful, mitigating the impact of previously introduced existing invasive species remains a high priority challenge. Invasive species control projects are guided by a science-based implementation plan. Ensuring native fish can persist in the Region and the restoration of the historic trophic structure to the lake will likely require partners to explore novel methods to control invasive species and abate the pressure they are placing on native species. Climate change driven shifts in the timing and form of precipitation in the Region pose a longer term threat to native fish that may need to be monitored.

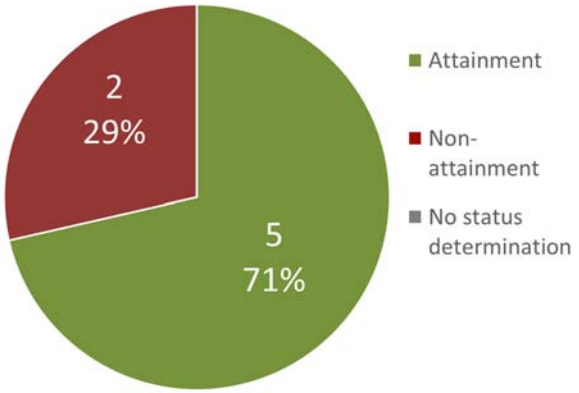


Figure ES-8: Summary of the status of fisheries standards

Wildlife

The wildlife standards are intended to enhance the suitability and extent of riparian habitats and maintain and protect special interest species like bald eagle, osprey, and goshawk.

Findings and Conclusions: Twelve of the 16 wildlife standards are in attainment. Over 50 percent of the land area in the Tahoe Region is designated for protection of listed special status species. Populations of special interest species are either stable or increasing.

Outlook: While wildlife species addressed in the existing standards are generally doing quite well, significant questions were raised by peer reviewers of both the 2011 and 2015 Threshold Evaluation reports. The reviewers' questions challenged the agency and partners in the Region to consider whether the species of special interest selected for concern in the 1980s remain most relevant and to revisit the ultimate goal for wildlife in the Region. Population standards for special interest species are limited today to avian species, and include five species of raptor and a suite of waterfowl species.

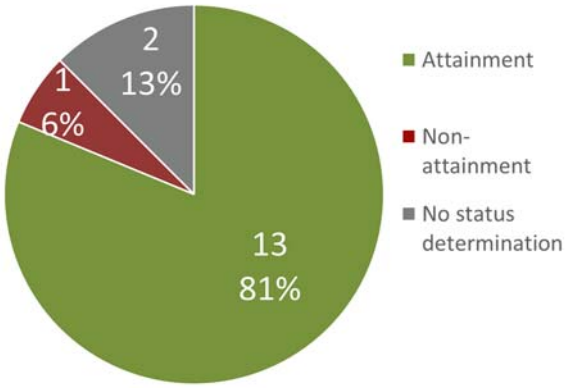


Figure ES-9: Summary of the status of wildlife standards

Scenic Resources

The Tahoe Region is a stunningly beautiful landscape that contains a striking combination of rugged mountain peaks, lakes, and forested slopes. Scenic standards are designed to ensure that the views from the Region's roadways, shoreline, viewpoints, and other recreational sites are preserved or improved.

Findings and Conclusions: Lake Tahoe attracts millions of visitors because of its stunning scenic quality, and the scenic quality of the region continued to improve over the last five years. TRPA's Scenic Program employs a highly robust monitoring protocol to assess and protect designated scenic values. The agency monitors the visual experience from 869 individual scenic units. Scenic gains were achieved in developed areas along roadways and scenic resources along the lake's shoreline, the areas most in need of additional scenic improvements. Overall, 93 percent (811 of 869) of the evaluated scenic resource units met the threshold standard and no decline in scenic quality was documented in any indicator category. A summary of the various scenic resources follows:

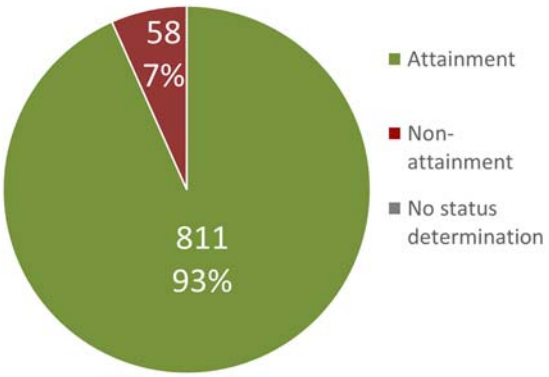


Figure ES-10: *Summary of the status of scenic resources standards*

- Travel route ratings for roadway travel units – 63 percent in attainment (34 of 54)
- Travel route ratings for shoreline travel units – 67 percent in attainment (22 of 33)
- Scenic quality ratings for roadway travel units – 99 percent in attainment (205 of 208)
- Scenic quality ratings for shoreline travel units – 92 percent in attainment (169 of 184)
- Public areas and bike trails – 98 percent in attainment (381 of 390)

Trend data suggest that programs such as the EIP and management actions implemented such as adoption of the scenic shoreline ordinances along with building design standards in new construction and redevelopment have improved scenic conditions and community character Region-wide.

Outlook: Roadside parking is emerging as a potential issue for scenic resources in the Region as more visitors use designated and undesignated roadsides for parking to access recreation. Strategies to improve access to recreation areas to ensure a high quality user experience and maintain the scenic beauty are increasingly an active planning priority for TRPA and partners.

Noise

Excessive noise can impact wildlife, visitors' experiences, and residents' quality of life. To maintain noise levels consistent with the needs of wildlife and values held by regional residents and visitors, both single event and cumulative ambient noise standards are specified for the noise threshold category.

Findings and Conclusions:
Ambient noise levels in seven of nine land-use categories are in attainment with standards, but because of the proximity of existing development to roadways just two of seven transportation corridors are in attainment with ambient targets. Due to insufficient data, status determinations were not possible for nearly half of the single event noise standards. Limited noise monitoring resources were prioritized towards collecting more robust information to analyze ambient noise standards, which are more conducive to influential management actions than are single event sources.

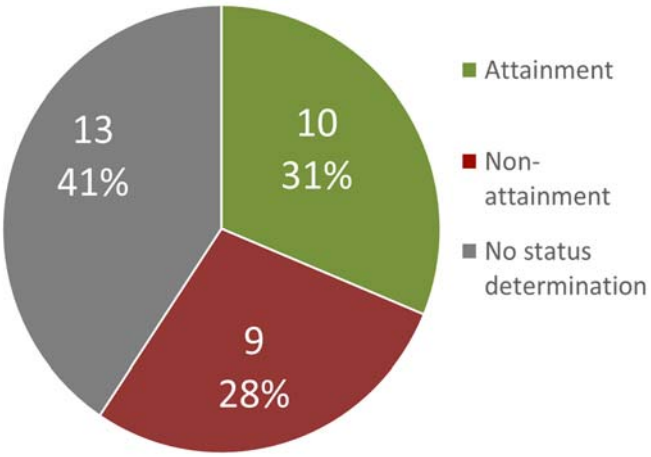


Figure ES-11: *Summary of the status of noise standards*

Outlook: Since 2011, when expert peer review suggested the regional framework for assessing noise was infeasible and should be fully revisited, TRPA has worked to overhaul the implementation of its noise monitoring program. These changes allow us to more rigorously monitor and report with greater confidence on noise levels in transportation corridors. The changes were lauded by the peer reviewers of the 2015 Threshold Evaluation Report. However, they again challenged us to comprehensively review the standards and one referred to the evaluation of single event noise standards against a zero exceedance criteria as "unrealistic." The feasibility of meeting the currently adopted single and cumulative noise events standards (maximum allowable ambient noise levels) should be evaluated to ensure the standards are protective and realistically achievable.

Recreation

The Lake Tahoe area is a mecca for the outdoor recreation enthusiast. Recreation threshold standards recognize the value of improving public access and maintaining Lake Tahoe's environmental quality in order to perpetuate society's desire to recreate in the Lake Tahoe Region.

Findings and Conclusions: Both adopted recreation policy statements have been implemented as elements of the Regional Plan and are in attainment. A broad suite of user surveys completed over the last four years suggest that visitor satisfaction with the recreational experience remains high. Public agency land acquisition programs and the Lake Tahoe Environmental Improvement Program have contributed to improved access and visitor and resident satisfaction with the quality and spectrum of recreation opportunities. Partner agencies have improved existing recreation facilities and created new ones, including providing additional access to Lake Tahoe, hiking trailheads, and bicycle trails.

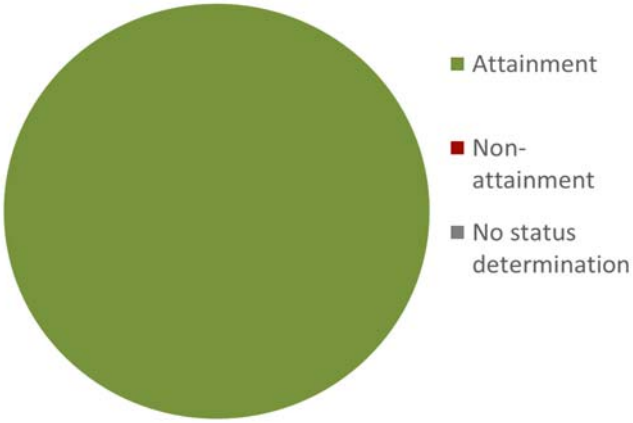


Figure ES-12: *Summary of the status of recreation standards*

Outlook: The many limitations of the existing recreation standards are outlined in this report. Anecdotal evidence suggests that demand for Tahoe's unique recreational experience is growing. New evidence suggests that day trippers make up a significant portion of visitors to the Region. When the standard was adopted, ensuring availability of lands and sewer utility capacity for recreational opportunities was the driving concern. Today, approximately 90 percent of the Region is in public land ownership (up from 70 percent in the 1970s), so that concern is no longer at the forefront. One exception may be shoreline access, where public acquisition has not occurred at the same pace. Today, 45 percent of the shoreline is in public ownership. TRPA and partners are working to update shoreline regulations. Today's emerging concerns are transportation access to recreation sites and maintaining quality recreation experiences as demand grows, concerns that may require the Region to revisit policies and goals for the recreation threshold standards.

Agency Direction in Light of Threshold Evaluation Findings

The threshold evaluation report is a comprehensive periodic synthesis of information about the state of the environment of the Region. While its breadth is an impressive collection of information, like any scorecard, it is a snapshot. And the report's contents become valuable only if the information is translated to knowledge. To this end, we are inspired by guidance from the World Bank on using information to improve governance.

> *"It is tempting—but dangerous—to view* monitoring and evaluation (*M&E) as having inherent value. The value of M&E does not come simply from conducting M&E or from having such information available; rather, the value comes from using the information to help improve government performance."* - (Mackay 2007)

The threshold evaluation report is not an end point. We can and will draw on it, and on the thoughtful suggestions from independent scientific peer review, to improve how we operate and promote attainment of the Region's shared vision. As we reflect on the effort, a number of themes for action emerged that cut across the specific recommendations within individual threshold

categories. We highlight some of the key overarching themes here and provide additional details on TRPA's direction in Chapter 13, Conclusions and Recommendations.

Collaboration is the Key

The world is more interconnected today than ever before which has implications for how the agency conducts effective business. TRPA is charged not with implementing projects itself in isolation but with coordinating the many partners in the Region to achieve a set of shared goals that cut across jurisdictions, organizations, and governments. Recognizing the complex landscape in which threshold progress and restoration occur is essential to the basin's collective impact. Partnerships are how we develop and implement the plans that transform our aspirational goals into reality.

A decade ago, TRPA changed its approach and renewed its commitment to a partnership operating model and set strategic goals to make partnership and collaboration more successful and sophisticated. In many ways, this partnership model exemplified the dawn of a new era for how we do business. The 2015 Threshold Evaluation Report is an example in itself of growing and improving partnerships between scientists and management agencies. Partnership and collaboration among federal, state, and local governments implement the majority of the projects in the EIP. Private citizens and local businesses in the Region install water quality best management practices and create defensible space around residential and commercial properties. These aggregate contributions make environmental progress possible and accelerate threshold gains. It also means that both the successes and failures are a product of these partnerships.

The Lake Tahoe Aquatic Invasive Species Coordination Committee is a recent example of how continually growing partnerships leads to successful response to emergent issues. When the threat to the Tahoe Region of quagga mussel invasion became apparent nearly 10 years ago, TRPA and partners convened to set the direction and guide AIS management in Tahoe. The committee is comprised of representatives from 14 agencies – federal, regional, state – and is further supported by local governments and private NGOs. The AIS program now also reaches outside the Region to a larger western states and national coalition to leverage legislative influence, funding, and best practices. Building and maintaining an environment where these types of far-reaching and robust partnerships are successful is the first step toward the actions needed in response to evaluation reports like this one.

New and similar partnerships are now being built and nurtured in added areas responsive to the emerging conditions flagged in the 2015 report. Coalitions are working to address interregional transportation, large forest and vegetation landscapes, recreation and visitor engagement, and nearshore water quality conditions. It is these new associations of partners collaborating on solutions to emergent issues that will account for continued progress toward our regional shared goals.

Connections and System Integration

We've learned through decades of experience that the partnership's effectiveness depends on shifting our focus from silos to understanding system dynamics. As with the 2011 report, the siloed evaluation approach of the current threshold system was again questioned by the 2015 scientific experts in the peer review. For example, the reviewers wondered about the artificial segmentation of issues like water quality, fisheries, and aquatic invasive species to understanding of the larger system of evaluation of nearshore health. The linkage of each silo to the ecosystem dynamic may be recognized or not, but the required evaluation of 178 separate siloed standards perhaps diverts focus from asking or understanding the ecosystem's most important driving influences.

When we see linkages of individual threshold standards to the larger system dynamics, we respond with active management interventions. A clear and pressing example is the nexus among threshold standards for scenic, recreation, and air quality. Visitation to the Region may be growing and visitation patterns changing. This evaluation found that increasing visitation also poses a challenge for the recreation experience and scenic quality. As visitors frequent Lake Tahoe, the roadsides are increasingly cluttered with parked cars. Roadside parking is an emerging stressor on scenic resources. TRPA recently commissioned the development of a recreation travel study to better understand how visitors are getting to and moving around the Region. Understanding visitor systems dynamics is increasingly important to adaptively managing transportation, recreation access, and quality of recreation experience. When the threshold system was conceived, the primary concerns of recreation travel were confined to impacts on air and water quality and sewer capacity for recreation facilities. As the system dynamics change, new values and impacts may today take precedence over historic issues that are today largely resolved.

In other areas where the linkage of standards to system effects are less apparent, the peer reviewers are suggesting we ask whether our siloed standards still reflect the most important system drivers, and if not, to bring the standards up to date.

Adaptive Management and Effectiveness

Understanding where our Region stands in the health of its systems is essential to understanding where to go next. TRPA tracks hundreds of standards and performance measures. Based on the 178 adopted standards we now rely on for threshold evaluation, the findings of this report indicate that the environmental health of the Region is continuing to improve in important areas and flags other areas for action. Knowing that we are making progress is important. Understanding what factors are contributing to improvement or decline is an altogether different and daunting challenge. Today, the greatest opportunity lies in turning this information into knowledge to signal to TRPA and its partners which actions are the most effective and which offer the best potential return on investment. To this end, the peer reviewers of the 2015 Threshold Evaluation Report challenged TRPA to do more to figure out what is working and what is not. Use of the adaptive management cycle *(plan-do-check-adjust)* is the best tool we have to continually and effectively translate information to knowledge. And for a decade we've been using it to accelerate the incidence and frequency of plan improvements and implementation program prioritization to improve effectiveness and better allocate resources to achieve desired outcomes.

Because change is happening all around us and the need to iterate more regularly to adapt to changing needs and conditions is important, we have made the goal of continual adaptive management intentional and support it with more frequent annual, quarterly, and now even real time reporting so decision-makers have the best info available. Relying on adaptive management, we have set in motion work programs in every major resource area to accomplish this need. We are already on track to take needed action with prioritized strategic initiatives in AIS control, forest health management, water quality operations and maintenance, shoreline recreation access, transformative transportation systems management to address growing demands for recreation visitor access, and development rights system modifications to accelerate environmentally beneficial redevelopment.

While we are getting better at mobilizing to make adaptive changes to programs in response to evaluative information, the area where we have not adapted as well is in keeping our evaluation standards and measures of effectiveness up to date. Now it is time for the Region to relook at the standards by which we judge and evaluate our progress.

Climate Change

Both the 2015 report and the peer review comments point to a growing body of knowledge we have been urged to bring into our standards and evaluations. Globally, 2015 was the warmest year on record. Temperatures in 2015 were over 1.5°F (0.8°C) warmer than the average temperatures of the 20th century, breaking the record set just a year earlier (NOAA & NASA 2016). The fingerprints of climate change are already visible in the Region. Tahoe City is 2°F (1.1 °C) warmer today that it was 100 years ago (U. S. Bureau of Reclamation 2015). Average minimum air temperature has increased by 4.3°F (2.4 °C) over the last 100 years (UC Davis - TERC 2016). With rising temperatures, there has been a correspondent decrease in the number of days each year with below freezing temperature, which have declined by almost 30 days over the same period (UC Davis - TERC 2016). The lake has steadily warmed since regular measurements began in 1970, and the volume averaged temperature of the lake is now nearly 0.8 °F (0.24 °C) warmer than it was 35 years ago (UC Davis - TERC 2016).

We have already started to plan for climate adaptive actions. In 2013, TRPA and the Lake Tahoe Sustainable Communities Program released the award-winning Sustainability Action Plan which lays out a comprehensive framework for building sustainability and climate change considerations into the decisions that impact the Region's future. For TRPA, considering, responding, and adapting to climate change is part of a process. Not every action we take will be need to be altered by climate considerations, but when planning our programs, policies, and actions, we must ask ourselves if the impacts of changing climate are likely to influence the effectiveness of the strategy. This is evident in how the agency is approaching its multiple strategic initiatives.

For example, climate forecasts for the Lake Tahoe Region suggest that warm temperatures and more variable rainfall are likely to lead to more frequent and dramatic fluctuations in lake levels (U. S. Bureau of Reclamation 2015) and observations from the last 15 years suggest that this is already the case (UC Davis - TERC 2016). To address a more uncertain future, the shoreline strategic initiative set up a joint fact finding committee made up of policy makers, stakeholders, and scientists to address questions about what assumptions should be made about future lake levels and determine the best resources available to planners today about future lake levels. This information will be used to develop proposals for adapting the lake's system of boating access to longer and more frequent periods of low lake levels.

Although climate is changing globally, its effects will emerge locally. Global climate change may alter the composition of the Lake Tahoe Region's vegetation communities and plant species and exacerbate existing stressors. Forecasts suggest high elevation areas such as Lake Tahoe may experience range shifts, re-sorting of species associations, extirpations, and extinctions (e.g. Seastedt et al. 2004, Loarie et al. 2008, Tomback and Achuff 2010). In response, through the forest health strategic initiative, TRPA and its partners are actively exploring forest health treatments beyond the WUI to increase the resilience of Tahoe's forests. These and other important climate adaptations will be considered as we adjust plans and as we update our standards and measures.

Review and Update the Threshold Standard System

All of the action themes outlined above lead to the threshold update strategic initiative endorsed as a priority by the TRPA Governing Board in 2015. The initiative will review and update the threshold standard system, including the thresholds standards and the monitoring, evaluation, and reporting structure that supports the system. This and previous threshold evaluations are a part of the critical evidence base that will inform that process.

The peer reviewers of this report and the 2011 Threshold Evaluation Report challenged us to ask difficult questions about our current system, many of which are likely to help inform the review of the threshold standard system. In area after area, they challenged us to ask "Why?":

- Why were these specific species selected as the focus of your wildlife program?
- Why focus on total area of SEZ restored when benefits vary significantly by the location and type of restoration?
- Why focus on fish habitat rather than on fish populations?

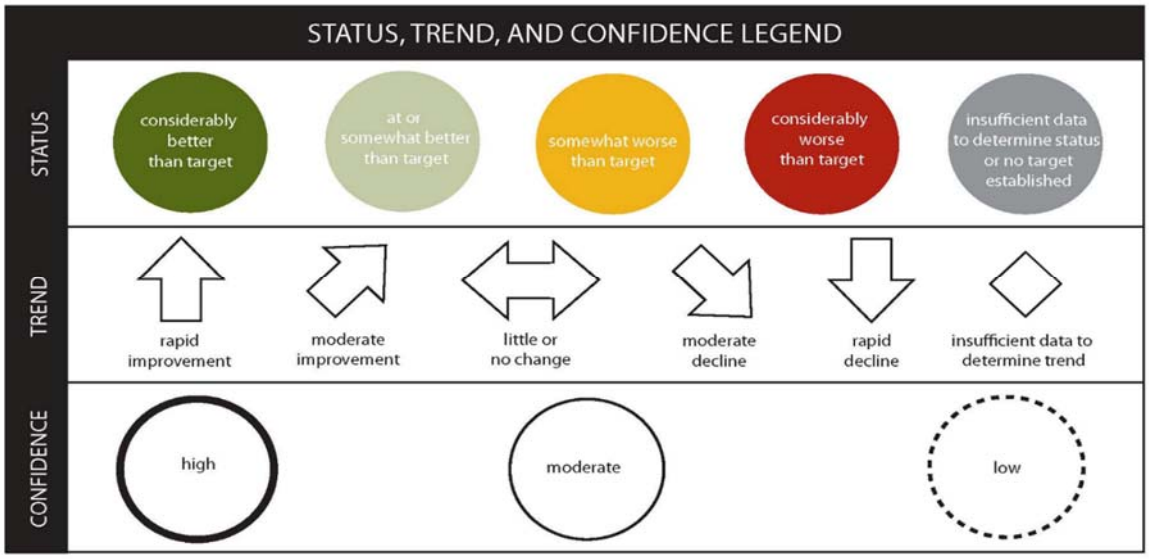
Again and again, these and many more of the peer review comments and questions are all derivatives of the larger question that frames the threshold update initiative: "Do our current goals (threshold standards) give us the information we need to make decisions that will ensure a healthy future for Lake Tahoe?" So to finish where we started, do each of our current 178 adopted threshold standards improve regional governance? TRPA alone cannot answer these questions. We look forward to drawing on the expertise and experience of partners and stakeholders as we address them through the threshold update initiative.

This threshold evaluation report lays the foundation for the initiative to review the threshold standard system. The assessment included in the recommendations and conclusions chapter of this report proposes to systematically review the formulation of the threshold standards against best practice, and we have already begun work with the Tahoe Science Advisory Council to complete that assessment.

The Tahoe Basin has proven over the last several decades that partnership and collaboration can drive positive progress for the environment and communities that surround the lake. The ongoing challenges flagged by the 2015 evaluation and future challenges such as climate change will be tackled head on with TRPA leading and facilitating regional partnerships. As President Obama said during the 20th Lake Tahoe Summit in August 2016, "Our healing of Lake Tahoe proves it's within our power to pass on the incredible bounty of this country to a next generation."

Status and Trend Summary Charts for all Standards

Reporting Icon Legends



In instances where there are too many standards and/or indicators to present each one in its own indicator sheet a pie chart showing the percentage of indicators in each status category are presented instead. The colors of the pie chart correspond to the status colors.

Status Category	Description	Reporting Icon
Implemented	The Management Standard has been integrated into the *Regional Plan* as policy and/or as an ordinance or regulation and is consistently applied to a project design or as a condition of project approval as a result of project review process. Greater than three examples of programs or actions can be represented to support the Management Standard's implementation. Adopted programs or actions support all aspects of the Management Standard's implementation, or address all major threats to implementation of the Management Standard.	I
Partially Implemented	The Management Standard has been integrated into the *Regional Plan*, but is not consistently applied during the course of the project review process. No more than two examples of programs or actions can be identified to support the Management Standard's implementation and/or adopted programs or actions support some aspects of the Management Standard or address some major threats to implementation of the Management Standard.	PI
Not Implemented	The Management Standard has not been integrated into the *Regional Plan* and is not applied during the course of project review. No examples of programs or actions can be identified to support implementation of the Management Standard.	NI

Air Quality Status & Trend Summary

Standard	2011	2015
Carbon Monoxide		
Highest 1-hour Concentration of Carbon Monoxide		
Highest 8-hour Average Concentration of Carbon Monoxide		
Average Daily Winter Traffic Volume, Presidents Weekend		
Ozone		
Highest 1-hour Average Concentration of Ozone		
Highest 8-hour Average Concentration of Ozone		
3Year Average of the 4th Highest 8-hour Concentration of Ozone		
Oxides of Nitrogen Emissions		
Regional Visibility		
Regional Visibility 50th Percentile ("Average Visibility Days")		
Regional Visibility 90th Percentile ("Worst Visibility Days")		
Subregional Visibility		
Subregional Visibility 50th Percentile ("Average Visibility Days")		
Subregional Visibility 90th Percentile ("Worst Visibility Days")		

Standard	2011	2015
Respirable and Fine Particulate Matter		
Highest 24-hour PM_{10} Concentration		
Annual Average PM_{10} Concentration		
24-hour $PM_{2.5}$ Concentration		
Annual Average $PM_{2.5}$Concentration		
Nitrate Deposition		
Reduce generation and transport of nitrate to achieve water quality standards		
Vehicle Miles Traveled (VMT)		
Odor - Reduce diesel engine fumes		

Water Quality Status & Trend Summary

Standard	2011	2015
Pelagic Lake Tahoe		
Winter Average Secchi Disk Transparency (relative to interim target)		Removed (12-12-2012)
Secchi Depth (Clarity Challenge)		
Secchi Depth	Not assessed	
Phytoplankton Primary Productivity		

Standard	2011	2015
Clarity – Vertical Extinction Coefficient (VEC)	Not assessed	
Littoral Lake Tahoe		
Nearshore Turbidity (Stream Influence)		
Nearshore Turbidity (No Stream Influence)		
Nearshore Attached Algae	Not assessed	
Aquatic Invasive Species	Not assessed	
Tributaries		
Suspended Sediment Concentration		
Phosphorus Concentration		
Nitrogen Concentration		
Suspended Sediment Load		
Fine Sediment Load		
Phosphorus Load		
Nitrogen Load		

Standard	2011	2015
Surface Runoff		
Suspended Sediment Concentration		
Phosphorus Concentration		
Nitrogen Concentration		
Suspended Sediment Load		
Phosphorus Load		
Nitrogen Load		
Groundwater		
Nutrient Concentration Standards		
Sediment Concentration Standards		
Other Lakes		
Nutrients		
Secchi Depth		
Other Parameters		

Soil Conservation Status & Trend Summary

Standard	2011	2015
Impervious Cover		
Percent of Land Coverage Within Land Capability Class 1a (allow up to 1% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 1b (allow up to 1% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 1c (allow up to 1% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 2 (allow up to 1% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 3 (allow up to 5% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 4 (allow up to 20% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 5 (allow up to 25% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 6 (allow up to 30% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 7 (allow up to 30% impervious coverage)		
Stream Environment Zones		
Preserve and Restore Stream Environment Zones		

Vegetation Status & Trend Summary

Standard	2011	2015
Common Vegetation		
Vegetation Community Richness		
Relative Abundance of Meadow and Wetland Vegetation		
Relative Abundance of Deciduous Riparian Vegetation		
Relative Abundance of Shrub Vegetation		
Relative Abundance of Yellow Pine Forest in seral stages other than mature		
Relative Abundance of Red Fir Forest in seral stages other than mature -		
Size of forest openings and juxtaposition of vegetation communities – Management Standard		
Consistency with Bailey Land Capability System		
Non-Degradation of Stream Environment Zones		
Appropriate Management Practices		
Uncommon Plant Communities		
Deepwater Plants of Lake Tahoe		
Grass Lake (sphagnum fen)		

Standard	2011	2015
Osgood Swamp		
Freel Peak Cushion Plant Community		
Hell Hole (sphagnum fen)		
Upper Truckee Marsh		
Taylor Creek Marsh		
Pope Marsh		
Sensitive Plants		
Tahoe yellow cress (*Rorippa subumbellata*)		
Tahoe Draba (*Draba asterophora var. asterophora*)		
Cup Lake Draba (*Draba asterophora var. macrocarpa*)		
Long-petaled Lewisia (*Lewisia pygmaea longipetala*)		
Galena Creek rockcress *(Arabis rigidissima var. demote)*		
Late Seral and Old Growth Forest Ecosystems		
Sub-alpine Zone		

Standard	2011	2015
Upper Montane Zone		
Montane Zone		

Fisheries Status & Trend Summary

Standard	2011	2015
Stream Habitat		
Miles of Stream Habitat in Excellent Condition		
Miles of Stream Habitat in Good Condition		
Miles of Stream Habitat in Marginal Condition		
Instream Flow		
Non-degradation Standard for Instream Flow		
Divert Stream Intakes to Lake Sources		
Lahontan Cutthroat Trout		
Lake Habitat		
Acres of "Prime" Fish Habitat		

Wildlife Status & Trend Summary

Standard	2011	2015
Special Interest Species		
Northern Goshawk Population Sites		
Osprey Population Sites		
Wintering Bald Eagle Population Sites		
Nesting Bald Eagle Population Sites		
Golden Eagle Population Sites		
Peregrine Falcon Population Sites		
Waterfowl Population Sites		
Deer		
Disturbance Free Zones Management Standards		
Habitats of Special Significance		
Riparian Habitat		

Scenic Resources Status & Trend Summary

Standard	2011	2015
Roadway and Shoreline Units		
Travel Route Ratings for Roadway Travel Units		
Travel Route Ratings for Shoreline Travel Units		
Scenic Quality Ratings for Roadway Travel Units (Scenic Resources)		
Scenic Quality Ratings for Shoreline Travel Units (Scenic Resources)		
Other Areas		
Public Recreation Areas and Bike Trails		
Built Environment (Community Design)		
Built Environment (Community Design)		

Noise Status & Trend Summary

Standard	2011	2015
Single Noise Events		
Aircraft Departures/Arrivals		

Standard	2011	2015
Watercraft Shoreline Test		
Watercraft Pass-By Test		
Watercraft Stationary Test		
Motor Vehicles Less Than 6,000 GVW		
Motor Vehicles Greater Than 6,000 GVW		
Motorcycles		
Off-Road Vehicles		
Snowmobiles		
Cumulative Noise Events		
High-Density Residential Areas		
Low-Density Residential Areas		
Hotel/Motel Areas		

Standard	2011	2015
Commercial Areas		
Industrial Areas		
Urban Outdoor Recreation Areas		
Rural Outdoor Recreation Areas		
Wilderness and Roadless Areas		
Critical Wildlife Habitat Areas		
South Lake Tahoe Airport Transportation Corridor		
State Route 28 Transportation Corridor		
Highway 50 Transportation Corridor		
State Route 89 Transportation Corridor		
State Route 207 Transportation Corridor		
State Route 267 Transportation Corridor		

Standard	2011	2015
State Route 431 Transportation Corridor		
Policy Statement Assessment - Adopt noise standards for Transportation Corridors		

Recreation Status & Trend Summary

Standard	2011	2015
Quality of Recreation Experience & Access to Recreational Opportunities		
Fair Share Distribution of Recreation Capacity		

CHAPTER 3
Air Quality

Air quality conditions in the Lake Tahoe Region can affect human health, visibility, forest health, and regional lake water quality, including the famed clarity of Lake Tahoe. The primary factors known to influence the basin's air quality are motor vehicle emissions, vehicle entrainment of road dust, wildfire, residential wood smoke, topography, meteorology, and pollutants transported from sources outside the Region (Green et al. 2011; Chen, Watson, and Wang 2011; Zhu, D. et al. 2009; Zhu et al. 2011; Gertler, A.W. et al. 2006; Gertler, A.W. et al. 2008; Cliff and Cahill 2000). Attainment of state, federal and TRPA air quality threshold standards represent conditions that reflect the public's values for protecting human and environmental health. Achievement of air quality threshold standards could also provide partial evidence that the TRPA Regional Plan and associated programs, and state and federal air quality regulations and programs, are effective at improving air quality in the Region.

This chapter provides an evaluation of current air quality conditions and trends in air pollutants relative to adopted air quality threshold standards and applicable state and federal air quality standards. It also assesses indicators related to factors such as traffic volume that potentially influence air pollutant concentrations. In TRPA Resolution 82-11, TRPA adopted threshold standards for carbon monoxide, ozone, visibility (atmospheric haze), respirable and fine particulate matter, nitrate deposition and odor. National Ambient Air Quality Standards (NAAQS) addressed in this evaluation fulfill requirements of the Bi-State Compact to measure and address the status of compliance with state and federal standards, and in part, requirements of California Air Resources Board (Mulford-Carrell Act) and the Federal Clean Air Act (40 CFR part 50). For air quality threshold standards, this evaluation addresses the status of several numerical standards, management standards with numerical targets, and one policy statement (Table 3-1). This threshold evaluation follows the conventions of the 2011 threshold evaluation report and organizes the findings based on the indicator reporting categories adopted in TRPA Resolution 82-11 (Table 3-1). Overall, 16~~5~~ of 20~~16~~ indictors were in attainment with almost all having improving trends. Two indicators had insufficient data to make a status determination.

Table 3-1. TRPA threshold standards and state and federal air quality standards addressed for Tahoe regional air quality.

Indicator Category	Name of Standard	Standard Type	Adopted TRPA Threshold Standard (TRPA Resolution 82-11)	Applicable State and Federal Standards	TRPA Indicator	Unit of Measure
Carbon Monoxide (CO)	8-hour Carbon Monoxide	Numerical	Maintain carbon monoxide concentrations at or below 6 parts per million averaged over 8 hours.	**Carbon Monoxide 8-hour Average** California and Nevada: Not to exceed 6 ppm Federal: Not to exceed 9 ppm more than once per year.	First and second highest CO concentration measured at Stateline, Nevada monitoring station	Parts Per Million (ppm)
	1-hour Carbon Monoxide	Numerical (State Standard)	No adopted standard	**Carbon Monoxide 1-hour Average** California: Not to exceed 20 ppm Federal and Nevada: Not to exceed 35 ppm more than once per year.	Highest CO concentration measured at Stateline, Nevada monitoring station	Parts Per Million (ppm)
	Winter Traffic Volume	Management (With Numerical Target)	Reduce traffic volumes on the U.S. Highway 50 Corridor by 7 percent during the winter from the 1981 base year between 4 p.m. and midnight, provided that those traffic volumes shall be amended as necessary to meet any state standards if they are developed.	No standard	Percent increase/decrease from 1981 winter (December through March) traffic volumes on U.S. Highway 50 at Park Avenue	Percent (%)
Ozone (O_3)	1-hour Ozone	Numerical	Maintain ozone concentrations at or below 0.08 parts per million averaged over 1 hour.	**Ozone 1-hour Average** California: Not to exceed 0.09 ppm Nevada: Not to exceed 0.10 ppm	Highest 1-hour average ozone concentration measured within a year at any monitoring station	Parts Per Million (ppm)

Indicator Category	Name of Standard	Standard Type	Adopted TRPA Threshold Standard (TRPA Resolution 82-11)	Applicable State and Federal Standards	TRPA Indicator	Unit of Measure
	8-hour Ozone	Numerical (State Standard)	No adopted standard	**8-hour Average** California: Not to exceed 0.070 ppm Nevada: no standard Federal: 0.070 ppm, 3-year average of the fourth-highest daily maximum must not exceed concentration standard.	Highest 8-hour average ozone concentration measured within a year at any monitoring station	Parts Per Million (ppm)
	Oxides of Nitrogen	Numerical	Maintain oxides of nitrogen (NO_x) emissions at or below the 1981 level.	**Nitrogen Dioxide Annual Average** Nevada and Federal: Not to exceed 53 ppb California: Not to exceed 30 ppb **Nitrogen Dioxide 1-hour Average** Federal: 100 ppb, 3-year average of the 98th percentile of the daily maximum 1-hour average must not be exceeded California: Not to exceed 0.18 ppm	**Nitrogen Dioxide Annual Average** Highest annual average concentration of NO_x and NO_2 **Nitrogen Dioxide 1-hour Average** Federal: 3-year average of the 98th percentile of the daily maximum 1-hour average of NO_2 California: Highest 1-hour concentration measured within a year at any site	Federal: Parts Per Billion (ppb) California: Parts Per Million (ppm)

Indicator Category	Name of Standard	Standard Type	Adopted TRPA Threshold Standard (TRPA Resolution 82-11)	Applicable State and Federal Standards	TRPA Indicator	Unit of Measure
Visibility	Regional Visibility	Numerical	Achieve an extinction coefficient of 25 Mm^{-1} at least 50 percent of the time as calculated from aerosol species concentrations measured at the Bliss State Park monitoring site (visual range of 97 miles); Calculations will be made on three year running periods using the existing monitoring data as the performance standards to be met or exceeded.	California: 8-hour average extinction coefficient of 0.07 per kilometer – visibility of 30 miles or more due to particles when relative humidity is less than 70%.	Extinction coefficient and distance of visibility.	3-year running average of Extinction coefficient. Light extinction (Mm^{-1}) and Miles or Kilometers
		Numerical	Achieve an extinction coefficient of 34 Mm^{-1} at least 90 percent of the time as calculated from aerosol species concentrations measured at the Bliss State Park monitoring site (visual range of 71 miles). Calculations will be made on three year running periods using the existing monitoring data as the performance standards to be met or exceeded.	California: 8-hour average extinction coefficient of 0.07 per kilometer – visibility of 30 miles or more due to particles when relative humidity is less than 70%.	Extinction coefficient and distance of visibility.	3-year running average of Extinction coefficient. Light extinction (Mm^{-1}) and Miles or Kilometers
	Sub-Regional Visibility	Numerical	Achieve an extinction coefficient of 50 Mm^{-1} at least 50 percent of the time as calculated from aerosol species concentrations measured at the South Lake Tahoe monitoring site (visual range of 48 miles);	No standard	Extinction coefficient and distance of visibility. 3-year running average of extinction coefficient.	Light extinction (Mm^{-1}) and Miles or Kilometers
		Numerical	Achieve an extinction coefficient of 125 Mm^{-1} at least 90 percent of the time as calculated from aerosol species concentrations measured at the South Lake Tahoe monitoring site (visual range of 19 miles).	No standard	Extinction coefficient and distance of visibility. 3-year running average of extinction coefficient.	Light extinction (Mm^{-1}) and Miles or Kilometers

Indicator Category	Name of Standard	Standard Type	Adopted TRPA Threshold Standard (TRPA Resolution 82-11)	Applicable State and Federal Standards	TRPA Indicator	Unit of Measure
Respirable and Fine Particle Matter	Respirable Particulate Matter (PM_{10})	Numerical	Maintain PM_{10} at or below 50 µg/m³ measured over a 24-hour period in the portion of the Region within California, and maintain PM_{10} at or below 150 µg/m3 measured over a 24-hour period in the portion of the Region within Nevada.	Federal: 150 µg/m³ (24-hr mean, not to be exceeded more than 3 times in 3 years) California: 50 µg/m³	Number of 24-hr periods exceeding the applicable federal or state standards at any monitoring station	Micrograms per cubic meter (µg/m³)
		Numerical	Maintain PM_{10} at or below annual arithmetic average of 20 µg/m3 in the portion of the Region within California, and maintain PM_{10} at or below annual arithmetic average of 50 µg/m3 in the portion of the Region within Nevada.	California: 20 µg/m³	Annual average PM_{10} concentrations at any permanent monitoring station (µg/m³)	Micrograms per cubic meter (µg/m³)
	Fine Particulate Matter ($PM_{2.5}$)	Numerical	Maintain Particulate Matter2.5 at or below 35µg/m3 measured over a 24-hour period using gravimetric or beta attenuation methods or any equivalent procedure which can be shown to provide equivalent results at or near the level of air quality standard.	Federal: 35 µg/m³, 3-year average of the 98th percentile of 24-hour concentration must not exceed concentration standard	Number of 24-hr periods exceeding the applicable federal or state standards at any monitoring station (µg/m³)	Micrograms per cubic meter (µg/m³)

Indicator Category	Name of Standard	Standard Type	Adopted TRPA Threshold Standard (TRPA Resolution 82-11)	Applicable State and Federal Standards	TRPA Indicator	Unit of Measure
		Numerical	Maintain Particulate Matter2.5 at or below annual arithmetic average of 12µg/m3 in the portion of the Region within California and maintain Particulate Matter2.5 at or below annual arithmetic average of 15µg/m3 in the portion of the Region within Nevada. Particulate Matter2.5 measurements shall be made using gravimetric or beta attenuation methods or any equivalent procedure which can be shown to provide equivalent results at or near the level of air quality standard	Federal: 12.0 µg/m^3, 3-year average of weighted annual mean concentration must not exceed. California: 12 µg/m^3 Annual concentration must not be exceeded.	Annual average $PM_{2.5}$ concentrations at any permanent monitoring station (µg/m^3)	Micrograms per cubic meter (µg/m^3)
Nitrate Deposition	Vehicle Mile Traveled	Numerical	Reduce vehicle miles traveled in the basin by 10% of the 1981 base year values.	No standard	A10% reduction from 1981 base year estimated VMT is 2,030,938 VMT (Source: TRPA TransCAD Model)	Vehicle Miles Traveled (VMT) and Percent (%)
	Nitrate Deposition	Management	Reduce the transport of nitrates into the basin and reduce oxides of nitrogen (NOx) produced in the basin consistent with the water quality thresholds.	No standard	Implementation of management standard into the Regional Plan	N/A
Odor	Odor	Policy Statement	It is the policy of the TRPA Governing Board in the development of the Regional Plan to reduce fumes from diesel engines to the extent possible.	No standard	Implementation of policy statement into the Regional Plan	N/A

Information Sources: *Federal Standards:* http://www3.epa.gov/ttn/naaqs/criteria.html*; California Standards: http://www.arb.ca.gov/research/aaqs/aaqs2.pdf; Nevada Standards: http://ndep.nv.gov/baqp/monitoring/docs/445b391.pdf: TRPA Threshold Standards: http://www.trpa.org/wp-content/uploads/Adopted-Regional-Plan_20160614_Clean.pdf(Attachment C)*

Air Quality Data Sources

The data used to compare air pollutant concentrations to the established threshold standards in this chapter were sourced from TRPA, U.S. Environmental Protection Agency (EPA), California Air Resources Board (CARB), Nevada Department of Environmental Protection, Bureau of Air Pollution Control (NDEP), Placer County Air Pollution Control District and other state and local air quality monitoring. Data were analyzed for comparison by Desert Research Institute using evaluation methodologies established by the EPA, CARB, and NDEP.

Data Limitations

Three factors affect the ability to comprehensively evaluate the status and trends of air quality indicators in the Lake Tahoe Basin: 1) degree of spatial coverage of monitoring sites, 2) extent of long-term operations of monitors at a given site, and 3) the nature of existing indicators used to evaluate air quality in the Region. A substantial expansion of the spacing and density of monitoring sites would be needed to know the distribution of maximum and minimum pollutant concentrations throughout the basin.

Cost and maintenance of equipment, land access agreements and vandalism have caused variability overtime in monitoring locations and data. Monitoring sites have been operated intermittently or shut down after a few years, with the exception of the Bliss visibility monitoring site. Locations of monitoring sites have also been changed, making it more difficult to determine with a high degree of certainty whether a trend was due to a real change in the atmosphere or a result of the site change. These circumstances are accounted for by reducing the confidence rating for a given status and trend determination as noted in indicator summaries. These data limitations are being addressed. TRPA and state and county air quality authorities are working to increase the spatial coverage and robustness of air quality monitoring data for the Region.

The indicators presented here are related to state, federal and TRPA standards. In most instances, each indicator only takes into account the highest recorded measurements (e.g. highest, second highest) and does not take into account the distribution of measurements throughout a given year. As a consequence, these indicators do not completely characterize the range of conditions that occur within a year. Thus, the measurements could be significantly better than the standard most of the year, but one high measurement could trigger a determination that the standard is out of attainment.

Table 3-2 summarizes the results of the 2015 assessment. The table provides a summary of the status and trend of standards in the air quality reporting categories as well as the results from the 2011 Threshold Evaluation Report for comparison. Figure 3-1 and Table 3-3 provide a key to the symbols used to communicate status, trends, and confidence. A detailed description of how these conclusions are reached is provided in the methodology section. The indicator sheets that follow contain more detailed assessment of the status and trend of each indicator, descriptions of the methods used, and recommendations for modification of the standard or analytic approach used to assess the standard.

Table 3-2: Summary of status and trend of air quality indicator reporting categories from the 2011 and 2015 Threshold Evaluation Reports.

Standard	2011	2015
Carbon Monoxide		
Highest 1-hour Concentration of Carbon Monoxide	↑	↗
Highest 8-hour Average Concentration of Carbon Monoxide	↑	↗
Average Daily Winter Traffic Volume, Presidents Weekend	↗	↗
Ozone		
Highest 1-hour Average Concentration of Ozone	↔	↗
Highest 8-hour Average Concentration of Ozone	↔	↗
3Year Average of the 4th Highest 8-hour Concentration of Ozone	↔	↗
Oxides of Nitrogen Emissions	↗	↗
Regional Visibility		
Regional Visibility 50th Percentile ("Average Visibility Days")	↔	↔
Regional Visibility 90th Percentile ("Worst Visibility Days")	↔	↔
Subregional Visibility		
Subregional Visibility 50th Percentile ("Average Visibility Days")	◇	◇
Subregional Visibility 90th Percentile ("Worst Visibility Days")	◇	◇
Respirable and Fine Particulate Matter		

Standard	2011	2015
Highest 24-hour PM_{10} Concentration		
Annual Average PM_{10} Concentration		
24-hour $PM_{2.5}$ Concentration		
Annual Average $PM_{2.5}$Concentration		
Nitrate Deposition		
Reduce generation and transport of nitrate to achieve water quality standards		
Vehicle Miles Traveled (VMT)		
Odor - Reduce diesel engine fumes		

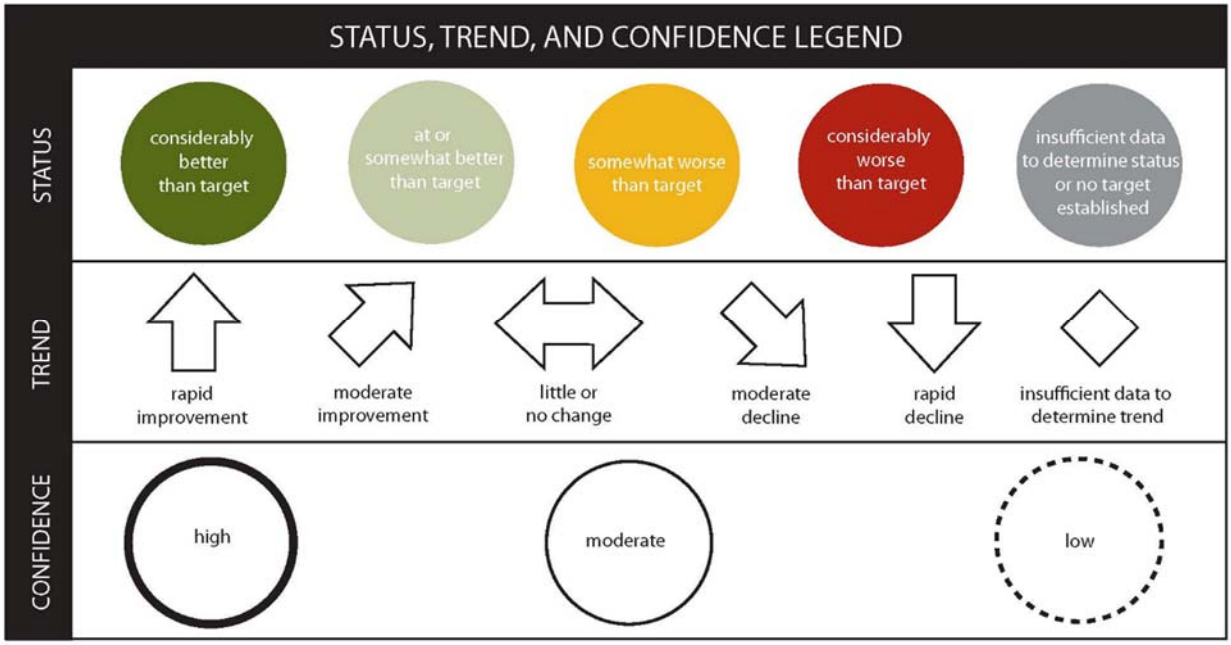


Figure 3-1: A key to the symbols used to assess status, trends, and confidence levels.

Table 3-3. Key to the reporting icon used to characterize the implementation status of management standards and policy statements.

Status Category	Description	Reporting Icon
Implemented	The management standard or policy statement has been integrated into the Regional Plan and is consistently applied to a project design or as a condition of project approval as a result of project review process. Examples of programs or actions can be identified to support the management standard's implementation. Adopted programs or actions support all aspects of the management standard or policy statement's implementation, or address all major threats to implementation.	I
Partially Implemented	The management standard or policy statement has been integrated into the Regional Plan, but is not consistently applied during the project review process. No more than two examples of programs or actions can be identified to support the management standard's implementation and/or adopted programs or actions support some aspects of the management standard or policy statement's implementation, or address some major threats to implementation.	PI
Not Implemented	The management standard or policy statement has not been integrated into the Regional Plan and is not applied during the project review process. No examples of programs or actions can be identified to support implementation.	NI

Carbon Monoxide

Carbon monoxide (CO) is a tasteless, odorless, and colorless gas. It is a public health concern because elevated concentrations affect human and animal health by reducing the supply of oxygen to body tissues. This can result in shortness of breath, seizures, coma, or even death. Carbon monoxide is created through the incomplete combustion of carbon-based fuels. The primary anthropogenic sources of CO are on-road motor vehicles (30 percent), residential wood burning (28 percent), motorized watercraft (16 percent), and off-highway vehicles (8 percent) (California Air Resources Board 2006). Wildfires are a natural source of CO. Meteorology also plays a key role in influencing the concentration of CO within the Region as wind and inversion layers can affect concentrations.

Policy and management actions implemented through the TRPA Regional Plan to control CO emissions focus on reducing private automobile use through improvements to public transportation and bike/pedestrian trail infrastructure. Vehicle emission standards enacted by state and federal governments have also reduced CO emissions in the Region, mainly by requiring improvements in engine and exhaust technologies. State air quality agencies regulate the timing and magnitude of forest biomass prescribed burning or pile burning.[1]

The status and trends of three indicators, 1-hour and 8-hour CO standards and winter traffic volume, were evaluated to characterize the overall status and trend of the carbon monoxide indicator reporting category. Following this introduction for carbon monoxide are indicator summaries that provide a more detailed evaluation of each indicator relative to adopted threshold standards. In general, each of the carbon monoxide indicators were considerably better than the threshold standards in almost all years since monitoring began and trends are improving. During the summer months, exceptional events such as uncontrolled forest fires can cause uncharacteristic spikes in carbon monoxide concentrations. In 2007, the EPA promulgated the Exceptional Events Rule that allows for the exclusion of air quality monitoring data influenced by exceptional events from use in determinations of exceedances or violations of the air quality standards.

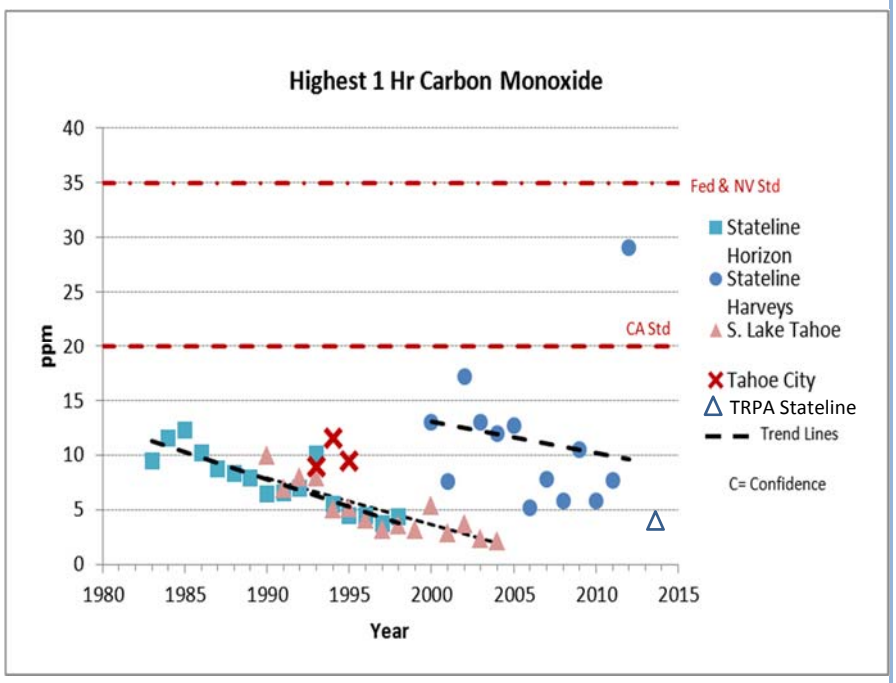
[1] *http://www.arb.ca.gov/smp/progdev/pubeduc/pbfs.pdf*

Carbon Monoxide: **Highest 1-Hour Concentration of Carbon Monoxide**

Status	Trend

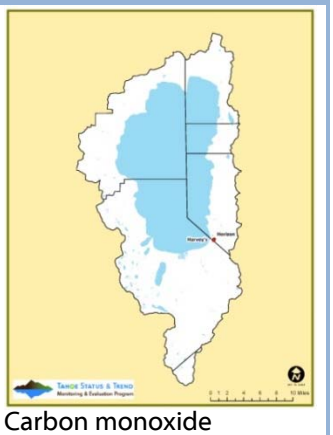
HIGHEST 1-HOUR CONCENTRATION OF CARBON MONOXIDE

Status: **Considerably Better than Target**
Trend: **Moderate Improvement**
Confidence: **Moderate**



Annual maximum 1-hour CO in the Tahoe Basin from 1983 to present. The extremely high 2012 CO reading is likely a false reading and is therefore not used to assess the current status (please see "Status" section for further description). In lieu of an adopted TRPA standard, the stricter California state standard is used to assess the indicator. Source: Desert Research Institute

Map



Carbon monoxide monitoring sites located at Horizon and Harvey's Casinos in the Lake Tahoe Basin.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Carbon monoxide (CO) in high concentrations affects human health by reducing the supply of oxygen to the tissues of the body. Health effects can include headaches, nausea, reduced mental alertness, and even death at very high concentrations. Federal and state standards with varying time-averaging periods have been adopted to protect the public from this pollutant. This indicator addresses the highest CO concentrations averaged over every 1 hour for the calendar year.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Carbon Monoxide (CO)

Adopted Standards – TRPA does not have an adopted standard for this indicator so the strictest California state standard is used instead. California standard: Maintain 1-hour concentrations of carbon monoxide at or below 20 ppm. Nevada and federal standard: Maintain 1-hour concentrations of carbon monoxide below 35 parts per million (PPM).

Type of Standard – Numerical

Indicator (Unit of Measure) – Highest 1-hour concentration in parts per million (ppm) of carbon monoxide measured within a calendar year.

Human & Environmental Drivers – Carbon monoxide is created by incomplete fuel combustion and emitted by sources such cars, trucks, boats, construction equipment, fireplaces, woodstoves, furnaces, and wildfire.

MONITORING AND ANALYSIS

Monitoring Partners – Nevada Division of Environmental Protection (NDEP), U.S. Environmental Protection Agency (EPA), Desert Research Institute (DRI), California Air Resources Board CARB)

Monitoring Approach – Between 1983 and 1998, CO was monitored at the Horizon Hotel in Stateline, Nevada. In 1999, the monitoring site was relocated to Harvey's Resort in Stateline, Nevada. The site was located to monitor the highest CO concentrations in the Lake Tahoe Basin because historically this area received the highest traffic volume, and was intended to be representative of both the California and Nevada sides of the South Shore Resort District. NDEP successfully petitioned the EPA to remove this monitoring site on June 30, 2012 because of the continued compliance with established CO concentration standards. The CARB provided TRPA with a CO monitor which was installed on the roof the building at TRPA building in Stateline, NV in 2013.

Analytic Approach – Trend was calculated using the Theil-Sen robust regression method (Theil 1950). Trend was analyzed beginning in 2000 for the Stateline Harvey's site to account for the change in monitoring location. Trend analysis of the resulting indicator values was performed by DRI under TRPA contract.

INDICATOR STATE

Status – Considerably better than target. The Region has been well within compliance with the TRPA, State and Federal standards for many years. In April of 2012, The NDEP submitted its' second 10-year Maintenance Plan to EPA recommending that the monitoring site be discontinued due to the low concentrations recorded at the site. In explaining the decision to discontinue monitoring, NDEP writes, "NDEP concludes that 33 years of clean data, all of it under 80 percent of the NAAQS and most recently at 34 percent, with on-going downward trends is sufficient evidence of continued attainment through 2024…(NDEP 2012)." Prior to discontinuation of the monitoring site, a high recording of 29.1 ppm was recorded, but is believed to a be a false/faulty reading. The 2012 reading was nearly double the "exceptional events" readings recorded during wildfire 2003/2004 and was almost three times the level that would be expected based on the long term trend in the data. The 2012 reading did not exceed the 1hr NV state standard (35 ppm) and was thus not flagged for additional analysis by NDEP.

Surrogate monitoring conducted by TRPA recorded a maximum 1-hour CO reading of 4 ppm during the current monitoring period. While the TRPA monitor is not "official" data because the monitoring station has not been approved by the EPA, it provides quality assured data and is further evidence to support the belief that the 29.1ppm levels recorded in 2012 were not accurate. For these reasons, the 2012 reading is not used to assess status and instead the long term trend line is used. The long term trend line shows the current status as considerably better than target.

Trend – Moderate improvement. The long-term trend lines indicate statistically significant decreasing trends at the Horizon site between 1983 and 1998, and at the Harvey's site between 2000 and 2012 (Campbell 2015). 1-hour CO concentrations decreased by an average of 0.3 ppm per year at the Harvey's

site, which is a decrease of 1.5 percent per year in relation to the standard of 20 ppm. Therefore, a trend of moderate improvement was determined. The 2012 data appears to be an anomaly and was not indicative of the overall trend.

Confidence –

Status – Moderate. There is moderate confidence in the status because data was collected using widely accepted protocols, are subject to quality assurance requirements, and were collected consistently between 1983 and 2012 with the exception of moving the monitoring site approximately one-quarter mile in 1999. While only one monitoring site is used to determine indicator status, the monitoring site is located within the South Shore Resort District that represents the greatest volume of vehicle traffic in the Region, and the measurements are thought to represent the highest source of CO emissions. Confidence would be "high," but moving the monitoring location one-quarter mile in 1999 significantly changed CO levels, raising questions about the representative nature of data (Campbell, D. 2016)

Trend – Moderate. Confidence in the trend at the Stateline Harvey's site is moderate ($p = 0.18$).

Overall – Moderate.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Public transit operations, state and federal vehicle emission standards, TRPA and country wood stove retrofit programs, intersection improvements, bicycle trail infrastructure improvements, the Heavenly Gondola Project, among others factors, all contribute to reduced emissions.

Effectiveness of Programs and Actions – Current CO status and trends suggest TRPA, state, and federal actions to reduce CO emissions and decrease traffic volumes are effective at reducing 1-hour CO concentrations at this location.

Interim Target – While the most recent data from 2012 was out of attainment, all signs points to this data being an anomaly, and overall it is likely the Region is an attainment. Therefore, it is not necessary to establish an interim target.

Target Attainment Date – While the most recent data from 2012 was out of attainment, all signs points to this data being an anomaly, and overall it is likely the Region is an attainment. Therefore, it is not necessary to establish a target attainment date.

RECOMMENDATIONS

Analytic Approach – Clarification is needed on whether to assess the indicator based on the most current year of data available or on a multi-year average.

Monitoring Approach – No changes recommended. TRPA continues to monitor CO at a site on the roof of the TRPA building in Stateline, NV. In response to the long term record of attainment, and direction from EPA, NDEP discounted monitoring at the Horizon Stateline site in 2012.

Modification of the Threshold Standard or Indicator – No changes recommended.

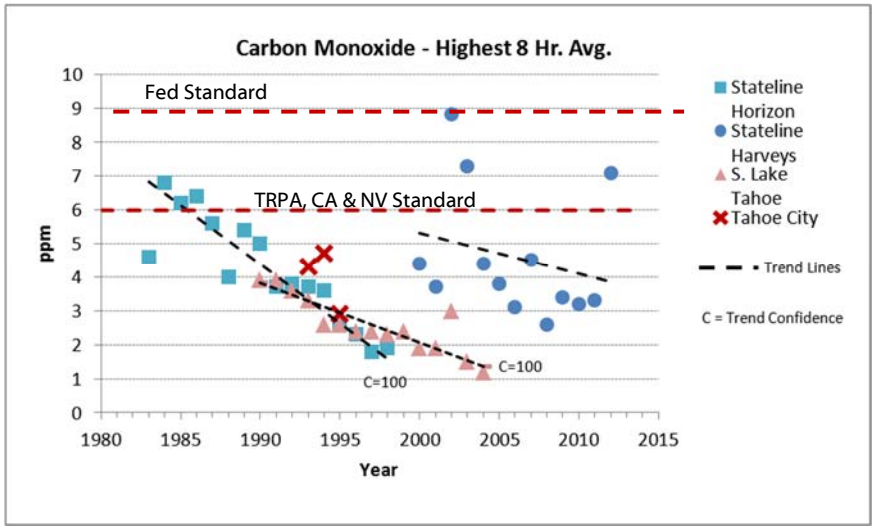
Attain or Maintain Threshold – No changes recommended.

Carbon Monoxide: **Highest 8-hour Average Concentration of Carbon Monoxide**

Status	Trend

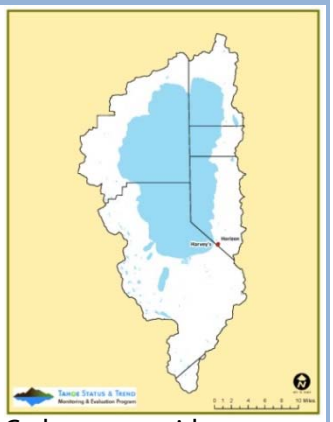
HIGHEST 8-HOUR AVERAGE CONCENTRATION OF CARBON MONOXIDE

Status: **Considerably Better than Target**
Trend: **Moderate Improvement**
Confidence: **Moderate**



Highest and second highest annual maximum 8-hour CO in the Tahoe Basin from 1980 to present. The 2012 CO reading was not due to any "exceptional event" such as wildfire. However, it is likely a false reading and is not used to assess the current status (please see "status" section for further description). High CO readings in 2003/2004 were "exceptional events" caused by wildfire. Source: Desert Research Institute

Map



Carbon monoxide monitoring sites located at Horizon and Harvey's Casinos in the Lake Tahoe Basin.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Carbon monoxide (CO) in high concentrations affects human health by reducing the supply of oxygen to the tissues of the body. Health effects can include headaches, nausea, reduced mental alertness and even death, at very high concentrations. TRPA, federal and state standards have been adopted to protect the public from this harmful pollutant. This indicator addresses the highest CO concentrations averaged over every 8-hours for the calendar year.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Carbon Monoxide (CO)

Adopted Standards – Maintain carbon monoxide concentrations at or below 6 parts per million (7 mg/m3) averaged over 8 hours. California and Nevada: Highest 8-hour average of 6 ppm is not to be exceeded.

Type of Standard – Numerical

Indicator (Unit of Measure) –Highest 8-hour average CO concentration (ppm). The second highest is provided to demonstrate the magnitude of difference between the highest and second highest 8-hour concentrations in the Region.

Human & Environmental Drivers – Carbon monoxide is emitted from incomplete fuel combustion by sources such as cars, trucks, boats, construction equipment, fireplaces, woodstoves, furnaces, and wildfire. The ambient concentration of CO is highly dependent on meteorological conditions such as temperature, wind speed, and mixing conditions.

MONITORING AND ANALYSIS

Monitoring Partners – Nevada Division of Environmental Protection (NDEP), U.S. Environmental Protection Agency (EPA), Desert Research Institute (DRI), and Tahoe Regional Planning Agency (TRPA).

Monitoring Approach – Between 1983 and 1998, CO was monitored at the Horizon Hotel in Stateline, Nevada. In 1999, the monitoring site was relocated to Harvey's Resort parking garage in Stateline, Nevada. The site is located to monitor the highest CO concentrations in the Lake Tahoe Basin because historically this area received the highest traffic volume, and is intended to be representative of both the California and Nevada sides of the South Shore Resort District. NDEP successfully petitioned the EPA to remove this monitoring site on June 30, 2012 because of the continued compliance with established CO concentration standards. The CARB provided TRPA with a CO monitor which was installed on the roof the building at TRPA building in Stateline, NV in 2013.

Analytic Approach – Trend was calculated using the Theil-Sen robust regression method (Theil 1950). Trend for the highest 8-hour average CO was analyzed beginning in 2000 for the Stateline Harvey's site to account for the change in monitoring location. Trend analysis of the resulting indicator values was performed by DRI under TRPA contract.

INDICATOR STATE

Status – Considerably better than target. The Region has been well within compliance with the strictest adopted threshold standard every year except 2012 (Campbell 2015). In 2012, the maximum 8-hour CO concentration at the Stateline Harvey's site and was 7.1ppm. However, this is likely a false reading. Surrogate monitoring of the 8-hr standard supports the conclusion that the 2012 observation was an anomaly. Further, NDEP and EPA deemed it no longer necessary to monitor CO at this location because recorded levels were consistently below state and federal standards. In explaining the decision to discontinue monitoring, NDEP writes, "NDEP concludes that 33 years of clean data, all of it under 80 percent of the NAAQS and most recently at 34 percent, with on-going downward trends is sufficient evidence of continued attainment through 2024…(NDEP 2012)." For these reasons, the 2012 reading is not used to assess status and instead the long term trend line is used. The long term trend line shows the current status as considerably better than target.

Trend – Moderate improvement. The trend line at the Stateline Harvey's site shows a decrease of 0.1ppm per year, which is a 1.7 percent decrease per year in relation to the standard of 6ppm (Campbell 2015). Therefore, a trend of moderate improvement was determined.

Confidence –

Status – Moderate. There is moderate confidence in the status because data was collected using widely accepted protocols, are subject to quality assurance requirements, and were collected consistently between 1983 and 2012 with the exception of moving the monitoring site approximately ¼ mile in 1999. The one monitoring site used to determine indicator status is located at the South Shore Resort District which represents the greatest volume of vehicle

traffic in the Region, and consequently the measurements are thought to be representative of the highest concentrations in the basin. Confidence would be high, however, changes in the monitoring location of less than ¼ mile in 1999 significantly changed CO levels, raising questions about the representative nature of the data collected at other sites (Campbell, D. 2016).

Trend – Moderate. The confidence in the trend is moderate (p = 0.13).

Overall – Moderate.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Public transit operations, state and federal vehicle emission standards, TRPA and country wood stove retrofit programs, intersection improvements, bicycle trail infrastructure improvements, the Heavenly Gondola Project, among others factors, all contribute to reduced emissions.

Effectiveness of Programs and Actions – Current CO status and trends suggest TRPA, state, and federal actions to reduce CO emissions and decrease traffic volumes are effective at reducing 8-hour CO concentrations at this location.

Interim Target – Not applicable. The long term trend suggests the 2012 exceedance was an anomaly and CO concentrations should return to within the current standard.

Target Attainment Date – Not applicable. The long term trend suggests the 2012 exceedance was an anomaly and CO concentrations should return to within the current standard.

RECOMMENDATIONS

Analytic Approach – Clarification is needed on whether to assess the indicator based on the most current year of data available (current approach) or on a multi-year average.

Monitoring Approach – No changes recommended. TRPA continues to monitor CO at a site on the roof of the TRPA building in Stateline, NV. In response to the long term record of attainment, and direction from EPA, NDEP discounted monitoring at the Horizon Stateline site in 2012.

Modification of the Threshold Standard or Indicator – No changes recommended.

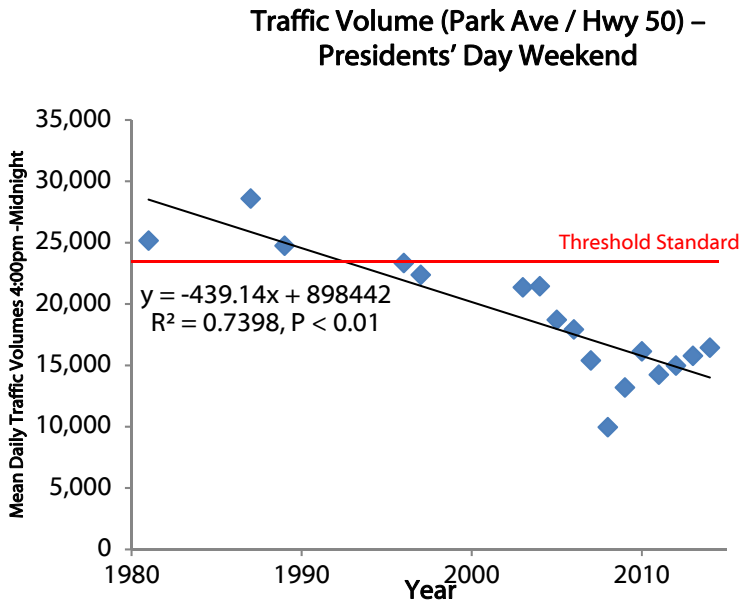
Attain or Maintain Threshold – No changes recommended.

Carbon Monoxide: **Average Daily Winter Traffic Volume, Presidents' Weekend**

Status	Trend

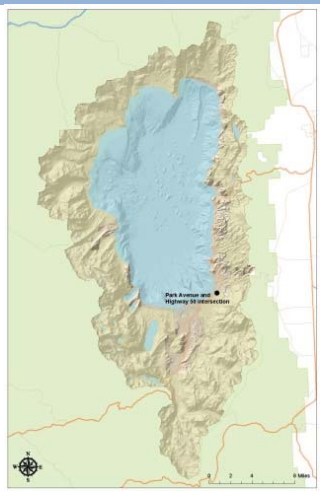
AVERAGE DAILY WINTER TRAFFIC VOLUME, PRESIDENTS' WEEKEND

Status: **Considerably Better than Target**
Trend: **Moderate Improvement**
Confidence: **Moderate**



Average daily winter traffic volume measured between 4 p.m. and midnight (vehicles/day) on Presidents' Day Weekend at U.S. Highway 50 and Park Avenue, South Lake Tahoe, California, 1981 to 2014. Note: data not collected for 1982-1986, 1990–1995, and 1998-2002 periods resulting in a decrease in confidence in trend determination. Data Source: Caltrans and TRPA

Map



Location of Presidents' Day Weekend traffic volume monitoring at the Hwy. 50/Park Ave site.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures traffic ~~congestion~~ volumes ~~levels~~ during winter months and provides a proxy measure of carbon monoxide concentration levels according to TRPA Resolution 82-11.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Carbon Monoxide (CO)

Adopted Standards – Reduce traffic volumes on the U.S. 50 Corridor by 7 percent during the winter from the 1981 base year between 4:00 p.m. and 12:00 midnight, provided that those traffic volumes shall be amended as necessary to meet the respective state standards.

Type of Standard – Management standard with a numeric target

Indicator (Unit of Measure) – Average daily traffic volumes measured at Park Avenue and U.S. Highway 50 between 4 p.m. and midnight on the Saturday of Presidents Day weekend (vehicles per day).

Human & Environmental Drivers – Several factors can influence traffic volumes measured on Presidents' Day weekend, including weather, economy, and availability of alternative modes of transportation. In winter 2001/2002, Heavenly Resort improved its free skier shuttle services and installed a Gondola near the site where traffic volumes are measured. It is presumed that the continuing availability of these alternative modes of transportation and the Gondola project have helped reduce traffic volumes to a level below the TRPA threshold standard.

MONITORING AND ANALYSIS

Monitoring Partners – California Department of Transportation (Caltrans) and TRPA

Monitoring Approach – Caltrans measures this indicator continuously using automated counters placed in the roadway at the intersection of Park Avenue and U.S. Highway 50 in South Lake Tahoe, including on the Saturday of Presidents' Day weekend from 4 p.m. and midnight, coinciding with the historical period of the most frequent exceedance of California's carbon monoxide (CO) standards. Data are summarized by Caltrans and subsequently accessed by TRPA for reporting purposes.

Analytic Approach – Simple linear regression is used to assess trend.

INDICATOR STATE

Status – Considerably better than target. Data from winter 2014 indicate that average daily traffic volume measured on Presidents' Day weekend is 16,453, 70.3 percent of the standard of 23,411 vehicles per day. Consequently, the Region is considerably better than the target to reduce by 7 percent 1981 traffic volume levels. Every year during the current monitoring period (2011 to 2014) was better than the target. The seven percent reduction from 1981 base year value of 25,173 vehicles per day between 4 p.m. and midnight, establishes a target of 23,411 vehicles per day.

Trend – Moderate Improvement. The long-term trend shows an average decrease in traffic volume at the monitoring site of 439 vehicles per day per year between 1981 and 2014, a 1.8 percent annual decrease in relation to the standard of 23,411 vehicles per day. Therefore, the overall trend is one of moderate improvement.

While the overall trend has been decreasing traffic volumes, since 2011 there is an upward trend. Daily traffic volumes between 2011 and 2014 grew by 2,210 vehicles overall, which is approximately four percent per year. This is still within the target.

Confidence –

> **Status –** High. Traffic volume is continuously measured with an automated traffic counter at Park Avenue and U.S. Highway 50 that is regularly calibrated according to protocols and maintained by Caltrans. There is high confidence in the current status determination because established protocols are used, data has been continuously collected since 2003, and current data is available.
>
> **Trend –** Moderate. Confidence in the long term trend line is moderate ($r^2 = 0.7398$, $P < 0.01$). There were several gaps in data collection between 1982 to1986, 1990 to 1995, and 1998 to 2002 that resulted in reduced confidence in data presented prior to 2003.

Overall – Moderate. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Public transit operations such as free skier shuttle service, BlueGo, and Tahoe Area Rapid Transit, intersection improvements, improved walkability through environmental redevelopment at Stateline, and the Heavenly Gondola project.

Effectiveness of Programs and Actions – Since overall traffic volumes have decreased since 1982, programs and actions appear to be somewhat effective. However, recent traffic increases since 2011 show that there is continued work that needs to be done to address traffic volumes.

Because the Park Avenue monitoring site is located in close proximity to the Heavenly Gondola project, it allows direct measurement of the impacts of the Gondola project on traffic volumes. Average winter traffic volumes and rate of traffic volume change were compared between dates prior to and after the Heavenly Gondola project implementation in 2001. The average daily traffic volume before the Heavenly Gondola project was 24,854 vehicles per day, and post-project was 16,307 vehicles per day, representing an average reduction of 8,547 vehicles per day. While outside factors beyond the Gondola project could be partly responsible for this decrease, this analysis suggests the Gondola project may have reduced overall winter traffic volumes, and resulted in a more rapid decline in traffic volumes than if the project had not been implemented.

Interim Target – Not applicable. In attainment.

Target Attainment Date – Not applicable. In attainment.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

Attain or Maintain Threshold – No changes recommended.

Ozone

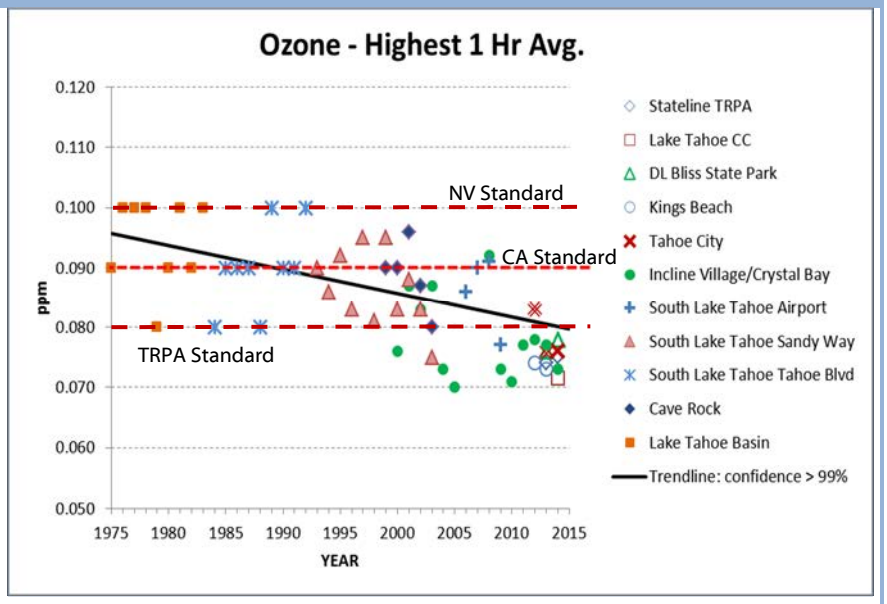
Ozone (O_3) is created through a photochemical reaction between atmospheric oxygen, hydrocarbons and/or carbon monoxide, oxides of nitrogen, and sunlight. At high concentrations at ground level in the lower atmosphere, O_3 is an air pollutant that can harm the respiratory systems of people and animals and damage plant tissue. Young and elderly people are especially susceptible to elevated O_3 levels, which can cause lung and other respiratory illnesses. Ozone damages trees and plants, particularly ponderosa pines, Jeffrey pines, and quaking aspen that make up a large portion of the basin's tree population (Davis and Gerhold 1976).
Ground-level ozone is not directly emitted from typical pollutant sources like automobiles or industrial activities, but instead is created through a complex photochemical reaction between precursor gases such as hydrocarbons and oxides of nitrogen and sunlight in the lower atmosphere. The primary sources of the precursor gases in the Lake Tahoe Basin include on-road motor vehicles, residential fuel combustion, motorized watercraft, off-road equipment, solvent and fuel evaporation, and off-road recreational vehicles (California Air Resources Board 2006). Ozone can also be transported into the Lake Tahoe Basin from outside sources, although these sources are reported not to substantially contribute to overall O_3 concentrations (CARB 2004). Research into the amount of ozone transport from outside ozone sources is on-going. Because ozone formation is a photochemical process, higher concentrations are created on cloud-free summer days when the sun's radiation is at its peak. Overall, all the indicators for ozone are in attainment and have an improving or level trend.

Ozone: **Highest 1-Hour Average Concentration of Ozone**

Status	Trend

HIGHEST 1-HOUR AVERAGE CONCENTRATION OF OZONE

Status: **At or Somewhat Better than Target**
Trend: **Moderate Improvement**
Confidence: **High**



The highest 1-hour ozone concentration in parts per million (ppm) measured at all monitoring sites in the Lake Tahoe Region. Hollow symbols represent data that does not meet regulatory requirements for data completeness or validation. Source: Desert Research Institute

Map

Current ozone monitoring locations in the Lake Tahoe Basin.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Ozone (O_3) in high concentrations can cause health effects such as lung inflammation and other respiratory illness. Ozone can also cause damage to trees and plants at concentrations lower than the human health based ambient air quality standards. TRPA, federal and state standards have been adopted to protect human health. This indicator addresses the highest monitored O_3 concentration averaged over every 1-hour for the calendar year.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Ozone

Adopted Standards – TRPA: Maintain ozone concentrations at or below 0.080 parts per million averaged over 1-hour; California: not to exceed 0.090 ppm; Nevada: not to exceed 0.10 ppm.

Type of Standard – Numerical

Indicator (Unit of Measure) – Highest 1-hour average concentration of ozone measured at any monitoring station in the Lake Tahoe Basin.

Human & Environmental Drivers – Ozone is a secondary pollutant created by photochemical reactions between hydrocarbons (HC) and oxides of nitrogen (NOx) in sunlight. The primary sources of HC and NOx include in-basin mobile sources such as cars, trucks, boats, aircraft and off-road vehicles; biomass burning such as wood stoves, wildfires and prescribed burning; and consumer products such as solvents. Ozone is also transported into the basin to a lesser extent from populated areas surrounding the basin. The ambient concentration of O_3 is highly dependent on meteorological conditions such as sunlight, temperature, wind speed, and mixing conditions. Typically, the greater the volume of sources such as increased traffic contributing to precursor gas concentration during optimal weather conditions, the higher the concentration of ozone.

MONITORING AND ANALYSIS

Monitoring Partners – California Air Resources Board, Washoe County Air Quality Management Division, U.S. Environmental Protection Agency, Desert Research Institute (DRI), Placer County Air Pollution Control District and Tahoe Regional Planning Agency.

Monitoring Approach – Ozone is monitored at a number of locations around the Lake Tahoe Basin through the years by a variety of partners. Data is collected, analysed, and reported by the respective agency.

Analytic Approach – Trend was calculated using the Theil-Sen robust regression method (Theil 1950). Trend analysis of the resulting indicator values was performed by DRI under TRPA contract.

INDICATOR STATE

Status – At or somewhat better than target. For 2014, the latest year data is available, the maximum 1-hour average ozone concentration at sites that met regulatory reporting requirements was 0.076 ppm at Tahoe City, approximately 95 percent of the target of 0.080 ppm (Campbell 2015). Therefore, a status of at or somewhat better than target is determined. Additionally, only one location and year, Tahoe City in 2012, was above the threshold standard during the current 2012 to 2015 monitoring period.

Trend – Moderate improvement. There is a statistically significant downward trend based on the long term trend line of sites that met regulatory reporting requirements. The trend line shows a 0.0004 ppm per year decrease from 1975 to 2013, a decrease of 0.5 percent per year in relation to the standard of 0.080 ppm (Campbell 2015). Therefore, a trend of moderate improvement was determined.

Confidence –

> **Status –** High. There is high confidence in the status determination because the data was collected using widely accepted protocols, was subject to quality assurance requirements, and has been collected continuously across the Region since 1975.
> **Trend –** High. The confidence in the long term trend is high ($p = 0.01$)
> **Overall Confidence –** High.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Regional, state and federal emission standards for motor vehicles, motorized watercraft, gas appliances, and woodstoves. Transportation infrastructure improvements such as more efficient intersections, sidewalks, and bicycle infrastructure development. Public transportation systems. Regional and state restrictions on prescribed burning days.

Restricted development of "drive-up window" commercial uses.

Effectiveness of Programs and Actions – Based on current 2012 to 2015 monitoring period results, it appears current programs and actions are successful in reducing 1-hour maximum ozone values. If data continues to show the indicator below the threshold in the future, there will be higher confidence in this statement.

Interim Target – Not applicable. Currently the indicator is in attainment.

Target Attainment Date – Not applicable. Currently the indicator is in attainment.

RECOMMENDATIONS

Analytic Approach – A specific definition of how the indicator will be evaluated is needed. Potential options include:

1. Take the average maximum 1-hour readings of all monitoring stations during current monitoring period and compare it to the standard.
2. Take the average maximum 1-hour readings of all monitoring stations during the most recent monitoring period and compare it to the standard.
3. Report on the number of exceedances during the current monitoring period.
4. Report on the number of exceedances during the most recent monitoring period.
5. Use the highest reading from the current monitoring period and compare it to the standard.
6. Use the highest reading from the most recent monitoring period and compare it to the standard. This is the current evaluation method.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

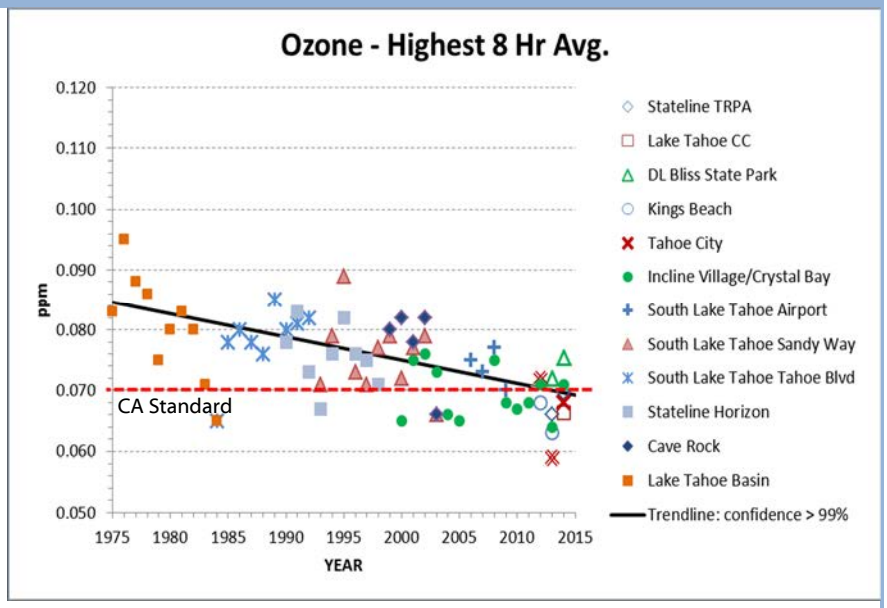
Attain or Maintain Threshold – No changes recommended.

Ozone: **Highest 8-Hour Average Concentration of Ozone**

Status	Trend

HIGHEST 8-HOUR AVERAGE CONCENTRATION OF OZONE

Status: **Somewhat Worse than Target**
Trend: **Moderate Improvement**
Confidence: **High**



The highest 8-hour ozone concentration in parts per million (ppm) measured at all monitoring sites in the Lake Tahoe Basin. Hollow symbols represent data that does not meet regulatory requirements for completeness or validation. Source: Desert Research Institute

Map

Current ozone monitoring locations in the Lake Tahoe Basin.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator addresses the highest monitored ozone concentration averaged over every 8 hours for the calendar year. Ozone (O_3), in high concentrations, can cause health effects such as lung inflammation and other respiratory illness. O_3 can also cause damage to trees and plants at concentrations lower than the human health based ambient air quality standards. Standards, with varying time averaging periods, have been adopted to protect human health.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Ozone

Adopted Standards – TRPA and Nevada: no standard. California: not to exceed 0.070 ppm 8-hour

average concentration.

Type of Standard – Numerical

Indicator (Unit of Measure) – Highest 8-hour average concentration measured at any monitoring site.

Human & Environmental Drivers – Ozone is a secondary pollutant created by reactions between sunlight and hydrocarbons (HC) and oxides of nitrogen (NOx). The primary sources of HC and NOx include in-basin mobile sources such as cars, trucks, boats, aircraft and off-road vehicles; biomass burning such as wood stoves, wildfires and prescribed burning; and consumer products such as solvents. Ozone is also transported into the basin to a lesser extent from populated areas surrounding the basin, and the ambient concentration of O_3 is highly dependent on meteorological conditions such as sunlight, temperature, wind speed, and mixing conditions.

MONITORING AND ANALYSIS

Monitoring Partners – California Air Resources Board, Washoe County Air Quality Management Division, U.S. Environmental Protection Agency, Placer County Air Pollution Control District, Lake Tahoe Community College and the Tahoe Regional Planning Agency.

Monitoring Approach – Ozone is monitored at a number of locations around the Lake Tahoe Region through the years by a variety of partners. Data is collected, analyzed, and reported by the respective agency.

Analytic Approach – Trend was calculated using the Theil-Sen robust regression method (Theil 1950). Trend analysis of the resulting indicator values was performed by DRI under TRPA contract.

INDICATOR STATE

Status – Somewhat worse than target. For 2014, the latest year data is available, the maximum 8-hour ozone concentration at sites that met regulatory reporting requirements was located at Incline Village and was 0.071ppm, approximately 101 percent of the standard of 0.070ppm (Campbell 2015). Therefore, a status of somewhat worse than target was determined.

Trend – Moderate improvement. There is a statistically significant downward trend based on the long term trend line of sites that meet regulatory reporting requirements. The trend line shows a 0.0004 ppm per year decrease from 1975 to 2014, a decrease of 0.57 percent per year in relation to the standard of 0.70 ppm (Campbell 2015). Therefore, a trend of moderate improvement was determined.

Confidence –

> **Status –** High. There is high confidence in the status determination because the data was collected using widely accepted protocols, was subject to quality assurance requirements, and has been collected continuously across the Region since 1975.
> **Trend –** High. The confidence in the long term trend is high, with confidence level in a trend of over 99 percent (P = 0.01)
> **Overall Confidence -** High.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Regional, state and federal emission standards for motor vehicles, motorized watercraft, gas appliances and woodstoves. Transportation infrastructure improvements such as more efficient intersections, sidewalks, and bicycle infrastructure development. Public transportation systems. Regional and state restrictions on prescribed burning days. Restricted development of "drive-up window" commercial uses.

Effectiveness of Programs and Actions – Current programs appear to be effective in reducing ozone,

although a continued downward trend is needed for attainment.

Interim Target – No interim target needed. Current trends show the current standard is achievable in the near term.

Target Attainment Date – While it is clear that the Basin is moving towards attainment in the near term, due to the variability of the data, it is not possible to estimate an attainment date.

RECOMMENDATIONS

Analytic Approach – A specific definition of how the indicator will be evaluated is needed. Potential options include:

1. Take the average maximum ~~1~~eight-hour readings of all monitoring stations during current monitoring period (e.g. 2012 to 2015) and compare it to the standard.
2. Take the average maximum ~~1~~eight-hour readings of all monitoring stations during the most recent (ex. 2015) monitoring period and compare it to the standard.
3. Report on the number of exceedances during the current monitoring period.
4. Report on the number of exceedances during the most recent monitoring period.
5. Use the highest reading from the current monitoring period and compare it to the standard.
6. Use the highest reading from the most recent monitoring period and compare it to the standard. This is the current evaluation method.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

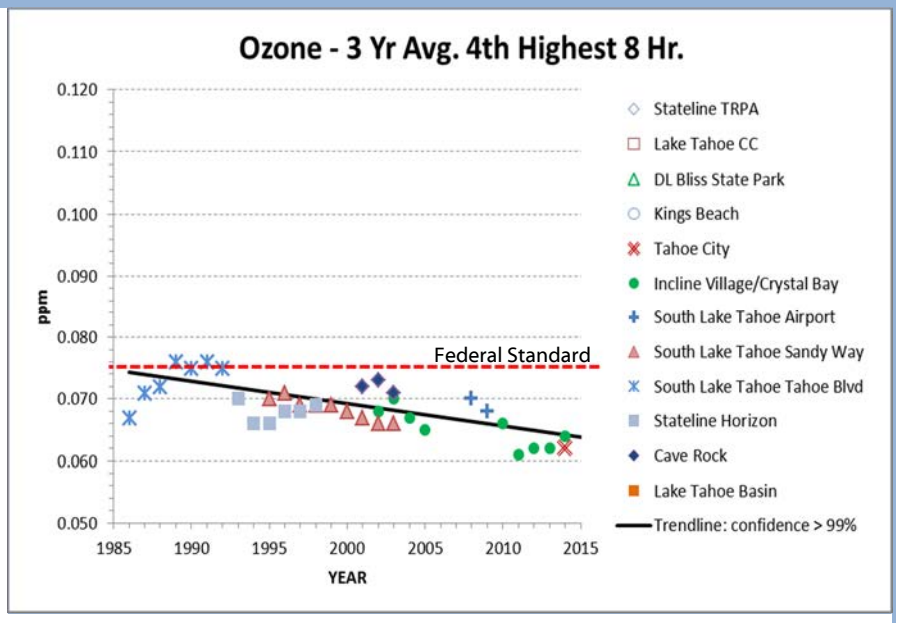
Attain or Maintain Threshold – No changes recommended.

Ozone: **3-Year Average of the 4th Highest 8-hour Average Concentration of Ozone**

Status	Trend

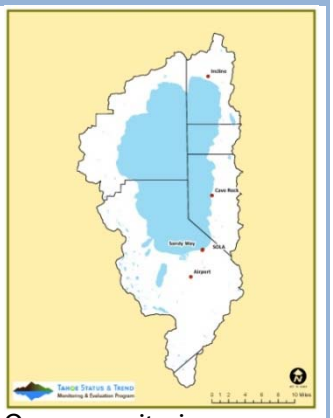
3-YEAR AVERAGE OF 4th HIGHEST 8-HOUR AVERAGE CONCENTRATION OF OZONE

Status: **At or Somewhat Better than Target**
Trend: **Moderate Improvement**
Confidence: **High**



NAAQS ozone design value in the Tahoe Region from 1985 to present. Because TRPA has no adopted standard, the federal standard is used. Source: Desert Research Institute

Map



Ozone monitoring locations in the Lake Tahoe Basin.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator addresses the 3-year average of the 4th-highest 8-hour average ozone concentration, which is the basis of the federal standard. Ozone (O_3), in high concentrations can cause health effects such as lung inflammation and other respiratory illness. Ozone can also cause damage to trees and plants at concentrations lower than the human health based ambient air quality standards. TRPA, and federal and state standards, with varying time averaging periods, have been adopted to protect the public from this harmful pollutant.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Ozone

Adopted Standards – Federal: The 3-year average of the 4th-highest daily maximum must not exceed concentration standard of 0.075 ppm. Because TRPA does not have a standard the federal standard is used.

Type of Standard – Numerical

Indicator (Unit of Measure) – 3-year average of the 4th-highest daily maximum ozone concentration in parts per million (ppm) at any monitoring location.

Human & Environmental Drivers – Ozone is considered a secondary pollutant, created by photochemical reactions between hydrocarbons (HC) and oxides of nitrogen (NOx) in sunlight. The sources of HC and NOx include mobile sources (cars, trucks, boats, aircraft, off-road vehicles, etc.), biomass burning (wood stoves, wildfires, prescribed burning), and consumer products such as solvents. Ozone is transported from populated areas around the Lake Tahoe Region into the basin, and the ambient concentration of O_3 is highly dependent on meteorological conditions such as sunlight, temperature, wind speed and mixing conditions.

MONITORING AND ANALYSIS

Monitoring Partners – California Air Resources Board, Washoe County Air Quality Management Division, U.S. Environmental Protection Agency, Desert Research Institute (DRI), Placer County Air Pollution Control District, Lake Tahoe Community College and the Tahoe Regional Planning Agency (TRPA).

Monitoring Approach – Ozone is monitored at a number of locations around the Lake Tahoe Region through the years by a variety of partners. Data is collected, analyzed, and reported by the respective agency.

Analytic Approach – Trend was calculated using the Theil-Sen robust regression method (Theil 1950). Trend analysis of the resulting indicator values was performed by DRI under TRPA contract.

INDICATOR STATE

Status – Somewhat better than target. Of all the monitoring stations where recent data is available, the highest 3-year average of the 4th-highest daily maximum ozone concentration was 0.064 ppm in Incline Village, 85 percent of the standard (Campbell 2015). Therefore, a status of "somewhat better than target" was determined. The indicator has been in attainment at all monitoring locations since 1993.

Trend – Moderate improvement. The trend line for all monitoring stations since 1986 shows a decrease of 0.0004 ppm per year, a decrease of 0.53 percent per year in relation to the standard of 0.075 ppm (Campbell 2015). Therefore, a trend of moderate improvement is determined.

Confidence –

> **Status –** High. There is high confidence in the status determination because data is collected using federal reference methods (EPA 2011a), are subject to quality assurance requirements, and are collected continuously across the Region since 1975.
> **Trend –** High. Confidence in the trend is high with a confidence in a trend of 99 percent (P = 0.01)
> **Overall Confidence –** High.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Regional, state and federal emission standards for motor vehicles, motorized watercraft, gas appliances, and woodstoves. Transportation infrastructure improvements such as more efficient intersections, sidewalks, and bicycle infrastructure development. Public transportation systems. Regional and state restrictions on prescribed burning days.

Restricted development of "drive-up window" commercial uses.

Effectiveness of Programs and Actions – Existing programs and actions implemented are effective based on the long-term indicator data, which shows that the standard has not been exceeded in the years that monitoring occurred.

Interim Target – Not applicable. Indicator is in attainment.

Target Attainment Date – Not applicable. Indicator is in attainment.

RECOMMENDATIONS

Analytic Approach – A specific definition of how the indicator will be evaluated is needed. Potential options include:

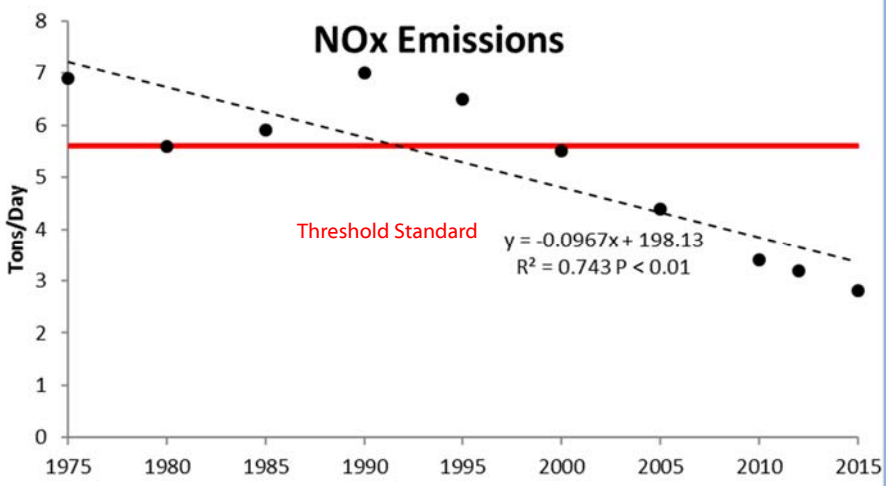
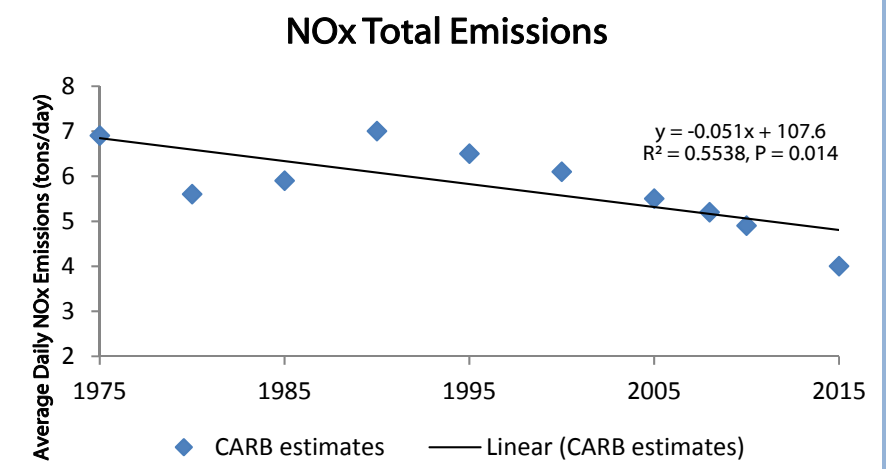
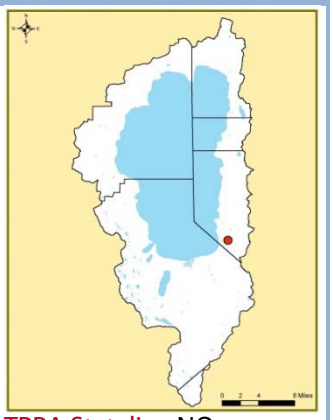
1. Take the average maximum 1-hour readings of all monitoring stations during current monitoring period (e.g. 2012 to 2015) and compare it to the standard
2. Take the average maximum 1-hour readings of all monitoring stations during the most recent (ex. 2015) monitoring period and compare it to the standard
3. Report on the number of exceedances during the current monitoring period
4. Report on the number of exceedances during the most recent monitoring period
5. Use the highest reading from the current monitoring period and compare it to the standard
6. Use the highest reading from the most recent monitoring period and compare it to the standard. This is the current evaluation method.

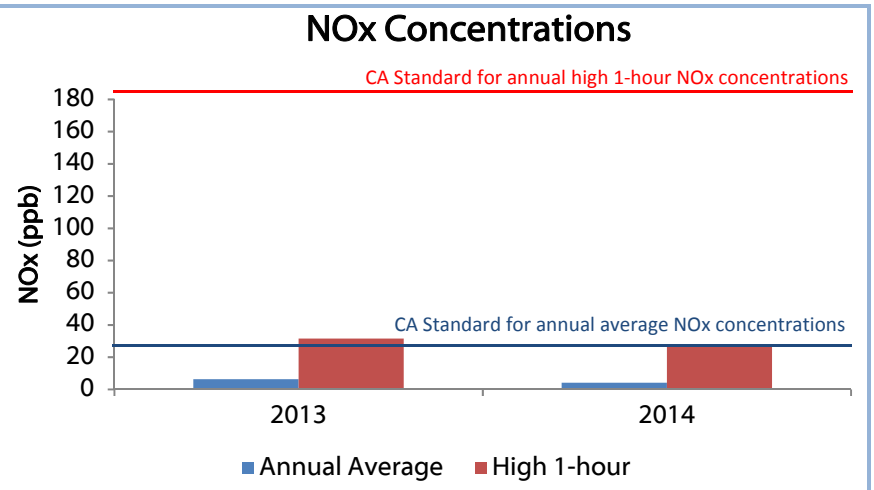
Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

Attain or Maintain Threshold – No changes recommended.

Ozone: **Oxides of Nitrogen Emissions**

Status	Trend
 OXIDES OF NITROGEN EMISSIONS Status: **Considerably Better than Target** Trend: **Moderate Improvement** Confidence: **Moderate**	
Map	
 TRPA Stateline NOx monitoring location ~~in the Lake Tahoe Basin~~.	~~Trend in~~ Annual estimated nitrogen oxide emissions (tons/day) for the California portion of the Lake Tahoe Region. While the TRPA 1982 Threshold Study Report estimated 1981 NOx daily emissions to be 9.4 tons, CARB estimated 1980 levels to be 5.6 tons/day (red line). Because consistent CARB data exists, CARB estimates are used as the threshold standard. Source: CARB (2015) emission inventory for the California portion of the Lake Tahoe Air Basin and TRPA.



NOx concentrations as measured at the newly established TRPA Stateline monitoring location. While no official TRPA standards exist for NOx concentrations, this data is used to evaluate NOx concentrations against CA and Federal standards. Source: TRPA

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator estimates daily emissions of nitrogen oxides (NOx) based on the California Air Resources Board (CARB) emission inventory for the California portion of the Lake Tahoe Region and the recently installed monitoring at the TRPA offices in Stateline, Nevada. Nitrogen dioxide (NO2) is one of a group of highly reactive gasses known as "nitrogen oxides." Other nitrogen oxides include nitrous acid and nitric acid. While federal standards cover the entire group of NO_x. NO_2 is the component of greatest interest and the indicator for the larger group of NO_x. In addition to contributing to the formation of ground-level ozone and fine particle pollution, NO_2 is linked with regional haze, global warming, water quality degradation, and a number of adverse effects on the respiratory system (EPA 2011c). Current scientific evidence links short-term NO_2 exposure ranging from 30 minutes to 24-hours with adverse respiratory effects, including airway inflammation in healthy people, and increased respiratory symptoms in people with asthma (EPA 2011b).

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Ozone

Adopted Standards –

- ***Total Emissions*** - TRPA: Maintain oxides of nitrogen (NOx) emissions at or below the 1981 levels (9.4 tons per day) for an average summer day, as reported in the Study Report for the Establishment of Environmental Threshold Carrying Capacities (TRPA 1982).
- ***Concentrations*** – TRPA standards for concentrations exist. California: Annual average NO_2 concentration not to exceed 0.030 ppm, highest one-hour, not to exceed 0.18 ppm; Nevada/Federal: Annual average NO_2 concentration not to exceed 0.053 ppm and highest one-hour concentration not to exceed 0.10 ppm.

Type of Standard – Numerical

Indicator (Unit of Measure) – Average tons per day of NOx emission (tons/day)

Human & Environmental Drivers – Ozone is considered a secondary pollutant, created by photochemical reactions between hydrocarbons (HC) and oxides of nitrogen (NOx) in sunlight. The sources of HC and NOx include mobile sources (cars, trucks, boats, aircraft, off-road vehicles, etc.), biomass burning (wood stoves, wildfires, prescribed burning), and consumer products such as solvents. Ozone is transported from populated areas around the Lake Tahoe Region into the basin, and the ambient concentration of O_3 is highly dependent on meteorological conditions such as sunlight, temperature, wind speed and mixing conditions.

MONITORING AND ANALYSIS

Monitoring Partners – California Air Resources Board (CARB), Washoe County Air Quality Management Division, U.S. Environmental Protection Agency, Desert Research Institute, Placer County Air Pollution Control District and the Tahoe Regional Planning Agency.

Monitoring Approach – CARB compiles data to create the criteria pollutant emission inventory, which includes information on the emissions of reactive organic gases (ROG), oxides of nitrogen (NOx), oxides of sulfur (SOx), carbon monoxide (CO), and particulate matter (PM_{10}). Data are gathered continuously and stored in the California Emission Inventory Development and Reporting System (CEIDARS). A summary of the criteria pollutant inventory is published annually. The California emission inventory contains information on the following air pollution sources:

- Stationary sources - approximately 13,000 individual facilities defined as point sources. Point sources are fixed pollution sources such as electric power plants and refineries.
- Area-wide sources - approximately 80 source categories. An area-wide source category is made up of sources of pollution mainly linked to human activity. Examples of these sources include consumer products and architectural coatings used in a region
- Mobile sources - all on-road vehicles such as automobiles and trucks; off-road vehicles such as trains, ships, aircraft; and farm equipment

The principal agencies contributing data to the stationary and area-wide source inventory are the CARB and the California air pollution control and air quality management districts. The CARB, the California Department of Transportation (Caltrans), and regional transportation agencies are the principal agencies involved in developing the mobile source inventory. Information represented in the California emission inventory is a snap-shot of a variety of dynamic and variable processes. As such, the emission inventory can only represent an estimate of what is actually occurring. In summer 2011, a new NO_x monitoring station was installed at the TRPA offices in Stateline, Nevada. Data from 2013 and 2014 for this site are now available.

Analytic Approach – ~~Simple~~ L~~l~~inear regression was used to assess trend.

INDICATOR STATE

Status – Considerably better than target.

- **Total Emissions (NOx tons/day):** In 2015, CARB estimated an average of ~~four~~ 2.8 tons per day of NOx emissions for the Tahoe Basin. This is 50~~71~~ percent of the CARB estimates for 1980 of 5.6 tons per day. Therefore, the status is determined to be "considerably better than target." CARB estimates are used instead of earlier TRPA estimates because they have been measured consistently.
- **Concentrations (NOx ppb):** *Annual Average Concentration:* 2014 data from the TRPA Stateline site shows an annual average concentration of 4.1 ppb, 14 percent of the strictest California

standard of 30 ppb. *Highest 1-hour Concentrations:* 2014 data from the TRPA Stateline site shows an annual high 1-hour concentration of 27.9 ppb, 15.5 percent of the strictest California standard of 180 ppb. Both of these are "considerably better than target."

Trend – Moderate improvement. The long-term trend line for average tons per day of NOx emissions shows an annual decrease of 1~~0~~.5~~9~~ percent~~ in relation to the CARB estimate of 5.6 tons per day in 1981~~. Therefore, a trend of moderate improvement was determined. Additionally, a very strong decreasing trend is evident from 1990 onward with consistent reductions in NOX levels.

Confidence –

Status – High. Data is collected following well-established protocols for air quality monitoring, therefore confidence in the status is high.

Trend – Moderate. The overall improving trend in emissions reported by CARB is moderate (R^2 = 0.5538, P = 0.014). Trend from the Stateline site is not applicable because only two years of data exists.

Overall Confidence – Moderate. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Regional, state and federal emission standards for motor vehicles, motorized watercraft, gas appliances and woodstoves. Transportation infrastructure improvements such as more efficient intersections, sidewalks, and bicycle infrastructure development. Low emission public transportation systems. Restricted development of "drive-up window" commercial uses.

Effectiveness of Programs and Actions – Existing federal, state and regional programs and actions are effective, based on CARB emission estimates and TRPA monitoring data. The CARB emission inventory indicates a decreasing trend in NOx emissions, which indicates the effectiveness of state and federal vehicle emission standards and programs implemented through the Regional Transportation Plan.

Interim Target – Not applicable. Indicator is in attainment.

Target Attainment Date – Not applicable. Indicator is in attainment.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – A threshold standard amendment is recommended to clarify the existing TRPA NO_x standard. It is also recommended to favor the adoption of a numerical standard consistent with state and federal concentration standards because baseline NO_x emissions in 1981 were not documented (only 1980 NO_x emission estimates were reported). Measurement of NO_x concentration would more accurately represent contributions from all sources of NO_x, not just vehicle associated NO_x as represented by modeled NO_x values presented here. It is recommended to continue monitoring modeled NO_x emissions for an additional five years, contemporaneously with NO_2 concentrations for comparison purposes.

Attain or Maintain Threshold – No changes recommended.

Visibility

TRPA established threshold standards for "visibility" to protect the unique aesthetic scenic values of the Tahoe Region. Visibility measures the distance at which an object or light can be clearly discerned by the human eye. Light through the atmosphere is scattered, or absorbed by gases and airborne particles, causing a reduction in visibility. Without anthropogenic influences, visual range can be up to 248.5 miles. Several natural phenomenon and human generated pollutants are known to impair visibility, including fog, ice fog, mist, haze, smoke, volcanic ash, dust, sand, and snow. Haze is a term used to describe an atmospheric phenomenon where dust, smoke, and other dry particles obscure the clarity of the sky. When viewed from around Lake Tahoe's shoreline or atop the basin's ridgeline, haze may appear brownish or bluish, while mist or fog tends to be bluish-grey. Sources of locally generated haze pollutants include entrained/suspended roadway particles, vehicle emissions, residential wood burning, campfires, prescribed fires, and wildfires (Green et al. 2011; Kuhns, H. et al. 2004). Some particles responsible for the degradation of regional visibility in the Lake Tahoe Region include dust and other pollutants transported into the basin from areas as far as Asia (Green et al. 2011).

TRPA's visibility threshold standards aim to improve and then maintain air quality at the regional and sub-regional scale. The regional visibility threshold standard established visibility objectives for the entire basin, while the sub-regional visibility threshold standard established a local visibility objective for the South Lake Tahoe portion of the Tahoe Basin.

TRPA Resolution 82-11 identifies two numerical standards for regional visibility. These standards are:

1. Achieving an extinction coefficient[2] of 25 Mm^{-1} at least 50 percent of the time, as calculated from aerosol species concentrations measured at the Bliss State Park monitoring site (visual range of 97 miles).
2. Achieving an extinction coefficient of 34 Mm^{-1} at least 90 percent of the time, as calculated from aerosol species concentrations measured at the Bliss State Park monitoring site (visual range of 71 miles).

In addition, there are two numerical standards for sub-regional visibility. These standards are:

1. Achieving an extinction coefficient of 50 Mm^{-1} at least 50 percent of the time, as calculated from aerosol species concentrations measured at the South Lake Tahoe monitoring site (visual range of 48 miles).
2. Achieving an extinction coefficient of 125 Mm^{-1} at least 90 percent of the time, as calculated from aerosol species concentrations measured at the South Lake Tahoe monitoring site (visual range of 19 miles).

Calculations for regional and sub-regional visibility standards are to be made on three year running periods. Beginning with the 1991 to 1993 monitoring data as the performance standard to meet or exceed.

Both regional visibility standards were in attainment, but there was insufficient data to determine the status of the two sub regional standards.

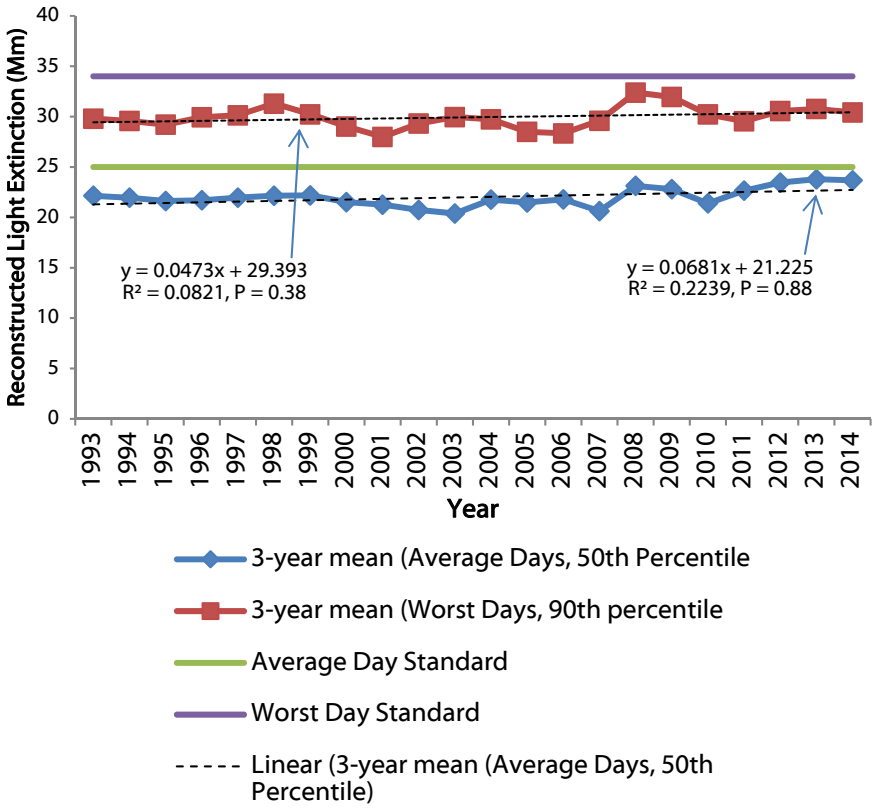
[2] *A measure of light absorption and scattering in the atmosphere measured in inverse megameters (Mm^{-1})*

Visibility: **Regional Visibility**

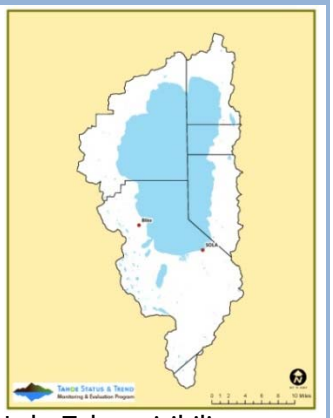
Status	Trend

REGIONAL VISIBILITY AND 50th PERCENTILE REGIONAL VISIBILITY 90th PERCENTILE

Status: **At or Somewhat Better than Target**
Trend: **Little or No Change**
Confidence: **Moderate**



Map



Lake Tahoe visibility monitoring locations (D.L. Bliss State Park was used for Regional measurements and South Lake Tahoe "SOLA" was used for sub-regional measurements).

Regional visibility conditions were monitored at the D. L. Bliss IMPROVE monitoring station (western portion of the basin) from 1991 through 2014 using the 3-year running average reconstructed light extinction (b_{ext}) indicator. Light extinction measures the amount of absorption and dispersion of light in the atmosphere. The Tahoe Region is currently meeting adopted regional visibility threshold standards for the 3-year running average indicator and has throughout the monitoring record. Trends for both "average days" (50th percentile) and "worst day" (90th percentile) exhibit little or no change."

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures regional visibility and the distance that the human eye can see. It is measured by using a reconstructed light extinction (b_{ext}) value, which is derived from an equation that combines measured concentrations of several gasses and particles. The equation is corrected for humidity and natural "background" light scattering. B_{ext} is summarized by "average visibility days" (50th percentile values) and "worst visibility days" (90th percentile values) for each year, followed by

calculating the 3-year running average. This threshold standard has been adopted to protect regional visibility and air quality.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Visibility

Adopted Standards – TRPA: 1) Achieve an extinction coefficient of 25 Mm^{-1} at least 50 percent of the time as calculated from aerosol species concentrations measured at the D.L. Bliss State Park monitoring site (visual range of 97 miles), and 2) Achieve an extinction coefficient of 34 Mm^{-1} at least 90 percent of the time, as calculated from aerosol species concentrations measured at the D.L. Bliss State Park monitoring site (visual range of 71 miles). Calculations will be made on three year running periods, beginning with the existing 1991 to 1993 monitoring data as the performance standards to be met or exceeded.

Type of Standard – Numerical

Indicator (Unit of Measure) – 3-year running average of the reconstructed light-extinction (Mm^{-1}, "inverse mega meters") from data collected at the D.L. Bliss Monitoring Site.

Human & Environmental Drivers – Particulate matter in the atmosphere is the primary driver of visibility impairment because of the optical properties and long retention times in the air (Green et al. 2011, 201). The main sources of particulate matter in the basin are residential and wildfire smoke, and entrained roadway dust (DRI 2011a). Effective motor vehicle tail pipe emission controls, residential wood combustion controls, appropriately managed prescribed burning, and road dust emission control aid in improving regional visibility conditions (Chen, Watson, and Wang 2011). There is uncertainty related to visibility condition in the future due to predicted increases in frequency and intensity of wildfires in the western U.S.

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service, U.C. Davis, U.S. National Park Services, Desert Research Institute, Colorado State University, California State Parks and TRPA.

Monitoring Approach – Air samples needed to calculate b_{ext} were collected at least every six days at D.L. Bliss State Park. This is an appropriate site for monitoring regional conditions because it is not influenced by urban sources ((L.-W. Antony Chen, Watson, John G., and Wang, Xiaoliang 2011)). Data are collected, analyzed, and reported by the IMPROVE (national Interagency Monitoring of Protected Environments) network using nationally accepted protocols.

Analytic Approach – Simple linear regression was used to analyze trend.

INDICATOR STATE

Status – At or somewhat better than target. The most recent data for the 3-year average visibility from 2012 to 2014 show that "average visibility days" are 23.67 Mm^{-1}, and "worst visibility days" are 30.43 Mm^{-1}. The most recent 3-year running average values for "average visibility days" were 95 percent of the target, while 3-year running average values for "worst days" were 90 percent of the target. Therefore, both were determined to be at or somewhat better than target. According to the monitoring record, the Region has been in compliance with regional standards for "average days" and "worst days" in all years. Decreases in visibility occurring in 2008 and 2009 running average values were attributed to wildfires burning outside the Lake Tahoe Region; more than 2.3 million acres were consumed by wildfires in California according to (L.-W. Antony Chen, Watson, John G., and Wang, Xiaoliang 2011)) and the CAL Fire incident database, similar effects are likely for the 2013 and 2014 Rim and King fires.

Trend – Little to no change. Both indicators show a statistically insignificant upward trend small enough to be considered little to no change.

Confidence –

Status – High. There is high confidence in the determination of regional visibility conditions because current b_{ext} data were compared with optical measurements from 1999 to 2003 and showed a good correspondence ((L.-W. Antony Chen, Watson, John G., and Wang, Xiaoliang 2011)). Results of the Lake Tahoe Atmospheric Deposition Study (California Air Resources Board 2006) and satellite remote sensors confirmed that the location of the regional monitoring site at D.L. Bliss State Park was representative of visibility conditions for the Tahoe Region (Chen, Watson, and Wang 2011). B_{ext} data are also collected using the IMPROVE national protocol that has been reviewed extensively.

Trend – Moderate. Although data has been consistently collected according to the IMPROVE protocol, overall confidence for trend would be low according to the methodology laid out in this report ($R^2 = 0.0821$, $P = 0.38$; $R^2 = 0.22$, $P = 0.88$). However, because low R^2 values often correlate with data that shows little or no trend, the confidence in trend has been increased to moderate.

Overall Confidence – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Prescribed burning controls, residential woodstove replacement programs and emission standards, public transportation systems, pedestrian sidewalks and bikeways projects, automobile trip reduction programs, state and federal vehicle emission standards.

Effectiveness of Programs and Actions – The improving long-term trend for "average visibility days" suggests that the programs and actions were effective at maintaining and improving visibility between 1991 and 2014. Wildfires from outside of the basin appear to negatively influence visibility conditions in the Region; the agency has no ability to regulate or otherwise control this source of visibility impairment. Prescribed burning and burn days should continue to be regulated by appropriate state authorities.

Interim Target – Not applicable. Indicator is in attainment.

Target Attainment Date – Not applicable. Indicator is in attainment.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

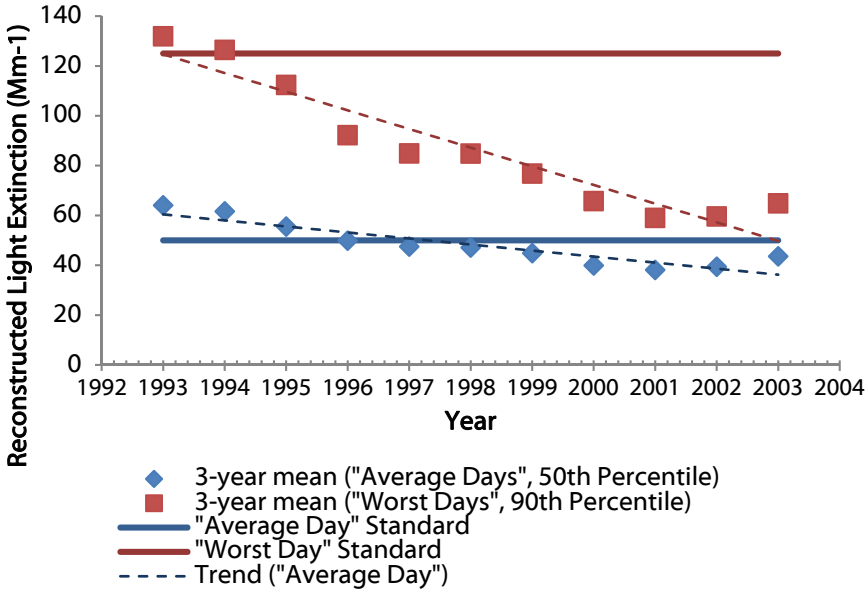
Attain or Maintain Threshold – No changes recommended.

Visibility: **Sub-Regional Visibility**

Status	Trend

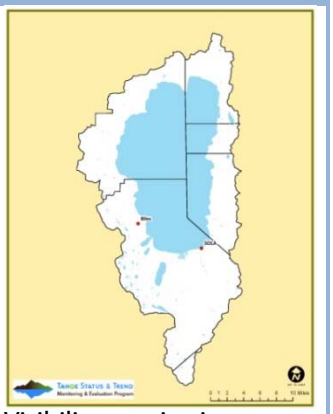
SUB-REGIONAL VISIBILITY 50th PERCENTILE AND SUB-REGIONAL VISIBILITY 90th PERCENTILE

Status: **Insufficient Data to Determine Status**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Not Applicable**

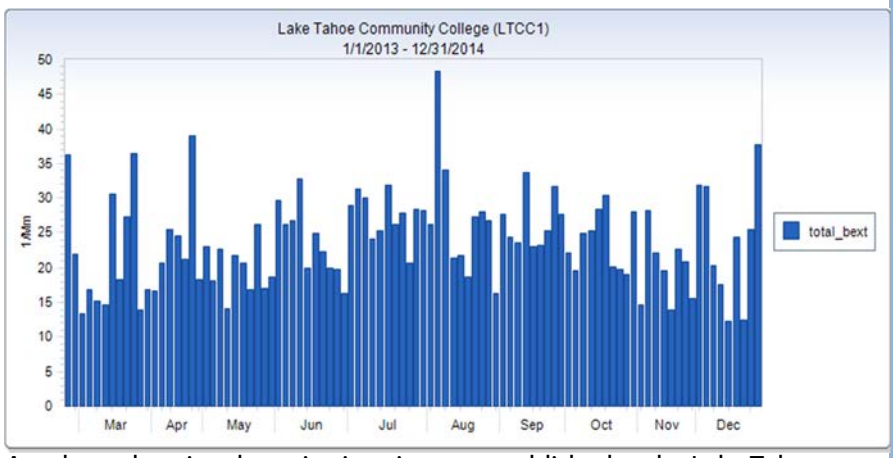


Sub-regional visibility conditions were monitored at the South Lake Tahoe monitoring station (southern urbanized portion of the Region) from 1991 through 2003 using the 3-year running average reconstructed light extinction (b_{ext}) indicator. Light extinction measures the amount of absorption and dispersion of light in the atmosphere. Prior to 2004, trends for both "average days" and "worst days" indicators showed moderate to rapid improvement ($P<0.01$).

Map



Visibility monitoring stations in the Lake Tahoe Region. The South Lake Tahoe ("SOLA") monitoring site, located in the southern portion of the Region, was used to characterize sub-regional visibility conditions from 1991 to 2003.



Another subregional monitoring site was established at the Lake Tahoe Community College in 2014, but 3-year running averages will not be available until 2017. Monthly reconstructed light extinction (b_{ext}) monitoring data for the Lake Tahoe Community College site are shown between the months of January 2013 and December 2014.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures sub-regional visibility in South Lake Tahoe and the distance that the human eye can see. It is measured by using a reconstructed light extinction (b_{ext}) value derived from an equation that combines measured concentrations of several gasses and particles. The equation is corrected for humidity and natural "background" light scattering. B_{ext} is summarized by "average visibility days" (50th percentile values) and "worst visibility days" (90th percentile values) for each year followed by calculating the 3-year running average. This threshold standard has been adopted to protect sub-regional visibility and air quality.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Visibility

Adopted Standards – TRPA: 1) Achieve an extinction coefficient of 50 Mm^{-1} at least 50 percent of the time as calculated from aerosol species concentrations measured at the South Lake Tahoe monitoring site (visual range of 48 miles), and 2) Achieve an extinction coefficient of 125 Mm^{-1} at least 90 percent of the time as calculated from aerosol species concentrations measured at the South Lake Tahoe monitoring site (visual range of 19 miles).

Type of Standard – Numerical

Indicator (Unit of Measure) – 3-year running average of the reconstructed light-extinction (Mm^{-1}, "inverse mega meters") from data collected at the South Lake Tahoe SOLA monitoring site.

Human & Environmental Drivers – Particulate matter in the atmosphere is the primary driver of visibility impairment because of the optical properties and long retention times in the air ((Green et al. 2011)). The main sources of particulate matter in the basin are smoke and entrained roadway dust (Chen, Watson, and Wang 2011). Improving visibility trends are attributable to effective controls over motor vehicle, residential wood combustion, regulatory controls over prescribe burn days and road dust emissions (Chen, Watson, and Wang 2011). The most substantial risk to visibility is the increased frequency and intensity of wildfires in the Western U.S.

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service, U.C. Davis, U.S. National Park Services, Lake Tahoe Community College and Colorado State University.

Monitoring Approach – Air samples needed to calculate b_{ext} were collected at least every six days at a South Lake Tahoe site. Data were collected, analyzed and reported by the IMPROVE network using nationally accepted protocols. A monitoring site was set up at Lake Tahoe Community College in 2014, but 3-year running averages will not be available until 2017.

Analytic Approach – Simple linear regression was used to analyze trend.

INDICATOR STATE

Status – Insufficient data to determine status. A monitoring site was set up at Lake Tahoe Community College in 2014 and 3-year running averages will not be available until 2017. Therefore, due to insufficient data the current status is unknown for both "average visibility days" and "worst visibility days" at the sub-regional scale. Historical annual average data from 2003 showed that "average visibility days" were 42.62 Mm^{-1} and "worst visibility days" were 72.73 Mm^{-1} at the sub-regional scale. The 3-year running average for 2003 showed that "average visibility days" were 43.55 Mm^{-1} and "worst visibility days" were 64.89 Mm^{-1} at the sub-regional scale. The most recent 3-year running average values (2003) for "average visibility days" were 12.9 percent better than the regional 50th percentile standard of 50

Mm^{-1} resulting in a determination of "somewhat better than the target." The most recent 3-year running average values (2003) for "worst days" were 48 percent better than the regional 90th percentile standard resulting in a determination of "considerably better than target." According to the monitoring record, the Region has been in compliance with regional standards for "average days" and "worst days" since 1996.

Although not official, preliminary data available from the LTCC site shows a running average (based on slightly more than 1 year of data) of approximately 23 Mm^{-1}, which would be well within the standard.

Trend – Insufficient data to determine trend. A Theil regression analysis was used to determine trends for the sub-regional 3-year running average visibility indicator prior to 2004. The estimated trend for the 3-year running average of the historical "average visibility days" data (1991 to 2003) for reconstructed light extinction was improving (less light extinction) at a rate of 4.47 percent per year ($P<0.01$) indicating a rapid improvement. The trend for the 3-year running average estimated for "worst visibility days" based on historical data (1991 to 2003) was improving at a rate of six percent per year also indicating a rapid improvement ($P<0.01$).

Confidence –Not applicable. Because of insufficient data for 2004 to 2015, confidence in the determination of status and trends was not applicable.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Prescribed burning controls, residential woodstove emission standards, public transportation systems, pedestrian sidewalks and bikeways projects, automobile trip reduction programs, state and federal vehicle emission standards.

Effectiveness of Programs and Actions – Historical trends for "average visibility days" and "worst visibility days" suggest that programs and actions were effective at maintaining and improving visibility between 1991 and 2003.

Interim Target – Not applicable. Indicator state is currently unknown.

Target Attainment Date – Not applicable. Indicator state is currently unknown.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – The South Lake Tahoe monitoring site (SOLA) was decommissioned in 2004 as a result of the property being sold. A monitoring site was set up at Lake Tahoe Community College in 2014, but 3-year running averages will not be available until 2017.

Modification of the Threshold Standard or Indicator – No changes recommended.

Attain or Maintain Threshold – No changes recommended.

Respirable and Fine Particulate Matter

Atmospheric particulate matter consists of very small liquid and solid particles, designated PM_{10} for particulate matter of 10 microns (10µ) or less in diameter. The primary sources of PM_{10} in the basin are motor vehicles, pulverized road-traction abrasives, decomposed road surfaces, salt, fugitive dust from local sources and abroad, and smoke from residential burning, prescribed burning, and wildfires. PM_{10} is among the most harmful of air pollutants. When inhaled, these particles invade the respiratory system's natural defenses and lodge deep in the lungs. PM_{10} can increase the number and severity of asthma attacks, cause or aggravate bronchitis and other lung diseases, and reduce the body's ability to fight infections. These effects are particularly harmful to children, active adults, and the elderly.

Particles small enough to be inhaled into the deepest parts of the lungs are another concern to public health. These fine particles are known as $PM_{2.5}$ for particulate matter of 2.5 microns (2.5µ) or less in diameter. Due to this pollutant's tiny size, it can be inhaled deep into the lungs and can make its way directly into the bloodstream. Some of these particles are generated by combustion and they can contain carcinogens. For this reason, state and federal governments have adopted standards and placed increasing efforts on the study of this pollutant.

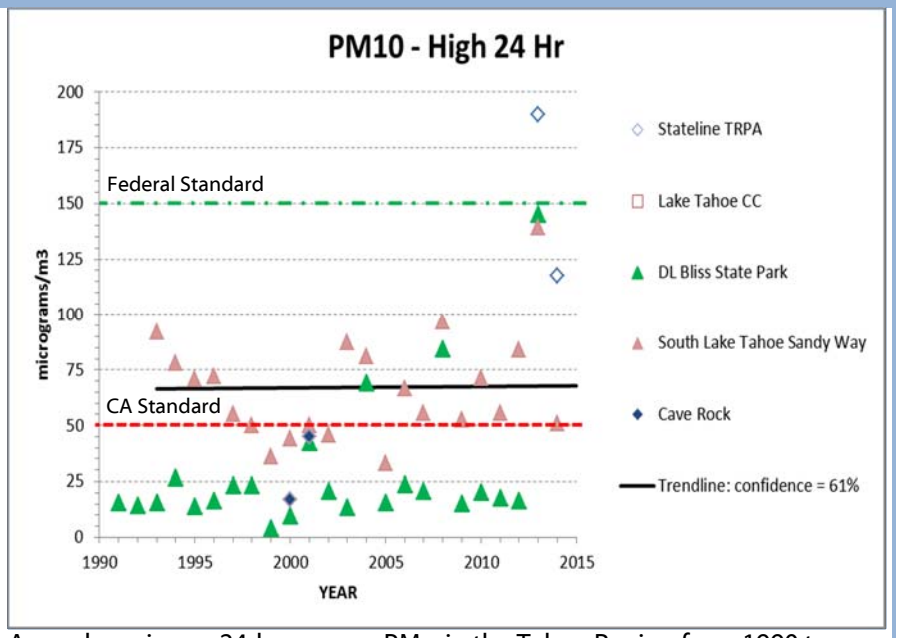
Atmospheric particles are also known to settle out of the air and deposit onto the landscape, including into Lake Tahoe. Lahontan Water Quality Control Board has implicated particles equal or smaller than 16µ diameter in the decline of Lake Tahoe transparency, and estimated that about 15 percent of the particle loads to Lake Tahoe are from atmospheric sources (Lahontan 2010). Measures of PM10 and PM2.5 concentrations may in part provide a surrogate measure of this atmospheric pollutant known to affect Lake Tahoe's transparency.

Respirable and Fine Particulate Matter: **Highest 24-Hour Average PM_{10} Concentration**

Status	Trend

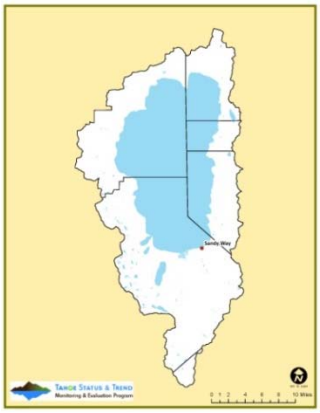
HIGHEST 24-HOUR AVERAGE PM_{10} CONCENTRATION

Status: **Somewhat Worse than Target**
Trend: **Little to No Change**
Confidence: **Moderate**



Annual maximum 24-hr average PM_{10} in the Tahoe Region from 1990 to present. 2014 data for South Lake Tahoe Sandy Way site is preliminary and subject to revision. In lieu of TRPA standards, the stricter California state standard is used to assess this threshold. Hollow symbols represent data that does not meet regulatory requirements for completeness or validation. Source: Desert Research Institute

Map



PM_{10} monitoring location in the Lake Tahoe Basin.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures the highest monitored PM_{10} concentration averaged over every 24-hours for the calendar year. Particulate matter in high concentrations less than or equal to 10 microns in size can lodge in the lungs and cause or aggravate the effects of asthma, lung diseases, and heart disease. Elevated concentrations of PM_{10} have also been attributed to reductions in regional visibility and increased regional haze. Federal and state standards with varying time averaging periods have been adopted to protect human health and regional visibility.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Visibility

Adopted Standards – Maintain Particulate Matter10 at or below 50μg/m3 measured over a 24-hour period in the portion of the Region within California, and maintain Particulate Matter10 at or below 150

µg/m3 measured over a 24-hour period in the portion of the Region within Nevada. Particulate Matter10 measurements shall be made using gravimetric or beta attenuation methods or any equivalent procedure which can be shown to provide equivalent results at or near the level of air quality standard.

Type of Standard – Numerical

Indicator (Unit of Measure) – Highest 24-hour average concentration of PM_{10} within a calendar year measured at any site in the Tahoe Region (micrograms per cubic meter of air, µg/m³).

Human & Environmental Drivers – Particulate matter pollution consists of very small liquid and solid particles in the air. The primary sources of PM_{10} in the Lake Tahoe Basin are motor vehicle emissions, paved and unpaved road dust, wood smoke, wildfire smoke, and construction dust. The ambient concentration of PM_{10} is highly dependent on meteorological conditions such as wind speed and mixing conditions.

MONITORING AND ANALYSIS

Monitoring Partners – Interagency Monitoring of Protected Visual Environments (IMPROVE), California Air Resources Board, U.S. Environmental Protection Agency, Desert Research Institute (DRI), and Tahoe Regional Planning Agency (TRPA).

Monitoring Approach – Particulate matter is monitored in the Tahoe Basin as part of a national network. These sites used the IMPROVE sampler, which is not a Federal Reference Method $PM_{2.5}$ sampler but is accepted for determining compliance with regional haze regulations.

Analytic Approach – Trend was calculated using the Theil-Sen robust regression method ((Theil 1950)) applied to the highest 24-hour average measured each calendar year at any site within the basin. Trend analysis of the resulting indicator values was performed by DRI under TRPA contract.

INDICATOR STATE

Status – Somewhat worse than target. For the latest year data is available (2014) at sites that meet regulatory reporting requirements, the South Lake Tahoe Sandy Way site had the highest 24-hr PM_{10} concentration and was 50.8 micrograms/^{m3}, 102 percent of the stricter California standard (Campbell 2015). Therefore, a status of somewhat worse than target was determined.

Trend – Little to no change. The long term trend line shows an increase of 0.1 µg/m3 per year, an increase of 0.2 percent per year in relation to the stricter California standard (Campbell 2015). Therefore, a trend of little to no change was determined.

Confidence –

> **Status –** High. There is high confidence in the status determination because the data is collected using federal reference methods (EPA 2011a), are subject to quality assurance requirements, and are collected continuously across the Region since 1992.
> **Trend –** Moderate. Confidence in the trend is moderate with a confidence level in a trend at 61 percent (P = 0.39)
> **Overall Confidence –** Moderate. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Prescribed burning controls, residential woodstove stove replacement programs and emission standards, public transportation systems, pedestrian sidewalks and bikeways, trip reduction programs, state and federal vehicle emission standards.

Effectiveness of Programs and Actions – The observed trends show little to no change in PM_{10}

concentrations with highly variable data, indicating that it is unclear how existing program and actions are affecting concentrations.

Interim Target – Due to highly variable data, it is not possible to set an interim target.

Target Attainment Date – Due to highly variable data, it is not possible to set a target attainment date.

RECOMMENDATIONS

Analytic Approach – A specific definition of how the indicator will be evaluated is needed. Potential options include:

1. Take the average of all monitoring stations during the current monitoring period (e.g. 2012 to 2015) and compare it to the standard,
2. Take the average readings of all monitoring stations during the most recent (e.g. 2015) monitoring period and compare it to the standard,
3. Report on the number of exceedances during the current monitoring period,
4. Report on the number of exceedances during the most recent monitoring period,
5. Use the highest reading from the current monitoring period and compare it to the standard, or
6. Use the highest reading from the most recent monitoring period and compare it to the standard. This is the current evaluation method.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

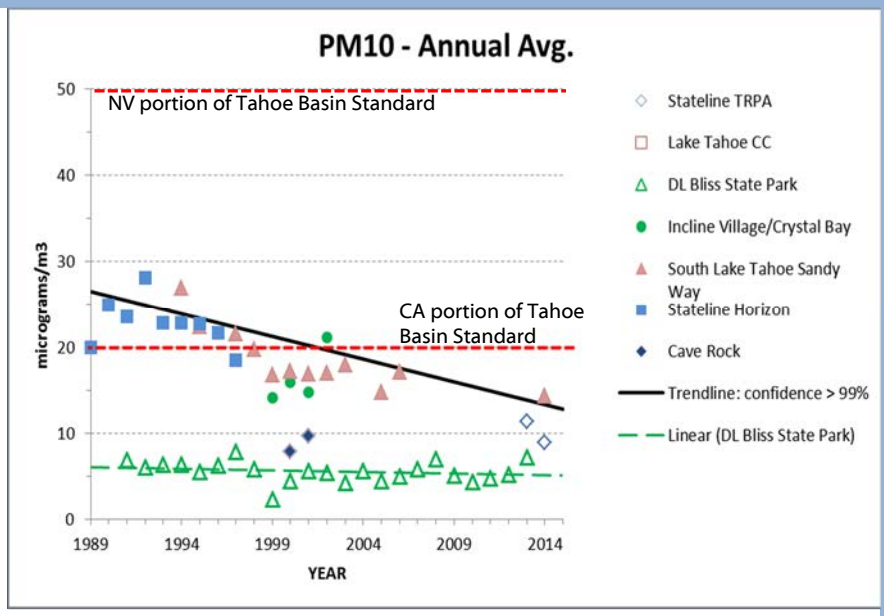
Attain or Maintain Threshold – This indicator not being in attainment with the most conservative standard suggests that existing programs and actions could be more effectively implemented, such as more frequent street sweeping to control entrained road dust. TRPA should continue to implement the requirement that residential woods stove meet EPA emission standards, and perhaps, if conditions decline, consider options for restricting residential or other wood burning during periods of elevated ambient PM concentrations. Respective state air quality management authorities already regulate prescribed burning of forest biomass and burning in the Region is only allowed during appropriate meteorological conditions and following conditions of an approved burn plan.

Respirable and Fine Particulate Matter: **Annual Average PM_{10} Concentration**

Status	Trend

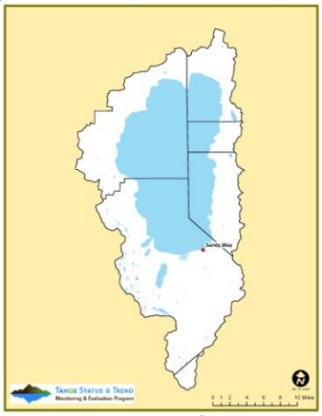
ANNUAL AVERAGE PM_{10} CONCENTRATION

Status: **Considerably Better than Target**
Trend: **Moderate Improvement**
Confidence: **Moderate**



Annual average PM_{10} in the Tahoe Region from 1989 to present. 2014 data for South Lake Tahoe Sandy Way site is preliminary and subject to revision. Hollow symbols are used for sites not conforming to regulatory monitoring protocols, which were not used to estimate the trend.
Source: Desert Research Institute

Map



PM_{10} monitoring location in the Lake Tahoe Basin.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures the annual average concentration of particulate matter less than or equal to 10 microns in size (PM_{10}). In high concentrations this pollutant can lodge in the lungs and cause or aggravate the effects of asthma, lung diseases, and heart disease. Federal and state standards have been adopted to protect the public from this pollutant.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Respirable and Fine Particulate Matter

Adopted Standards – TRPA: Maintain Particulate Matter10 at or below annual arithmetic average of 20μg/m3 in the portion of the Region within California, and maintain Particulate Matter10 at or below annual arithmetic average of 50μg/m3 in the portion of the Region within Nevada. Particulate Matter10

measurements shall be made using gravimetric or beta attenuation methods or any equivalent procedure which can be shown to provide equivalent results at or near the level of air quality standard.

Type of Standard – Numerical

Indicator (Unit of Measure) – Annual average PM_{10} concentrations measured at any permanent monitoring station within a calendar year ($\mu g/m^3$).

Human & Environmental Drivers – Particulate matter pollution consists of very small liquid and solid particles in the air. The primary sources of PM_{10} in the Lake Tahoe Region are motor vehicles, paved and unpaved road dust, wood smoke, and construction dust. The ambient concentration of PM_{10} is dependent on meteorological conditions such as wind speed and atmospheric mixing.

MONITORING AND ANALYSIS

Monitoring Partners – Interagency Monitoring of Protected Visual Environments (IMPROVE), California Air Resources Board, Nevada Division of Environmental Protection, U.S. Environmental Protection Agency, Desert Research Institute (DRI), and Tahoe Regional Planning Agency. (TRPA)

Monitoring Approach – Particulate matter is monitored at one site in the Tahoe Basin as part of a national network. These sites used the IMPROVE sampler, which is not a Federal Reference Method $PM_{2.5}$ sampler but is accepted for determining compliance with regional haze regulations.

Analytic Approach – Trend was calculated using the Theil-Sen robust regression method (Theil 1950). Trend analysis of the resulting indicator values was performed by DRI under TRPA contract.

INDICATOR STATE

Status – Considerably better than target. The highest annual average PM_{10} concentration at monitoring sites that met regulatory reporting requirements was found at the South Lake Tahoe Sandy Way site and was 14.3 ug/m^3 for 2014, the most recent year monitoring data was available (Campbell 2015). It was approximately 70 percent of the stricter California standard. Therefore, it is considerably better than target.

Trend – Moderate improvement. The trend line shows a significant decrease in overall PM_{10} concentrations of 0.5 $\mu g/m^3$ per year across the basin, a decrease of 2.5 percent per year relative to the California standard (Campbell 2015). Therefore, a trend of moderate improvement was determined.

Confidence –

> **Status –** Moderate. Data was collected continuously between 1989 and 2006 using federal reference methods at CARB's South Lake Tahoe Sandy Way site (EPA 2011a), and the data was subject to extensive quality assurance requirements. However, gaps exist in the data from 2007-2013 and therefore confidence is moderate.
> **Trend –** High. Confidence in the trend is high with a confidence of greater than 99 percent.
> **Overall Confidence –** Moderate. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Prescribed burning controls, residential woodstove replacement programs and emission standards, public transportation systems, pedestrian sidewalks and bikeways, automobile trip reduction programs, state and federal vehicle emission standards. The improving long-term trend for this indicator suggests that the programs and actions were effective at controlling concentrations of PM_{10} between 1989 and 2006; 2014 data shows that this improving trend has continued.

Effectiveness of Programs and Actions – The observed declining trends in PM_{10} concentrations suggest

that the programs and actions are effective at controlling concentrations of PM_{10}.

Interim Target – Not applicable. Indicator is in attainment.

Target Attainment Date – Not applicable. Indicator is in attainment.

RECOMMENDATIONS

Analytic Approach – A specific definition of how the indicator will be evaluated is needed. Potential options include:

1. Take the average of all monitoring stations during the current monitoring period (e.g. 2012 to 2015) and compare it to the standard,
2. Take the average readings of all monitoring stations during the most recent (e.g. 2015) monitoring period and compare it to the standard,
3. Report on the number of exceedances during the current monitoring period,
4. Report on the number of exceedances during the most recent monitoring period,
5. Use the highest reading from the current monitoring period and compare it to the standard, or
6. Use the highest reading from the most recent monitoring period and compare it to the standard. This is the current evaluation method.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

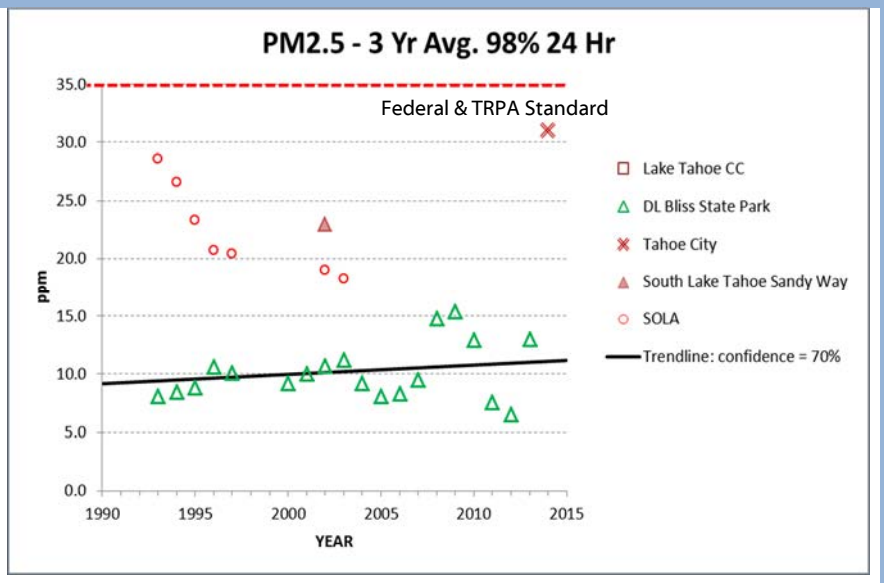
Attain or Maintain Threshold – No changes recommended.

Respirable and Fine Particulate Matter: **24-hour $PM_{2.5}$ Concentration**

Status	Trend

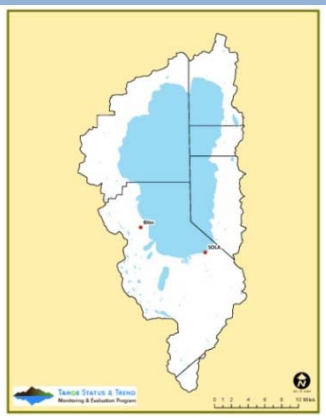
24-HOUR $PM_{2.5}$ CONCENTRATION

Status: **At or Somewhat Better than Target**
Trend: **Little to No Change**
Confidence: **Moderate**



National Ambient Air Quality Standard design values for $PM_{2.5}$ in the Tahoe Region from 1990 to present. Insufficient valid regulatory data is available, so the regression line is based on data from Bliss State Park. Source: Desert Research Institute

Map



$PM_{2.5}$ monitoring locations in the Lake Tahoe Basin.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures the 3-year running average of the 98th percentile 24-hour average concentration of $PM_{2.5}$. Particulate matter less than or equal to 2.5 microns in size ($PM_{2.5}$) is extremely small and can be inhaled deep into the lungs causing or aggravating asthma, lung diseases, and heart disease. Some particles pass into the bloodstream and some are considered carcinogens. Federal standards have been adopted to protect the public from this pollutant.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Respirable and Fine Particulate Matter

Adopted Standards – Maintain Particulate Matter2.5 at or below 35μg/m3 measured over a 24-hour period using gravimetric or beta attenuation methods or any equivalent procedure which can be shown to provide equivalent results at or near the level of air quality standard. Federal: The 3-year average of

the 98th percentile 24-hour $PM_{2.5}$ concentration must not exceed 35 $\mu g/m^3$.

Type of Standard – Numerical

Indicator (Unit of Measure) – 3-year average of the 98th percentile 24-hour $PM_{2.5}$ concentration at any monitoring station ($\mu g/m^3$)

Human & Environmental Drivers – Particulate matter pollution consists of very small liquid and solid particles in the air. The primary sources of $PM_{2.5}$ in the Lake Tahoe Region are residential fuel combustion, wood smoke from wildfires and prescribed fires, motor vehicles, and paved and unpaved road dust. $PM_{2.5}$ results from primary emission sources, condensation of semi-volatile organic gases, and from secondary formation from reactions of gases in the atmosphere. Small particles are also transported into the Lake Tahoe Basin, and the ambient concentration of $PM_{2.5}$ is highly dependent on meteorological conditions such as wind speed and mixing conditions.

MONITORING AND ANALYSIS

Monitoring Partners – Interagency Monitoring of Protected Visual Environments (IMPROVE), Tahoe Regional Planning Agency, Desert Research Institute and the Placer Air Quality Improvement District.

Monitoring Approach – Particulate matter is monitored at two sites around the Tahoe Region as part of a national network. These sites used the IMPROVE sampler, which is not a Federal Reference Method PM_2 sampler but is accepted for determining compliance with regional haze regulations.

Analytic Approach – Standard evaluation follows federal guidelines for attainment 24-hour $PM_{2.5}$ concentration (3-year average of the 98th percentile). 24-hour Trend was calculated using the Theil-Sen robust regression method at the Bliss State Park location. This location is the only one with a data period long enough to analyze trend (Theil 1950). Trend analysis of the resulting indicator values was performed by DRI under TRPA contract.

INDICATOR STATE

Status – At or somewhat better than target. Of all the monitoring stations where recent data is available that meets regulatory reporting requirements, the highest 3-year average of the 98th percentile 24-hour $PM_{2.5}$ concentration for 2014 was 31 ug/m^3 at Tahoe City, approximately 88 percent of the standard (Campbell 2015). Therefore, it is somewhat better than target. The monitoring station at D.L. Bliss has much lower 24-hour $PM_{2.5}$ concentrations and its highest average concentration was approximately 40 percent of the target during the current 2012 to 2015 monitoring period.

Trend – Little to no change. The trend line for the D.L. Bliss monitoring site, the only site with comparable data across a long time series, shows an increase in the 98th percentile 24-hour $PM_{2.5}$ concentration of 0.1 $\mu g/m^3$ per year, an increase of 0.3 percent per year relative to the standard of 35 $\mu g/m^3$ (Campbell 2015). Therefore, a trend of little to no change was determined.

Confidence –

Status – High. There is high confidence in the determination of status. The Tahoe City site which was used to determine status is now a Federal Reference Method (FRM) $PM_{2.5}$ sampler, and can be used to judge attainment of National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$. There was extensive testing of the samplers, and rigorous quality control procedures employed at the measurement laboratories.

Trend – Moderate. Confidence in the trend at the D.L. Bliss monitoring site is moderate with confidence in a trend of 70 percent ($P = 0.30$). Additionally, the D.L. Bliss site does not meet regulatory reporting requirements.

Overall Confidence – Moderate. Overall confidence takes the lower of the two confidence levels.

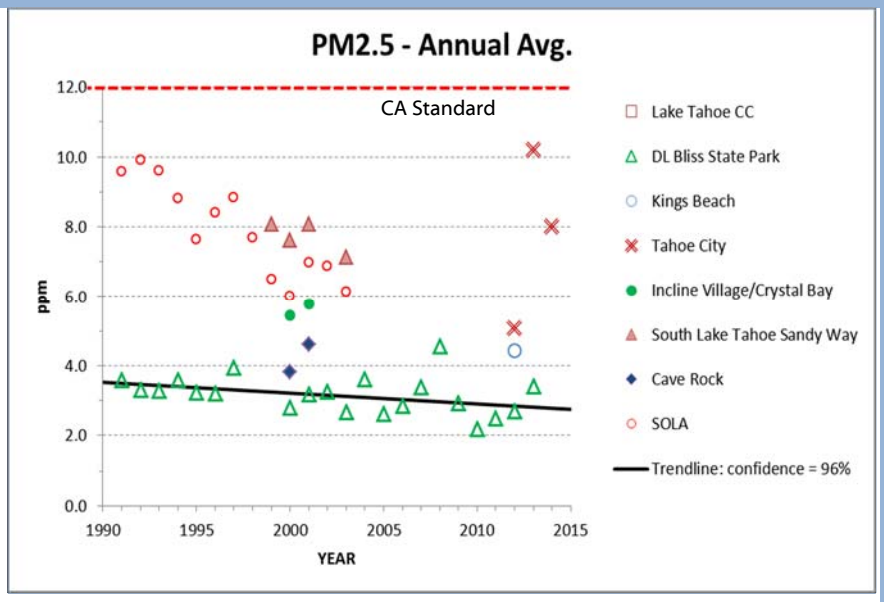
IMPLEMENTATION AND EFFECTIVENESS
Programs and Actions Implemented to Improve Conditions – Prescribed burning controls, residential woodstove replacement programs and emission standards, public transportation systems, pedestrian sidewalks and bikeways, automobile trip reduction programs, state and federal vehicle emission standards. **Effectiveness of Programs and Actions** – The current status recorded at monitoring sites for this indicator suggests that programs and actions are effective at maintaining concentrations of $PM_{2.5}$ below the adopted standard. However, the very slight increasing trend at the D.L. Bliss site warrants continued monitoring and further corrective actions if the trend continues to increase. A 2014 study by the Desert Research Institute found that prescribed burns had the largest impact on PM 2.5 levels, but during the 2010-2011 sampling season, no exceedances for PM 2.5 were caused by prescribed burns at ambient monitoring sites around the Lake Tahoe Basin. ((Chen, L.-W. Antony et al. 2014)) This report laid out recommendations for further research and actions to further mitigate air quality impacts. TRPA will continue to work with partners to implement best practices for prescribed burns based on best available science. **Interim Target** – Not applicable. Indicator is in attainment. **Target Attainment Date** – Not applicable. Indicator is in attainment.
RECOMMENDATIONS
Analytic Approach – No changes recommended. **Monitoring Approach –** It was suggested by peer reviewers that more attention and resources be paid to assess the impacts of prescribed burns on air quality in the Tahoe Basin. **Modification of the Threshold Standard or Indicator** – No changes recommended. **Attain or Maintain Threshold** – No changes recommended.

Respirable and Fine Particulate Matter: **Annual Average $PM_{2.5}$ Concentration**

Status	Trend

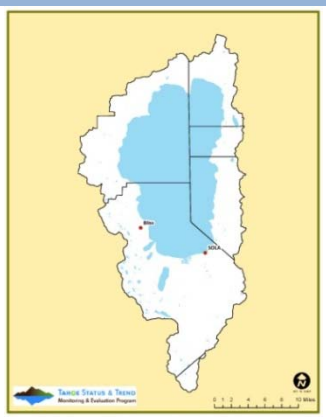
ANNUAL AVERAGE $PM_{2.5}$ CONCENTRATION

Status: **Considerably Better than Target**
Trend: **Little to No Change**
Confidence: **High**



Annual average $PM_{2.5}$ in the Tahoe Region from 1991 to present. Hollow symbols represent data that does not meet regulatory reporting requirements. The California standard of 12 µg/m³ is for the California portion of the basin. The Nevada standard of 15 µg/m³ is for the Nevada portion of the basin. Source: Desert Research Institute

Map



$PM_{2.5}$ monitoring locations in the Lake Tahoe Basin.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator addresses annual average $PM_{2.5}$ concentrations in the Lake Tahoe Region. Particulate matter less than or equal to 2.5 microns in size ($PM_{2.5}$) is extremely small and can be inhaled deep into the lungs, causing or aggravating asthma, lung diseases, and heart disease. Some particles pass into the bloodstream and some are considered carcinogens. Federal and state standards have been adopted to protect human health.

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Respirable and Fine Particulate Matter

Adopted Standards – California portion of the basin: 12 $\mu g/m^3$ annual concentration must not be exceeded; Nevada portion of the basin: 15 $\mu g/m^3$, 3-year average of weighted annual mean concentration must not be exceeded.

Type of Standard – Numerical

Indicator (Unit of Measure) – Annual average $PM_{2.5}$ concentrations at any permanent monitoring station ($\mu g/m^3$).

Human & Environmental Drivers – The primary sources of $PM_{2.5}$ in the Lake Tahoe Region are residential fuel combustion, wood smoke from wildfires and prescribed fires, motor vehicles and paved and unpaved road dust. $PM_{2.5}$ results from both primary emissions ($PM_{2.5}$ directly emitted from sources) and from secondary formation from reactions of gases in the atmosphere. Small particles are also transported into the Lake Tahoe Region, and the ambient concentration of $PM_{2.5}$ is highly dependent on meteorological conditions such as wind speed, and mixing conditions.

MONITORING AND ANALYSIS

Monitoring Partners – Interagency Monitoring of Protected Visual Environments (IMPROVE), Tahoe Regional Planning Agency, Placer Air Quality Management District and the Desert Research Institute (DRI).

Monitoring Approach – Particulate matter is monitored at a variety of sites around the Tahoe Basin as part of a national network. These sites used the IMPROVE sampler, which is not a Federal Reference Method PM_2 sampler but is accepted for determining compliance with regional haze regulations.

Analytic Approach – Trend was calculated using the Theil-Sen robust regression method (Theil 1950). Trend analysis of the resulting indicator values was performed by DRI under TRPA contract.

INDICATOR STATE

Status – Considerably better than target. The highest annual average $PM_{2.5}$ concentration for 2014 at sites that met regulatory reporting requirements was 8 ug/m^3 at Tahoe City, 67 percent of the stricter California standard (Campbell 2015). Therefore, it is considerably better than target. Additionally, every other monitoring station and year during the current monitoring period 2012 to 2015 was similarly in attainment.

Trend – Little to no change. The trend line for the D.L. Bliss monitoring site (the only site with comparable data across a long time series) shows a tiny decrease in overall $PM_{2.5}$ concentrations of 0.03 $\mu g/m^3$ per year across the basin, a decrease of 0.3 percent per year relative to the California standard (Campbell 2015). Therefore, a trend of little to no change was determined.

Confidence –

> **Status –** High. There is high confidence in the determination of status. The Tahoe City site which was used to determine status is now a Federal Reference Method (FRM) $PM_{2.5}$ sampler, and can be used to judge attainment of National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$. There was extensive testing of the samplers, and rigorous quality control procedures
> **Trend –** High. Confidence in the trend line is "high" with confidence in a trend greater than 96 percent (P = 0.04). However, because data from the D.L. Bliss monitoring location that does not meet regulatory reporting requirements was used to assess trend, confidence is "moderate".
> **Overall Confidence –** High.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Prescribed burning controls, residential woodstove replacement programs and emission standards, public transportation systems, pedestrian sidewalks and bikeways, automobile trip reduction programs, state and federal vehicle emission standards.

Effectiveness of Programs and Actions – The current status and the stable and declining trend recorded at the D.L. Bliss monitoring site for this indicator suggest the programs and actions were effective at

controlling concentrations of $PM_{2.5}$. A 2014 study by the Desert Research Institute found that prescribed burns had the largest impact on PM 2.5 levels, but during the 2010-2011 sampling season, no exceedances for PM 2.5 were caused by prescribed burns at ambient monitoring sites around the Lake Tahoe Basin(Chen, L.-W. Antony et al. 2014). This report laid out recommendations for further research and actions to further mitigate air quality impacts. TRPA will continue to work with partners to implement best practices for prescribed burns based on best available science.

Interim Target – Not applicable. Indicator is in attainment.

Target Attainment Date – Not applicable. Indicator is in attainment.

RECOMMENDATIONS

Analytic Approach – A specific definition of how the indicator will be evaluated is needed. Potential options include:

1. Take the average of all monitoring stations during the current monitoring period (e.g. 2012 to 2015) and compare it to the standard,
2. Take the average readings of all monitoring stations during the most recent (e.g. 2015) monitoring period and compare it to the standard,
3. Report on the number of exceedances during the current monitoring period,
4. Report on the number of exceedances during the most recent monitoring period,
5. Use the highest reading from the current monitoring period and compare it to the standard, or
6. Use the highest reading from the most recent monitoring period and compare it to the standard. This is the current evaluation method.

Monitoring Approach – It was suggested by peer reviewers that more attention and resources be paid to assess the impacts of prescribed burns on air quality in the Tahoe Basin.

Modification of the Threshold Standard or Indicator – No changes recommended.

Attain or Maintain Threshold – No changes recommended.

Nitrate Deposition

Nearly 78 percent of the air we breathe is nitrogen gas (N_2). Atmospheric N_2 is converted to nitrogen oxide by lightning, sunlight, and fossil fuel and biomass combustion. Industrial emissions and fossil fuel combustion contribute gaseous nitrous oxides and nitrate (as nitric acid) from sources sometimes hundreds of miles away. Excessive nitrate discharge into the air and subsequent deposition into water can negatively impact water quality. Atmospheric sources of biologically available forms of nitrogen have been linked to declines in lake transparency because different forms, such as nitrate and ammonium, provide nutrients for attached and free-floating algae ((TERC 2011)). Another nutrient of concern is phosphorous, which is found in the air in particulate form but has not been identified as a significant atmospheric source of lake transparency degradation ((Lahontan & NDEP 2010)). Because both gaseous nitric acid and particulate ammonium nitrate particles are small, less than 2.5 microns in diameter, they do not easily settle out of air. For this reason, they have also been linked to decreased visibility within the basin.

TRPA Resolution 82-11 identifies two standards for nitrate deposition regional visibility. These standards are:

1. Reduce the transport of nitrates into the Basin and reduce oxides of nitrogen (NOx) produced in the Basin consistent with the water quality thresholds.
2. Reducing vehicle miles traveled by 10 percent of the 1981 base values.

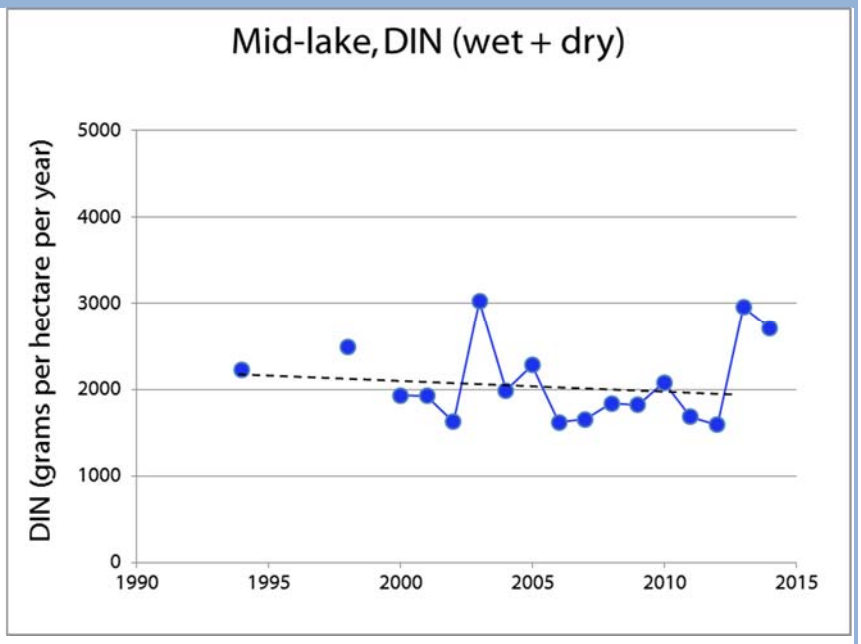
Both nitrate deposition standards are in attainment.

Management Standard Summary: **Nitrate Deposition**

Status	Trend

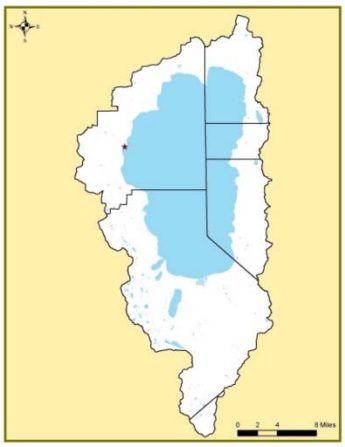
NITRATE DEPOSITION

Status: **Implemented**



Annual dissolved inorganic nitrogen "DIN" (NO3-N + NH4-N) loading at the mid-lake station Water Years 1994, 1998, 2000-2013. Red line is Generalized Additive Model (GAM) statistical line of fit r2 = 0.049, p=0.593. Trend for DIN is non-significant. Source: TERC 2015.

Map



Generalized location of Ward Creek nutrient deposition monitoring (red star). Source: TERC

Data Evaluation and Interpretation

BACKGROUND

Relevance – Excessive nitrate discharge into the air and subsequent deposition into water can negatively impact air and water quality. Atmospheric sources of biologically available forms of nitrogen have been linked to declines in lake transparency because different forms, such as nitrate and ammonium, provide nutrients for attached and free-floating algae (TERC 2011). Because both gaseous nitric acid and particulate ammonium nitrate particles are small, less than 2.5 microns in diameter, they do not easily settle out of the air or water. For this reason, they have also been linked to decreased visibility within the basin.

TRPA Threshold Category – Air Quality and Water Quality

TRPA Threshold Indicator Reporting Category – Nitrate Deposition, Pelagic Lake Tahoe and Littoral Lake Tahoe

Adopted Standards – TRPA adopted two inter-connected management standards that address nitrate deposition, one under the air quality threshold category and one under the water quality threshold category. The air quality threshold standard states: "*Reduce the transport of nitrates into the basin and reduce oxides of nitrogen (NOx) produced in the basin consistent with the water quality thresholds.*" The threshold standard under the water quality threshold category is a management standard with a numeric target that states: "*Reduce direct dissolved inorganic nitrogen (DIN) load on Lake Tahoe from atmospheric sources by approximately 20 percent of the 1973-1981 annual average.*" The annual average loading level for dissolved inorganic nitrogen from the 1973 to 1981 was estimated at 40 to 66 metric tons per year ((TRPA 1982)). The accuracy of this estimate was not validated, thus, it is not a reliable target to assess attainment status.

Type of Standard – Management Standard

Indicator (Unit of Measure) – Attainment of the management standards was evaluated using the following two criteria:

- Has TRPA (or other agencies) adopted sufficient policies, ordinances, and programs in support of the management standards?
- Is there empirical evidence that demonstrates a reduction in nitrogen deposition into Lake Tahoe?

Human & Environmental Drivers – Natural sources of oxides of nitrogen, nitrate, and dissolved inorganic nitrogen include wildfire and transformation of nitrogen resulting from sunlight and electrical storms. Human-generated sources include the combustion of fossil fuels, fertilizers, and industrial emissions from outside of the basin.

MONITORING AND ANALYSIS

Monitoring Partners – This is an evaluation of a management standard. For detailed monitoring information on nitrogen deposition, see the water quality section.

Monitoring Approach – This is an evaluation of a management standard. For detailed monitoring information on nitrogen deposition, see the water quality section.

Analytic Approach – Not applicable.

INDICATOR STATE

Status – Implemented. Policies, ordinances and environmental improvements have been implemented. However, their effectiveness could not be demonstrated with available information. TRPA has adopted several policies to encourage reduction in air and water pollutants, including sources of nitrate and dissolved inorganic nitrogen deposition into Lake Tahoe. TRPA has adopted several policies ((TRPA 1986); (TRPA 1992)) that support the use of alternative modes of transportation to reduce atmospheric sources of air pollutants such as nitrate and improve air quality (e.g., bicycle and pedestrian facilities, public transportation, postal delivery, and waterborne transportation). The TRPA Code of Ordinances, Chapter 93, includes regulations requiring that combustion appliances and wood heaters meet emission standards. The TRPA Code of Ordinances also requires that potential air quality impacts from a project be addressed as a component of the environmental documentation and permitting process (see chapters 5 and 6).

For sources of nitrogen pollution associated with surface and groundwater, TRPA has adopted policies and ordinances to reduce nitrogen loads into Lake Tahoe ((TRPA 1986)). For example, TRPA requires that stormwater is infiltrated (treated) on-site for each developed parcel in the basin. Initiatives such as the

Lake Tahoe Total Daily Maximum Load program administered by the states of Nevada and California require local jurisdictions to demonstrate pollutant load reductions from various sources, including atmospheric sources. The Environmental Improvement Program (EIP) administered by the TRPA in partnership with state, federal, and local governments, has facilitated a number of projects that were designed to aid in achieving this standard. Numerous projects under the EIP, such as bicycle trails and the Heavenly Gondola Project, have been implemented to reduce dependency on private automobiles, and thus, reduce pollutant loads to Lake Tahoe.

The California Air Resources Board and U.S. Environmental Protection Agency continue to require vehicle manufacturers to equip new cars with sophisticated emission control systems. These systems generally include a "three-way" catalyst that converts carbon monoxide and hydrocarbons to carbon dioxide and water and also helps to reduce nitrogen oxides to elemental nitrogen and oxygen, as well as on-board computers and oxygen sensors to control tailpipe emissions.

Data from UC Davis Tahoe Environmental Research Center (TERC) shows the pattern for dissolved inorganic nitrogen (DIN) loading at mid-lake since 1994. There was no statistically significant trend for DIN in atmospheric deposition at mid-lake for water years 1994, 1998, and 2000-2013. DIN loads in many of the sampled water years were near the median estimated water year loading (1924.39 g ha-1 yr-1 or 5.27 g ha-1 d-1) with the exception of noticeable peaks in 2003 and 2013. A generalized additive model (GAM) analysis was done to look for trends in DIN through time. The results of the GAM analysis indicated there was no statistically significant trend for DIN in atmospheric deposition at mid-lake for the period of record at the $p \leq 0.05$ level ($r2= -0.049$, $p=0.593$, $n=16$, $K=4$).

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Federal and state vehicle emission standards, state and local restrictions on open burning, TRPA policies and ordinances on land use, alternative fuels, postal service delivery, wood stove and gas-fired appliances, bicycle and pedestrian facilities, and public transit.

Effectiveness of Programs and Actions – Available information from TERC nutrient deposition monitoring at Ward Creek suggests there has been little or no statistical change in the amount of dissolved inorganic nitrogen (which include nitrate) deposited into Lake Tahoe annually, since the adoption of the TRPA Regional Plan and stricter vehicle federal and state emission standards and requirements.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

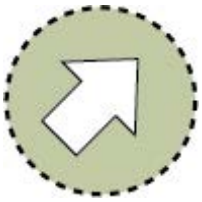
Monitoring Approach – The estimate for nitrogen deposition Lake Tahoe is based primarily on monitoring at a single location on the Lake. Consideration should be given to assessing how representative the location is of the wider deposition patterns on the Lake, and monitoring nitrate deposition at multiple sites around the lake should be considered.

Modification of the Threshold Standard or Indicator – Objective determination of "attainment" status for management standards without a specific target can be challenging. The standard should be assessed against best practice for the establishment of standards and monitoring and evaluating indicators, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – Additional research is necessary to identify cost effective management actions to reduce atmospheric and other land-based sources of nitrogen reaching the lake.

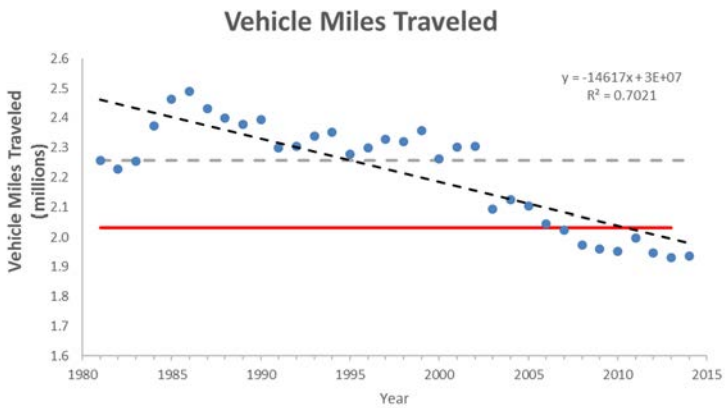
Nitrogen Deposition: **Vehicle Miles Traveled**

Status	Trend



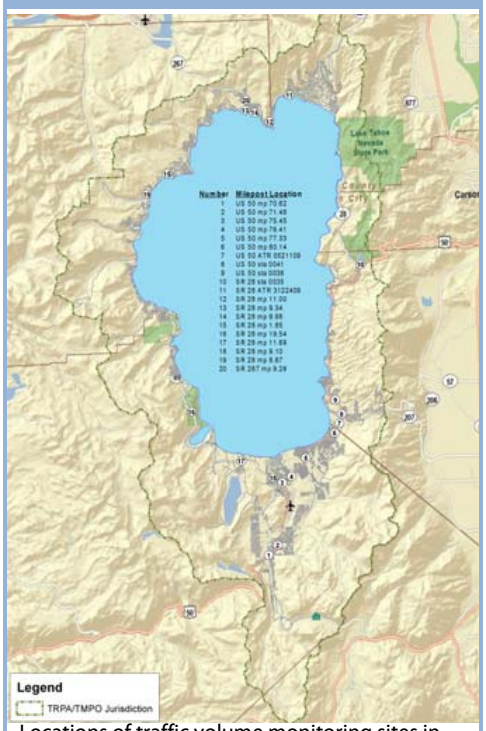
VEHICLE MILES TRAVELED

Status: **At or Somewhat Better than Target**
Trend: **Moderate Improvement**
Confidence: **Low**



Estimated annual vehicle mile travelled in the Tahoe Region 1981-2014. Source: TRPA TransCAD model using California Department of Transportation and Nevada Department of Transportation traffic counts.

Map



Locations of traffic volume monitoring sites in the Lake Tahoe Region.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Vehicle miles traveled (VMT) is a proxy measure of the production of nitrates in the Region and the nitrogen deposition into lake Tahoe. Nitrogen, a nutrient promoting growth and reproduction of plants, is considered a pollutant of concern in the Lake Tahoe Basin (Lahontan & NDEP, 2010a).

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category –Nitrate Deposition

Adopted Standards – Reduce vehicle miles of travel in the Basin by 10 percent of the 1981 base year values

Type of Standard – Management standard with a numeric target.

Indicator (Unit of Measure) – Peak day VMT.

Human & Environmental Drivers – VMT in the Region is a function of the complex interplay of a variety of factors including: population (both inside and outside the Region), gas prices, employment rates, local housing costs, demand and access for recreational opportunities in the Region, access to alternative forms of transportation, and secondary home ownership. Higher unemployment, higher fuel prices, increased congestion, work from home programs, employer car pool programs and concentration of development in centers are all linked with reductions in VMT. While population growth, higher household income, higher employment rates, increased fuel economy and greater roadway capacity are all linked to increasing VMT. Increasing access to transit services, access to bicycle and pedestrian facilities, and the relative desirability of alternative modes of transportation in comparison to the use of the personal automobile may reduce VMT.

MONITORING AND ANALYSIS

Monitoring Partners – TRPA, California Department of Transportation (Caltrans), and Nevada Department of Transportation (NDOT) and the Tahoe Regional Planning Agency.

Monitoring Approach –The identification of traffic volumes is a primary component towards tracking mobility with the Tahoe Region. Published traffic volumes are counted annually within the Lake Tahoe Region by both the California Department of Transportation (Caltrans) the Nevada Department of Transportation (NDOT) and local governmental jurisdictions. In addition to modeling compliance with the 1981 VMT Threshold, TRPA staff utilized the 1981 base year VMT estimate, and the corresponding traffic count stations that produce annual traffic counts to analyze increases or decreases in VMT.

Analytic Approach – Unlike traffic counts, which can precisely measure the number of cars passing through a specific location, all measures of VMT are approximations of actual vehicle miles traveled by automobiles in the Region. Vehicle miles traveled was estimated for 2014 using a sophisticated tour-based transportation model (TransCAD). The model uses a spatial representation of the Region's road network and parameters such as residential housing units, seasonal housing units, persons per household, income, hotel rooms and their occupancy rates, school enrollment, campgrounds and their occupancy rates, and employment to estimate VMT. Since 1981, the TRPA has used a series of progressively more sophisticated models to estimate VMT. As the VMT models improved, current day modelled VMT estimate comparisons with previous year VMT model estimates are not possible because different input parameters are used and mapped traffic zones are different. VMT estimates are calibrated with Caltrans and NDOT traffic count data. These count stations have been used consistently as a standard to calibrate previous modeled VMT estimates and give us a good understanding.

INDICATOR STATE

Status – At or somewhat better than target. In 2014, the most recent year where traffic modeling was available, there was an estimated 1,937,070 VMT, which is approximately 95 percent of the target. Therefore, a status of at or somewhat better than target was determined. This indicator has been in attainment since 2006.

Trend – Moderate improvement. The long-term trend line shows an annual decrease of 0.7 percent per year in relation to the standard of 2,030,938 VMT per year. Therefore, a determination of moderate

improvement was determined.

Confidence –

Status – Moderate. VMT data is collected and modelled following standardized procedures based on data from a wide variety of traffic sensors. ~~Therefore, confidence in current status is high.~~

Trend – Low. There is high confidence in traffic data collected by Caltrans and NDOT that has been collected since 1981. The TransCAD model has been used to estimate VMT since 2005, and there is relatively high confidence in model output. Model output is calibrated to the Caltrans and NDOT traffic data further increasing confidence in the VMT estimates. However, over the course of the last 25 years, TRPA has used a series of progressively more sophisticated models to estimate VMT. VMT model improvement has been accompanied by a change in the suite of parameters used to estimate VMT. Change in the parameters required by the model to estimate VMT has precluded the use of the current model to back-cast VMT estimates for earlier periods, because of parameter availability. The low confidence in trend determination reflects lower confidence in VMT estimates prior to 2005.

Overall Confidence – Low. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions –The 2012 regional plan update contains incentives to cluster population and employment in relatively compact town centers that are well served by transit, pedestrian and bicycle infrastructure. Thoughtful land-use planning is central element of TRPA's growth management system and an important strategy used to attain the VMT and other thresholds. The Transfer of Development Rights Program (TDR) program provides incentive to transfer coverage development rights from sensitive lands and remote areas into less sensitive lands located in town centers. Within the program, if 10 tourist accommodation units (TAUs) were removed from a SEZ and transferred to a town center, an additional 20 TAUs would be awarded for this transfer, for a total of 30 TAUs (i.e. 1:3 transfer ratio). As part of the 2015 strategic initiative to review the commodities system and TDR program, TRPA is working with stakeholders to improve the program and accelerate transfers and implementation of the regional plan.

Since 2010 partners in the basin have, built over 30 miles of bicycles and pedestrian facilities, constructed 18 bus-shelters, revitalized street corridors and created new public spaces. Land-use planning, Public transportation systems, pedestrian sidewalks and bikeways projects, automobile trip reduction programs and transportation improvement projects such as the Heavenly Gondola project all contribute to reducing VMT in the Region.

Effectiveness of Programs and Actions – The status and trend in estimated VMT suggest that current programs and policies are mostly effective in reducing VMT. Lagging economic conditions and recent low-snow winters likely also contributed to lower VMT.

Interim Target – Not applicable. Indicator is in attainment.

Target Attainment Date – Not applicable. Indicator is in attainment.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – As fuel mix technology, vehicle emissions standards, and overall fuel economy of the nation's vehicle fleet improve, the relationship between VMT and NOx emissions has evolved. Nationally, VMT continues to increase while NOx emissions have drastically declined. On average, NOx emissions have decreased from 3.6 grams/mile in 1955 to 0.217

grams/mile in 2013, and are forecast to be 0.13 grams/mile in 2020. Consistent with the recommendations of past threshold evaluation report, the link between the standard and the desired conditions should be assessed to ensure that it is still the appropriate air quality measure.

Recommended actions to Attain or Maintain Threshold – Continue to implement the policies in the regional plan update and the regional transportation plan project list, which contains over 100 projects designed to reduce VMT and promote other threshold gains.

Air Quality: **Odor**

Status	
ODOR Status: **Implemented**	

Data Evaluation and Interpretation

BACKGROUND

Relevance – Air quality conditions in the Lake Tahoe Region can affect human health, visibility, forest health, and the clarity of Lake Tahoe. Motor vehicle emissions are one of the primary factors influencing air quality conditions. To address environmental and human health concerns from vehicle emissions, specifically fumes attributed to diesel engines, TRPA adopted ordinances in 1987 that regulate motor vehicle "odor" in the basin. According to the odor policy statement, "*...it is a policy of the TRPA Governing Board in the development of the Regional Plan to reduce fumes from diesel engines to the extent possible.*"

TRPA Threshold Category – Air Quality

TRPA Threshold Indicator Reporting Category – Odor

Adopted Standards – It is the policy of the TRPA Governing Board in the development of the Regional Plan to reduce fumes from diesel engines to the extent possible.

Type of Standard – Policy statement

Indicator (Unit of Measure) – This policy statement was evaluated by determining whether TRPA and other agencies have adopted sufficient policies, ordinances, and programs in support of the odor threshold policy statement.

Human & Environmental Drivers – The main concern of TRPA when It comes to odor is the odors caused by vehicles, especially exhaust from diesel vehicles.

MONITORING AND ANALYSIS

Monitoring Partners – Not applicable. No monitoring occurs.

Monitoring Approach – Not applicable. No monitoring occurs.

Analytic Approach – This policy statement was evaluated by determining whether TRPA and other agencies have adopted sufficient policies, ordinances, and programs in support of the odor threshold

policy statement.

INDICATOR STATE

Status – Implemented. The odor threshold standard was determined to be implemented. A review of the current adopted policies, ordinances, and rules of TRPA, state and federal agencies has found support of the policy statement. These agencies have adopted policies and measures that address diesel odor. However, because no monitoring occurs, it is not possible to say whether or not these policies, ordinances, and rules are having their intended effect.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA policies, ordinances, and programs: support for attainment of this policy statement is comprised of adopted policies and ordinances. This policy is a component of transportation control measures in the Regional Transportation Plan, and *"…limits vehicle idling in the Region."*[3] More specifically, this policy refers to components adopted in the TRPA Code of Ordinances, Chapter 91, which addresses vehicle idling restrictions, exemptions, and compliance programs. The relevant code is cited below. These ordinances are implemented at the project scale through the project review process.

91.7 Idling Restrictions: A program to control extended vehicle idling is a Reasonably Available Control Technology in the Clean Air Acts of 1977, and is a contingency measure in the 1992 Air Quality Plan for the Lake Tahoe Basin.

91.7A Duration: No person shall control a combustion engine in a parked auto, bus, or boat to idle for more than 30 consecutive minutes in the following Plan Areas: 070A, 080, 089A, 089B, 090, 091, and 092. The following projects and activities are not subject to this limitation:

(1) Activities specifically permitted, after environmental impact analysis, to idle more than 30 minutes

(2) Emergency vehicles, snowplows, or combustion engines required in the case of emergencies or repair

(3) Vehicles in transit on public rights of way

91.7B Drive-Up Windows: New drive-up windows are prohibited.

91.7C Compliance Program: TRPA shall implement the provisions of Subsection 91.7.A primarily through educational programs, notification programs, and cooperative arrangements with charter operators, property owners in the affected plan areas, and local government. As appropriate, TRPA may take direct action to obtain compliance with this section, including, but not limited to, actions under Chapter 8 and 9 of the Code.

According to the adopted ordinance found in the TRPA Code of Ordinances, a compliance program addressing the idling restriction shall be implemented *"…primarily through educational programs, notification programs, and cooperative arrangements with charter operators, property owners in the affected plan areas, and local government."* According to TRPA's Long Range and Transportation Planning Division, the agency continuously works with local public transportation providers to fund and support the purchase of alternative fuel buses in support of this ordinance. Because of more stringent state and federal policies and tail-pipe emission standards, and ordinances and programs that reduce diesel emissions, it was found that TRPA should focus on this type of policy support, instead of focusing on

[3] *Transportation Control Measures of the Regional Transportation Plan*

specific education and outreach programs.

There are currently no monitoring efforts underway that could be used to assess the effectiveness of implemented TRPA policies and ordinances on diesel emissions. However, stringent state and federal measures and programs have been shown to be effective in reducing odor emissions.

State and Federal Odor Reduction Measures- Adopted in 1988, California diesel fuel regulations set limits on aromatic hydrocarbon content (10 percent by volume) and on sulfur content (500 parts per million by weight, ppmw). These regulations, in effect since 1993, reduce emissions from diesel engines and equipment as follows:

- 7 percent less oxides of nitrogen (NOx)
- 25 percent less particulate matter (PM)
- 80 percent less sulfur oxides (SO_2) and several other toxic substances such as benzene and polynuclear aromatic hydrocarbons (PAHs)

The California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA) implemented a stricter "low sulfur" diesel fuel restriction requiring a sulfur level of 15 ppmw or less beginning in 2007 (phase-in schedule 2007-2010). CARB is also responsible for an anti-idling rule, specifically applying to drivers of diesel-fueled commercial vehicles with a gross weight rating of more than 10,000 pounds. The anti-idling rule imposes a five-minute idling limit for these vehicles at any location in California. Lastly, the rule requires all 2008 and newer model-year diesel engines *"…either be equipped with a non-programmable automatic engine shutdown system that shuts the idling engine down after a minimum period of time or must be certified to a NOx idling emission standard of 30 grams per hour*." Exceptions to these idling restrictions include school buses, recreational vehicles, and military vehicles.

The following odor reduction measures have been implemented specifically by CARB:

- *CARB Specific Diesel Emission Reduction Measures*: The identification of diesel particulate matter (PM) as a toxic air contaminant in 1998 led CARB to adopt the Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles in September 2000.
- *Fleet Rule for Transit Agencies (adopted 2000):* This regulation cuts NOx and PM emissions from approximately 10,000 buses operated by transit agencies. The fleet rule for transit agencies moves forward in steps over 10 years, requiring cleaner engines, cleaner fuel, and retrofitting of older buses. Amendments proposed for 2004 will require transit agencies to clean up the buses that had not been covered in the original rule.
- *School Bus Idling Restrictions (adopted 2002):* To reduce the exposure of children to toxic PM emissions, CARB enacted a rule to stop the prolonged idling of diesel school buses and other diesel vehicles near schools. Buses and commercial diesel vehicles are required to turn off their engines after arriving at a school and are allowed to start the engine no more than 30 seconds before departing, unless required for safety or work.
- *Stationary Engines (adopted 2004):* There are approximately 26,000 stationary diesel-fueled engines in California. Most are used as emergency backup in the event of a power failure. Others are used to pump water in agricultural areas, to run compressors, cranes and other equipment. New CARB standards for these engines will bring an approximate 80 percent PM reduction by 2020 through stricter standards for new engines and requirements to retrofit existing engines.
- *Transport Refrigeration Units (adopted 2004):* Transport refrigeration units (TRUs) are diesel-powered units that cool temperature-sensitive products while they are being

shipped in trucks, trailers, shipping containers and rail cars. Although the diesel engines powering TRUs tend to be relatively small, there are about 40,000 of them operating in California. Their PM emissions will be reduced by 65 percent by 2010 and by 92 percent by 2020.

In addition to regulations and standards for diesel engine emissions, the U.S. EPA has developed assistance programs that award funding for clean diesel projects and technologies. As part of the Energy Policy Act of 2005, the Diesel Emissions Reduction Act (DERA) authorizes funding of up to $200 million annually to help fleet owners reduce diesel emissions.

Additional Reductions Attributed to State and Federal Measures – As a result of the "low sulfur" diesel fuel restriction implemented in 2007, which required a diesel fuel sulfur level of 15 ppmw or less, refiners began producing cleaner burning fuels beginning in 2006. The EPA estimates that 2.6 million tons of smog-causing nitrogen oxide emissions will be reduced each year, with particulate matter being reduced by 110,000 tons a year. In addition, this diesel fuel requirement substantially decreases negative health effects associated from these harmful emissions. According to the U.S. EPA, *"…an estimated 8,300 premature deaths, 5,500 cases of chronic bronchitis and 17,600 cases of acute bronchitis in children will be prevented annually,"* with an additionally estimated "*...360,000 asthma attacks and 386,000 cases of respiratory symptoms in asthmatic children also avoided every year*" (EPA's Office of Transportation and Air Quality 2016)

Effectiveness of Programs and Actions – Because no actual odor monitoring occurs, it is not possible to say whether or not these policies, ordinances, and rules are having their intended effect.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – One peer reviewer suggested TRPA initiate an odor "hotline" to track odor complaints. The number of complaints was suggested as a way to track the status and trend of odor over time. This recommendation should be considered during the threshold review process.

Modification of the Threshold Standard or Indicator – Resolution 82-11 intended that policy statements be incorporated into the TRPA Regional Plan. This evaluation demonstrates that TRPA and other agencies have incorporated and supported the policy statement. Consequently, it is recommended that this policy statement be removed from the list of adopted threshold standards in Resolution 82-11, or translated into a numerical standard for which an objective determination of status can be determined. For example, TRPA could instead use applicable ambient air quality standards for NO_x, SO_2, CO and PM that are directly related to diesel engine emissions to measure attainment with the diesel odor standard.

Attain or Maintain Threshold – No changes recommended.

Chapter 3 Air Quality References

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CHAPTER 5
Soil Conservation

Landscape modification and land use over the past 150 years have impacted the Region's soil resources. These impacts are especially prevalent in and around developed areas, and in areas influenced by Comstock era logging. Urban development in particular has physically altered the landscape, resulting in soil removal, grading, compaction, and higher erosion risk. These impacts have altered the ability of soils and vegetation communities to cycle nutrients and absorb and store water.

Soils provide a variety of key functions including sustaining vegetation, water filtration and storage, providing habitat for a wide variety of organisms, and providing a platform for development. The soil conservation threshold standards protect the Region's soil resources and provide their continued ability to filter and retain nutrients for a variety of purposes.

These goals are directly reflected in the policies of the Regional Plan, which serve to:

- Direct the location of impervious cover and limit its extent
- Prevent soil erosion from the Region's watersheds by focusing development on more suitable soil types and ensuring development activities occur when soils are less susceptible to erosion.
- Protect existing stream environment zones (SEZ) and restore modified SEZ

Stream environment zone (SEZ) is a term unique to the Tahoe Region, that the TRPA Code of Ordinances defines as "*Generally an area that owes its biological and physical characteristics to the presence of surface or ground water*" (TRPA, 2012a). This definition includes perennial, intermittent, and ephemeral streams; wet meadows, marshes, and other wetlands; and riparian areas or other areas expressing the presence of surface and ground water.

These policies also play a critical role in contributing to the water quality, vegetation, and wildlife goals of the region.

The soil conservation thresholds are grouped into two reporting categories, impervious cover and SEZ. Impervious cover is a primary indicator of land disturbance. Excessive impervious surface contributes to sediment and nutrient inputs to Lake Tahoe and its tributaries, alters surface hydrology and modifies groundwater recharge regimes. The results are often negative impacts on soil health, fisheries, wildlife habitat and vegetation growth(Lahontan & NDEP, 2010; Raumann and Cablk, 2008). SEZs provide a variety of critical services in the basin, including water quality maintenance through nutrient cycling and sediment retention, flood attenuation, infiltration and

groundwater recharge, open space, scenic and recreational enjoyment, wildlife habitat, and wildfire abatement, among many other functions and values (Roby et al., 2015).

This section provides an evaluation of the status of indicators relative to the 10 soil conservation targets related to impervious cover and one indicator related to SEZs (Table 5-1).

Table 5-1: *Summary of threshold standards for the soil conservation category*

Indicator Reporting Category	Standard	Type of Standard	Indicator
Impervious Cover	Impervious cover shall comply with the *Land-Capability Classification of the Lake Tahoe Basin, California-Nevada, A Guide for Planning*, Bailey, 1974. • Land Capability 1a (1% allowable cover) • Land Capability 1b (1% allowable cover) • Land Capability 1c (1% allowable cover) • Land Capability 2 (1% allowable cover) • Land Capability 3 (5% allowable cover) • Land Capability 4 (20% allowable cover) • Land Capability 5 (25% allowable cover) • Land Capability 6 (30% allowable cover) • Land Capability 7 (30% allowable cover)	Management (with Numerical Targets)	Percent of Impervious Cover within Each Land Capability District
Stream Environment Zone	Preserve existing, naturally functioning SEZ lands in their natural hydrologic condition. Restore all disturbed SEZ lands in undeveloped, un-subdivided lands. Restore 25 percent of the SEZ lands that have been identified as disturbed, developed or subdivided to attain a five percent total increase in the area of naturally functioning SEZ lands.	Numerical	Acres of SEZs restored, policy framework in place to protect and restore SEZs.

The results of the 2015 assessment for the status and trend of standards in the soil conservation reporting categories are summarized in Table 5-2, as well as the results from the 2011 Threshold Evaluation Report for comparison. Figure 5-1 provides a key to the symbols used to communicate status, trends, and confidence, and a detailed description of each is provided in the methodology section. The indicator sheets that follow contain more detailed assessment of the status and trend of each indicator and provide descriptions of the methods used and recommendations for modification of the standard or analytic approach used to assess the standard.

Table 5-2: Comparison of soil conservation status and trend in the 2011 and 2015 Threshold Evaluation Reports.

Standard	2011	2015
Impervious Cover		
Percent of Land Coverage Within Land Capability Class 1a (allow up to 1% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 1b (allow up to 1% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 1c (allow up to 1% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 2 (allow up to 1% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 3 (allow up to 5% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 4 (allow up to 20% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 5 (allow up to 25% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 6 (allow up to 30% impervious coverage)		
Percent of Land Coverage Within Land Capability Class 7 (allow up to 30% impervious coverage)		
Stream Environment Zones		
Preserve and Restore Stream Environment Zones		

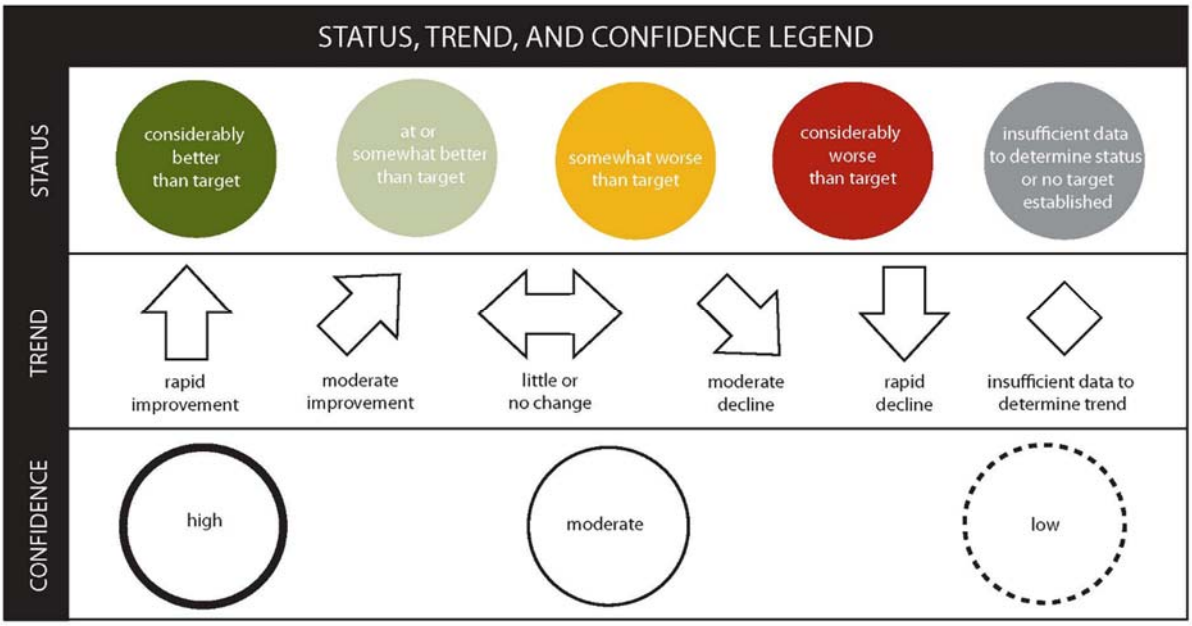


Figure 5-1: A key to the symbols used to assess status, trends, and confidence levels.

Impervious Cover

Impervious cover (also referred to as land coverage) is a primary indicator of land disturbance. Excessive impervious cover within a watershed contributes to sediment and nutrient inputs to Lake Tahoe and its tributaries impairing water quality, altering surface hydrology and groundwater recharge regimes. The results are often negative impacts on soil health, fisheries, wildlife habitat and vegetation growth.

Two types of impervious cover are defined by TRPA: hard and soft cover. These designations reflect degrees of imperviousness. Hard cover precludes any infiltration of water into the soil, whereas soft cover may allow limited infiltration into the soil. Hard cover refers to land that is artificially covered by materials such as buildings, pavement, and concrete. Soft cover refers to disturbed or degraded soils that are not covered by any type of structure or paved surface. Examples of soft cover includes soil compacted by vehicles or machinery parking or driving on unpaved areas, and repeated foot traffic over dirt trails and undesignated pathways. Both hard and soft cover impede infiltration altering the natural hydrologic regimes. Reduced infiltration reduces groundwater recharge, inhibits plant growth, and reduces water quality. A structure, improvement, or covering is not considered land coverage by TRPA if it allows at least 75 percent of normal precipitation to directly reach the ground, and allows growth of vegetation on the approved species list (TRPA, 2012a).

The impervious cover threshold standard is guided by the land capability classification system for the Lake Tahoe Basin (Bailey, 1974).[1] The system organizes the basin into land capability classes based on soil type, erosional hazard, soil drainage, and other features. The land capability classes reflect the amount of development an area can support without experiencing soil or water quality degradation. The land capability classes range from one to seven, with one being the most environmentally sensitive and seven having the highest capability for supporting development.

Bailey assigned each land capability class an allowable percentage of impervious cover, ranging from one percent for sensitive lands in classes 1a, 1b, 1c, and 2, to 30 percent for lands most suitable for development in classes 6 and 7 (Table 5-3). The impervious cover threshold standard requires compliance with Bailey's impervious cover limits set for each land capability class. This evaluation provides a characterization of the proportion of each land capability class that may be covered with impervious surfaces.

[1] *The complete report is available on the TRPA website at* http://www.trpa.org/wp-content/uploads/Bailey-Land-Capability-Report.pdf

Table 5-3: Basis of land capability classification for Lake Tahoe Basin lands (from Bailey 1974)

Capability Levels	Tolerance for Use	Slope Percent[2]	Relative Erosion Potential	Runoff Potential[3]	Disturbance Hazards
7	Most	0-5	Slight	Low to Moderately Low	Low Hazard Lands
6		0-16	Slight	Low to Moderately Low	
5		0-16	Slight	Moderately High to High	
4		9-30	Moderate	Low to Moderately Low	Moderate Hazard Lands
3		9-30	Moderate	Moderately High to High	
2		30-50	High	Low to Moderately Low	High Hazard Lands
1a	Least	30+	High	Moderately High to High	
1b	Least	Poor Natural Drainage			
1a	Least	Fragile Flora and Fauna[4]			

For the 2011 Threshold Evaluation Report, impervious cover was estimated using high-resolution Light Detection and Ranging (LiDAR) data and multispectral imagery (Worldview 2 Satellite, DigitalGlobe, Inc.) collected in August 2010. Specialists from the Spatial Informatics Group and the University of Vermont developed a preliminary algorithm (set of rules) to model the remote sensing data and create an automated assessment of land-cover mapping using object-based image analysis. This automated procedure systematically interpreted and classified the LiDAR and multispectral imagery data into two generic land cover types based on spectral (color) and landform (topography) information (O'Neil-Dunne et al., 2014). This map was then intersected with the Natural Resources Conservation Service (NRCS) land capability map (USDA-NRCS, 2007) to produce preliminary estimates of impervious surface by land capability type at the Tahoe Region scale.

The estimates of impervious cover must be taken as educated approximations based on best available data. TRPA and the consultant specialists are continuing to refine the estimates of impervious cover in the basin using advanced remote sensing data and the information collected through project permitting.

[2] *Most slopes occur within this range. There may be, however, small areas that fall outside the range given.*

[3] *Low to moderate low-hydrologic soil groups A and B; moderately high to high-hydrologic soil groups C and D.*

[4] *Areas dominated by rocky and stony land.*

2007 NRCS Soil Map

Since 1974, the available data and technology to delineate acreage in each land capability class has improved dramatically. NRCS completed an updated soil survey of the entire Tahoe Region in 2007 (Loftis, 2007; USDA-NRCS, 2007). The 2007 soil map replaced the 1974 soil map (Rogers, 1974)(Rogers 1974) used by Bailey (Bailey, 1974), to assign each soil map unit to a land capability class and while too late to be incorporated into the 2006 Threshold Evaluation Report, the updated soil information was recommended for use in subsequent threshold evaluations.

The mapping resolution of the 2007 map nearly doubled that of the 1974 map, providing a more refined estimate of the extent and location of all land capability classes. The higher resolution revealed that some areas assigned to a single class in 1974 may now be distinguished as several different classes. Most of the class refinements occurred outside of the urban boundary, for example, in Desolation Wilderness (Loftis, 2007). These class refinements were made possible by higher mapping resolution, additional data collection and better mapping technology, and standardization in mapping methodology. For instance, Global Positioning System (GPS) and Geographic Information Systems (GIS) tools now allow more accurate acreage accounting than was possible four decades ago.

In addition to higher mapping resolution and additional data, the land capability classification presented in Table 5-3 differs in two ways from the 1974 classification. First, erosion hazard was not included in the 2007 NRCS classification because it was effectively redundant with slope (Loftis, 2007). Second, the 2007 soil survey did not reclassify land capability classes based on surrounding soil classes. During the land capability analysis and mapping effort, Bailey found instances where pockets of high capability lands were fully enveloped within a geomorphic high hazard area. For example, there are small pockets of gently sloping, deep soils within the Desolation Wilderness. While high capability, these pockets are essentially inaccessible from a development standpoint as they are fully surrounded by high hazard areas with steep, erodible, rocky slopes. Bailey reclassified these pockets of high capability soils as low capability lands. These pockets were not reclassified in the 2007 soil survey.

It is a common misconception to conclude that because the map used as the basis for standard assessment has been updated to reflect the best available science that the allowable impervious coverage has therefore also changed. In the original report on land capability, Bailey (1974) cautioned against overestimating the accuracy of land capability maps in the report: *"In addition, because of the small scale of the map and the maps from which it was compiled, land capability within individual map units may not be uniform… It is therefore necessary that the final land capability classification for individual parcels be based on detailed site evaluations and more detailed application of the classification criteria.* Site level verification has always been a fundamental component of the permitting process used by TRPA and partners to ensure that development adheres to the principles of Bailey. Prior to TRPA permitting development on a parcel, land capability verification determines its land capability class. Site assessment of land use capability within the Bailey framework ultimately dictates the extent of allowable impervious cover on a site.

The 2011 Threshold Evaluation Report used the 2007 updated soil survey to assess the extent of impervious cover in each land capability class defined by Bailey (1974), and the higher resolution data from the 2007 NRCS survey is also used in the 2015 Threshold Evaluation Report (Table 5-4).

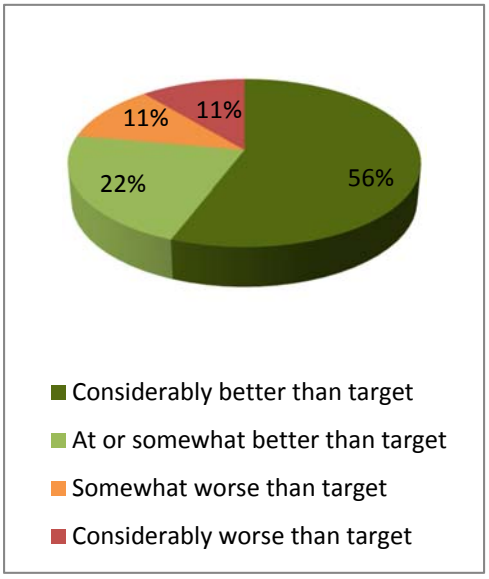
Table 5-4: Estimated impervious cover in each Bailey land capability class in the Lake Tahoe Region in 2015. Impervious cover in land capability class 1b and 2 are estimated to exceed allowable cover by 659.6 and 43 acres, respectively. Cover in all other land capability classes is below the allowable level. Land capability data is based on the 2007 NRCS Soil Survey (USDA-NRCS 2007). Impervious cover estimates based on evaluations of high resolution LiDAR and multispectral data collected in August 2010 and permitted development between August 2010 and August 2015.

Land Capability Class	Total Acres Within Class	Allowable Impervious Cover	Estimated Impervious Cover 2010	Change August 2010-August 2015 (Acres)	Estimated Impervious Cover 2015	Acres above or Below Allowable Cover
1a	23,558	236 (1%)	175 (0.7%)	0.82 removed	174 (0.7%)	61.8 below
1b	11,304	113 (1%)	783 (6.9%)	10.39 removed	773 (6.8%)	659.6 above
1c	53,957	540 (1%)	505 (0.9%)	0.17 added	505 (0.9%)	34.8 below
2	23,648	236 (1%)	279 (1.2%)	0.03 removed	279 (1.2%)	43.0 above
3	16,920	846 (5%)	358 (2.1%)	0.06 added	358 (2.1%)	487.9 below
4	32,386	6,477 (20%)	1,263 (3.9%)	2.42 added	1265 (3.9%)	5,211.6 below
5	10,347	2,587 (25%)	1,099 (10.6%)	4.90 added	1104 (10.7%)	1,483.1 below
6	24,308	7,292 (30%)	2,214 (9.1%)	6.93 added	2221 (9.1%)	5,071.1 below
7	5,525	1,658 (30%)	1,283 (23.2%)	3.52 added	1287 (23.3%)	371.5 below
Total	**201,953**	**19,984 (9.9%)**	**7,959 (3.9%)**	**6.75 added**	**7974 (3.9%)**	**12,010.2 below**

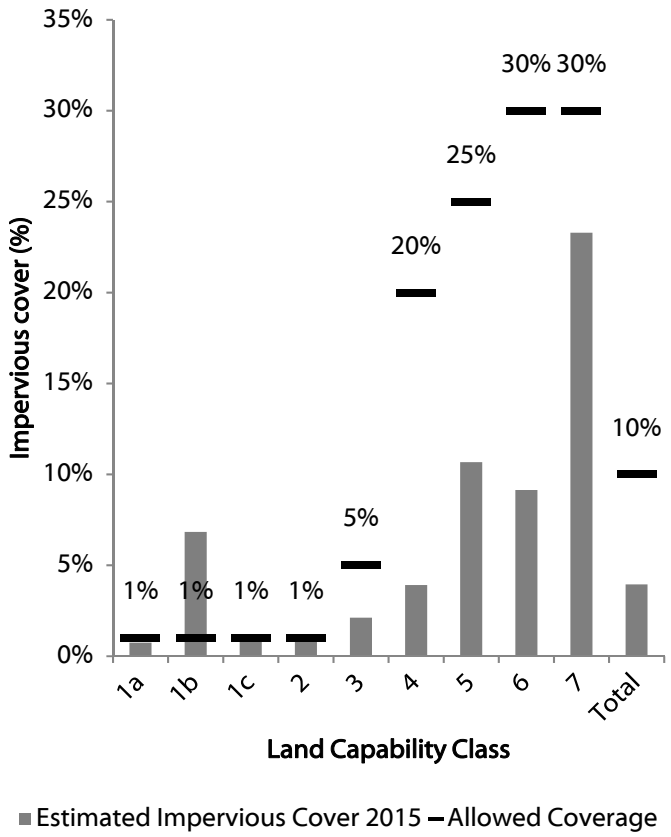
Soil Conservation: **Percent of Land Coverage within Land Capability Classes**

Status	Data

PERCENT OF LAND COVERAGE WITHIN LAND CAPABILITY CLASSES



Summary of the status of the nine individual land capability class indicators in the reporting impervious cover reporting category.



Percent cover in each Bailey land capability class relative to the allowable coverage in class.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures the percent of land coverage on different land capability classes as described by Bailey (Bailey, 1974) and updated with the most recent soil survey by the Natural Resources Conservation Service (NRCS) in 2007 (Loftis, 2007; USDA-NRCS, 2007). Impervious cover is a primary indicator of land disturbance. Excessive impervious surface within a watershed contributes to sediment and nutrient inputs to Lake Tahoe and its tributaries impairing water quality, altering surface hydrology and groundwater recharge regimes. The results are often negative impacts on soil health, fisheries, wildlife habitat and vegetation growth. Impervious surfaces include hard coverage such as roads, buildings, driveways, and parking lots, and soft coverage with soil compaction as a result of use, but where no structure is in place.

TRPA Threshold Category – Soil Conservation

TRPA Threshold Indicator Reporting Category – Impervious Cover

Adopted Standard – Impervious cover shall comply with the *Land-Capability Classification of the Lake Tahoe Basin, California-Nevada, A Guide for Planning*, (Bailey, 1974).

Type of Standard – Management Standard with Numerical Standard

Indicator (Unit of Measure) – Percent impervious cover within each land capability class.

Human & Environmental Drivers – Impervious cover is created through use or development on natural lands. This could be for commercial, residential, recreational, and other activities, and encompasses the spectrum of human uses that involve physical modification of the environment. The economy plays a large role in the housing market and the business environment, which are both among the most important drivers of new land coverage in the basin.

MONITORING AND ANALYSIS

Monitoring Partners – California Tahoe Conservancy, Nevada Division of State Lands, El Dorado County, Placer County, City of South Lake Tahoe, Washoe County.

Monitoring Approach – The base impervious coverage layer for the Region was sourced from a LiDAR survey completed in August 2010. LiDAR is a remote sensing technology that uses laser and light refraction to image objects and terrain. The 2010 LiDAR analysis mapped the extent of hard and soft impervious cover in the Region. The cost of acquiring LiDAR data for the Region makes quadrennial LiDAR surveys infeasible. To assess change in impervious cover without the benefit of new LiDAR imagery, information collected from project permitting by TRPA and partners was used to determine added/new coverage. Land capability as defined in the 2007 soil survey was used as the primary unit to measure coverage in a land capability class, both because it was used in the 2011 Threshold Evaluation Report (TRPA, 2012b) and because it is more detailed than the 1974 Bailey report (Loftis, 2007). Information about coverage removed was provided by the California Tahoe Conservancy (CTC), Nevada Division of State Lands (NDSL) and the TRPA parcel tracker tool.

Analytic Approach – Indicator status is assessed through simple aggregation.

INDICATOR STATE

Status – See summary in Table 1. All land capability classes are in attainment except for class 1b and class 2. Since August 2010, 19.09 acres of hard impervious cover have been permitted within the basin and 10.4 acres of cover in class 1b have been removed. Commodity transfers by private parties as part of the Transfer of Development Rights Program accounted for 8.08 acres removed from class 1b and 2.45 acres were removed by the CTC and NDSL. No estimate is provided for changes in unpermitted impervious cover. Unpermitted cover refers to cover that may have been added or created in the Region, for which no permit was acquired.

Table 1: *Status determination by land capability class including percent of target*

Land Capability Class	Percent of Target	Status Determination
1a	26% below	Considerably better than target
1b	584% above	Considerably worse than target
1c	6% below	At or somewhat better than target
2	18% above	Somewhat worse than target
3	58% below	Considerably better than target
4	80% below	Considerably better than target
5	57% below	Considerably better than target
6	70% below	Considerably better than target
7	22% below	At or somewhat better than target

Trend – See summary in Table 2. The percent change relative to target across all land capability classes over the four-year analysis period was 0.01 percent. The largest percent change relative to target was the 1.84 percent decrease in the 1b class, which would be classified as moderate improvement (see

methodology section). Percent change relative to target for all other land capability classes was less than 0.07 percent indicating little or no change. The added coverage amounts to an increase of 0.01 percent in coverage basin-wide, which indicates little or no change overall.

Table 2: Summary of trend determination by land capability class

Land Capability Class	Percent Change Relative to Target	Trend Determination
1a	-0.07	Little or No Change
1b	-1.84	Moderate Improvement
1c	0.01	Little or No Change
2	0.00	Little or No Change
3	0.00	Little or No Change
4	0.01	Little or No Change
5	0.04	Little or No Change
6	0.02	Little or No Change
7	0.04	Little or No Change

Confidence –

Status – Moderate. The 2011 Threshold Evaluation Report assessed the accuracy of the impervious cover map as moderate (TRPA, 2012b). The rigorous tracking and permitting process of TRPA and partners in the Region is extensive and would yield a high confidence if assessed independently.
Trend – High. Even though a statistical analysis was not used to test if trends were significant, there is high confidence in the cumulative accounting of acres of cover added in each land capability class.
Overall Confidence – Moderate. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Parcel level verification of sites' land capability class is the primary mechanism by which TRPA and partners ensure that development in the basin adheres to the Bailey system and that excess coverage is not added within a land capability class. Removal of coverage from sensitive lands is primarily facilitated by Environmental Improvement Program (EIP) implementation partners and the California and Nevada land banks through the Excess Coverage Mitigation Program. In addition to the actions of EIP partners, the Transfer of Development Rights Program is a central part of TRPA's growth management system and an important strategy used to attain multiple environmental thresholds, by providing an incentive to transfer coverage to less sensitive lands. Within the program, if 10 tourist accommodation units (TAUs) were removed from a SEZ and transferred to a town center, an additional 20 TAUs would be awarded for this transfer, for a total of 30 TAUs (i.e. 1:3 transfer ratio). TRPA is actively seeking new mechanisms to encourage removal of excess coverage on sensitive lands. For example, the TRPA Governing Board recently took action to allow coverage transfers across Hydrologically Related Area (HRA) boundaries. With this update, coverage can be transferred across HRA boundaries if it is removed from sensitive lands in one HRA and sent to lands that are non-sensitive and not located along the shoreline of Lake Tahoe. In addition, the new Excess Coverage Mitigation Program usage requirements state that the land banks should give preference to the retirement of coverage in sensitive lands. Both actions were taken at the Dec. 16, 2015 meeting of the

TRPA Governing Board.

Effectiveness of Programs and Actions –Physical removal of impervious cover is readily verifiable and contributes to standard attainment. Standard TRPA permitting conditions for projects that remove cover, include the requirement the natural hydrologic function and services are restored after cover is removed. Site restoration is field verified as well prior to a project being determined complete.

Interim Target – The class 1b target is not expected to be attained in the foreseeable future, given the magnitude of change needed and public funding levels. The rate of coverage removal from class 1b lands over the last four years averaged 2.5 acres annually. At this rate the 1b target would not be attained for 264 years. Continuing this rate over the next four years would result in the removal of an additional 10 acres from class 1b. Impervious cover in class 2 lands is currently 43 acres above the target level. Removing 43 acres of cover is potentially achievable within 10 to15 years if sufficient funding is available and focused on attainment of the class 2 target. While it is conceivable that the class 2 target could be achieved if actions were targeted solely to promote attainment of the individual threshold standard, project prioritization should also consider the potential for projects to contribute to threshold gains in any number of categories. For example, consideration of the multiple threshold benefits may result in prioritizing restoration projects in SEZ lands (which are generally class 1b) because their restoration may also result in greater benefits to water quality, wildlife and vegetation thresholds than restoration efforts on class 2 lands. Such a prioritization framework is more consistent with the intent of land capability classes, which are described as a means to achieve a range of objectives rather than an end point in and of themselves. "Criteria were developed for classifying lands – according to their inherent physical capability to provide for use without endangering achievement of the goals established in the Bi-State Compact (P.L. 91-148) for protection of environmental qualities of the basin (Bailey, 1974)."

Interim Target Attainment Date – 2019 Threshold Evaluation Report.

RECOMMENDATIONS

Analytic Approach – Evaluation of the effectiveness of the individual policies or programs implemented to facilitate removal of coverage is challenging because of the diversity of contributing factors, but is essential to informing program design and should remain a priority.

Monitoring Approach – Detailed LiDAR analysis like the one conducted in 2010 is the most reliable method for determining the extent of impervious cover in the Region and should be acquired at regular intervals. The next LiDAR analysis could also be used to assess the accuracy of coverage estimates obtained through permit accounting. To improve the accuracy of the Region-level maps of land capability, information collected during parcel land capability verifications could be integrated into the gross scale maps of land capability.

Modification of the Threshold Standard or Indicator –The 2007 NRCS soil survey, produced at field verified scale of 2.5 acres is significantly more detailed than the previous Bailey map at a 10-acre scale, is the highest quality and most accurate estimate of basin-level land capability classes. It is the best available information for use by TRPA as the base map for standard evaluation and its adoption should be considered. Its adoption was also recommended in the 2011 Threshold Evaluation Report (TRPA, 2012b).

Attainment of the impervious cover standard for the 1b land capability class would require the removal and/or relocation of 659 acres of impervious cover, roughly 8.3percent of all impervious cover in Region. Removal or relocation of this magnitude may be infeasible in a reasonable time-frame. It would also likely require removal and buyout (with transfers or retirement) of large portions of existing private development (residential, tourist, commercial) in the Region's local communities.

Attain or Maintain Threshold – Existing land use policies and regulations should continue to evolve and may need to be amended to better facilitate the transfer and restoration of urban development-oriented coverage from less suitable land capability classes that historically supported wetland and meadow vegetation to areas with a greater land capability.

Stream Environment Zone

Stream environment zone (SEZ) are defined by hydrology, soil, and water-associated vegetation. Although SEZ plant communities constitute only a small portion of the basin's total land area, they are extremely rich and productive. SEZs provide a variety of critical services in the basin, including water quality maintenance through nutrient cycling and sediment retention, flood attenuation, infiltration and groundwater recharge, open space, scenic and recreational enjoyment, wildlife habitat, and wildfire abatement, among many other functions and values (Roby et al., 2015). The water quality benefits of functioning SEZ areas in the basin were empirically documented more than 40 years ago, when estimated nutrient and sediment load reductions were between 72 percent to 94 percent of loading (TRPA, 1977). Protecting and restoring SEZs is essential for improving and maintaining the environmental amenities of the basin, and contributes to the attainment and maintenance of threshold standards for water quality, vegetation preservation, fisheries, and wildlife.

Large scale SEZ disturbance in the Region likely began in the 1800s through activities like logging, grazing, stream and river channelization, damming, and fire suppression, with environmental consequences that are still evident in the landscape today. Legacy impacts, and continuing development pressure, are being addressed through a comprehensive SEZ program with regulations and policies that limit development and other disturbances in SEZs and support public acquisition and restoration of these sensitive parcels.

Threshold Standard: *Preserve existing naturally functioning SEZ lands in their natural hydrologic condition, restore all disturbed SEZ lands in undeveloped, un-subdivided lands, and restore 25 percent of the SEZ lands that have been identified as disturbed, developed, or subdivided, to attain a 5 percent total increase in the area of naturally functioning SEZ lands.*

Challenges in Standard Evaluation: Three factors complicate evaluation of the SEZ standard:

1. Ambiguous objectives - The standard contains a number of terms that are not uniformly understood. These include: a) "preserve," b) "naturally functioning," c) "disturbed," ~~and~~ d) "developed or subdivided~~.~~", and "restore." While these terms may seem clear, the interpretation of the terms has varied in past threshold evaluations.

2. Absence of an accepted baseline against which the standard can be assessed - Consistent and objective evaluation requires the spatial delineation of all SEZ lands and classification of the SEZ lands based on the following criteria: a) "disturbed" or "undistributed," b) "naturally functioning" or "functionally impaired," c) "developed" or "non-developed," and d) "subdivided" or "non-subdivided."

3. The presence of multiple clauses within the standard - The numerous clauses in the standard make interpretation and consistent evaluation of the standard challenging. Clarification that addresses the relation of the targets specified in the clauses to one another is necessary to ensure consistent and objective evaluation.

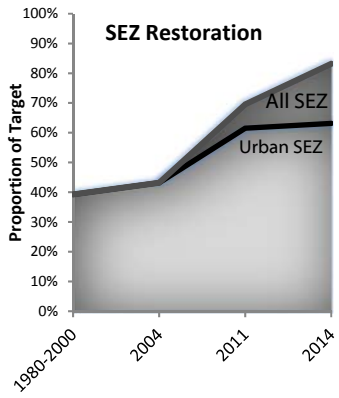
Soil Conservation: **Stream Environment Zones**

Status

STREAM ENVIRONMENT ZONES

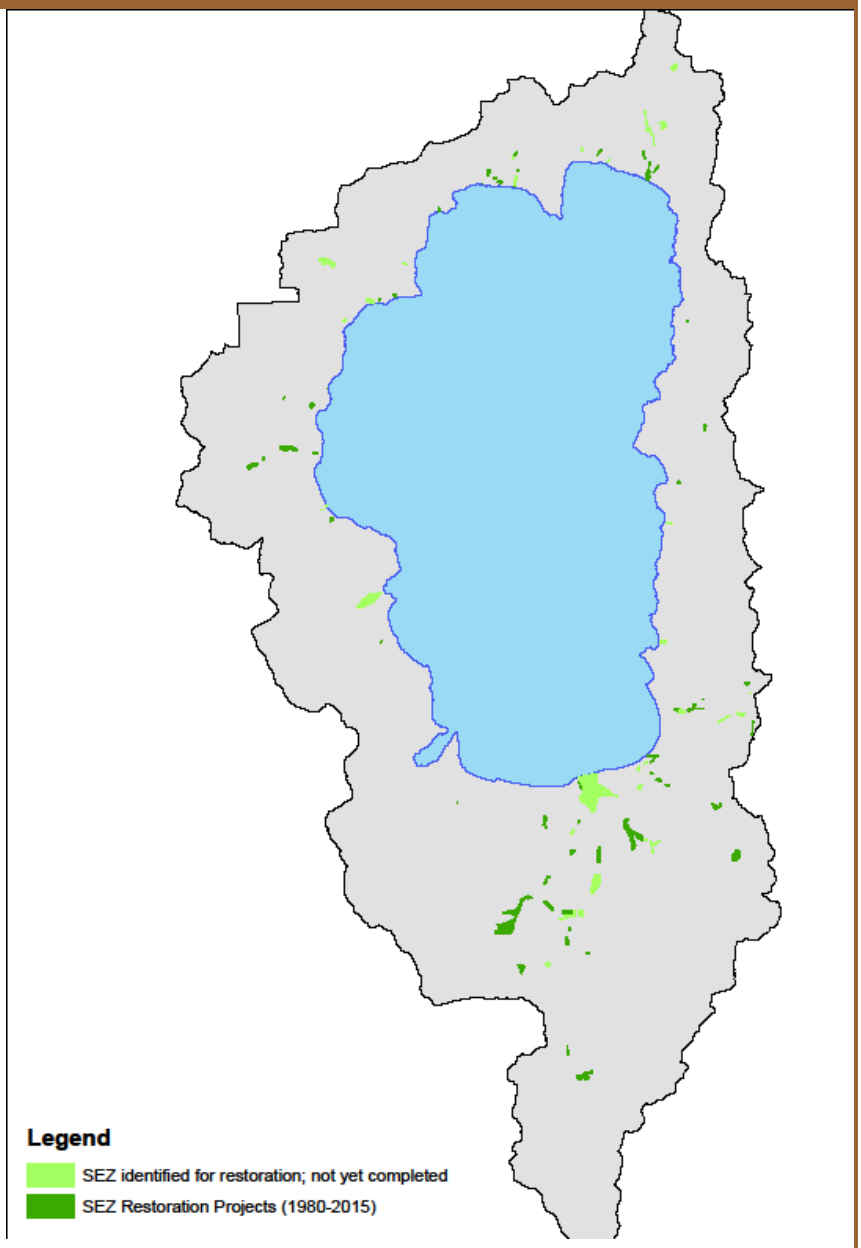
Status – **Considerably Worse than Target**
Trend - **Moderate Improvement**
Confidence - **Moderate**

Trend



Cumulative SEZ restoration in the Lake Tahoe Region between 1980 and 2015 as a proportion of SEZ restoration target achieved.

Map



Planned and completed SEZ Restoration Projects in the Tahoe Basin 1980-2015. Note: some projects listed in the table of SEZ Restoration Projects are not shown on the map because their exact location is unknown (mostly pre-1990 projects). Projects listed as planned were identified in the 1988 TRPA Water Quality Plan and may not be included on the EIP list.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures protection, restoration and enhancement of stream environment zones (SEZ). SEZs play a variety of critical roles including natural water filtration, storage, and conveyance of surface runoff (Roby et al., 2015). Encroachment on these areas reduces their potential to filter sediment and nutrients and the amount of surface runoff they can effectively treat. Naturally functioning SEZs also provide open space, flood flow capacity, riparian vegetation, fish and wildlife habitat, and buffer urban uses in developed areas. SEZ protection and restoration can also contribute to the achievement of other environmental threshold standards, including water quality, wildlife, fisheries, vegetation preservation, recreation, and scenic resources. Even seemingly unrelated threshold standards such as air quality and noise are affected by SEZs. For instance, aspen stands in SEZs next to roadways have been shown to moderate roadway noise and help block particulates from spreading to adjacent areas.

TRPA Threshold Category – Soil Conservation

TRPA Threshold Indicator Reporting Category – Stream Environment Zones

Adopted Standard – Preserve existing naturally functioning SEZ lands in their natural hydrologic condition, restore all disturbed SEZ lands in undeveloped, unsubdivided lands, and restore 25 percent of the SEZ lands that have been identified as disturbed, developed or subdivided, to attain a 5 percent total increase in the area of naturally functioning SEZ lands.

Type of Standard – Numerical Standard

Indicator (Unit of Measure) – Acres of SEZs restored, policy framework in place to protect and restore SEZs.

Human & Environmental Drivers – Disturbance and degradation of SEZs in the Tahoe Region began in the 1800s through logging, grazing, stream and river channelization, development, damming, fire suppression, and other activities, with environmental consequences that are still evident today. Higher temperatures and altered precipitation regimes forecasted as a result of climate change (Coats et al., 2010) further threaten to alter the dynamics of SEZs in the basin.

MONITORING AND ANALYSIS

Monitoring Partners – California Tahoe Conservancy, U.S. Forest Service, Nevada State Lands, El Dorado County, Placer County, City of South Lake Tahoe and other Environmental Improvement Program (EIP) partners.

Monitoring Approach – Information sourced from EIP implementing partners. Implementation agencies submit information to TRPA through the EIP Project Tracker website. TRPA validates reported project information prior to the information being posted on the website. The information is publicly available on the website: https://eip.laketahoeinfo.org/

Analytic Approach – Indicator status is assessed through simple aggregation. The basis for evaluation of the 25 percent restoration standard for "disturbed, developed, or subdivided" is drawn from the 1991 Threshold Evaluation Report which estimated that there were 4,400 acres of "disturbed, developed, or subdivided" lands in the Region. and the basis for target attainment (1,100 acres).

INDICATOR STATE

Status – Considerably worse than target. The standards for SEZ restoration are evaluated individually below. The standards include a management standard and three numerical standards for SEZ restoration. The numeric SEZ restoration standards are written as percentage based targets that have historically been evaluated against an estimate of the extent of SEZ in the basin from 1991. There have been numerous attempts to develop maps of SEZ in the basin (Roby et al., 2015), but TRPA has not formally adopted an SEZ map. Basin wide maps of SEZ are often referred to as "potential" SEZ areas because many of the mapped

SEZ lands have not been field verified. The two soil (and associated land capability) maps of the basin (Bailey, 1974; USDA-NRCS, 2007), are often referred to or confused with SEZ maps. While soil type is recognized as an indicator of SEZ, it is not a direct surrogate for SEZ (Roby et al., 2015). The lack of a detailed uniformly accepted SEZ map or potential SEZ map for the Region means that the percentage targets are subject to change as the estimated extent of SEZ in the basin is revised based on new information. The individual subparts of the standard are numbered and evaluated below:

1. *Preserve existing naturally functioning SEZ lands in their natural hydrologic condition*. This element of the threshold standard is a management directive that can be evaluated with respect to the polices and regulations adopted by TRPA and partners. While neither "preservation" nor "naturally functioning" is commonly defined, preservation is interpreted to mean that no new development should occur in naturally functioning SEZs. This interpretation was used in the 2011 Threshold Evaluation Report and it is used again in this report (TRPA, 2012c). In addition, when the standard was recommended it was suggested that it could be "attained with existing ordinances and compliance with the 208 Plan (TRPA 1982a)." Since the adoption of the 1987 Regional Plan, new coverage or even temporary disturbance in SEZ has been prohibited. The Regional Plan was updated in 2012 and included similar protection for SEZ lands (TRPA, 2012d)(TRPA 2012d). These restrictions are supported by predevelopment land capability verification which prevents development on actual SEZ even when not identified on the map. Exceptions are granted on a limited basis for public outdoor recreation, public service, and water quality control facilities. In the rare instances where permitted projects include coverage in an SEZ, the permitting requirements include both mitigation and include design requirements intended to ensure natural hydrologic conditions are not disturbed. Projects that include coverage in SEZ are primarily those of the EIP that are designed to deliver environmental benefits and are subject to appropriate environmental review, that includes exploration of alternative to avoid or minimize SEZ disturbance. Land acquisition of SEZs by TRPA partner agencies also aids in achieving this element of the threshold standard. Overall Region-wide policies and programs are in place that recognize and protect the myriad of critical functions of SEZs. This standard is in attainment.

2. *Restore 25 percent of the SEZ lands that have been identified as disturbed, developed or subdivided.* This component of the standard is a numerical standard. Over five threshold evaluation reports and three decades it has not been consistently quantified or evaluated. The last two threshold evaluation reports (2006 and 2011) provided different interpretations of "disturbed, developed, or subdivided" with implications for which SEZ restoration projects contribute toward attainment of the threshold standard (TRPA, 2012c, 2007). The 2006 Threshold Evaluation Report suggests a narrower reading of the standard, and that SEZ restoration projects on "un-subdivided lands should be excluded from the tally of projects that contribute towards the objective of restoring *25 percent of the SEZ lands that have been identified as disturbed, developed, or subdivided* (TRPA, 2007)*."* The 2011 Threshold Evaluation Report suggests that the criteria used in 2006 Threshold Evaluation Report imposed an unstated requirement that restored SEZ be located inside the urban boundary in order to count towards achievement of the standard. The 2011 Threshold Evaluation Report suggests a broader reading of the standard: "*It seems reasonable to conclude that the 25 percent threshold standard goal does not have to be attained exclusively within the 'urban areas,' but does need to be attained adjacent to, or associated with, disturbed, developed, or subdivided lands in the Region* (TRPA, 2012c). "There is little evidence within the standard to support the application of a strict location-based criteria where restoration of 25 percent of the SEZ must occur. Such a reading seems to be based on an improper juxtaposition of the two clauses in the standard that treats restoration of "*all disturbed SEZ lands in undeveloped, un-subdivided lands*," and "*restore 25 percent of the SEZ lands that have been identified as disturbed, developed, or subdivided*" as mutually exclusive objectives. Treating the standards as mutually exclusive rather than supporting seems to have its origin in the 2006 Threshold Evaluation Report (TRPA, 2007). Earlier threshold evaluation reports treated the two objectives as concordant and self-reinforcing rather than mutually exclusive (TRPA, 2001, 1996, 1991). While the 2006 and 2011 Threshold Evaluation Reports read the standard differently, no accompanying adjustment of the numeric target was made to accommodate the new spatial criteria. The total

amount of SEZ inside urban boundaries is estimated to be 3,496 acres (including beaches and the Tahoe Keys), significantly less than the 4,400 acres of disturbed developed or subdivided SEZ that has historically been used as the benchmark for standard assessment. If all SEZ inside urban boundaries was disturbed or developed, then the restoration of 25 percent would require restoration of 874 acres. The first Threshold Evaluation Report (1991) estimated that there were 4,400 acres of "disturbed, developed, or subdivided" lands in the basin and the basis for target attainment (1,100 acres) has historically been calculated using this number. Of this amount, it was estimated 2,500 acres were developed or disturbed and that 1,900 acres were subdivided but not developed and still retained their natural hydrologic regime (TRPA, 1988). This baseline for target attainment can be found in the 1988 208 plan for the basin, which provided a project roadmap for attainment of the 25 percent restoration standard. To attain the 1,100-acre target, the 208 plan identified 452 acres of restoration projects inside the urban boundary and an additional 701 acres of restoration opportunity outside urban areas (TRPA, 1988). The report establishing the thresholds in 1982 suggested that there were 4,376 acres of developed or subdivided SEZ that could be preserved or restored to their natural state, which also suggests that restoration would not be required on all 4,376 acres because some could simply be preserved (TRPA, 1982).

Given the ambiguities in the standard and its interpretation, the data presented in Appendix E of the 2015 Threshold Evaluation Report allow for evaluation using any of the prior interpretations. The status determination icon follows the conventions of the 2011 Threshold Evaluation Report. It used the 25 percent restoration target for disturbed, developed, or subdivided SEZ as the primary basis for standard evaluation, and limits SEZ restoration projects that count towards that standard to those that are inside or adjacent to urban areas (TRPA, 2012c). The choice to follow the conventions of the 2011 Threshold Evaluation Report for status icon determination was made in the interest of consistency and improving the ability of readers to compare results between threshold evaluation reports. It should not be seen as an endorsement of the 2011 interpretation of the standard. Earlier documents including, 1988 208 plan, the 1991, 1996, and 2001 threshold evaluation reports all interpreted the standard to include all SEZ restoration projects (TRPA, 2001, 1996, 1991, 1988). The threshold standard establishes a 25 percent target for restoration of the 4,400 acres of disturbed, developed, or subdivided SEZ, or 1,100 acres. Between 1980 and 2014, 546 acres of SEZ were restored in projects completed in or adjacent to urban areas in the Region. An additional 369 acres of SEZ have been restored outside urban boundaries, resulting in a total of 924 acres of SEZ restored in the Region. If only SEZ restoration inside urban areas is used to assess standard attainment (and the standard is still assessed against the 1,100-acre benchmark), the target is about 50 percent achieved; thus, the threshold standard status is designated "considerably worse than target." If all SEZ restoration contributes to target attainment, the target is 83 percent achieved; thus, the threshold standard status is designated "somewhat worse than target." In addition to the projects listed in Appendix E that have historically formed the basis for standard evaluation, the U.S. Forest Service restored 680 acres of SEZ between 1984-1987, and the Forest Service and California Tahoe Conservancy acquired and protected over 900 acres of SEZ (TRPA 1988). In total 2,495 acres of SEZ have been restored or acquired since 1980.

3. *Restore all disturbed SEZ lands in undeveloped, un-subdivided lands*. The restoration goal for undeveloped and unsubdivided lands, all, is considerably higher than the goal for developed or subdivided because of the recognized cost to benefit trade-off of restoration. "The cost of restoring all SEZ to their natural state would be cost prohibitive. This solution should only be applied in limited situations where benefits received would also be substantial.(TRPA, 1978)" Because "*all disturbed SEZ lands in undeveloped, un-subdivided lands*," does not have a commonly understood, defined or mapped baseline. Prior threshold evaluation reports have not made a status determination relative to this part of the standard. The 2011 threshold evaluation report wrote that no status determination was made "because this element of the Threshold Standard is not the focus of the Threshold Standard." Earlier threshold evaluation reports provided no indication for why the standard was not evaluated. The SEZ component of the 1988 water quality management plan suggests this target may relate to 200 acres of National Forest land of SEZ that the U.S. Forest Service identified in 1987 as requiring restoration (TRPA, 1988). The plan

suggests that between 1984 and 1987, 680 acres were rehabilitated by the U.S. Forest Service and that the standard could be attained shortly (TRPA, 1988). The status is "unknown due to insufficient data."

4. *Attain a 5 percent total increase in the area of naturally functioning SEZ lands.* There are approximately 21,944 acres of SEZ in the Region, comprising about 11 percent of the basin area (TRPA, 2001). About 4,400 acres of SEZ are estimated to be disturbed, developed, or subdivided. If it is assumed that the 4,400 acres of disturbed, developed, or subdivided SEZ are not naturally functioning, then the basis for evaluation of the standard is 17,544 acres (21,944-4,400 acres). If we assume that the SEZs reported as restored are naturally functioning, then the standard established a goal of 877 acres of SEZ restoration (5 percent of 17,544). A 5 percent increase would require an increase to 18,421 acres of SEZ. Since the standard was adopted, 924 acres of SEZ have been restored. This standard is "at or somewhat better than target" and is in attainment.

The SEZ standard has never been assessed to be in attainment since adoption, even though the individual parts of the standard have been identified as being in attainment. The evaluation criteria used in this evaluation largely follows the convention of the 2011 Threshold Evaluation Report to facilitate comparisons between the reports as required by the TRPA Code of Ordinances (TRPA, 2012a). As it was in the 2011 Report, the SEZ standards are determined to be considerably worse than target. This determination is based on the reading that the primary focus of the standard is the second part of the standard, *"restore 25 percent of the SEZ lands that have been identified as disturbed, developed or subdivided*." The conventions of the 2011 Threshold Evaluation Report are followed for this report to enable comparison of progress between reporting cycles and should not be read as an endorsement of the interpretation of the standard that places attainment of the second part of the standard (*restore 25 percent of the SEZ lands that have been identified as disturbed, developed or subdivided*) above the other parts. Further recommendations are included below.

Trend – Moderate improvement. The average rate of SEZ restoration in the Region from 1980 through 2014 was 26.9 acres per year, which represents a 2.95 percent increase relative to the target and yields a determination of rapid improvement. The average restoration rate for urban SEZ in the Region between 1980 and 2014 was 20 acres per year, which represents a 2.24 percent increase relative to the target and yields a determination of moderate improvement. Between 2010 and 2014, the SEZ restoration rate has been 37 acres per year, which represents a 4.06 percent increase relative to the target and yields a determination of rapid improvement. More recently (2010 to 2014), the average restoration rate for urban SEZ was 11 acres per year, equivalent to a restoration rate 0.49 percent, which yields a determination of little to no change. A trend determination of moderate improvement was made in this evaluation to reflect the underlying ambiguity in interpretation and application in the threshold standard and the different analytic methods used in prior threshold evaluations.

Confidence –

Status – Moderate. There is high confidence in the current status determination for SEZ restoration acreage because the project information was provided directly from EIP partner agencies and previous threshold evaluation reports that documented verified completed projects. There is also high confidence that the policies implemented by partners in the Region are protecting SEZ lands from development. There is lower confidence in the estimates for the extent of SEZ in the Region or the baseline for assessing attainment. The effectiveness of these projects in achieving the restoration objective of restoring natural hydrologic function is unknown because of lack of ongoing effectiveness monitoring. Additionally, ambiguity in the standard lowers confidence in our ability to objectively assess its status.

Trend – Moderate. Even though a statistical analysis was not used to test if trends were significant, there is high confidence in the cumulative accounting of acres restored because trusted partner agencies regularly track and report project information.

Overall Confidence – Moderate.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Currently, the preservation of naturally functioning SEZ is accomplished through TRPA, Lahontan Regional Water Quality Control Board, and Army Corps of Engineer regulations that limit development and other disturbances in these areas. In addition, Nevada State Lands, California Tahoe Conservancy, U.S. Forest Service, California State Parks, City of South Lake Tahoe, and other entities preserve SEZs through strategic acquisition of identified SEZ parcels. Disturbed SEZs occur in both urban and non-urban environments and actions to restore these are ongoing. The Environmental Improvement Program, in partnership with the California Tahoe Conservancy, U.S. Forest Service and others, acquires and restores priority environmentally sensitive lands, with a primary focus on protecting and enhancing meadows, wetlands, rivers, streams. Since 1997, more than 3,099 acres of SEZ/sensitive lands have been acquired by state and federal agencies in the Region (TRPA, 2016, 2010).

Effectiveness of Programs and Actions – The SEZ program and policies have successfully limited new development in SEZs (Raumann and Cablk, 2008). Acquisition of private parcels in SEZs by the U.S. Forest Service, California Tahoe Conservancy, and Nevada State Lands has increased contiguous SEZ areas, allowed for restoration, and provided buffers to urban development. Vegetation enhancement projects such as fuels reduction may also improve the biologic and hydrologic functions of SEZ and help restore natural hydrologic regimes of the Region. In the past they have not been considered SEZ restoration and have not counted towards target attainment.

Interim Target – Two large SEZ restoration projects are currently moving forward in the Region. The Upper Truckee marsh restoration project will restore 500 acres of SEZ and is scheduled to begin in 2019 and be completed in 2023. The project was approved by the California Tahoe Conservancy Board on December 18, 2015 and the TRPA governing board certified the EIS for the project on February 24, 2016. The completion of the Upper Truckee marsh restoration project will result in the attainment of the *Restore 25 percent of the SEZ lands that have been identified as disturbed, developed or subdivided* sub-component of the standard. A USFS restoration project in the Taylor-Tallac area is also expected to restore or enhance 250-300 acres of SEZ (Muskopf et al., 2009).

Interim Target Attainment Date –2023 Threshold Evaluation Report.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – Consideration should be given to the development of a monitoring plan that enables assessment of SEZ condition.

Modification of the Threshold Standard or Indicator – Standard revision should consider the establishment of specific and measurable targets that address the three factors identified below to facilitate objective and consistent evaluations of status. At present, evaluation is complicated by three factors: 1) ambiguous objectives, 2) absence of an accepted baseline against which the standard can be assessed, and 3) the presence of multiple clauses within the standard. Complications arising from these factors are discussed below.

1. *Ambiguous objectives*: The standard(s) contains a number of terms that are ambiguous and subject to interpretation. These include: a) "preserve," b) "naturally functioning," c) "disturbed," ~~and~~ d) "developed or subdivided, ~~.~~"and e) "restore." Their interpretation has varied in past threshold evaluations. Prior to the 2006 report, no location-based criteria were used in defining the set of SEZ that were "disturbed, developed or subdivided." The 2006 Threshold Evaluation Report interpreted "disturbed, developed or subdivided" to mean "within the urban boundary" (TRPA, 2007), while the 2011 Threshold Evaluation Report reinterpreted "disturbed, developed or subdivided" to include areas adjacent to the urban boundary (TRPA, 2012b). Further, the relationship among the individual terms should be clearly articulated. For example, does disturbance (drawing from the

Thresholds Study Report (TRPA, 1982) and the 208 Plan (TRPA, 2013)) include any and all instances of filling, grading, draining, encroaching, removing vegetation, altering or blocking drainage, channelizing streams, grazing, and off-road vehicle use? And do these actions always impair the natural function of an SEZ? Or can the potential impacts of all or some of the above activities be mitigated sufficiently to ensure natural function is retained?

Consistent application of terms such as "disturbed" or "naturally functioning" may require clarifying objectives or establishing criteria for differing qualities of SEZ in the basin. Riparian areas, wet meadows, and beaches are all classified as SEZ, yet their functions and values are likely type specific (Roby et al., 2015).

2. *Absence of an accepted baseline against which the standard can be assessed*: Consistent and objective evaluation requires the spatial delineation and classification of all SEZ lands based on the criteria enumerated in the standard: a) "disturbed or undisturbed," b) "naturally functioning" or "functionally impaired," c) "developed or non-developed," and d) "subdivided or non-subdivided."

   The lack of spatial representations of areas that fall into the above categories has caused confusion and inconsistency in past evaluations. For example, the 1991 Threshold Evaluation Report estimated that there were 4,400 acres of disturbed, developed or subdivided SEZ (TRPA, 1991). This estimate has generally served as the basis for assessing attainment. While the basis for assessing attainment has remained consistent, the interpretation of contributing SEZ restoration projects has varied (as described above). While the 2006 and 2011 Threshold Evaluation Reports changed the reading of the standard, no accompanying adjustment of the numerical target associated with disturbed, developed or subdivided SEZ was made to accommodate the new spatial criterion. Thus the overall target remained the same (1,100 acres, based on a 25 percent target) while the project's -- potential, planned and implemented--that would count toward attainment was reduced.

   Similar issues exist with the target related to "a 5 percent total increase in the area of naturally functioning SEZ." The 1991 Threshold Evaluation Report estimated that there were 4,400 acres of disturbed, developed or subdivided SEZ. Assuming all SEZ areas not identified as "disturbed, developed or subdivided" are "naturally functioning", then when the standard was written it was believed that there were 17,544 acres of "naturally functioning" SEZ (the total estimated area of SEZ in the Basin, 21,944 - 4,400 acres of disturbed, developed or subdivided SEZ). A five percent increase in "naturally functioning" SEZ would thus require restoration of 877 acres (0.05 multiplied by 17,544). This would result in a standard of 84 percent of the SEZ in the Region being in a naturally functioning state. However, the use of the 4,400 acres of disturbed, developed or subdivided may result in an underestimate of the total standard for SEZ restoration, because of the implicit assumption that subdivided SEZ are currently not functioning naturally. Subdivided but undeveloped SEZ could be naturally functioning. That would mean there are more than the standard's estimate of 18,421 acres of naturally functioning SEZ, and require more SEZ restoration than previously calculated.

   A 1998 report estimated the extent of disturbed, developed or subdivided SEZ in the Basin at 5,379 acres, almost 1,000 acres more than the 4,400 acres generally used to assess attainment (Huffman & Associates, Inc., 1998). If the 5,379-acre estimate was used to assess the percentage based targets, then;

   - The 25 percent target for SEZ restoration would increase to 1,345 acres (5,379 acres multiplied by 0.25), rather than the 1,100-acre target used today
   - The five percent target for increase in "naturally functioning" SEZ would decrease to 828 (21,944 acres minus 5,379 multiplied by 0.05), from the 877 acres used in the evaluation.

3. *Presence of multiple clauses within the standard:* Numerous clauses in the standard make consistent and objective evaluation of the standard challenging. The clauses and their targets need to be clarified and reconciled. This clarification should either split the standard into individual standards that can be independently evaluated or specifically state the criteria that should be used to aggregate the clauses in order to arrive at an attainment determination. The 2011Threshold Evaluation Report recommended removing the fourth part of the standard, "…to attain a 5 percent total increase in the area of naturally functioning SEZ lands" because it saw the target as redundant with the threshold standard 25 percent restoration goal in disturbed, developed or subdivided lands (i.e. 1,100 acres) (TRPA, 2012c). That reading is clearly inconsistent with this Threshold Evaluation Report, which interprets the two goals as concordant and self-reinforcing, further highlighting the need for clarification.

Revision or clarifications of the standards should also consider the findings and recommendations contained in the Roby (2015) SEZ review project. The review recommended numerous modifications to SEZ field delineation protocols to ensure they can be consistently applied to delineate SEZ (Roby et al., 2015). The project also developed a high resolution SEZ map for the basin that provides a typology of SEZ types with associated functions and values for each (Roby et al., 2015). The effort described and mapped the extent of eight types of SEZ: fens, forested, freshwater estuarine, lacustrine (beach), lacustrine (lakes/ponds), meadows, riverine, and seeps/springs. The map estimates that there are 29,391 acres of SEZ in the basin, covering 12.9 percent of the basin excluding the area of Lake Tahoe (Roby et al., 2015). It has previously been recognized, and this review supports the notion, that the establishment of standards for SEZ and management of SEZ towards those standards requires a detailed understanding of how SEZs function, the services individual SEZ provide, the value people place on those services, society's goal for those services, and how those services are impacted by human activities (Huffman & Associates, Inc., 1998; Roby et al., 2015; TRPA, 2012b).

Attain or Maintain Threshold – Maintain policies that limit activities on SEZ lands and continue to support the restoration of degraded SEZ lands. Review policies to further encourage the transfer of coverage from SEZ to higher capability lands. Revise field verification protocols to ensure consistency and compliance with the latest science (Roby et al., 2015)

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CHAPTER 6
Vegetation Preservation

Lake Tahoe lies within a unique geologic Region in the Sierra Nevada. Lake Tahoe's natural rim sits at an elevation of 6,223 feet, and the surrounding mountain peaks reach heights of up to 10,886 feet. A strong rain shadow effect causes a pattern of decreasing precipitation from west to east, and this with topographic effects produces many localized climates (Elliot-Fisk et al. 1997). Elevation gradients and local climate variability produce a diversity of vegetation types; for example, the most recent vegetation map of the Region identified over 67 discrete types (Greenberg et al. 2006). Tree dominated vegetation is most abundant, followed by shrub dominated, with a small proportion of herbaceous dominated types (Greenberg et al. 2006).

A total of 1,077 vascular plant species have been confirmed in the Region with another 360 possibly occurring. In addition, the Region is home to 115 species of non-vascular plants (Murphy and Knopp 2000). There are 14 special status plant species[1] documented in the Region (11 vascular and three non-vascular), and an additional 14 special status plant species may occur (either suitable habitat occurs, or plants are known only from historic records) but have not been documented (McKnight and Rowe 2015). In addition, 13 species are on a U.S. Forest Service 'watch list,' and one species, whitebark pine (*Pinus albicaulis)* is a candidate for listing under the Federal Endangered Species Act. Tahoe yellow cress (TYC) is the only plant listed as endangered by California and Nevada. In 2015, U.S. Fish and Wildlife Service determined not to list TYC based on the strength of the TYC conservation plan and the regional partners' success in implementing the plan over the last 20 years.

Humans have occupied the Tahoe Region for at least 8,000 years (Elliot-Fisk et al. 1997), and the pattern and condition of its vegetation today are in part a reflection of past and current human activities (Elliot-Fisk et al. 1997, Murphy and Knopp 2000, Taylor 2007). Prior to the early 1800s, the Washoe people occupied the Tahoe Region. Natural resource management by the Washoe over at least 1,300 years, in combination with natural processes, maintained a diversity of forest types (Murphy and Knopp 2000). Extensive logging activities to support the Comstock era mining boom began in 1859, and within 40 years approximately 60 percent of the Tahoe watershed had been

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[1] *Special status species are generally thought of as having low abundance, limited distributions, or small population sizes. Special status plant species are identified through an evaluation of multiple parameters that may include any or all of the following criteria:*

- *Rarity or limited distribution throughout the species' range or the region*
- *Endemism (species endemic to the Basin are found only within the basin and nowhere else)*
- *Presence of threats and perceived vulnerability to local extirpation or extinction*

clear-cut (Elliot-Fisk et al. 1997, Murphy and Knopp 2000). The remaining unlogged land was generally alpine, barren, or inaccessible (Murphy and Knopp 2000). As a result, most forestlands of the Region are less than 150 years old, with few examples of young and very old forest stands (Elliot-Fisk et al. 1997, Murphy and Knopp 2000). Livestock grazing also had pervasive effects on the Region's vegetation during and after the Comstock era. Sheep grazing was ubiquitous in the Region's forests and shrublands, and was so intensive that the understory was often denuded and browse species were extirpated from some areas (Elliot-Fisk et al. 1997, Murphy and Knopp 2000). Meanwhile cattle were grazed in all of the Region's meadows and in subalpine areas (Elliot-Fisk et al. 1997, Murphy and Knopp 2000). A grazing allotment system was put in place in the 1930s, limiting livestock to specific areas.

After the period of intensive logging, federal and state governments began acquiring lands in and around the Tahoe Region in 1899 and intensified acquisition in the 1930s; today the Forest Service manages 78 percent of the Region (Elliott-Fisk et al., 1996; USFS LTBMU, 2015). Little active management other than fire suppression occurred over the past 100 to 150 years until the late 1970s when fuels reduction treatments began. As a result, much of the forestland is even-aged and densely stocked (McKelvey et al. 1996, Elliot-Fisk et al. 1997, Taylor 2007, Beaty and Taylor 2008). Vegetation types that depend on frequent fire to maintain them such as Jeffrey pine (*Pinus jeffreyi*) are gradually being replaced by shade-tolerant species such as white fir (*Abies concolor*]) (McKelvey et al. 1996, Elliot-Fisk et al. 1997, Taylor 2007). The long history of fire suppression, combined with periods of drought and insect-induced mortality, has resulted in stands with high concentrations of hazardous fuels (Murphy and Knopp 2000, Barbour et al. 2002, Beaty and Taylor 2008, Raumann and Cablk 2008). This condition has increased the threat of catastrophic wildfire and is typical of a forest where natural disturbance processes have been excluded. Since the 2007 Angora fire in South Lake Tahoe, several land management agencies have intensified fuel reduction treatments in conifer forests in the Region, especially in areas surrounding urban development (e.g Marlow et al. 2007).

Housing, commercial, and infrastructure construction has also influenced today's vegetation patterns (e.g. Claassen and Hogan 2002). Not only has vegetation been cleared, but the composition of remaining vegetation has been changed through landscaping. These changes in cover and composition have resulted in increased erosion and nutrient runoff from developed lots (Claassen and Hogan 2002, Grismer and Hogan 2005), and the introduction of non-native species into the Region. A major effect of urbanization has been the loss and degradation of the Region's wetlands, with approximately 75 percent of the marshlands and 50 percent of the meadows degraded since 1900 (Murphy and Knopp 2000). Consequently, the conservation of the remaining wetland and riparian vegetation types is critical.

Global climate change also poses a threat to the integrity of the Region's vegetation communities and plant species. Warming temperatures and decreased snowpack due to less snow and more rain and earlier snowmelt are already occurring, and are predicted to continue for the Sierra Nevada (e.g. Hayhoe et al. 2004, Dettinger 2005, Safford et al. 2012). In the Lake Tahoe Region, these changes appear to be happening at an accelerated pace (Coats 2010). These changes are predicted to cause range shifts, re-sorting of species associations, extirpations, and extinctions in high elevation vegetation areas such as the Lake Tahoe Region (e.g. Seastedt et al. 2004, Loarie et al. 2008, Tomback and Achuff 2010). These changes have already begun, and will likely affect both common and uncommon plant communities and species. For example, Jeffrey pine is widespread in montane elevations in the Region today, but a recent study suggested populations are declining in low elevation areas, expanding in mid elevation, and slowly expanding in higher elevations (Gworek et al. 2007). Whitebark pine, a keystone high elevation conifer of western North America

including the Sierra Nevada, has experienced widespread mortality due to the combined effects of warming and increased severity of pathogens such as native mountain pine beetle and non-native white pine blister rust (Tomback and Achuff 2010); hence its status as a candidate for federal listing as a threatened species. A study on the potential distribution of whitebark pine under forecasted climate change scenarios in British Columbia found 73 percent of current habitat could be lost, but alpine areas could become suitable habitat (Hamann and Wang 2006). Elevations in the Tahoe Region, are not high enough to support upslope migration of whitebark pine, and this important vegetation type could be extirpated from the region by climatic changes. Many of the Region's high elevation species could be extirpated given the relatively low elevations of the area (e.g. Loarie et al. 2008). This includes the Freel Peak cushion plant community, and many of the Region's sensitive plant species. The Region's wetlands are also vulnerable, with a drier climate potentially leading to lower water tables which are critical for sustaining fens (e.g. Cooper et al. 1998), while earlier and more intensive snow melt and rain events may alter flow regimes and increase erosion.

Today, approximately 85 percent of the land in the Region is managed by federal and state agencies. The majority of the remaining 15 percent is privately owned, with a small percentage owned by local districts and governments. The high percentage of public ownership represents a significant opportunity for coordinating the conservation and restoration of the plant communities in the Lake Tahoe Region. On private lands too, responsible stewardship and management of vegetation resources remains key to their sustainability.

Prior to the adoption of threshold standards, TRPA established two value statements related to vegetation conservation and management in the Region: *"1) provide for a wide mix and increased diversity of plant communities in the Tahoe Basin, including such unique ecosystems as wetlands, meadows, and other riparian vegetation; and 2) conserve threatened, endangered, and sensitive plant species and uncommon plant communities of the Lake Tahoe Basin."* These values guided the development of the vegetation threshold standards and remain important values today.

Threshold standards for the late seral and old growth forest ecosystems indicator reporting category were adopted in 2001 in response to the U.S. Forest Service Sierra Nevada Forest Plan Amendment.[2] Threshold standards and associated indicators used to measure the progress toward meeting the threshold standards are presented in Table 6-1.

[2] *USDA Forest Service, Pacific Southwest Region. 2001. Sierra Nevada Forest Plan Amendment, Final Environmental Impact Statement.*

Table 6-1: Summary of vegetation indicator reporting categories, adopted TRPA threshold standards by type, and indicators used to assess adopted standards.

Indicator Reporting Category	Standard	Type of Standard	Indicator
Common Vegetation	• Maintain the existing species richness of the Region by providing for the perpetuation of the following plant associations [9 vegetation associations]: o **Yellow Pine Forest**: Jeffrey pine, white fir, incense cedar, sugar pine. o **Red Fir Forest**: red fir, Jeffrey pine, lodgepole pine, western white pine, mountain hemlock, western juniper. o **Subalpine Forest**: whitebark pine, mountain hemlock, mountain mahogany. o **Shrub Association**: greenleaf and pinemat manzanita, tobacco brush, Sierra chinquapin, huckleberry oak, mountain whitethorn. o **Sagebrush Scrub Vegetation**: Region sagebrush, bitterbrush, Douglas chaenactis. o **Deciduous Riparian**: quaking aspen, mountain alder, black cottonwood, willow. o **Meadow Associations (Wet and Dry Meadow):** mountain squirrel tail, alpine gentian, whorled penstemon, asters, fescues, mountain brome, corn lilies, mountain bentgrass, hairgrass, marsh marigold, elephant heads, tinker's penney, mountain timothy, sedges, rushes, buttercups. o **Wetland Associations (Marsh Vegetation):** pond lilies, buckbean, mare's tail, pondweed, common bladderwort, bottle sedge, common spikerush. o **Cushion Plant Association (Alpine Scrub):** alpine phlox, dwarf ragwort, draba.	Management standard (with numeric target)	Species richness (number of major vegetation associations)

Indicator Reporting Category	Standard	Type of Standard	Indicator
	Relative Abundance - Of the total amount of undisturbed vegetation in the Tahoe Region: 1. Maintain at least four percent meadow and wetland vegetation. 2. Maintain at least four percent deciduous riparian vegetation. 3. Maintain no more than 25 percent dominant shrub association vegetation. 4. Maintain 15 to 25 percent of the yellow pine forest in seral stages other than mature. 5. Maintain 15 to 25 percent of the red fir forest in seral stages other than mature.	Management standard (with numeric targets)	Relative abundance (percent occurrence of each association)
	Provide for the proper juxtaposition of vegetation communities and age classes by: 1. Limiting size of new forest openings to no more than eight acres. 2. Adjacent openings shall not be of the same relative age class or succession stage to avoid uniformity in stand composition and age.	Management standard	Evidence of actions that support the management standard
Common Vegetation	A non-degradation standard to preserve plant communities shall apply to native deciduous trees, wetlands, and meadows while providing for opportunities to increase the acreage of such riparian associations to be consistent with the SEZ threshold.	Management standard	Evidence of actions that support the management standard
	Native vegetation shall be maintained at a maximum level to be consistent with the limits defined in the *Land Capability Classification of the Lake Tahoe Region, California-Nevada, A Guide for Planning, Bailey, 1974*, for allowable impervious cover and permanent site disturbance.	Management standard	Evidence of actions that support the management standard
	It shall be a policy of the TRPA Governing Board that a non-degradation standard shall permit appropriate management practices.	Policy statement	Evidence of support for policy

Indicator Reporting Category	Standard	Type of Standard	Indicator
Uncommon Plant Communities	Provide for the non-degradation of the natural qualities of any plant community that is uncommon to the Region or of exceptional scientific, ecological, or scenic value. This threshold shall apply but not be limited to 1. the deep-water plants of Lake Tahoe 2. Grass Lake (sphagnum fen) 3. Osgood Swamp 4. the Freel Peak Cushion Plant Community 5. Hell Hole (sphagnum fen) 6. Upper Truckee Marsh 7. Taylor Creek Marsh 8. Pope Marsh	Numerical standard (without numeric targets)	The natural qualities of the community (as determined by a qualified expert).
Sensitive Plants	Maintain a minimum number of population sites for each of five sensitive plant species. The minimum number of population sites is as follows: • *Arabis rigidissima* var. *demota* – Galena Creek rockcress (seven) • *Draba asterophora* var. *asterophora* – Tahoe draba (five) • *Draba asterophora* var. *macrocarpa* – Cup Lake draba (two) • *Lewisia pygmaea longipetala* – Long-petaled lewisia (two) • *Rorippa subumbellata* – Tahoe yellow cress (26)	Numerical standard	The number of population sites that are maintained as suitable habitat for sensitive plant species (as determined by a qualified expert).
Late Seral/ Old growth Ecosystems	Attain and maintain a minimum percentage of 55 percent by area of forested lands within the Tahoe Region (excluding TRPA designated urban areas) in a late seral or old growth condition, and distributed across elevation zones. To achieve the 55 percent, the elevation zones shall contribute as follows: • The sub-alpine zone (greater than 8,500 feet elevation) will contribute five percent (7,600 acres) of the late seral acres (61 percent of the subalpine zone must be in a late seral or old growth condition); • The upper montane zone (between 7,000 and 8,500 feet elevation) will contribute 30 percent (45,900 acres) of the late seral acres (60 percent of the upper montane zone must be in a late seral or old growth condition); • The montane zone (lower than 7,000 feet elevation) will contribute 20 percent (30,600 acres) of the late seral acres (48 percent of the montane zone must be in a late seral or old growth condition).	Numerical standard	Percent of subalpine, upper montane and montane zone stand acres that are dominated by late seral or old growth characteristics (tree size greater than 24-inches diameter at breast height)

Table 6-2 summarizes the results of the 2015 assessment. The table provides a summary of the status and trend of standards in the common vegetation, uncommon plant community, sensitive plants, and late seral and old growth forest ecosystems reporting categories today as well as the results from the 2011 Threshold Evaluation Report to facilitate comparison. Figure 6-1 provides a key to the symbols used to communicate status, trend, and confidence. A detailed description of each is provided in the methodology section. The indicator sheets that follow contain a more detailed assessment of the status and trend of each indicator and provide descriptions of the methods used and recommendations for modification of the standard or analytic approach used to assess the standard.

Table 6-2: Vegetation preservation status & trend summary

Standard	2011	2015
Common Vegetation		
Vegetation Community Richness		
Relative Abundance of Meadow and Wetland Vegetation		
Relative Abundance of Deciduous Riparian Vegetation		
Relative Abundance of Shrub Vegetation		
Relative Abundance of Yellow Pine Forest in seral stages other than mature		
Relative Abundance of Red Fir Forest in seral stages other than mature -		
Size of forest openings and juxtaposition of vegetation communities – Management Standard		
Consistency with Bailey Land Capability System		
Non-Degradation of Stream Environment Zones		
Appropriate Management Practices		
Uncommon Plant Communities	**2011**	**2015**
Deepwater Plants of Lake Tahoe		

Standard	2011	2015
Grass Lake (sphagnum fen)		
Osgood Swamp		
Freel Peak Cushion Plant Community		
Hell Hole (sphagnum fen)		
Upper Truckee Marsh		
Taylor Creek Marsh		
Pope Marsh		
Sensitive Plants	**2011**	**2015**
Tahoe yellow cress (*Rorippa subumbellata*)		
Tahoe Draba (*Draba asterophora var. asterophora*)		
Cup Lake Draba (*Draba asterophora var. macrocarpa*)		
Long-petaled Lewisia (*Lewisia pygmaea longipetala*)		
Galena Creek rockcress *(Arabis rigidissima var. demote)*		
Late Seral and Old Growth Forest Ecosystems	**2011**	**2015**
Sub-alpine Zone		
Upper Montane Zone		
Montane Zone		

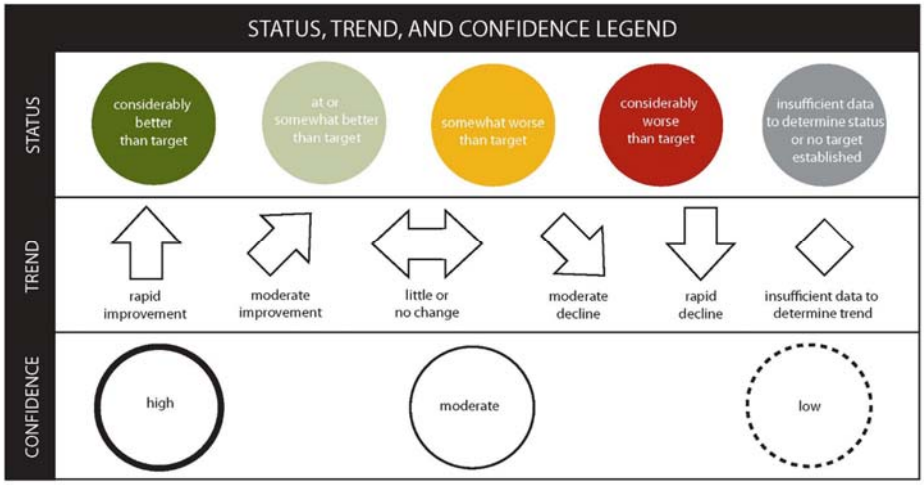


Figure 6-1: A key to the symbols used to assess status, trend, and confidence levels.

Table 6-3. Key to the reporting icon used to characterize the implementation status of management standards and policy statements.

Status Category	Description	Reporting Icon
Implemented	The management standard or policy statement has been integrated into the Regional Plan and is consistently applied to a project design or as a condition of project approval as a result of project review process. Examples of programs or actions can be identified to support the management standard's implementation. Adopted programs or actions support all aspects of the management standard or policy statement's implementation, or address all major threats to implementation.	I
Partially Implemented	The management standard or policy statement has been integrated into the Regional Plan, but is not consistently applied during the project review process. No more than two examples of programs or actions can be identified to support the management standard's implementation and/or adopted programs or actions support some aspects of the management standard or policy statement's implementation, or address some major threats to implementation.	PI
Not Implemented	The management standard or policy statement has not been integrated into the Regional Plan and is not applied during the project review process. No examples of programs or actions can be identified to support implementation.	NI

Common Vegetation

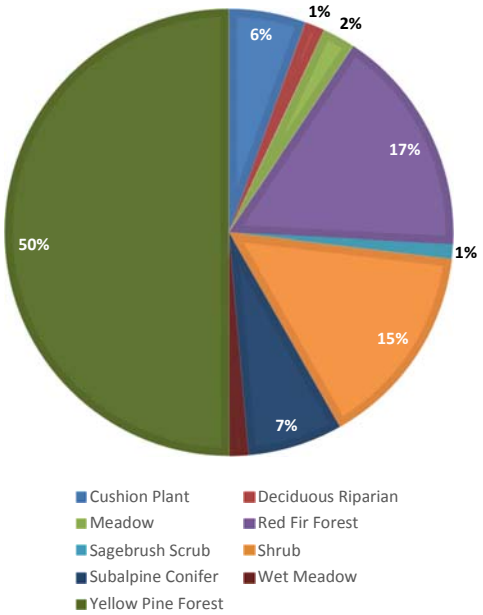
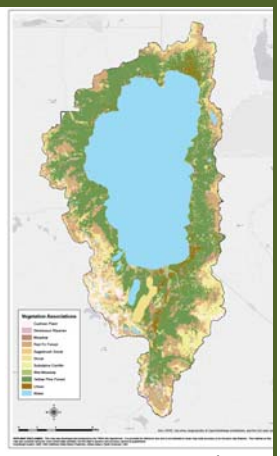
The vegetation of Lake Tahoe's landscape as an essential component of the "Tahoe experience" and critical to supporting the wildlife of the Region. The common vegetation indicator reporting category primarily addresses the types of vegetation that most people experience: conifer forests, deciduous riparian hardwoods, meadows, wetlands and shrubs. Each of these major categories of vegetation contributes to the species richness of the Region. Factors that influence distribution and extent of common vegetation include forest management, urban development, past land use, natural disturbance such as wildfire, competition with invasive and introduced species, climate, soils, aspect, elevation, and disease.

The extensive logging during the Comstock era, livestock grazing, and fire suppression heavily influenced the landscape of today. Most forests in the Region are less than 150 years old and are denser than the forests that occupied the area prior to the Comstock era. Over the past 150 years there has been a shift in the Region's forest composition, with white fir and cedar becoming more abundant and pines becoming less abundant (Murphy and Knopp, 2010).

The TRPA Regional Plan is designed to maintain the diversity of native vegetation, encourage appropriate forest management, and restore and protect relatively rare vegetation types such as meadows and wetlands and old forest ecosystems. The status and trends of six indicators related to management standards with numeric targets were evaluated to characterize the overall status and trend of the common vegetation indicator reporting category. The six indicators are 1) vegetation community species richness, 2) immature red fir forests, 3) immature yellow pine forests, 4) deciduous riparian hardwoods, 5) meadows and wetlands, and 6) shrubs. There was no change in the status of any of the common vegetation or late seral and old growth indicators from 2011. There are policies, rules, and implementing practices in place that prevent degradation of these communities and encourage management practices that promote healthy forests. Absent stand replacing events, common vegetation communities generally change slowly over time.

Due to four years of consecutive drought beginning in 2012, the southern Sierra is experiencing a bark beetle epidemic, leaving at least 66 million dead trees on the landscape since 2010, including over 26 million new dead trees found between October 2015 and June 2016 (U.S. Forest Service, 2016). The Tahoe Region is also experiencing increased beetle activity but has not yet experienced infestations on the scale observed in the south. Drought and overcrowding reduce trees' ability to fend off beetle attacks, and increase the risk of large scale infestations and tree die-offs. Regional partners have been working for over a decade on fuels reduction and forest health projects in the wildland urban interface (WUI) with the primary goal of protecting communities from wildlife. In the face of multiple threats, the science of forest management has begun to focus on landscape level forest resilience or "the capacity of the system to resist damage and recover quickly when challenged by environmental pressures" (Fuller and Quine, 2016). Regional partners are actively exploring forest health treatments beyond the WUI to increase the resilience of Tahoe's forests.

Common Vegetation: **Vegetation Community Richness**

Status	Graph
VEGETATION COMMUNITY RICHNESS Status: **At or Somewhat Better than Target** Trend: **Little to No Change** Confidence: **Moderate**	 Estimated proportion of land covered by different TRPA vegetation communities (associations) in the Lake Tahoe Region (USDA, 2009).
Map	
 Common vegetation in the Tahoe Region, including the changes from the 2007 Angora fire (TRPA 2015).	

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures the number and persistence of major native vegetation communities (associations) throughout the Lake Tahoe Region. It is not a measure of plant species richness. This measure can be used to indicate whether a major vegetation community has been lost in the Region.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Common Vegetation

Adopted Standards – Maintain the existing species richness of the Region by providing for the perpetuation of the following plant associations:

- Yellow pine forest: Jeffrey pine, white fir, incense cedar, sugar pine
- Red fir forest: red fir, Jeffrey pine, lodgepole pine, western white pine, mountain hemlock, western juniper
- Subalpine forest: whitebark pine, mountain hemlock, mountain mahogany
- Shrub association: greenleaf and pinemat manzanita, tobacco brush, Sierra chinquapin, huckleberry oak, mountain whitethorn
- Sagebrush scrub vegetation: Region sagebrush, bitterbrush, Douglas chaenactis
- Deciduous riparian: quaking aspen, mountain alder, black cottonwood, willow
- Meadow associations (wet and dry meadow): mountain squirrel tail, alpine gentian, whorled penstemon, asters, fescues, mountain brome, corn lilies, mountain bentgrass, hairgrass, marsh marigold, elephant heads, tinker's penney, mountain timothy, sedges, rushes, buttercups
- Wetland associations (marsh vegetation): pond lilies, buckbean, mare's tail, pondweed, common bladderwort, bottle sedge, common spikerush
- Cushion plant association (alpine scrub): alpine phlox, dwarf ragwort, draba

Type of Standard – Management standard with numeric target (maintain nine major vegetation associations)

Indicator (Unit of Measure) – Number of vegetation associations. For this assessment, TRPA vegetation associations were compared with California Wildlife Habitat Relationship types (CWHR, 2011) (attributed in TMU_Strata_07 map, USFS 2009c) to determine which types could be considered equivalent. Using Table 1, the California Wildlife Habitat Relationship types were used to estimate relative proportions of TRPA vegetation associations in the Tahoe Region:

Table 1: *TRPA vegetation associations compared with California Wildlife Habitat Relationship types*

TRPA Association	California Wildlife Habitat Relationship Type
Cushion Plant	Barren
Deciduous Riparian	Aspen
Deciduous Riparian	Mixed Hardwood-Conifer
Deciduous Riparian	Montane Riparian
Meadow	Perennial Grass
Red Fir Forest	Juniper
Red Fir Forest	Lodgepole Pine
Red Fir Forest	Red Fir
Sagebrush Scrub	Bitterbrush
Sagebrush Scrub	Low Sagebrush
Sagebrush Scrub	Sagebrush
Shrub	Alpine Dwarf Shrub
Shrub	Montane Chaparral
Subalpine Forest	Subalpine Conifer
Wetland	Wet Meadow
Yellow Pine Forest	Eastside Pine
Yellow Pine Forest	Jeffrey Pine
Yellow Pine Forest	Sierran Mixed Conifer
Yellow Pine Forest	White Fir

Human & Environmental Drivers – Climate, elevation, soils, aspect, geomorphology, interspecies competition, and wildlife are natural influences on pattern and expression of vegetation communities in

the Lake Tahoe Region. Wildfires and fire suppression also influence the distribution and structure of vegetation communities. For example, the montane chaparral vegetation type has been decreasing in areal extent by about 10 percent per decade due to fire suppression (Nagel and Taylor, A.H., 2005). However, the Gondola (2002) and Angora fires (2007) created hundreds of acres of early successional vegetation. Forest treatments designed to remove biomass can also influence vegetation communities. Treated areas in the yellow pine forest have been shown to support higher plant species richness than in neighbouring untreated forest (Safford et al., 2012b); although this indicator category is not a direct measure of plant species richness, fostering intra-community species richness can potentially lead to future vegetation community richness. Trampling associated with unmanaged recreation can degrade rare high elevation plant communities, such as the cushion plant community.

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service – Lake Tahoe Region Management Unit and Pacific Southwest Remote Sensing Lab and TRPA. Quercus Consultants, Inc. collected field data in 2015 to support updating of the forest map layer and verification of forest structure.

Monitoring Approach – The map of dominate vegetation types in the Region was last updated in 2009. Since then only the Angora fire burn area has been updated. In 2009, satellite imagery, aerial photographs and field reconnaissance (USFS Forest Inventory and Analysis data) were used to delineate and classify vegetation types in the Lake Tahoe Region. This information is digitized into a geographic information system and subsequently analysed to summarize vegetation community richness. Information from the Tahoe Fire and Fuels Team (a multi-agency partnership) on forest fuels treatments and disturbance events are incorporated for year to year change in vegetative composition.

Analytic Approach – Proportion of the Region covered by individual vegetation types is calculated by dividing the area of the vegetation type by the total terrestrial area of the Region.

INDICATOR STATE

Status – At or somewhat better than target. All of the nine major vegetation associations identified in the TRPA Regional Plan (1987 as amended in 2012) persist today. Locations of individual vegetation communities are expected to shift over time as a result of natural disturbances such as wildfire, though community richness is expected to persist through successional processes.

Trend – Little to no change. No major disturbance events that would have significantly altered the extent of vegetative communities in the Region occurred between 2011 and 2015. The stand replacing event included in this assessment, the Angora fire, occurred in 2007, but was not included in 2011 Threshold Evaluation Report. Although there has been fluctuation in the extent of some vegetation communities in the Lake Tahoe Region (Raumann and Cablk, 2008a), there has been no loss or gain in the total number of native vegetation communities.

Confidence –

Status – High. Forest managers use best available technology and field reconnaissance to map and classify vegetation types throughout the Lake Tahoe Region about every five years; U.S. Forest Service vegetation mapping procedures meet regional and national vegetation mapping standards (FGDC, 1997; Warbington et al., 2011). Because vegetation communities are broadly defined and thus encompass larger spatial extents than individual habitat types, variation in the status and trend of the vegetation community richness indicator is not obvious at the relatively short time scales for which the indicator is remapped and reassessed. The accuracy assessment of TMU_Strata_07 map used for this summary was completed by the U.S. Forest Service, Pacific Southwest Region - Remote Sensing Lab

Trend – Moderate. There is moderate to high confidence that in the absence of disturbance events (e.g. fires, disease, clearing) the spatial extent of the vegetation communities at the regional scale does not change considerably over a four-year period.

Overall – Moderate. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Policies and ordinances for the conservation of Tahoe's native vegetation communities have been adopted in the TRPA Regional Plan and are implemented through the permitting process. The Environmental Improvement Program has a fuels reduction and ecosystem restoration program. To date more than 59,000 acres of forest treatments have been completed in support of sustaining native vegetation communities (TRPA, 2016). Treatments primarily include understory tree removal, biomass mastication, prescribed broadcast burning, and pile burning. Forest fuel treatments have been shown to reduce both the severity and tree mortality of forest fires (Safford et al., 2012b). Tree mortality in the absence of fires has also been found to be lower in lower density stands (Safford, 2013). Prevention of catastrophic wildfires is essential to maintaining the diversity and richness of vegetation in the Region.

Effectiveness of Programs and Actions – Qualitative observations suggest current regulations, programs, forest fuels treatments and isolated events, like the Gondola fire in 2002 and Angora fire in 2007, all appear to have contributed to the maintenance of vegetation community richness in the Tahoe Region.

Interim Target – Not applicable. The target is currently in attainment.

Target Attainment Date – Not applicable. The target is currently in attainment.

RECOMMENDATIONS

Analytic Approach – The TRPA Code of Ordinances defines a major evaluation interval as "*A fixed period of time during which TRPA will monitor and at the end of which TRPA will evaluate and report upon the interim status of a threshold or standard. Such intervals may be different for each threshold or standard* (TRPA, 2012a)." In future evaluations consideration should be given to establishing a major evaluation interval for common vegetation standards that more closely aligns with expected rates of change in vegetation community structure. The impact of climate change could be assessed through observed changes in the distribution of the major vegetation communities in the Region.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – Consideration should be given to amending the threshold standard to incorporate best available science including changing ecosystem dynamics due to climate change effects. The indicator does not lend itself well to helping managers understand the influence of human activity or changing ambient climate conditions. Consider evaluating overall changes in vegetation community composition at longer intervals than the current practice of every four years, while still reporting on changes due to disturbances such as wildlife, fuels reduction, and disease at four-year intervals.

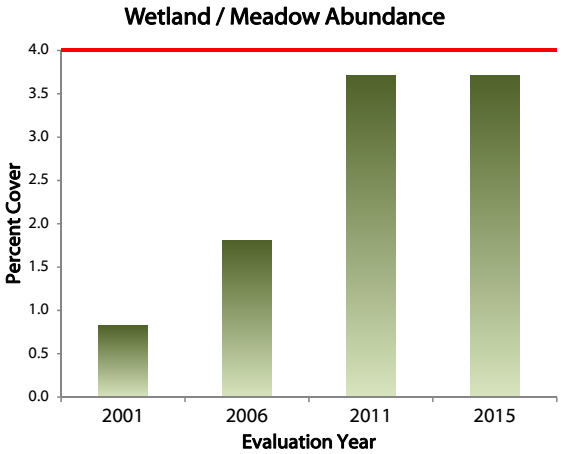
Attain or Maintain Threshold – No changes recommended.

Common Vegetation: **Relative Abundance of Meadows and Wetland Vegetation Types**

Status	Trend

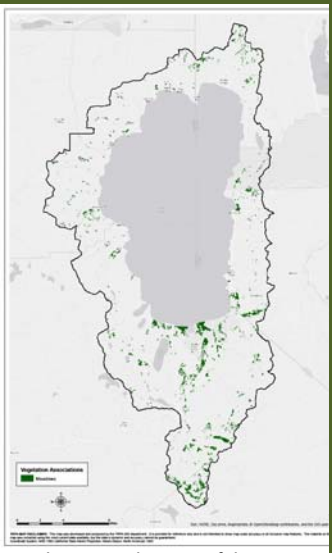
RELATIVE ABUNDANCE OF MEADOWS AND WETLAND VEGETATION TYPES

Status: **Somewhat Worse than Target**
Trend: **Little or No Change**
Confidence: **Moderate**



Estimated percent of land area occupied by meadow and wetland vegetation in the Lake Tahoe Region relative to TRPA adopted numeric target (red line). Changes in the percent cover are a result of different interpretations of the baseline amount of "undisturbed" vegetation and changing mapping techniques/resolution, not necessarily actual changes in vegetation type. Sources: ((TRPA, 2007, 2001; USDA, 2009)

Map



Distribution and extent of the meadow and wetland vegetation types (green areas) in the Lake Tahoe Region (USDA, 2009).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures the percentage of land cover dominated by meadow (wet and dry variants) and wetland vegetation in the Tahoe Region in relation to the total amount of undisturbed vegetation. The relative proportion of meadows and wetlands is important because the areas provide a

number of services including flood attenuation, wildlife habitat, ground water recharge, water filtration, and aesthetic and recreation values.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Common vegetation

Adopted Standards – Of the total amount of undisturbed vegetation in the Tahoe Region, maintain at least four percent meadow and wetland vegetation.

Type of Standard – Management standard with numeric target

Indicator (Unit of Measure) – Percent of Region's undisturbed vegetation that is dominated by meadow and wetland vegetation. Total acreage of undisturbed vegetation was calculated by subtracting the area covered by impervious surfaces from the total area of the Region (201,953 acres less 7,974 acres = 193,979 acres).

Human & Environmental Drivers – Several factors can influence the extent of meadow vegetation in the Tahoe Region. The primary factors responsible for meadow and wetland vegetation are the geomorphic setting and the seasonal or permanent presence of surface groundwater, subsurface groundwater, and/or saturated soil (Mitsch et al., 2009; Potter, 2005). A regular fire-return frequency in the Region historically contributed to the maintenance of meadow vegetation by eliminating encroaching conifer trees (Murphy and Knopp, 2010). Historic grazing and Comstock era land uses changed how water moves through meadows and wetlands, resulting in drier soils not capable of supporting meadow and wetland vegetation (Murphy and Knopp, 2010). Urbanization has similarly altered the movement of water through meadow and wetland systems through impoundments, water rerouting, and the creation of impervious surface such as paved roads and building footprints (Murphy and Knopp, 2010). Groundwater extraction for consumptive use may also influence the vigor of meadow and wetland vegetation in localized areas.

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service, U.S. Geological Survey and TRPA

Monitoring Approach – Vegetation types associated with meadows and wetlands (California Wildlife Habitat Relationship type "WTM" [wet meadow] and "PGS" [Perennial Grassland]) are queried and enumerated from the most recently available vegetation map (U.S. Forest Service - Remote Sensing Lab Pacific Southwest Region: TMU_Strata_07 [published 2009]). The Tahoe vegetation map is periodically updated with new satellite data (if available) and/or modelled and calibrated using field-based forest inventory and analysis data to assess the extent of different vegetation types and associated forest structure characteristics for the Region (USDA, 2009; Warbington et al., 2011).

Analytic Approach – Total wetland/meadow acreage was compared against the total acreage of undisturbed vegetation.

INDICATOR STATE

Status – Somewhat worse than target. The most recent data is from 2009 (USDA, 2009) and indicates there are 7,385 acres of meadow and wetland vegetation types in the Region. The management target is to achieve and maintain at least 7,956 acres (or four percent of undisturbed areas) of these vegetation types. Based on this target, the Region is at 93% of the objective of the management target. Consequently, a determination of somewhat worse than target was determined.

Trend – Little or no change. No major disturbance events (e.g. fires, disease, clearing) that would have significantly altered the extent of vegetative communities in the Region occurred between 2011 and 2015. The stand replacing event included in this assessment (Angora fire) occurred in 2007, but was not included in 2011 Threshold Evaluation Report.

Confidence –

Status – Moderate. The U.S. Forest Service Remote Sensing Lab (2009) estimates the overall accuracy of the map between 74 percent and 87 percent and no individual accuracy assessment was produced for wet meadows. Therefore, a confidence of moderate was assigned to status.

Trend – Moderate. There is moderate to high confidence that in the absence of disturbance events (e.g. fires, disease, clearing) the spatial extent of the vegetation communities in the Region does not change considerably over a four-year period.

Overall Confidence – Moderate.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA has adopted several policies and ordinances designed to promote the conservation and protection of existing meadow and wetland vegetation types (TRPA, 2012b, 1986). Agency partners affiliated with the Environmental Improvement Program (EIP) have implemented numerous meadow and wetland restoration and enhancement projects, which have resulted in an increase in wetland and meadow vegetation acres (e.g., California Tahoe Conservancy's Cove East project reclaimed 11.5 acres). Active conifer removal projects and the reestablishment of natural hydrologic regimes in previously disturbed wetland and meadow systems have also expanded and/or improved wetlands and meadows (e.g. High Meadows and Cookhouse Meadows restoration projects). Existing land use policies and regulations facilitate the transfer and restoration of urban development-oriented coverage from areas suitable for supporting wetland/meadow vegetation to areas with a greater capability to absorb the impact of coverage. Programs such as TRPA's transfer of development rights program provide additional incentives for moving development rights out of environmentally sensitive areas. Additional meadow and wetland restoration projects are planned that will likely increase the total acreage and improve the function of meadow and wetland vegetation types.

Effectiveness of Programs and Actions – Adopted policies and regulations in the TRPA Regional Plan have halted further development in areas that support meadow and wetland vegetation types. Raumann and Cablk (2008) reported that between 1987 and 2002, no wetland/meadow vegetation was lost to urban development in the southern portion of the Region where the majority of these vegetation types occur. This research indicated that the existing regulations have been effective at protecting wetland and meadow vegetation types from development. The research also indicated that on average community succession accounted for the transition of 7.9 acres/year of meadow/wetland to forest (Raumann and Cablk, 2008a). Recent projects to reduce conifer encroachment into meadows through prescribed burns and hand-thinning are aimed at reducing this trend (TRPA, 2016). Additionally, other projects implemented through the EIP have been effective at restoring and enhancing existing meadow/wetland habitat. However, only minor progress has been made to reclaim and restore meadows and wetlands (about 28 acres since 1987) that had previously been covered with urban development as part of TRPA's excess coverage mitigation program (TRPA, 2016). When new mapping data becomes available, progress from the EIP and transfers of development are expected to show a small expansion of wetland and meadow areas.

Interim Target – Trend information is not reliable for this indicator due to differences in mapping resolution and evaluation procedures across years. As a result, it is not possible to accurately estimate an interim target. A conservative interim target would be to increase the total acreage of this vegetation type by the next evaluation date through the continued implementation of wetland and meadow restoration project of the EIP.

Target Attainment Date – Due to insufficient trend information, a target attainment date cannot be set.

RECOMMENDATIONS

Analytic Approach – The TRPA Code of Ordinances defines a major evaluation interval as "*A fixed period of time during which TRPA will monitor and at the end of which TRPA will evaluate and report upon the interim status of a threshold or standard. Such intervals may be different for each threshold or standard*

(TRPA, 2012a)." Future evaluations should consider establishing a major evaluation interval for common vegetation standards that more closely aligns with expected rates of change in vegetation community structure.

Monitoring Approach – The current monitoring approach focuses only on presence or absence of the wetland and meadow vegetation. Prioritizing management to ensure the functional persistence requires information not just on presence but also on the condition. Future work should consider monitoring that enable detection of change in condition.

Modification of the Threshold Standard or Indicator – The standard establishes a target for wetland/meadow vegetation in proportion to the total undisturbed vegetation in the Region, however it does not provide a definition of what "undisturbed" means or the actual acreage required to achieve the target. As a result, prior threshold evaluation reports have assessed the target against different baselines. The most recent threshold evaluation (2011) interpreted the four percent target as 7,956 acres which would imply that there were 198,900 acres of undisturbed vegetation in the Region (TRPA, 2012c). However, the same report also estimated that 7,953 acres were covered by impervious surface. Using even a narrow definition of the term "undisturbed" suggests that in 2010 there were 193,994 undisturbed acres. The reports that established the threshold standards in 1982 suggested a far larger area of the Region was disturbed even in 1982, suggesting a more expansive definition of the term "disturbed" may have been used.

Table 1 summarizes the variation in target assessment basis. It shows the total acres of "undisturbed" vegetation in the Tahoe Region as reported in prior threshold evaluation reports and studies. The different basis used for standard assessment confounds comparisons between reporting periods. The 2001 and 2007 threshold evaluations used the total area of the Region to assess the standard.

Table 1: *Total acres of "undisturbed" vegetation in the Tahoe Region as reported in prior threshold evaluation reports and studies*

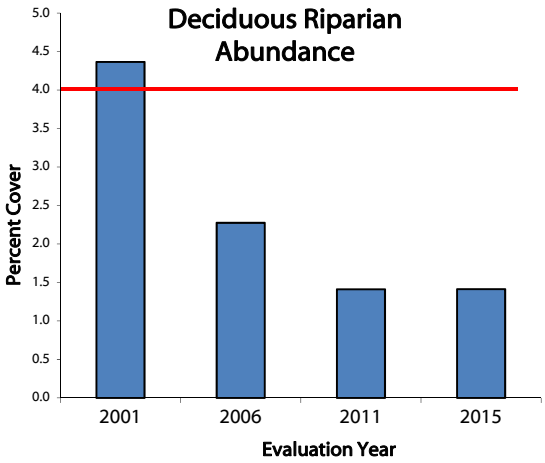
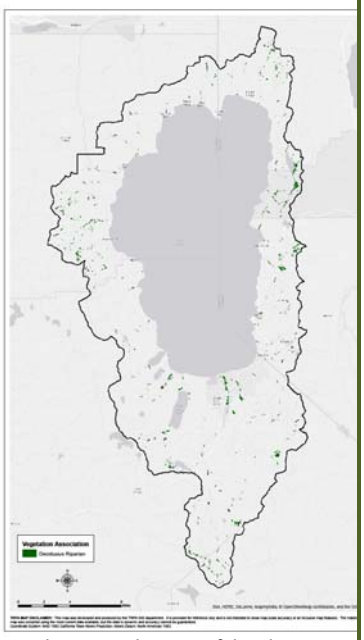
Source	**Target for acres of meadow and wetland vegetation** (based on four percent of total undisturbed vegetation)	**Total acres of undisturbed vegetation** (estimated)
1982 Threshold Evaluation Report	7,180	179,488
1982 Environmental Impact Statement (for 1982 Threshold Evaluation Report)	6,938	173,444
1991 Threshold Evaluation Report	7,882	197,060
1996 Threshold Evaluation Report	7,233	180,817
2001 Threshold Evaluation Report	8,078	201,953
2007 Threshold Evaluation Report	8,078	201,953
2011 Threshold Evaluation Report (for impervious cover)	7,760	193,994
2011 Threshold Evaluation Report (common vegetation)	7,956	198,900

	2015 Threshold Evaluation Report	7,759	193,979

This indicator does not measure the relative condition of meadows and wetlands or their ability to support various ecosystem services or attributes. The standard should be assessed against best practice for the establishment of standards and indicators for monitoring and evaluation, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – No recommended changes.

Common Vegetation: **Relative Abundance of Deciduous Riparian Vegetation Type**

Status	Trend
RELATIVE ABUNDANCE OF DECIDUOUS RIPARIAN VEGETATION TYPE Status: **Considerably Worse than Target** Trend: **Little or No Change** Confidence: **Low**	 Estimated percent of land area occupied by deciduous riparian vegetation in the Lake Tahoe Region relative to TRPA adopted numeric target (red line). Changes in the percent cover are a result of different interpretations of the baseline amount of undisturbed vegetation and changing mapping techniques/resolution, not necessarily actual changes in vegetation type. Sources: ((TRPA, 2007, 2001; USDA, 2009)
Map	
 Distribution and extent of deciduous riparian vegetation type (green areas) in the Lake Tahoe Region. Source: TRPA 2015.	

Data Evaluation and Interpretation
BACKGROUND
Relevance – This indicator measures the relative proportion of land covered by riparian hardwoods (known as deciduous riparian vegetation) in the Tahoe Region. This vegetation grouping is commonly associated with moist soils adjacent to streams, springs, wetlands and small lakes (Potter, 2005). Species considered to be riparian hardwood include alder, aspen, willow, cottonwood, and dogwood. The relative proportion of riparian hardwoods is important because this vegetation type enhances vegetation richness in the Region, provides habitat for a relatively high diversity of wildlife species (including sensitive species) and is rare in the Lake Tahoe Region (Manley and Schlesinger, 2001; Murphy and Knopp, 2010). Riparian hardwoods are also resilient to natural disturbance such as flooding and fire (Sheppard et al., 2006). This indicator does not measure the condition or vigor of riparian hardwoods. **TRPA Threshold Category** – Vegetation **TRPA Threshold Indicator Reporting Category** – Common vegetation **Adopted Standards** – 1. Of the total amount of undisturbed vegetation in the Tahoe Region – maintain at least four percent deciduous riparian vegetation 2. A non-degradation standard to preserve plant communities shall apply to native deciduous trees, wetlands, and meadows while providing for opportunities to increase the acreage of such riparian associations to be consistent with the SEZ threshold. **Type of Standard** – Management standard with numeric target **Indicator (Unit of Measure)** – Percent of the "undisturbed" vegetation dominated by deciduous riparian vegetation. **Human & Environmental Drivers** – Moist soils, direct sunlight and natural disturbance influence the abundance and distribution of riparian hardwoods. Fire suppression has allowed encroachment of shade-tolerant white fir into areas previously dominated by riparian hardwood species.
MONITORING AND ANALYSIS
Monitoring Partners – U.S. Forest Service, U.S. Geological Survey and TRPA **Monitoring Approach –**Vegetation types associated with deciduous riparian vegetation (montane riparian, aspen, and mix hardwood/conifer) were queried and enumerated from the most recently available vegetation map (U.S. Forest Service - Remote Sensing Lab Pacific Southwest Region: TMU_Strata_07 [published 2009]). The Tahoe vegetation map is periodically updated with new satellite data and/or modelled and calibrated using field-based forest inventory and analysis data to assess the extent of different vegetation types and associated forest structure characteristics for the Region (USDA, 2009; Warbington et al., 2011). **Analytic Approach –** Total deciduous plant community acreage was compared against the total acreage of undisturbed vegetation. Total acreage of undisturbed vegetation was calculated by subtracting the area covered by impervious surfaces from the total area of the Region (201,953 acres less 7,974 acres = 193,979 acres).
INDICATOR STATE
Status – Considerably worse than target. In the most recent data period available (2009), there was a total of 2,809 acres of deciduous riparian vegetation out of the total 193,979 undisturbed acres, for a total of 1.4 percent. This is 36 percent of the 7,759-acre target, and is therefore considerably worse than target.

Trend – Little to no change. No major disturbance events (e.g. fires, disease, clearing) that would have significantly altered the extent of vegetative communities in the Region occurred between 2011 and 2015. The stand replacing event included in this assessment (Angora fire) occurred in 2007, but was not included in 2011 Threshold Evaluation Report.

Confidence

Status –Low. Confidence in the status in 2011 was assessed as low, because no accuracy assessment was available for the map of riparian hardwood vegetation. In addition, a recently released map of the SEZ in the Region estimated that the forested SEZ class (which includes deciduous riparian) is the most widely distributed SEZ type in the Region (accounting for approximately 50 percent of the Region's SEZ) and covering 14,578 acres (6.4 percent of the Region) (Roby et al., 2015).

Trend – Moderate. There is moderate to high confidence that in the absence of disturbance events (e.g. fires, disease, clearing) the spatial extent of the vegetation communities at the regional scale does not change considerably over a four-year period.

Overall Confidence – Low. Overall confidence takes the lower of the two confidences determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA has adopted several policies and ordinances designed to promote the conservation and protection of existing deciduous vegetation types (TRPA, 2012b, 1986). Agency partners affiliated with the Environmental Improvement Program (EIP) have implemented numerous deciduous riparian restoration and enhancement projects, restoring or enhancing 659 acres of aspen habitat since 2008 (TRPA, 2016). Additional deciduous riparian restoration projects are planned as part of the EIP and will likely increase the acreage of this vegetation type.

Effectiveness of Programs and Actions –Policies and regulations in the TRPA Regional Plan have essentially halted further development in areas that support deciduous vegetation types (Raumann and Cablk, 2008a). Projects implemented through the EIP have been effective at restoring existing acres of this vegetation type (especially for aspen, where shade tolerant white fir were removed). However, the Region is still far from attaining the goal of 7,956 acres.

Interim Target – Insufficient data exists to establish an interim target for extent of deciduous riparian vegetation in the Region.

Target Attainment Date –Not applicable.

RECOMMENDATIONS

Analytic Approach –The TRPA Code of Ordinances defines a major evaluation interval as "*A fixed period of time during which TRPA will monitor and at the end of which TRPA will evaluate and report upon the interim status of a threshold or standard. Such intervals may be different for each threshold or standard* (TRPA, 2012a)." Future evaluations should consider establishing a major evaluation interval for common vegetation standards that more closely aligns with expected rate of change in vegetation community structure.

Monitoring Approach – The current monitoring approach focuses only on presence or absence deciduous riparian vegetation. Prioritizing management to ensure the functional persistence and desired benefits from SEZ requires information on condition and presence. Future work should consider monitoring that enables detection of change in condition.

Modification of the Threshold Standard or Indicator – The standard establishes a target for riparian deciduous vegetation as a proportion to the total undisturbed vegetation in the Region, however it does not provide a definition of what "undisturbed" means or the actual acreage required to achieve the target. As a result, prior threshold evaluation reports have assessed the target against different baselines. The most recent threshold evaluation (2011) interpreted the four percent target as 7,956 acres

which would imply that there were 198,900 acres of undisturbed vegetation in the Region (TRPA, 2012c). However, the same report also estimated that 7,953 acres were covered by impervious surface. Using even a narrow definition of the term "undisturbed" suggests that in 2010 there were 193,994 undisturbed acres. The reports that established the threshold standards in 1982 suggested a far larger area of the Region was disturbed even in 1982, suggesting a more expansive definition of the term "disturbed" may have been used.

Table 1 summarizes the variation in target assessment basis. It shows the total acres of "undisturbed" vegetation in the Tahoe Region as reported in prior threshold evaluation reports and studies. The different basis used for standard assessment confounds comparisons between reporting periods. The 2001 and 2007 threshold evaluations used the total area of the Region to assess the standard.

Table 1: *Total acres of "undisturbed" vegetation in the Tahoe Region as reported in prior threshold evaluation reports and studies*

Source	Target for acres of meadow and wetland vegetation (based on four percent of total undisturbed vegetation)	Total acres of undisturbed vegetation (estimated)
1982 Threshold Evaluation Report	7,180	179,488
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2007 Threshold Evaluation Report	8,078	201,953
2011 Threshold Evaluation Report (for impervious cover)	7,760	193,994
2011 Threshold Evaluation Report (common vegetation)	7,956	198,900
2015 Threshold Evaluation Report	7,759	193,979

The standard should be assessed against best practice for the establishment of standards and indicators for monitoring and evaluation, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

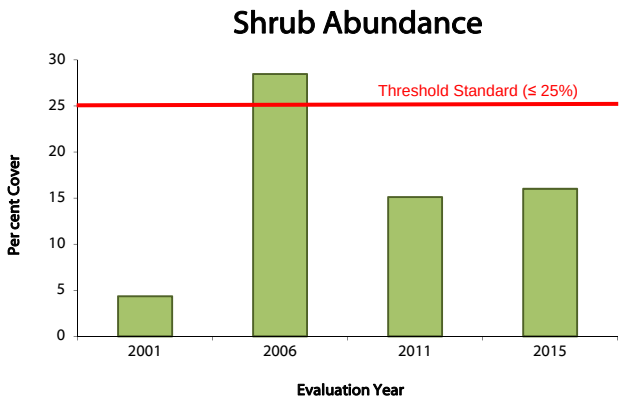
Attain or Maintain Threshold – No recommended changes.

Common Vegetation: **Relative Abundance of Shrub Vegetation Type**

Status	Trend

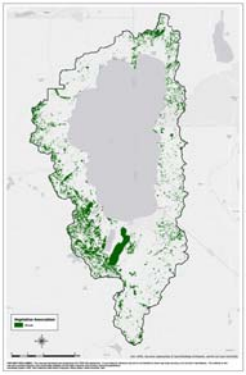
RELATIVE ABUNDANCE OF SHRUB VEGETATION TYPE

Status: **Considerably Better than Target**
Trend: **Little or No Change**
Confidence: **Low**



Estimated percent of land area occupied by "shrub" vegetation in the Lake Tahoe Region relative to TRPA adopted numeric target (red line). Changes in the percent cover are a result of the 2007 Angora fire as well as different interpretations of the baseline amount of "undisturbed" vegetation and changing mapping techniques/resolution, not necessarily actual changes in vegetation type. Sources: (TRPA 2001; TRPA 2007; USDA 2009)

Map



Recent distribution and extent of shrub vegetation type (green areas) in the Lake Tahoe Region. The 2007 Angora fire area is represented here.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures the proportion of land cover dominated by shrub vegetation in the Tahoe Region. Shrub vegetation represents an early successional stage of forest vegetation. The relative proportion of shrub type is important because it provides habitat for a wide diversity of wildlife species (Airola and Barrett, 1985; Coppeto et al., 2006; USDA, 2011) and complements vegetation diversity in the Region (Murphy and Knopp, 2010). The relative abundance of shrub vegetation type in the Tahoe Region is intended not to exceed 25 percent since it is valued as habitat by an array of wildlife species

when interspersed between other vegetation types, such as forests and meadows. Shrub vegetation is comprised of sagebrush, whitethorn, manzanita, bitterbrush, huckleberry oak, and chinquapin.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Common vegetation

Adopted Standards – Of the total amount of undisturbed vegetation in the Tahoe Region - Maintain no more than 25 percent dominant shrub association vegetation.

Type of Standard – Management standard with numeric target

Indicator (Unit of Measure) – Percent of the undisturbed landscape dominated by shrub vegetation.

Human & Environmental Drivers – Several factors can influence the extent of shrub vegetation in the Tahoe Region. The primary factors responsible for shrub vegetation are light exposure, soil type and moisture content, and extent and frequency of wildfire and other natural disturbances. Canopy-replacing wildfire create openings conducive to the establishment of shrub vegetation. Shrub vegetation is also known to occupy the understory of most mixed conifer forest landscapes in the Region.

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service, U.S. Geological Survey and TRPA.

Monitoring Approach – Updated vegetation maps were not available for this evaluation. Instead, the most recent data from 2009 is used. Periodically, the Tahoe vegetation map is updated with new satellite data (if available) and/or modeled and calibrated using field-based forest inventory and analysis data to assess the extent of different vegetation types and associated forest structure characteristics for the Region (USDA, 2009; Warbington et al., 2011). Vegetation types associated with shrubs were queried and enumerated from the most recently available vegetation map (U.S. Forest Service - Remote Sensing Lab Pacific Southwest Region: TMU_Strata_07 [published 2009]). As shown in Table 1 California Wildlife Habitat Relationship types were queried to represent shrub vegetation in this evaluation:

Table 1: *TRPA vegetation associations compared to California Wildlife Habitat Relationship types*

TRPA Association	California Wildlife Habitat Relationship (CWHR) Type
Sagebrush Scrub	Bitterbrush
Sagebrush Scrub	Low Sagebrush
Sagebrush Scrub	Sagebrush
Shrub	Alpine Dwarf Shrub
Shrub	Montane Chaparral

Analytic Approach – Total shrub plant community acreage was compared against the total acreage of undisturbed vegetation. Total acreage of undisturbed vegetation was calculated by subtracting the area covered by impervious surfaces from the total area of the Region (201,953 acres less 7,974 acres = 193,979 acres). The extent of the 2007 Angora fire burn area, which includes 3,100 acres, was reclassified as shrub for this evaluation since it was not previously reclassified for the 2011 Threshold Evaluation Report.

INDICATOR STATE

Status – Considerably better than target. Shrub communities cover 26,945 acres, approximately 14 percent of the total undisturbed vegetation in the Region. This is approximately 54 percent of the maximum allowable shrub coverage (48,495 acres), and is therefore considerably better than target. This estimate includes the area of the 2007 Angora fire, which was not included in the 2011 Threshold Evaluation Report. The management target for this threshold standard sets an objective to achieve and maintain less than 48,495 acres (or less than 25 percent of the land area) of this vegetation type.

Trend – Little to no change. No major disturbance events (e.g. fires, disease, clearing) that would have altered the extent of vegetative communities in the Region occurred between 2011 and 2015. The stand replacing event included in this evaluation (Angora fire) occurred in 2007, but was not included in 2011 evaluation. Thus the change percent of the landscape dominated by shrub between the two evaluation periods actually occurred prior to the 2011 report.

Confidence –

Status – Moderate. The U.S. Forest Service Remote Sensing Lab (2009) with regard to the most recent vegetation type map, there is 88 percent confidence that the mapped data accurately represents the distribution and extent of this vegetation types (shrub) on the landscape. Therefore, a confidence of moderate was assigned to status.

Trend – Moderate. There is moderate to high confidence that in the absence of disturbance events (e.g. fires, disease, clearing) the spatial extent of the vegetation communities at the regional scale does not change considerably over a four-year period.

Overall Confidence –Moderate.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA has adopted policies and ordinances designed to promote a diversity of native vegetation communities in the Region (TRPA, 2012b, 1986). TRPA currently does not have policies or regulations specific to the conservation of shrub vegetation. Forest fuels reduction projects affiliated with the EIP tend to target the removal of understory shrubs to meet fuels reduction objectives and to prevent an overabundance of shrub-dominated vegetation type.

Effectiveness of Programs and Actions – Existing policies and regulations appear to be effective based on the current status of this indicator. The existing extent and distribution of the shrub vegetation type is more likely a function of natural disturbance processes and succession occurring in upland ecosystems.

Interim Target – According to the most recent data on vegetation, the Region is in attainment with the adopted management target. Therefore, it is not necessary to establish an interim target for this indicator.

Target Attainment Date – According to the most recent data on vegetation, the Region is in attainment with the adopted management target. Therefore, it is not necessary to establish a target attainment date for this indicator.

RECOMMENDATIONS

Analytic Approach – The TRPA Code of Ordinances defines a major evaluation interval as "*A fixed period of time during which TRPA will monitor and at the end of which TRPA will evaluate and report upon the interim status of a threshold or standard. Such intervals may be different for each threshold or standard* (TRPA, 2012a)." Future evaluations should consider establishing a major evaluation interval for common vegetation standards that more closely align with expected rate of change in vegetation structure.

Monitoring Approach – Align monitoring and reporting with partners in Region, and ensure monitoring programs complement those of the U.S. Forest Service - LTMBU Forest Plan Monitoring and Evaluation Plan (USFS LTBMU, 2015).

Modification of the Threshold Standard or Indicator – Ensure standards reflect the most recent science on forest ecology and management including concepts such as historic range of variation or natural

range of variability (Safford, 2013; Safford et al., 2012a). Consider closer alignment with goals and policies of Region partners.

The adopted threshold standard is problematic for a number of reasons. First, it suggests the Region would be in attainment with the standard even if there was no shrub cover on the landscape. However, this outcome would be contrary to achieving the threshold standard for common vegetation richness, creating a possible direct conflict between the two threshold standards. Second, standard review should consider setting a target based on the desired function of the vegetation communities and the values they support. Third, simple accounting of the spatial extent (acres) of shrub vegetation does not provide managers with an understanding of the relative condition of this vegetation type.

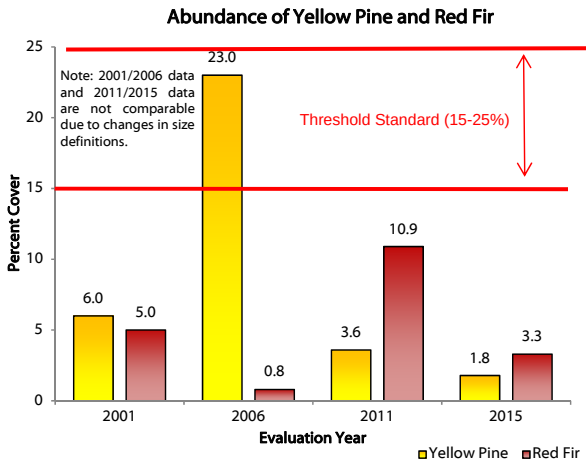
Table 2 summarizes the variation in target assessment basis. It shows the total acres of "undisturbed" vegetation in the Tahoe Region as reported in prior threshold evaluation reports and studies. The different basis used for standard assessment confounds comparisons between reporting periods. The 2001 and 2007 threshold evaluations used the total area of the Region to assess the standard.

Table 2: *Total acres of "undisturbed" vegetation in the Tahoe Region as reported in prior threshold evaluation reports and studies*

Source	Target for acres of shrub vegetation (based on less than 25% of total undisturbed vegetation)	Total acres of undisturbed vegetation (estimated)
1982 Threshold Evaluation	44,872	179,488
1982 Environmental Impact Statement (for 1982 Threshold Evaluation)	43,361	173,444
1991 Threshold Evaluation	49,265	197,060
1996 Threshold Evaluation	45,204	180,817
2001 Threshold Evaluation	50,488	201,953
2007 Threshold Evaluation	50,488	201,953
2011 Threshold Evaluation (for impervious cover)	48,499	193,994
2011 Threshold Evaluation	49,725	198,900
2015 Threshold Evaluation	48,495	193,979

Attain or Maintain Threshold – No changes recommended.

Common Vegetation: **Relative Abundance of Yellow Pine and Red Fir Forest in Seral Stages other than Mature**

Status	Trend
RELATIVE ABUNDANCE OF YELLOW PINE FOREST IN SERAL STAGES OTHER THAN MATURE Status: **Considerably Worse than Target** Trend: **Little or No Change** Confidence: **Moderate** **RELATIVE ABUNDANCE OF RED FIR FOREST IN SERAL STAGES OTHER THAN MATURE** Status: **Considerably Worse than Target** Trend: **Little or No Change** Confidence: **Moderate**	 Estimated percent cover of small diameter tree size-classes (less than 20 inches diameter at breast height in 2001 and 2006; less than10.9 inches diameter at breast height in 2011 and 2015) for yellow pine and red fir forests in the Lake Tahoe Region by evaluation year (TRPA, 2007, 2001; USDA, 2009) relative to adopted management target (the range within red lines, 15 percent to 25 percent). Differences in percent cover reflect changing mapping techniques/resolution, and do not necessarily reflect actual changes in the extent of immature red fir or yellow pine forest. Changes in forest in seral stages other than mature are attributed to: a) different evaluation criteria (2001 & 2006 versus 2011 & 2015), b) a reporting error in the 2011 Threshold Evaluation Report (2011 versus 2015), and c) updates based on the 2007 Angora fire (2011 vs. 2015).
Map	
 Geographic distribution of small diameter (less than 10.9 inches diameter at breast height) Yellow pine and red fir forests in the Lake Tahoe Region (USDA, 2009).	

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures the relative proportion of tree stands classified in seral stages other than mature for yellow pine and red fir forests in the Lake Tahoe Region. For this evaluation, "seral stages other than mature" was equated with stands dominated by small diameter trees (less than 10.9-inches diameter at breast height). The relative abundance of small-tree dominated stands is important because it provides a measure of forest sustainability; without young trees, Tahoe's forests will not be sufficiently stocked to replace dead and dying trees over time. Today, Tahoe's forests are dominated by an intermediate age/size class ranging in diameter from 11 inches to 23 inches due to past Comstock-era logging and ongoing fire suppression (Raumann and Cablk, 2008b; Taylor, 2007). The area in the Region dominated by Jeffery pine forest has increased since 2003 (USFS LTBMU, 2015).

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Common vegetation

Adopted Standards – Of the total amount of undisturbed vegetation in the Tahoe Basin:

1. Maintain 15 to 25 percent of the yellow pine forest in seral stages other than mature.
2. Maintain 15 to 25 percent of the red fir forest in seral stages other than mature.

Type of Standard – Management standard with numeric targets

Indicator (Unit of Measure) – Relative proportion of yellow pine and red fir forest tree stands dominated by small diameter trees less than 10.9-inches diameter at breast height.

Human & Environmental Drivers – The primary natural driver in creating patches of small diameter trees in the Lake Tahoe Region is wildfire and other natural disturbances events. Recent forest management practices have focused on reduction of understory fuel loads in the wildland urban interface. Only now are basin agencies beginning to plan treatments for multi-values in the larger forest landscape that could contribute to standard attainment.

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service, U.S. Geological Survey and TRPA

Monitoring Approach –For this evaluation, stands dominated by trees less than 10.9-inches diameter at breast height (dbh) were enumerated from the following California Wildlife Habitat Relationship (CWHR) Types (CWHR, 2011) attributed in the U.S. Forest Service - Remote Sensing Lab Pacific Southwest Region TMU_Strata_07 map layer (published 2009). Every five years, the Tahoe vegetation map is updated with new satellite data (if available) and/or modeled and calibrated using field-based forest inventory and analysis data to assess the extent of different vegetation types and associated forest structure characteristics for the Region (USDA, 2009; Warbington et al., 2011).

Table 1: *TRPA vegetation associations compared to California Wildlife Habitat relationship types and size class*

TRPA Association	California Wildlife Habitat Relationships (CWHR) Type	California Wildlife Habitat Relationships (CWHR) Size Class
Red Fir Forest	Red Fir	1"-5.9" and 6"-10.9"
Yellow Pine Forest	Eastside Pine	1"-5.9" and 6"-10.9"
Yellow Pine Forest	Jeffrey Pine	1"-5.9" and 6"-10.9"
Yellow Pine Forest	Sierran Mixed Conifer	1"-5.9" and 6"-10.9"
Yellow Pine Forest	White Fir	1"-5.9" and 6"-10.9"

Analytic Approach – Total acreage of red fir and yellow pine in stages other than mature was compared against the total acreage of undisturbed vegetation. Seral stages other than mature (interpreted for this evaluation as stands dominated by small diameter trees less than10.9-inches dbh) for both yellow pine and red fir forests. Total acreage of undisturbed vegetation was calculated by subtracting the area covered by impervious surfaces from the total area of the Region (201,953 acres less 7,974 acres = 193,979 acres).

INDICATOR STATE

Status – Considerably worse than target. Immature yellow pine forest covers 1.8 percent of the Region (12 percent of the low end of the target). Immature red fir forest covers 3.3 percent of the Region (26 percent of the low end of the target). Past evaluations also indicate that the Region was not meeting numeric targets, with the exception of yellow pine forest documented in the 2006 Threshold Evaluation Report.

Trend – Little to no change. No major disturbance events (e.g. fires, disease, clearing) that would have significantly altered the extent of vegetation communities in the Region occurred between 2011 and 2015. The stand replacing event included in this assessment (Angora fire) occurred in 2007, but was not included in 2011 Threshold Evaluation Report. The Angora fire consumed 15.2 acres of immature yellow pine and red fir forest. The rest of the difference between the 2011 and 2015 reports is attributable to a reporting error in 2011. This error caused the extent of red fir to be over reported by 2,599 acres and the extent of yellow pine to be over reported by 1,896 acres. Differences reported in earlier evaluation reports are likely attributable to changes in mapping resolution or refinement in standard interpretation. Most importantly, the 2006 Threshold Evaluation Report used a diameter limit of less than 20-inches dbh to represent small trees, while this evaluation and the 2011 Threshold Evaluation Report use a diameter limit of less than 10.9-inches dbh to represent small trees, The less than 10.9-inch dbh definition of small trees is thought to better represent the intent of the threshold standard (TRPA, 2012d). The previous definition (2006 and earlier) of Red Fir and Yellow Pine forest in stages "other than mature" as a DBH of twenty inches and under did not accurately represent "other than mature" stages. 10.9 inches DBH and under was used from 2011 on because it more accurately represents the size classes of early successional Red Fir and Yellow Pine forests, and is an established forest habitat type in the California Wildlife Habitat Relations Types.

Confidence –

Status –Moderate. The estimated overall accuracy of the map layer used for this evaluation was between 73 percent and 83 percent (USDA, 2009). This level of accuracy equates to a moderate confidence determination for status.

Trend – Moderate. There is moderate to high confidence that in the absence of disturbance events (e.g. fires, disease, clearing) the spatial extent of the vegetation communities at the Region scale does not change considerably over a four-year period.

Overall Confidence – Moderate.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The TRPA Code of Ordinances allows for the creation of forest openings of up to eight acres to facilitate the achievement of adopted management standards. The LTBMU forest management plan encourages "the creation of openings of varying sizes and shapes that retain reserve trees and clumps to produce spatial and structural heterogeneity in forest stands, and should give greater weight to openings from 2 to 7 acres."

Effectiveness of Programs and Actions – Forest fuels and health treatments over the last decade have focused on the wildland urban interface (WUI), which is at a lower elevation that where red fir are typically present. Only now are basin agencies beginning to plan treatment prescriptions for forest health and other values in the larger forest landscape outside the WUI. These prescriptions, if planned to include openings, could contribute to achieving and maintaining this standard.

Interim Target – Current trend information is insufficient to estimate an interim target date for the yellow pine and red fir forest indicators.

Target Attainment Date – Attaining the management standards for yellow pine and red fir forests is largely dependent upon natural events such as stand-replacing wildfires that promote regeneration of small trees.

RECOMMENDATIONS

Analytic Approach – The TRPA Code of Ordinances defines a major evaluation interval as "*A fixed period of time during which TRPA will monitor and at the end of which TRPA will evaluate and report upon the interim status of a threshold or standard. Such intervals may be different for each threshold or standard* (TRPA, 2012a)." Future evaluations should consider establishing a major evaluation interval for common vegetation standards that more closely align with the expected rate of change in vegetation structure.

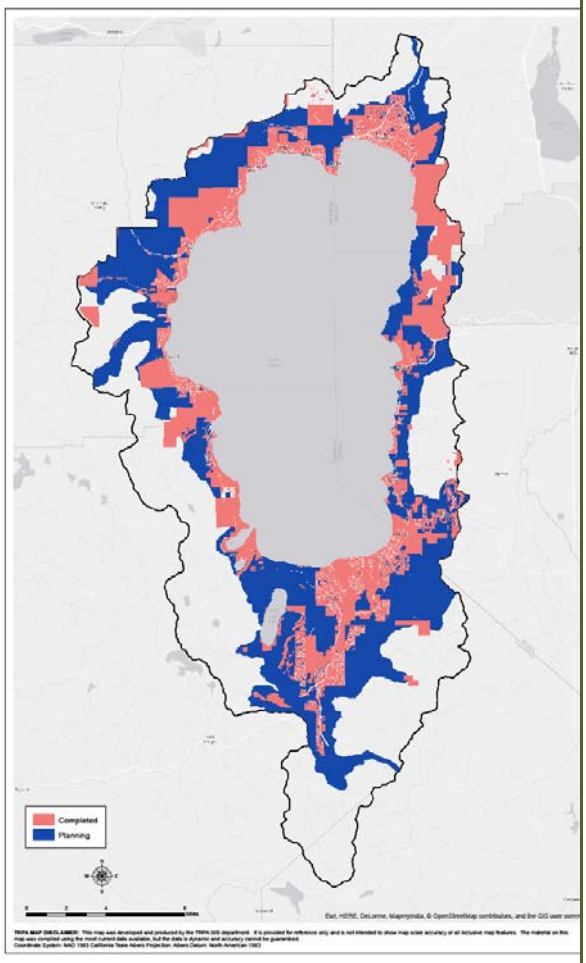
The U.S. Forest Service - LTBMU defines early, mid and late seral stages as stands that have quadratic mean diameters of zero to five inches, five to 25 inches, and greater than 25 inches dbh respectively (USFS LTBMU, 2015). This evaluation follows the precedent established in the 2011 Threshold Evaluation Report and defines trees as "other than mature" if dbh is less than 10.9-inches, but recognizes the LTBMU definition of early, mid and late seral stages is based on quadratic mean diameter (USFS LTBMU, 2015). It is recommended that the LTBMU alternative definition of "other than mature" be considered in future evaluations of the threshold standard. To use the more generalized and uniform definition renders identification of stand seral stage difficult for the generally small patch size and mixed age and size of Jeffery pine and white fir stands in the region (USFS LTBMU, 2015).

Monitoring Approach – Align monitoring and reporting with the work of other partners in Region, and ensure they complement activities associated with the U.S. Forest Service - LTMBU Forest Plan Monitoring and Evaluation Plan (USFS LTBMU, 2015).

Modification of the Threshold Standard or Indicator – Ensure standards reflect the most recent science on forest ecology and management including concepts such as historic range of variation or natural range of variability (Safford, 2013; Safford et al., 2012a). Consider closer alignment with goals and policies of Region partners. The LTBMU definition of "other than mature" should be applied to enable objective evaluation of the standard. Both the 2011 and 2006 Threshold Evaluation Reports also noted the lack of consistent definition as an issue (TRPA, 2012d, 2007). Recent research suggests that the forests that dominate the Region are composed of denser stands and contain more smaller trees relative to forests prior to Comstock logging (Taylor et al., 2014). These findings suggest that management objectives should focus on reducing density especially of smaller trees (Taylor et al., 2014), a strategy that is reflected in the management plan of the USFS LTBMU (USFS LTBMU, 2015).

Attain or Maintain Threshold – Support the updated programs and actions outlined in the LTMBU management plan which include focusing on "Vegetation treatments in montane forests [to] favor Jeffrey pine, sugar pine that is white pine blister rust-resistant, and aspen, species that have become much less common over the last century."

Common Vegetation: **Juxtaposition of Vegetation Communities and Age Class**

Status	Map
JUXTAPOSITION OF VEGETATION COMMUNITIES AND AGE CLASS Status: **Implemented**	 Map showing the distribution of fuels reduction treatments in the Lake Tahoe Region. Source: U.S. Forest Service, Tahoe Fire and Fuels Team (2015).
Image	
 Forest fuels reduction treatment.  2015 photo of the 2007 Angora burn area.	

Data Evaluation and Interpretation

BACKGROUND

Relevance – Vegetation is integral to many scenic and recreational amenities in the Lake Tahoe Region. Vegetation also provides many functional roles related to water cleansing, soil stabilization, wildlife habitat, nutrient catchment and release, air purification, and noise control. The focus of vegetation

preservation in the Region is to restore, protect and maintain these functions and contribute to other socioeconomic attributes. Specifically, this management standard discourages the creation of large forest openings, such as clear cuts, while providing tools to allow for forest openings of up to eight acres in size to meet specific management goals such as regeneration of shade intolerant species (e.g., Jeffery and sugar pine). It also encourages the perpetuation of a diversity of tree age classes, which is important for ensuring the sustainability of the Region's forests.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Common vegetation

Adopted Standards – Pattern **–** Provide for the proper juxtaposition of vegetation communities and age classes by:

1. Limiting acreage size of new forest openings to no more than eight acres, and
2. Adjacent openings shall not be the same relative age class or successional stage to avoid uniformity in stand composition and age.

Type of Standard – Management

Indicator (Unit of Measure) – Has TRPA adopted appropriate policies, ordinances and/or programs to support the proper juxtaposition of vegetation communities and age classes?

Human & Environmental Drivers – Prior to European settlement, low intensity fires burned every five to 18 years in lower elevation pine and mixed conifer forests in the Tahoe Region (Nagel and Taylor, A.H., 2005). As a result, these lower elevation forests in the Region typically had large, widely spaced conifers with a poorly developed shrub understory, in a mosaic pattern of different age classes from some higher-intensity, stand-replacing fires. Between 1875 and 1895, large-scale timber harvesting removed most of the large trees around Lake Tahoe (Lindstrom et al., 2000). Although the forest stands successfully regenerated, the past 100 years of fire suppression-focused forest management have resulted in a relatively homogenous landscape of similar-aged trees in denser stands than historic reference conditions. Urban development, grazing and more recent fuel reduction treatments continue to shape the distribution and health of vegetation communities in the Region.

MONITORING AND ANALYSIS

Monitoring Partners - The U.S. Forest Service, California Tahoe Conservancy, California State Parks, CAL FIRE, Nevada Division of Forestry, North Lake Tahoe Fire Protection District, Tahoe-Douglas Fire Protection District, Lake Valley Fire Protection District, Meeks Bay Fire Protection District, City of South Lake Tahoe, Fallen Leaf Fire Protection District, and North Tahoe Fire Protection District all contribute to the implementation and monitoring of forest management activities in the Tahoe Region.

Monitoring Approach – Every five years, the Tahoe vegetation map is updated with new satellite data (if available) and/or modeled and calibrated using field-based forest inventory and analysis data to assess the extent of different vegetation types and associated forest structure characteristics for the Region (USDA, 2009; Warbington et al., 2011). Information from the Tahoe Fire and Fuels Team is used to assess and report on forest management activities.

INDICATOR STATE

Status – Implemented. The Region is in attainment with this management standard. Policies and ordinances are in place to sustain common vegetation and a vegetation management restoration program has been underway to actively reduce unnaturally dense forest and restore fire resiliency of Tahoe's upland ecosystems (TRPA, 2012e, 1986). With few exceptions, the TRPA Code of Ordinances prohibits the manipulation of vegetation that would permanently impact forest integrity (TRPA, 2012e). Prior to approving any vegetation management project, TRPA must consider alternatives, complete environmental review, identify mitigation measures and make specific findings demonstrating that the project is consistent with the TRPA Regional Plan and will not exceed any environmental threshold

standard, including requirements for protecting upland and riparian vegetation(TRPA, 2012e) . TRPA administers the interagency Environmental Improvement Program (EIP), which facilitates the implementation of forest health restoration and other vegetation management projects. The Tahoe Fire and Fuels Team (TFFT) coordinates fuel reduction and forest management programs for the Region. Forest health/fuels reduction activities in the Region between 2000 and 2013 are detailed in Figure 1: (

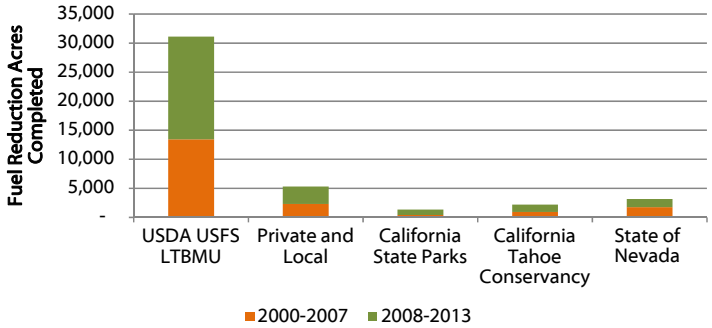


Figure 1: *Forest health/fuels reduction activities in the Region between 2000 and 2013 (Source TFFT 2015)*

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service and TFFT manage fuels reduction treatments. These treatments in the Tahoe Region have enhanced implementation of the juxtaposition of vegetation communities and age class indicator. While most fuels reduction treatments are relatively similar in nature and consist of understory ladder fuel removal and forest thinning, they are not thought to homogenize the landscape since they are typically interspersed between dense, even-aged untreated forests. This results in a mosaic pattern across a large area. Significant regulatory protections exist in the TRPA Code of Ordinances to regulate the prescriptions and methods of forestry operations. Since 2007, over 46,000 acres of forest have been treated (TRPA 2016).

Effectiveness of Programs and Actions – Since the adoption of the TRPA Regional Plan, TRPA's application of regulations through project review has improved and protected common vegetation in the Tahoe Region (Raumann and Cablk, 2008b).

Interim Target – Not applicable. The target is currently in attainment.

Target Attainment Date – Not applicable. The target is currently in attainment.

RECOMMENDATIONS

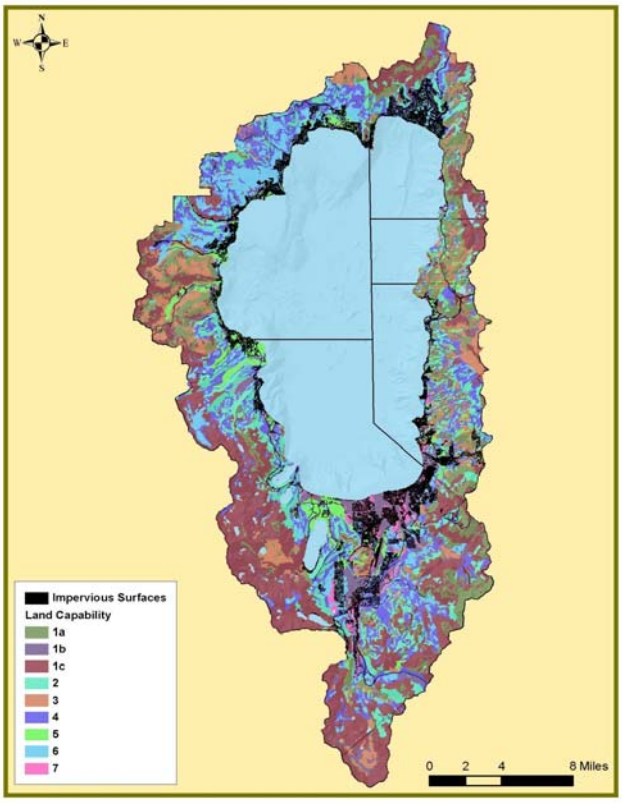
Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – Engage in collaborative planning with federal and state agencies to review forest management standards and prescription in view of emerging threats due to climate change impacts, drought and insect and disease tree mortality in the Sierras.

Attain or Maintain Threshold – No changes recommended.

Common Vegetation: **Consistency with Bailey Land Capability System**

Status	Map
I **CONSISTENCY WITH BAILEY LAND CAPABILITY SYSTEM** Status: **Implemented**	 Map showing the extent and distribution of impervious surface in the Lake Tahoe Region relative to Land Capability Districts. Source: TRPA GIS
Image	
  The land capability system was designed to minimize the impact of development on water resources and ecosystems.	

Data Evaluation and Interpretation

BACKGROUND

Relevance – Vegetation is integral to many scenic, wildlife, and recreational amenities in the Lake Tahoe Region. Vegetation also provides functional services including soil stabilization, nutrient cycling, surface water flow regulation, air purification, and noise control. The focus of vegetation preservation in the Region is to protect and maintain these and other attributes.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Common vegetation

Adopted Standards – Native vegetation shall be maintained at a maximum level to be consistent with

the limits defined in the *Land Capability Classification of the Lake Tahoe Region, California-Nevada, A Guide for Planning* (Bailey, 1974), for allowable impervious cover and permanent site disturbance. The report can be found on the TRPA website at: http://www.trpa.org/wp-content/uploads/Bailey-Land-Capability-Report.pdf

Type of Standard – Management

Indicator (Unit of Measure) – Are TRPA policies in place to conform to the adopted standard?

Human & Environmental Drivers – The structure and distribution of vegetation in the Tahoe Region is influenced by a variety of natural factors as well as past and current human activities, such as urban development. Impervious cover in two of the nine land capability classes exceeds the level recommended by Bailey (1974). These areas are typically in the commercial core zones of previously developed community centers, and work is underway to address the impacts of this legacy development. Landscaping around homes is typically left as native vegetation, or is converted into a more formal landscape, usually including irrigation and some non-native plants such as lawns and flowers.

MONITORING AND ANALYSIS

Monitoring Partners - Not applicable.

Monitoring Approach – Not applicable.

Analytic Approach – Not applicable.

INDICATOR STATE

Status – Implemented. The management standard has been implemented and is in attainment. Regulations are in place to limit the amount of allowable impervious coverage through the implementation of the Bailey land capability system. At the parcel level, the application of the land capability system requires that areas not covered by impervious surfaces be left in a native or acceptably landscaped state.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The Bailey land capability system is implemented through The TRPA Code of Ordinances and regulates allowable coverage within land capability classes and has been in place and effective since 1987. The *Home Landscaping Guide for Lake Tahoe and Vicinity* provides guidance for homeowners and includes landscaping recommendations for balancing erosion control with fire defensible space.

Effectiveness of Programs and Actions – Since the adoption of the TRPA Regional Plan, in 1987, application of regulations through project review has improved and protected common vegetation in the Tahoe Region and provided guidance on appropriate landscaping. The effectiveness of the regulatory framework in assuring compliance with the Bailey land capability system is further supported by the findings in the soil conservation chapter of this evaluation which found that more than 10 acres of impervious cover had been removed from land capability class 1b (sensitive lands) in the last four years, and transferred or new cover was placed in high capability land classes.

Interim Target – Not applicable. The target is currently in attainment.

Target Attainment Date – Not applicable. The target is currently in attainment.

RECOMMENDATIONS

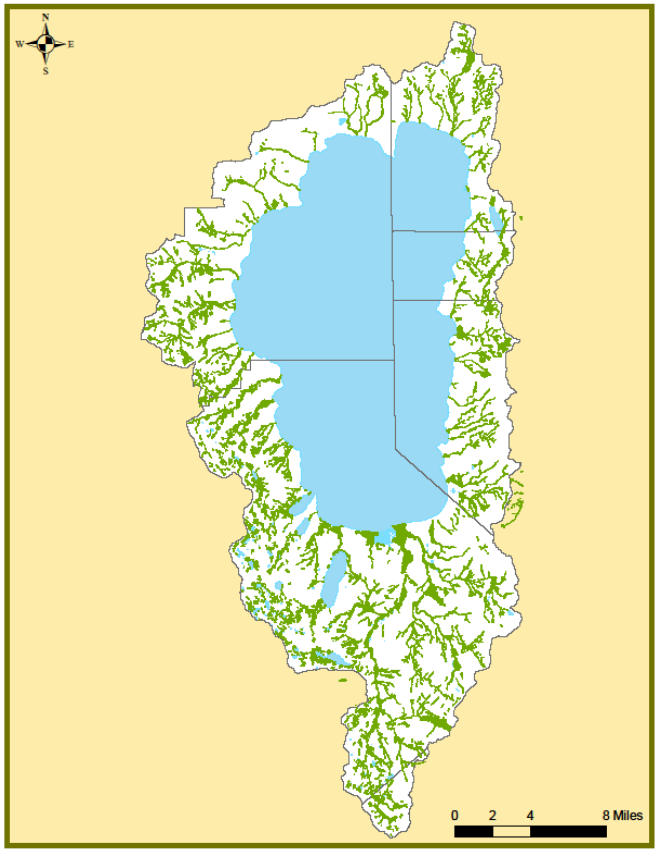
Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

Attain or Maintain Threshold – No changes recommended.

Common Vegetation: **Non-degradation of Stream Environment Zones**

Status	Map
NON-DEGRADATION OF STREAM ENVIRONMENT ZONES Status: **Implemented**	 Above: Riparian areas (green) protected by the habitats of special significance management standard and other policies.

Photos

Images of representative SEZ areas protected by TRPA's SEZ non-degradation standard.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Stream environment zones (SEZ) play a variety of critical roles in the Region including natural water filtration, storage, and conveyance of surface runoff (Roby et al., 2015). Encroachment on these areas reduces their potential to filter sediment and nutrients, and also reduces the amount of surface

runoff they can effectively treat. Naturally functioning SEZs also provide open space, flood flow capacity, riparian vegetation, and fish and wildlife habitat, and buffer urban uses in developed areas. SEZ protection and restoration contributes to achievement of other environmental threshold standards, including water quality, wildlife, fisheries, vegetation preservation, recreation, and scenic resources. Even seemingly unrelated threshold standards such as air quality and noise are affected by SEZs. For instance, aspen stands in SEZs next to roadways have been shown to help physically block air particulates from spreading to adjacent areas and moderate roadway noise.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Common vegetation

Adopted Standards –A non-degradation standard to preserve plant communities shall apply to native deciduous trees, wetlands, and meadows while providing for opportunities to increase the acreage of such riparian associations to be consistent with the SEZ threshold.

Type of Standard – Management

Indicator (Unit of Measure) – Whether or not the TRPA Goals and Policies continue to support the non-degradation of SEZs.

Human & Environmental Drivers –Historic logging, grazing, and direct manipulation of stream channels have impacted the functions of wetlands, streams and surrounding riparian areas. The activities degraded and reduced SEZ function resulting in decreased extent and vigour of riparian and wetland vegetation, and a reduction in the suitability of riparian and wetland areas for many wildlife species (Elliot-Fisk et al., 1996; Lindstrom et al., 2000). Ongoing restoration programs are a primary factor affecting the condition of riparian and wetland areas (Elliot-Fisk et al., 1996). These restoration projects may temporarily degrade habitat quality during and immediately following construction, but they result in a long-term increase in the extent and vigour of riparian and wetland vegetation and improved habitat conditions for multiple species. Other factors affecting the suitability of riparian and wetland areas include weather fluctuations and climate change, influences of non-native species (e.g. brown-headed cowbird or noxious weeds), and disturbance from recreational uses (Kattleman, R and Embury, M, 1996; Kondolf et al., 1996; Manley, P.N. et al., 2000).

MONITORING AND ANALYSIS

Monitoring Partners – Not applicable.

Monitoring Approach – Not applicable.

Analytic Approach – Threshold attainment is based on whether there is evidence that TRPA and other agencies have sufficiently adopted policies, ordinances and programs in support of the nondegredation standard.

INDICATOR STATE

Status – Implemented. The Region is in attainment with this management standard. As described below, regulations are in place to protect riparian and wetland areas from permanent disturbance such as residential and commercial development, and EIP restoration projects and programs have been underway to actively expand and restore riparian areas. The TRPA Code of Ordinances implements a land capability system that significantly limits development in riparian or wetland areas and provides incentives to relocate existing development from these areas to upland areas (TRPA, 2012e). With only limited exceptions, the TRPA Code of Ordinances prohibits the manipulation of vegetation that would permanently impact riparian or wetland integrity (TRPA, 2012e). Prior to approving any vegetation management project, TRPA must consider alternatives, complete environmental review, identify mitigation measures and make specific findings demonstrating that the project is consistent with the TRPA Regional Plan and will not exceed any environmental threshold standard, including requirements

for protecting upland and riparian vegetation (TRPA, 2012e). TRPA administers the interagency Environmental Improvement Program (EIP) which facilitates the implementation of projects to restore, protect, enhance and expand riparian and wetland areas.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – As described above, significant regulatory protections exist in the TRPA Code of Ordinances, which prohibit degradation of riparian and wetland areas. In the current reporting period where data is available (2011 through 2014), the EIP has helped protect and expand habitats of special significance. This includes protecting 74 acres of aspen habitat, as well as restoring or enhancing 294 acres of aspen habitat, 285 acres of wetlands and wet meadows, and 263 acres of stream environment zones (TRPA, 2016). Land management agencies have redirected potentially detrimental recreational uses away from riparian areas through projects such as the High Meadows Restoration and the Eagle Rock Trail re-alignment. In addition, the U.S. Forest Service and other agencies have actively removed conifers that have encroached into aspen stands and meadows in order to maintain and re-establish riparian areas.

Effectiveness of Programs and Actions – Since the adoption of the 1987 TRPA Regional Plan, TRPA regulations have protected the integrity of riparian and wetland habitat structure (Raumann and Cablk, 2008a), from direct impacts associated with construction projects or resource management actions. These protections were carried forward in the Regional Plan update in 2012 (TRPA, 2012a). Projects implemented through the EIP have expanded the extent of riparian and wetland areas and improved their conditions. Other projects have routed recreational access away from riparian and wetland areas.

Interim Target – Not applicable.

Target Attainment Date – Not applicable.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – The current monitoring approach focuses only on presence or absence of the wetland and meadow vegetation. Future work could consider monitoring that enables detection of change in SEZ condition and prioritization of management actions that promote function.

Modification of the Threshold Standard or Indicator – Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The two subparts of the standard add to this challenge. The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – No changes recommended.

Common Vegetation: **Appropriate Management Practices**

Status	Chart

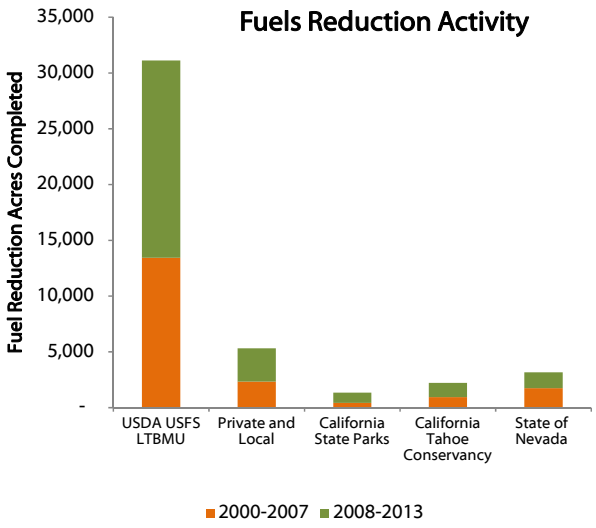
APPROPRIATE MANAGEMENT PRACTICES

Status: **Implemented**

Photos

Area before fuels reduction treatment.

Same area after fuels reduction treatment.



Data Evaluation and Interpretation

BACKGROUND

Relevance – Forest management activities have the potential for substantial impacts on the environment. However, the forests of Lake Tahoe are in need of active management to maintain forest health and reduce the threat of wildfire. The importance of appropriate low-impact forest management cannot be overstated, and this policy statement was intended to ensure that forest management activities comply with all TRPA Regional Plan policies and ordinances adopted to achieve multiple TRPA threshold standards.

TRPA Threshold Category – Common vegetation

TRPA Threshold Indicator Reporting Category – Appropriate management

Adopted Standards – It shall be a policy of the TRPA Governing Board that a nondegradation standard shall permit appropriate management practices.

Type of Standard – Policy statement

Indicator (Unit of Measure) – Detailed in the analysis section.

Human & Environmental Drivers – Not applicable.

MONITORING AND ANALYSIS

This policy statement was evaluated by determining 1) whether TRPA and other agencies have sufficiently adopted policies, ordinances and programs in support of the threshold policy statement and 2) whether TRPA and other agencies have been diligent in the implementation of best forestry practices.

Criteria 1: Chapter 61 of the TRPA Code of Ordinances regulates tree removal and forest management activities with ordinances that address techniques for forest management that reduce impacts to less than significant, and improve or maintain TRPA thresholds. These ordinances are applied through memoranda of understanding with land management agencies and through the permit review process. Chapter 61 contains specific provisions that allow for tree removal where it is deemed appropriate management, such as of dead or dying tree to enhance forest health, to protect property or lives where trees are hazardous, to reduce fire hazard, and provisions covering prescribed burns.

Criteria 2: Timber management project permitting begins with TRPA foresters reviewing proposed project plans and working with the project proponent to change and/or modify the proposed plan to meet all TRPA adopted policies and ordinances, and to assure all impacts are less than significant. After agreement on the plan and appropriate environmental analysis, TRPA issues a permit with special conditions. When the project is implemented, TRPA specialists inspect the operations to ensure compliance with the conditions of the permit, and to assure that all best management practices (BMPs) are in place. After the project is completed, TRPA foresters inspect the final project for compliance with all permit conditions, and to ensure the project site has been properly winterized.

INDICATOR STATE

Status – Implemented. Based on the evaluation criteria, it was determined that TRPA and other agencies have sufficiently incorporated the appropriate forest management policies into their respective planning documents, and ensure their application during the implementation of forestry projects.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The vast majority of forest management work in the Tahoe Region is completed using either hand crews or low-impact ground based equipment; however, helicopters and cable yarding have been used. Low-impact ground-based equipment is typically rubber-tired machines that exert low ground pressure, and therefore cause less ground disturbance and soil compaction than traditional forest management equipment. Cut-to-length systems that include a rubber-tired harvester and a rubber-tired forwarder are the machines most commonly used in the Lake Tahoe Region. These machines have been demonstrated for use in some stream environment zones without substantial impacts (Norman and Keely, 2008).

The U.S. Forest Service – Lake Tahoe Region Management Unit (LTBMU) implements timber management projects according to Forest Service guidelines and a Forest Plan that is specific to the Tahoe Region. These documents include many of the protections and best management practices currently in the TRPA Regional Plan. The LTMBU also follows a best management practices handbook for all projects in California to ensure compliance with the California State Water Resources Control Board requirements.

The California Tahoe Conservancy, California State Parks, Nevada Division of State Lands, and the five fire protection districts and one fire department in the Lake Tahoe Region follow all applicable local, state, and federal laws, and employ resource professionals to plan and implement their projects.

Entities implementing forestry projects in the Region follow the TRPA Code of Ordinances, and work closely with TRPA foresters when planning and implementing projects. When protection measures

required by TRPA differ from local, state, or federal laws, the strictest protection measures are implemented.

Effectiveness of Programs and Actions – Not applicable.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – The standard contains no specific criteria that would allow for objective evaluation of attainment. Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – No changes recommended.

Uncommon Plant Communities

The Tahoe Region supports a wide range of plant community types. Recent classification efforts have identified over 60 discrete vegetation types. Forest and shrub communities account for the majority of the classified types and occupy the majority of the landscape. Uncommon plant communities are primarily represented by fen, wetland, and meadow complexes associated with riparian systems or groundwater seeps. The exception is the Freel Peak cushion plant community, which occurs on high elevation mountain slopes. The uncommon plant communities' standards were established to "provide for the non-degradation of the natural qualities of any plant community that is uncommon to the Region or of exceptional scientific, ecological, or scenic values." Originally, four uncommon plant communities were identified based on their uniqueness and rarity in the Region: Grass Lake, Osgood Swamp, Freel Peak cushion plant community, and deepwater plants. Four additional areas (Hell Hole, Upper Truckee Meadow, Taylor Creek Marsh, Pope Marsh) were added to the uncommon plant communities 2002 (TRPA 2002).

Approximately 3.5 percent of the Lake Tahoe Region is wet and dry meadows and wetlands. Grass Lake, Osgood Swamp and Hell Hole are fens associated with ground water discharge and depressional Regions. Fens are rare wetlands and are among the most sensitive habitat types in the Sierra Nevada (Sikes et al. 2013). Upper Truckee Marsh, Taylor Creek Marsh, and Pope Marsh are wet meadows adjacent to the southern shore of Lake Tahoe. These marshes developed on buried lacustrine sediments, glacial outwash and recent alluvium. Sandy beach deposits typically form a barrier between the marsh and Lake Tahoe. Due to prolonged soil saturation and dense plant growth, the dominant soils have a rich organic surface (NRCS 2007). These marshes are lacustrine delta systems, formed at the mouth of the Upper Truckee River and Taylor Creek. Historically, Pope Marsh was part of the Upper Truckee Marsh, but it was disconnected by the development of the Tahoe Keys in the 1960s. Due to their proximity to Lake Tahoe, water table levels, channel gradients, and channel bed forms are influenced by the water level of Lake Tahoe.

When functioning properly, these meadows, wetlands, and riparian systems support a high diversity of flora and fauna and provide water, sediment, and nutrient storage. The broad, low gradient floodplains allow dispersal of floodwaters and reduce velocity so suspended sediments and nutrients settle out of suspension, and subsurface flow is filtered as it moves through the thick organic soil layers.

Many tributaries to Lake Tahoe have been altered by logging, road development, channel straightening, and urban runoff on impermeable surfaces, and other impacts, which affects their ability to function properly (Manley et al. 2010a, TERC 2015). Storm water runoff in urban environments has been identified as the primary source of fine sediments to Lake Tahoe, contributing approximately 67 percent of fine sediments, while stream channel erosion contributes about five percent. The main contribution of phosphorus to the lake is from watershed runoff in urban (18 percent) and non-urban environments (47 percent). The primary source of nitrogen is from atmospheric deposition (57 percent), with lesser contributions from watershed runoff in urban (seven percent) and non-urban areas (22 percent). In 2014, the Upper Truckee River remains, by far, the largest single contributor of sediments, nitrogen and phosphorous to the Lake (TERC 2015). Continued work is needed to reduce the storm water runoff in urban environments and improve stream and meadow conditions so they can capture and store these sediments and nutrients on floodplains.

The high elevation Freel Peak cushion plant community has limited distribution in the Lake Tahoe Region and supports a variety of uncommon plants. This community may be vulnerable to increased temperatures or changes in precipitation due to climate change and drought. The steep unstable slopes that this plant community occurs on are also vulnerable to recreational impacts due to the popularity of Freel Peak, the highest point in the Lake Tahoe Region, as a hiking destination. In 2006, the Global Observation Research Initiative in Alpine Environments (GLORIA) established a site on Freel Peak in the cushion plant community.

The 'natural qualities' or desired condition of the uncommon plant communities have never been defined. Thus, the status and trend determinations for each of the uncommon plant communities are based primarily on a qualitative assessment of known impacts, management actions, and knowledge of general vegetation and hydrologic conditions. Table 6-2 summarizes the status of each of the sites listed in the uncommon plant communities' indicator reporting category.

Since 2004, 66 long-term monitoring plots have been established in 36 meadows and marshes located throughout the Tahoe Region as part of the U.S. Forest Service, Region 5 Range Monitoring Program. The program is designed to quantify changes in the ecological condition of wetland plant communities. The plots were surveyed in 2009 and 2014 and results are expected from this data by September 2016. These results will provide a more quantitative picture of the status and trends for fens, meadows, and marshes.

Monitoring data on the deep-water plants of Lake Tahoe is extremely limited. The deep-water plant community was discovered in the 1960s during a study of lake-bottom invertebrates (Frantz and Cordone 1967). Several species of macroalgae, filamentous algae, mosses and liverworts were identified in Lake Tahoe that are referred to as deep water plant communities, typically found in depths from 200-350 feet. The only other survey for these communities occurred in 2008 to 2009. Although this recent survey focused primarily on deepwater invertebrates rather than the deepwater plant communities, the biomass of plant material was noted for each sample collected. Results indicated declines in deepwater plants and an 80 percent to 100 percent decline in Lake Tahoe's deepwater invertebrates relative to the density and range observed in the 1960s. The dramatic decline in invertebrates may be related to the loss of food and habitat that was provided by the deepwater plants (Caires et al. 2013).

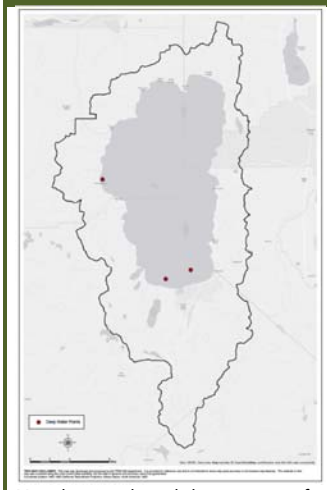
Uncommon Plant Communities: **Deepwater Plants of Lake Tahoe**

Status	Trend

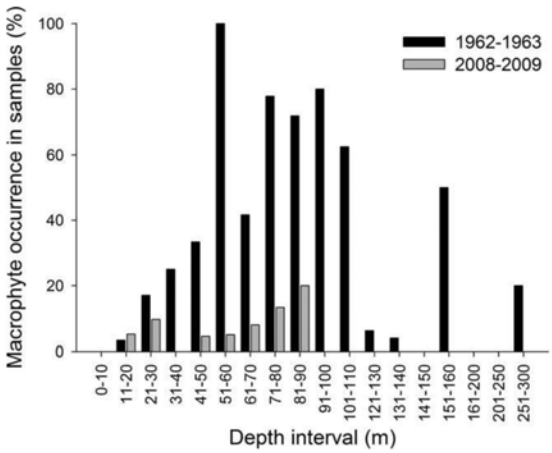
DEEPWATER PLANTS OF LAKE TAHOE

Status: **Considerably Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**

Map



Map showing the only known areas of deep water plants (Chara and moss) in Lake Tahoe. Bathymetric contour lines are given at 100 meter intervals. Deep water plants have declined dramatically in spatial and depth extent at the bottom of the lake since the 1960s. *Chara* was found in high abundance historically from 45-90 meters; in recent surveys it was found predominantly between 30-55 meters. The spatial area of the mixed *Chara*/moss bed at Camp Richardson is 0.105 km^2; the depth extent is 30-40 meters. The spatial extent of the mixed



A dramatic decline in the occurrence of plants from shallow to deep waters during the last 50 years has occurred (top figure). The decline in plants likely is one factor contributing to the decline of endemic and native benthic invertebrates that utilize the plants for habitat (Caires et al., 2013). Recent survey's confirmed the presence of the deepwater plants. Locations indicate patchy and variable plant mass depending on the location within one year. These beds support endemic and native communities of invertebrates which are in general decline since measurements were made in the 1960s. Regular samples have not been collected during the evaluation period and it is not possible to differentiate those changes that may be expected as result of natural population dynamics from those that are the result of external disturbance.

Chara/moss bed at the South Shore Mound is 0.002 km^2; the depth extent is 50-55 meters.	

Data Evaluation and Interpretation

BACKGROUND

Relevance – The uncommon deepwater plant communities include 10 species of moss (Bryophyta:Bryophytina), two species of stoneworts (Charophyta), and two species of liverworts(Caires et al., 2013). These communities support endemic and native invertebrate communities that likely play an important role in processing nutrients and carbon at the bottom of the lake. Endemic species include deepwater stonefly (*Capnia lacustra),* and two species of blind amphipod (*Stygobromus tahoensis* and *S. lacicolus*) (Caires et al., 2013; Chandra et al., 2015). Since 1960 when the deepwater communities were first surveyed there have been dramatic declines in both deepwater plants and macroinvertebrate communities, with estimated declines in native invertebrate density reaching 80 percent to 100 percent (Caires et al., 2013). Various explanations have been offered for the decline of deepwater plants (Caires et al., 2013; Chandra et al., 2015). The first mechanism may be due to changes in light penetration resulting from eutrophication. Increases in nutrient and particle concentration in the water reduce the amount of light reaching deepwater plant communities lowering their production. The second mechanism is a change in the biological community due to invasions by mysid shrimp and signal crayfish. Mysid shrimp migrate daily, feeding on the bottom either directly on sediment carbon, invertebrates, or algae that is growing on the deepwater plants thus disturbing them (Chandra et al., 2015). Signal crayfish migrate seasonally with some crayfish living in or near deepwater plant beds during the summer. This results in direct predation on plant beds and the associated invertebrates. While it is not likely that invasive mysid shrimp populations can be controlled in the lake at this time, slow growing crayfish which live nine to 10 years may have the potential for control. Research could lead to quantification of spatial distribution and variability, a better understanding of the influence of crayfish on plants and endemic invertebrates, and the association between plant habitat and the life-history of endemic invertebrates.

TRPA Threshold Category – Vegetation preservation

TRPA Threshold Indicator Reporting Category – Uncommon plant communities

Adopted Standards – Provide for the non-degradation of the natural qualities of any plant community that is uncommon to the Region or of exceptional scientific, ecological, or scenic value. The threshold standard shall apply, but not be limited to, 1) deep-water plants of Lake Tahoe, 2) Grass Lake, 3) Osgood Swamp, 4) Hell Hole, 5) Upper Truckee Marsh, 6) Taylor Creek Marsh, 7) Freel Peak Cushion Plant Community, and 8) Pope Marsh.

Type of Standard – Numerical (without numerical target)

Indicator (Unit of Measure) –Three indicators are used to assess the status of deepwater plant communities:
1) absolute and relative plant composition determined from (plant dry mass per unit area), 2) plant community production measured using change in dissolved oxygen with incubations in the laboratory, and 3) the depth and spatial extent of plant beds on the lake bottom as determined by divers.

Human & Environmental Drivers – Human and environmental drivers of distribution and abundance of deep water plants are likely the same as those driving cultural eutrophication and changes in water transparency in the lake (i.e. suspended particles, atmospheric deposition, nutrient loading, urban development, and local/regional climate change). The introduction of nonnative species including mysid shrimp, warmwater fish, signal crayfish densities may drive plant bed density through direct consumption of plant material. Basic monitoring and research that experimentally moves plants from one location to another in the lake (e.g. plug and grow) and studies focused on understanding light

limitation and endemic invertebrate life history association with plants is needed to quantify the dominant controls on deepwater plants.

MONITORING AND ANALYSIS

Monitoring Partners – University of Nevada, Reno and TRPA~~TPRA~~.

Monitoring Approach – The data used in this assessment was collected in 2008, 2009 and 2013 in an attempt to find endemic invertebrates and the deep water plants they depend on. Divers investigated the spatial extent and depth profiles of the only two known beds at Camp Richardson and the South Shore Mound during the 2013 survey. Routine monitoring is not currently underway for this indicator.

Analytic Approach – No trend can be assessed as only a baseline exists and monitoring is not currently underway for this indicator.

INDICATOR STATE

Status – Technically unknown or unknowable due to insufficient data. Likely considerably worse than target. In the most recent survey the deepwater plant communities were not found in the many areas of the lake they historically occupied. The standard is a nondegradation standard, so the absence of plants in areas inside their historical range suggests there has been degradation. When the standard was adopted in 1982 the most recent extensive survey of the deepwater plants in Lake Tahoe was already over 15 years old (Frantz and Cordone, 1967). Because no baseline was established at the time the standard was adopted it is impossible to say at what point in the last 50 years the decline of deepwater plants occurred or if declines are continuing today.

Trend – Insufficient data to determine trend. Due to limited sampling, there is insufficient data to determine trend. However, the magnitude of decline observed between the two sampling events is abnormally large for deepwater aquatic plant communities that generally have relatively stable population dynamics. Although the magnitude of decline cannot be accurately quantified because no estimates of biomass are available from the earliest surveys, the spatial extent of community decline suggests that there has been a rapid decline in the deep-water plant species over the last 40 years (Caires et al., 2013).

Confidence –

Status – Moderate. Regular samples have not been collected during the evaluation period. As a result, it is not possible to differentiate those changes that may be expected as result of natural population dynamics from those that are the result of external disturbance.

Trend – Low. No trend assessment can be completed at this time because only two samples are available. However, the magnitude of decline observed between the two sampling events is abnormally large for deep-water aquatic plant communities that generally have relatively stable population dynamics (Caires et al., 2013).

Overall – Low. Overall confidence takes the lower of the two confidence levels.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The factors driving the observed decline are not well understood, so it is difficult to say what actions are needed to improve conditions. Actions taken to improve water transparency are also likely to improve conditions for deep water plant bed spatial and depth extent.

Effectiveness of Programs and Actions – Cannot be evaluated at this time because of insufficient information on what is causing the observed decline.

Interim Target – There is insufficient information to establish an interim target at this time.

Target Attainment Date – There is insufficient information to establish a target attainment date.

RECOMMENDATIONS
Analytic Approach – No changes recommended. **Monitoring Approach –** At present there is no regular monitoring of deepwater plant communities. Monitoring of existing beds at regular intervals could provide useful information about the status and trend of known deepwater plant communities. In addition to regular surveys of known beds, a comprehensive survey of the lake between 30-50 meters in depth would ensure all populations are catalogued. Monitoring at fixed intervals within in a single growing season would provide additional information on the ecology of the communities to inform management. **Modification of the Threshold Standard or Indicator –** No baseline has been established against which the nondegradation of the community standard can be objectively evaluated. Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management. The endemic invertebrate species commonly associated with deepwater plant communities have precipitously declined. While the species are associated with the deepwater plant communities, reversing the decline or increasing the density of deepwater plants may not be sufficient to improve outcomes for endemic invertebrates. Consideration should be given to what goals and objectives are feasible for the endemic invertebrates. **Attain or Maintain Threshold** – Removal of crayfish in the lake may support increases in spatial and depth extent of deep water plant beds.

Uncommon Plant Communities: **Upper Truckee Marsh**

Status	Trend
 **UPPER TRUCKEE MARSH** Status: **Somewhat Worse than Target** Trend: **Little or No Change** Confidence: **Low**	 **Photo 1**: Trout Creek in the Upper Truckee Marsh. Desired condition. (Source: Marchel Munnecke, Pyramid Botanical Consultants)
Map	**Photo 2:** Upper Truckee River in the Upper Truckee Marsh. Degraded condition as evidenced by bank erosion, channel incision, and channel straightening (Source: Marchel Munnecke, Pyramid Botanical Consultants). 
 Upper Truckee Marsh as identified in previous threshold evaluation reportss. South Lake Tahoe, California	  **Photos 3 and 4**: Google Earth images of the Upper Truckee Marsh in December 1940 (left) and in April 2015 (Right). The yellow polygon (512 acres) is the approx. area of the Upper Truckee River and Marsh Restoration Project recently approved for restoration by the California Tahoe Conservancy (Conservancy) and TRPA. Detailed restoration design is underway.

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Data Evaluation and Interpretation
BACKGROUND
Relevance –The Upper Truckee Marsh is one of the largest meadow-wetland complexes in the Sierra Nevada, with over 500 acres in its present state. Development of the Tahoe Keys in the 1960s reduced the area of the wetland to less than half of its former size and more directly channeled the path of the Upper Truckee River to Lake Tahoe (Aecom and Cardno ENTRIX 2013), which degraded the stream and meadow. The Upper Truckee Marsh includes the mouth of the Upper Truckee River as it flows into Lake Tahoe in South Lake Tahoe just east of the Tahoe Keys. The confluence of the Upper Truckee River and Trout Creek is just upstream from Lake Tahoe within the marsh. The nearly level marsh and its proximity to Lake Tahoe reduce the hydraulic gradient and allow for long periods of soil inundation and saturation in a large portion of the meadow. Because of the low slopes and the wide delta flat, the natural channel morphology across the meadow is a braided and meandering network of channels. Prolonged high water tables support dense and productive sedge and willow communities, and aquatic plant communities exist in pools and ponds. These communities provide valuable habitat for a variety of birds, amphibians, fish, invertebrates, and other species. Since the Upper Truckee Marsh is at the most downstream reach of the Upper Truckee River and Trout Creek, it responds to disturbances upstream, and its status and trends also reflect the conditions of the upper watersheds. Extensive sandy beach deposits at the margin of Lake Tahoe support a robust population of the endangered Tahoe yellow cress (*Rorippa subumbellata*), which is a TRPA listed sensitive plant species (Stanton and Pavlik 2010). Freshwater marshes are one of the most productive ecosystems in the Tahoe Region and have been identified in the Tahoe Science Plan as special communities, which are small in extent but have great functional importance (Manley et al. 2010a). The Upper Truckee River drains the largest watershed in the Lake Tahoe Region, and the condition of the Upper Truckee Marsh is associated with several other TRPA threshold categories including water quality, wildlife, soil conservation, sensitive environmental zones, and fisheries. Water quality is affected by stream bank erosion and sediment delivery from upstream erosion. A properly functioning stream system would allow for the dispersal and retention of sediments across these floodplains, and increase water quality. The marsh plays an important role in storing carbon and nitrogen, recycling nutrients, maintaining stream banks, and filtering pollutants. However, due to urban runoff and delivery of fine sediments to the stream and deeply incised channels with high rates of bank erosion, the Upper Truckee River is the single largest source of suspended sediment entering Lake Tahoe (TERC 2015). Many species of wildlife are dependent on the diversity of wetland plant communities, and the long duration of saturation and ponded conditions in the marsh. Ponded conditions provide an important buffer from recreational hikers and dogs, which are deterred from entering the saturated marsh, but may hike further into the marsh during drought conditions and disturb wildlife (TRPA 2016). Saturated, anaerobic meadow soils have a very high density of soil carbon and nitrogen; however, drying of these meadows allows for the decomposition of organic matter, and a decline in carbon and nitrogen density (Norton et al. 2011). A properly functioning wet meadow has at least twice the carbon, nitrogen, dissolved organic carbon, and dissolved organic nitrogen as a nonfunctioning meadow (Norton et al. 2011). Increasing carbon sequestration reduces the amount of carbon released to the atmosphere, reducing greenhouse gasses. Restoration plans are in progress for the Upper Truckee Marsh, and a robust, integrated, monitoring plan will improve our understanding of these marsh systems. **TRPA Threshold Category** – Vegetation **TRPA Threshold Indicator Reporting Category** – Uncommon plant communities **Adopted Standards** – Provide for the nondegradation of the natural qualities of any plant community that is uncommon to the Region or of exceptional scientific, ecological, or scenic value. The threshold standard shall apply, but not be limited to, 1) deep-water plants of Lake Tahoe, 2) Grass Lake, 3) Osgood Swamp, 4) Hell Hole, 5) Upper Truckee Marsh, 6) Taylor Creek Marsh, 7) Freel Peak Cushion Plant Community, and 8) Pope Marsh.

Type of Standard – Numerical (without numerical target)

Indicator (Unit of Measure) – The status and trend determination was based on a qualitative assessment of the natural qualities of a plant community. The natural qualities of a plant community include the current plant species assemblage, the health, age, and ecological condition of those plant species, and the condition of the hydrologic regime.

Human & Environmental Drivers – During the mid-1800s approximately 80 percent of the forests in Tahoe were clear-cut during the Comstock era (Elliott-Fisk et al. 1996). Virtually all meadows in the Lake Tahoe Region were heavily grazed by cattle and sheep, and there were over 13 dairy farms around the lake. Most meadows were fenced for cattle grazing, while sheep roamed the mountains and denuded much of the forbs and grasses (Elliott-Fisk et al. 1996). Livestock may have affected the present composition of vegetation by selectively grazing palatable species and trampling susceptible species. Grazing can affect channel morphology by removing bank stabilizing vegetation such as willows, and by trampling stream banks when accessing the stream.

The construction of the Lake Tahoe Dam between 1909 and 1913 raised the water level of the lake by a maximum of six feet above the natural rim (6,223') (Aecom and Cardno ENTRIX 2013). High lake levels flood into the low marshes of the Upper Truckee, and low lake levels influence subsurface hydrology. The development of the Tahoe Keys in the 1960s straightened and confined the Upper Truckee River and altered the groundwater gradient, so that now groundwater flows west to the marina water level rather than to the north to Lake Tahoe (Aecom and Cardno ENTRIX 2013). The consequence of these and other hydrological changes in the Upper Truckee Marsh has been a lowering of the ground water table during dry years when lake levels are low, and the development of an incised unstable channel. Vegetation has shifted to drier upland species in many areas, and the area influenced by saturated conditions and frequent ponding and flooding has decreased.

Upstream, the Upper Truckee River was straightened by eliminating meander loops in the Washoe Meadows in the 1930s and for construction of the Tahoe Airport in in the 1960s (Purdy et al. 2014). Undersized bridges confine the Upper Truckee River within the Washoe Meadows golf course, and the Upper Truckee River is confined as it passes under the U.S. Highway 50 bridge in South Lake Tahoe, causing channel incision and bank erosion that has lasting effects downstream (Purdy et al. 2014). Upstream channel deterioration affects the Upper Truckee Marsh by increasing sediment loads and influencing channel morphology.

Several channel restoration projects are in progress or have been implemented on the lower reaches of the Upper Truckee River from Christmas Valley to the Upper Truckee Marsh. The airport reach restoration was completed in 2011 by the City of South Lake Tahoe. Middle Reaches 1 and 2, Sunset Reaches 5 and 6, and the golf course reach are under construction or in planning (2ndNature 2014). In 2001, a channel reconstruction project was completed on Trout Creek, which reconstructed approximately 3.5 miles of channel and restored 107 acres of meadow (2ndNature 2010, CTC 2016). The California Tahoe Conservancy (Conservancy) removed 84,000 yards of fill by the Tahoe Keys Marina in 2001 during the Lower West Side Restoration project that expanded the floodplain area near the mouth of the Upper Truckee River (Stuart Roll, pers. comm). On December 18, 2015, the Conservancy Board approved Alternative 3 (the middle marsh corridor) restoration plan for the 500-acre Upper Truckee River Restoration project.

As with other wetlands, extended drought and climate change pose a threat to the system. Recent California based climate models predict a nine-degree Fahrenheit increase in temperature by 2100, and more conservative models predict a two- to four-degree Fahrenheit increase in winter and four- to eight-degree increase in summer (Safford et al., 2012a). Models are more variable for precipitation, but recent models for the Sierra Nevada predict similar to slightly less precipitation. Most models predict drier summer conditions, since more of the precipitation is predicted to come as rain, and snow melt will occur earlier in spring (Hayhoe et al. 2004, Dettinger 2005, Safford et al. 2012, Drexler et al. 2013). In the Lake

Tahoe Region, these changes appear to be happening at an accelerated pace (Coats 2010). Changes in precipitation and the timing of snow melt will likely result in decreased stream flow and increased stream temperatures in the summer and fall (Purdy et al. 2014). Many cold water fishes are vulnerable to increased stream temperatures, and unsuitably warm temperatures have already been recorded in the Upper Truckee River (Purdy et al. 2014). Increased canopy can shade stream channels and help maintain cooler steam temperatures. Climate change may create larger or more frequent flood events if more precipitation comes as rain instead of snow. Properly functioning streams are more resilient to these changes. Prolonged drought can lower water tables in the meadows, decreasing overall biomass production and can cause a decline in sensitive, obligate wetland species (Rejmankova et al. 1999).

MONITORING AND ANALYSIS

Monitoring Partners – California Tahoe Conservancy, U.S. Forest Service Lake Tahoe Basin Management Unit, United States Geologic Survey.

Monitoring Approach – The status and trend determinations were based on a qualitative assessment of factors influencing the condition of the site, including historical alterations, ongoing hydrologic impacts, sources of recreation-related disturbance, and surrounding land use and management. Two long term meadow monitoring plots were installed in the Upper Truckee Marsh in 2014, following the protocol in the U.S. Forest Service Region 5 Range Monitoring Program (Weixelman 2011). The protocol is designed to classify a meadow according to wetland index and plant functional types, which provides a quantitative ecological condition scorecard for that meadow type (Weixelman and Gross In Review). Distance to meadow edge, distance to stream channel, degree of channel incision, and evidence of Sierra lodgepole pine (*Pinus contorta* var. *murrayana*) encroachment data is collected at each transect. This data has been collected but the analysis methods are currently in the peer review process, and are expected to be publicly available by September 2016.

Initial monitoring surveys have been completed by the Conservancy to establish a baseline from which to assess the effectiveness of restoration work, but these do not provide the information necessary to retrospectively assess changes in the natural qualities of the plant community. The long-term monitoring design for the Upper Truckee Marsh restoration project is under development. Initial data includes channel measurements, water quality monitoring (turbidity and discharge), water table monitoring, vegetation mapping based on infrared satellite imagery using the normalized difference vegetation index (NDVI), and wildlife surveys. Fish surveys, benthic macroinvertebrate, and aquatic habitat monitoring exist for the lower 10 miles of the Upper Truckee River.

Analytic Approach – Qualitative assessment of factors influencing the condition of the Marsh.

INDICATOR STATE

Status –Somewhat worse than target. The Upper Truckee Marsh is a highly disturbed system, as described previously. Despite these disturbances, the Upper Truckee Marsh remains a unique and productive ecosystem in the Lake Tahoe Region. Trout Creek, on the eastern side of the marsh, has high functioning areas with floodplain connectivity, high water tables, and high production of rhizomatous sedges and willows. By contrast, the Upper Truckee River on the west side, is confined within a deeply incised channel due to channel confinement by the Tahoe Keys and channel constriction from the U.S. Highway 50 bridge (Purdy et al. 2014). The Upper Truckee Marsh is also impacted by upstream channel erosion and sediments. Although it is not possible to quantitatively assess the degree of degradation without data regarding desired reference conditions, it is evident that the marsh has not achieved its desired condition. Therefore, the status of the Upper Truckee Marsh is considered to be somewhat worse than target.

Trend –Little to no change. The 2011 Threshold Evaluation Report considered the Upper Truckee Marsh to be somewhat worse than target. There is no quantitative evidence available indicating there has been any particular decline or improvement in the condition of the marsh over the last five years. Due to the lack of quantitative evidence indicating an improvement or decline in the condition of the Upper Truckee Marsh, the trend was assessed as little or no change. Aerial photo analysis suggests an improvement in

vegetation including willow abundance following the cessation of grazing on the site.

Confidence – Low. Confidence in the status and trend analysis is low because both determinations were based on a qualitative assessment of the hydrological condition, resource management actions, and surrounding land uses, and was not supported by sufficient quantitative data.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA and partners protect stream environment zones and uncommon plant communities through a suite of regulations and SEZ restoration is a focus of the EIP. Anthropogenic activities known to impact these areas are prohibited. The Conservancy acquired over 500 acres of the Upper Truckee Marsh between 1988 and 2002, eliminated grazing, and installed a beach enclosure for Tahoe yellow cress. Beginning in 2001, the Conservancy has had an Upper Truckee Marsh land steward on patrol in the summer months to educate users about the sensitive resources in the marsh; encouraging users to observe the Tahoe yellow cress enclosure, remain on the main trails of the property, and keep their dogs leashed at all times. A seasonal dog ban on over 300 acres of the marsh from May 1 through July 31 was initiated in 2011 to protect wildlife and water quality during spring runoff. In 2010, encroaching conifers were removed from a portion of the marsh. A partnership of federal, state, local agencies, and stakeholders, are coordinating restoration efforts through the Upper Truckee River Watershed Advisory group. On December 18, 2015 the Conservancy board approved Alternative 3 (the middle marsh corridor) restoration plan for the 500-acre Upper Truckee River Restoration project, and anticipates starting on the ground restoration in 2019 (CTC 2016). The TRPA Governing Board certified the EIS for the Conservancy project to restore the Upper Truckee Marsh in February 2016. Alternative 3 will fill the current incised Truckee River channel and redirect flow to a system of braided channels in the middle of the meadow (Aecom and ENTRIX, 2013).

Additional project work has targeted the watersheds feeding the marsh. Since 2008, eight restoration projects have been completed in the tributaries of the marsh (see Table 1).

***Table 1**: Restoration projects completed since 2008 in the tributaries of the Upper Truckee Marsh*

EIP Project Number	Project Name	Lead Implementer	Year
01.02.01.0013	Angora Fire: Gardner Mountain Meadow Restoration	U.S. Forest Service - Lake Tahoe Region Management Unit	2014
01.02.01.0015	High Meadows/Cold Creek Restoration	U.S. Forest Service - Lake Tahoe Region Management Unit	2014
01.02.01.0025	Upper Truckee River Angora Sub-Watershed Restoration and Sediment Control Project	California Department of Parks and Recreation	2014
01.02.01.0024	Upper Truckee River Restoration Project - Airport SEZ Restoration (Reaches 3 and 4)	City of South Lake Tahoe	2012
01.02.01.0020	Angora Creek Fisheries/SEZ Enhancement Project	El Dorado County	2010
01.02.01.0016	Taylor, Tallac, and Spring Creek Watershed Ecosystem NEPA and Restoration Plan	U.S. Forest Service - Lake Tahoe Region Management Unit	2009
01.02.01.0021	Erie Circle Stream Environment Zone	California Tahoe Conservancy	2009
01.02.01.0029	Cold Creek Fisheries Enhancement Project	El Dorado County	2008

Effectiveness of Programs and Actions –The Land Steward Program has been effective in increasing dog leash compliance and reducing incursions into sensitive areas, including the Tahoe yellow cress enclosure. Annual bird surveys completed by the Conservancy indicate an increase in bird diversity,

potentially associated with the dog ban (Stuart Roll, pers. comm.). More information is needed to objectively evaluate the effectiveness of other actions that have been implemented.

Interim Target – It is not possible to set a numerical interim target until additional monitoring data are available to gauge the status and trend of the site.

Target Attainment Date – 2023 Threshold Evaluation Report. The Upper Truckee Marsh restoration project is expected to be a three- to four-year project with construction activities between 2019 to 2023 and monitoring to continue thereafter.

RECOMMENDATIONS

Analytic Approach – The U.S. Forest Service meadow monitoring plots will provide a standardized quantitative measure of meadow health and long term trends. The longer term analytical approach for the Upper Truckee Marsh restoration project is under development. Remotely sensed imagery integrated with on the ground surveys could provide a cost-effective way to assess trends in plant communities.

Monitoring Approach – Coordination of multiple monitoring regimes in and around the Upper Truckee Marsh is essential to promoting better understanding of the system and actions taken to manage it. TRPA will continue to collaborate in the design of the long-term monitoring protocol for the Upper Truckee Marsh Restoration project. Development of a comprehensive database to store information collected as part of the various monitoring regimes, including channel morphology, water quality, vegetation communities, fish, benthic macroinvertebrates, would facilitate data analysis.

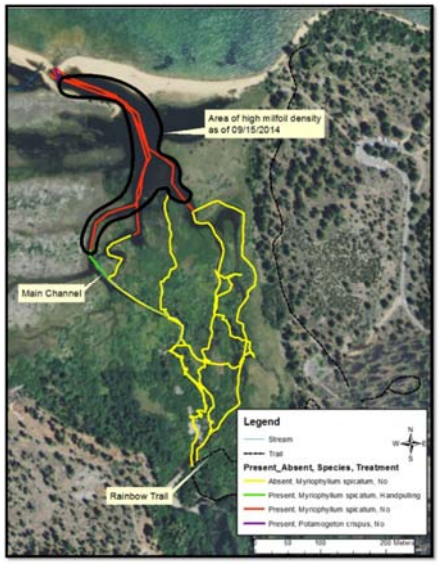
Agencies monitor and report on different cycles. Threshold reporting is on a four-year cycle, the LTBMU is monitoring vegetation plots on a five-year cycle, and the Conservancy has annual monitoring planned. Synchronization would be beneficial. Web-based reporting in the future will enable more continuous reporting and data analysis.

~~**Analytic Approach** – The U.S. Forest Service meadow monitoring plots will provide a standardized quantitative measure of meadow health and long term trends. The longer term analytical approach for the Upper Truckee Marsh restoration project is under development. Remotely sensed imagery integrated with on the ground surveys could provide a cost effective way to assess trends in plant communities.~~

Modification of the Threshold Standard or Indicator – No baseline has been established against which the nondegradation of the community standard can be objectively evaluated. Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – The Conservancy-led project will restore 500 acres of the Upper Truckee Marsh and 10,000 feet of the Upper Truckee River. The project aims to restore natural and self-sustaining river and floodplain processes and functions that will contribute significantly to attainment of this threshold standard. The project will also result in threshold benefits in a number of threshold categories including water quality, soil conservation, wildlife, fisheries, and recreation.

Uncommon Plant Communities: **Taylor Creek Marsh**

Status	Photos
 **TAYLOR CREEK MARSH** Status: **Insufficient Data to Determine Status** Trend: **Insufficient Data to Determine Trend** Confidence: **Low**	 **Photo 1:** Distribution of Eurasian water milfoil and curly leaf pondweed in Sept. 2015. Source: USFS, LTBMU
Map  Map showing location of Taylor Creek Marsh and surrounding area.	 **Photo 2:** Mouth of Taylor Creek, June 7, 2013. Source: Marchel Munnecke, Pyramid Botanical Consultants.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Taylor Creek Marsh covers more than 250 acres adjacent to the U.S. Forest Service Baldwin Beach and Kiva Beach on the South Shore of Lake Tahoe, and the drainage area of Taylor Creek. The

creek mouth supports a robust population of Tahoe yellow cress (*Rorippa subumbellata*). The nearly level marsh and its proximity to Lake Tahoe reduce the hydraulic gradient and allow for long periods of soil inundation and saturation in a large portion of the meadow. Low slopes, a wide alluvial flat, and beaver influence means there are several side channels with channel avulsion events. Prolonged high water tables support dense and productive sedge and willow communities.

Taylor Creek Marsh provides important waterfowl nesting habitat, habitat for bald eagles, and supports a multitude of other species, including some that depend on the marsh for their entire life cycle (Manley et al. 2010a). The Taylor and adjacent Tallac Creek areas historically provided habitat for Sierra Nevada yellow-legged frog, an endangered species under the Endangered Species Act (LTBMU 2014). The area is also the only occupied nesting habitat in the Tahoe Region for the willow flycatcher, a species listed as sensitive by the U.S. Forest Service (LTBMU, 2014). Freshwater marshes are one of the most productive ecosystems in the Region and have been identified in the Tahoe Science Plan (Manley et al. 2010a) as special communities which are small in extent but have great functional importance.

The condition of the Taylor Marsh is associated with several other TRPA threshold categories including water quality, wildlife, soil conservation, sensitive environmental zones, fisheries, and recreation. The marsh system plays an important role in storing carbon and nitrogen, recycling nutrients, and filtering pollutants. In addition, wetland vegetation stabilizes streambanks, and provides canopy shade, maintaining cooler stream temperatures. Saturated, anaerobic meadow soils have a very high density of soil carbon and nitrogen; however, drying of these meadows allows for the decomposition of organic matter, and a decline in carbon and nitrogen density (Norton et al. 2011). A properly functioning wet meadow has at least twice the carbon, nitrogen, dissolved organic carbon, and dissolved organic nitrogen of a nonfunctioning meadow (Norton et al. 2011).

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Uncommon plant communities

Adopted Standards – Provide for the nondegradation of the natural qualities of any plant community that are uncommon to the Region, or of exceptional scientific, ecological, or scenic value. The threshold standard shall apply, but not be limited to, 1) the deep-water plants of Lake Tahoe, 2) Grass Lake, 3) Osgood Swamp, 4) Hell Hole, 5) Upper Truckee Marsh, 6) Taylor Creek Marsh, 7) Freel Peak Cushion Plant Community, and 8) Pope Marsh.

Type of Standard – Numerical (without numerical target)

Indicator (Unit of Measure) – The status and trend determination was based on a qualitative assessment of the natural qualities of a plant community. The natural qualities of a plant community include the current plant species assemblage, the health, age and ecological condition of those plant species, and the condition of the hydrologic regime.

Human & Environmental Drivers – The Taylor Creek Marsh is not subject to any of the main activities that generally threaten wetlands in the Sierra Nevada including road and trail construction, livestock trampling, off-road vehicles, marina development, and ground and surface water pumping, although water pollution from the state highway may be a concern (Manley et al. 2000). Recreation impacts from user-created trails and dogs in the vicinity of the Taylor Creek Visitor Center at Taylor Creek Marsh exist and are not likely to be removed in the future (Engelhardt and Gross 2011b). Lake level, stream flow, and shoreline processes interact in conjunction with wave action to dictate the opening and closing of the sandbars across the mouth of Taylor and Tallac Creeks. In low water years, the barrier beach is sometimes artificially breached to facilitate kokanee salmon spawning in late summer and fall. A dam at Fallen Leaf Lake regulates flows to Taylor Creek. Historically, Tallac Creek flowed into Taylor Marsh via a series of swales that contour the shoreline of Lake Tahoe (LTBMU 2014). These swales are currently blocked by the road to the Baldwin Beach parking lot. A restoration plan is in progress. It aims to reconnect Tallac Creek to Taylor Creek by diverting channel flow and removing obstructions in the swales (LTBMU, 2014).

Similar to other wetlands, extended drought and climate change pose a threat to the system. Recent California based climate models predict a nine-degree Fahrenheit increase in temperature by 2100, and more conservative models predict a two to four-degree Fahrenheit increase in winter and four to eight-degree increase in summer (Safford et al., 2012a). Models are more variable for precipitation, but recent models for the Sierra Nevada predict similar to slightly less precipitation. Most models predict drier summer conditions, since more of the precipitation is predicted to come as rain, and snow melt-off will occur earlier in spring (Hayhoe et al. 2004, Dettinger 2005, Safford et al. 2012, Drexler et al. 2013). In the Lake Tahoe Region, these changes appear to be happening at an accelerated pace (Coats 2010). These changes will likely result in decreased stream flow and increased stream temperatures in the summer and fall (Purdy et al. 2014). Many cold water fishes are vulnerable to increased stream temperatures (Purdy et al. 2014). Climate change may create larger or more frequent flood events if more precipitation comes as rain instead of snow. Properly functioning streams are more resilient to these changes. Prolonged drought can lower water tables in the meadows, increasing the area dominated by drier upland grasses and forbs, and reduce the presence of less resistant and resilient obligate wetland plants (Rejmankova et al. 1999).

Beaver activity is substantial in the Taylor Creek Marsh. Beavers were once thought to be non-native to the Sierra Nevada, but carbon dating of old beaver dams has shown that beavers have been in the Sierra Nevada since AD 580 (James and Lanman 2012, Lanman et al. 2012). Beaver trapping eliminated beavers from the higher Sierra Nevada by the mid-1800s. Beavers were reintroduced into the Upper Truckee River in the Lake Tahoe Region in 1938 (Tappe 1942). Other introductions may have occurred. Since then populations have expanded to many watersheds around Lake Tahoe (Beier and Barrett 1987). Beaver dams help maintain high water tables and increase flood frequency and extent of flooding across the floodplain, allowing for greater sediment and nutrient deposition (EDAW 2005). Beaver influenced habitat can increase small mammal populations, and bird density and richness (EDAW, 2005).

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service Lake Tahoe Basin Management Unit

Monitoring Approach – The status and trend determinations were based on a qualitative assessment of factors influencing the condition of the site including historical alterations, ongoing hydrologic impacts, sources of recreation-related disturbance, and surrounding land use and management. One permanent plot, following the protocol in the Region 5 Range Monitoring Program, was installed at Taylor Creek Marsh in 2004 (Weixelman 2011). Two plots were installed in 2004 in the adjacent Tallac Creek Meadow. The protocol is designed to classify a meadow according to wetland index and plant functional types, which provides a quantitative ecological condition scorecard for that meadow type (Weixelman and Gross In Review). The plots were re-visited in 2009/2010 and 2014/2015 but the data is not yet available (Engelhardt and Gross 2011b).

Analytic Approach –Qualitative assessment of factors influencing the condition of the marsh.

INDICATOR STATE

Status – Insufficient data to determine status. Taylor Creek Marsh is adjacent to Baldwin Beach and Kiva Beach, which receive moderate to high levels of recreational use in the summer months. Most of the use is concentrated on the beaches themselves and the area around the U.S. Forest Service Taylor Creek Visitor Center east of the marsh. The visitor center includes a paved trail through the marsh, numerous user trails, and a stream profile viewing chamber on Taylor Creek. A road to the beach parking lots bisects the entire complex, and disconnects the historic stream flow from Tallac Creek to Taylor Creek. A fire burned through a portion of the site in 2002 and the burned area has since supported one of the largest infestations of invasive bull thistle (*Cirsium vulgare*) on National Forest lands in the Lake Tahoe Region. St. John's wort, (*Hypericum perforatum*), another noxious weed species, has also established in wetter unburned areas. The U.S. Forest Service is monitoring these infestations and removing bull thistle and St John's wort by hand when possible. The invasive Eurasian watermilfoil (*Myriophyllum spicatum*) is present in the mouths of both Taylor and Tallac Creeks, and curly-leaf Pondweed (*Potamogeton crispus*) was recently found in the mouth of Taylor Creek (LTBMU, 2015). In 2013, an attempt to hand

pull Eurasian watermilfoil proved to be detrimental, as the population expanded substantially after treatment (LTBMU 2015). Eurasian watermilfoil can re-establish from fragments or pieces of plant left behind during hand pulling. Future eradication methods might include using bottom barriers, diver assisted removal, suction dredging, or a combination. Eurasian watermilfoil alters the aquatic ecosystem by increasing stream temperatures, dissolved oxygen, and nutrients, and converts the stream bottom substrate from sandy material to a silty-mucky material. These alterations create a habitat conducive for many non-native warm water fishes, such as brown bullhead, bluegill, and largemouth bass, as well as the large non-native American bullfrog (Sarah Muskopf, pers. comm.). These species are already present in the warm waters of the marshes and swales. Dogs, which may harass wildlife, trample vegetation, and add unwanted nutrients to the system, are prohibited at Baldwin Beach, but are allowed on leash at areas accessed by the Taylor Creek Visitor Center. Along the beach, portions of the Tahoe yellow cress populations have been fenced, beginning as early as the 1980s, and these enclosures have continually supported robust numbers of plants (Stanton and Pavlik 2010).

Management actions to control invasive weed spread, direct recreational use, and reduce fuel loads, fire risk, and hazardous dead trees have been implemented, but the area of Eurasian milfoil has substantially increased. A benthic macroinvertebrate (BMI) assessment in 2004 concluded that Tallac and Taylor Creek had some of the lowest Tahoe Region multimetric index (MMI) ratings among the creeks surveyed (Fore 2007). These results likely indicate a negative response to human disturbance. No additional BMI assessments have been completed for these watersheds since this survey, but the results indicate poor habitat or stream conditions, or that the MMI index is not appropriate for marsh systems, which naturally have different habitat potential than higher gradient stream systems, with courser channel substrate or more riparian shrub canopy. There are impacts from recreation in limited portions of the marsh complex.

Trend – Insufficient data to determine trend. Due to the presence and substantial increase of invasive species -- Eurasian milfoil, curly leaf pondweed, non-native warm water fishes, and the American bullfrog (LTBMU, 2015) -- the aquatic area near the mouth of the creek might be in moderate decline.

Confidence –

Status – Low. Where insufficient data is available to determine status the confidence is determined to be low.
Trend – Low. Where insufficient data is available to determine trend the confidence is determined to be low.
Overall – Low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA and partners implement regulations and programs related to the protection of stream environment zones and uncommon plant communities. Anthropogenic activities known to impact these areas are prohibited. The U.S. Forest Service has a restoration plan in progress for Taylor, Tallac and Spring Creek Watersheds. The AIS prevention program is designed to prevent new invasives from being introduced to the Lake and the AIS Control program implements actions to remove AIS from the system.

Effectiveness of Programs and Actions – Current regulations and protection measures appear effective. Projects to control invasive species have met with mixed results. In 2013, an attempt to hand pull Eurasian watermilfoil proved to be detrimental, as the population expanded substantially after treatment (LTBMU 2015). Eurasian watermilfoil can re-establish from fragments or pieces of plant left behind during hand pulling. Alternative eradication methods might include using bottom barriers, diver assisted removal, suction dredging, or a combination. The effectiveness of methods to control invasive plants is being studied and is the subject of a continuous adaptive management regime (Wittmann and Chandra, 2015). Tallac meadow has seen positive vegetative response since grazing pressure has been removed in 2008 (Sarah Muskopf, pers. comm.).

Interim Target – Insufficient data is available at this time to establish and interim target.

Target Attainment Date – Not applicable.

RECOMMENDATIONS

Analytic Approach – Data from the U.S. Forest Service long term meadow monitoring plots are expected to provide a standardized quantitative measure of meadow health and long term trends. Coordination in the analysis of long term data and data gathered as part of the planning and implementation of the restoration could provide a more robust view of community condition.

Agencies monitor and report on different cycles. Threshold reporting is on a four-year cycle, and the LTBMU is monitoring vegetation plots on a five-year cycle. Synchronization would be beneficial. Web-based reporting in the future will enable more continuous reporting and data analysis.

Monitoring Approach - TRPA will continue to be involved with the design of the Tallac and Taylor Creek long term monitoring plan.

Modification of the Threshold Standard or Indicator – No baseline has been established against which the nondegradation of the community standard can be objectively evaluated. Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management. Threshold review should consider expanding the area to include Tallac Creek based on the historic hydrologic connectivity and the planned restoration project, which will reconnect these streams.

Attain or Maintain Threshold – The LTBMU is evaluating plans to restore the Taylor-Tallac meadow and wetland complex (EDAW, 2005; LTBMU, 2014; Muskopf et al., 2009). The planned restoration will restore or enhance 250 acres of SEZ.

Uncommon Plant Communities: **Pope Marsh**

Status	Photos

POPE MARSH

Status: **Insufficient Data to Determine Status**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**

Map

Location of Pope Marsh and surrounding area.

Photo 1: Northern Pope Marsh, May 28, 2013. Source: Alice Miller, Pyramid Botanical Consultants.

Photo 2: Southern Pope Marsh, May 28, 2013. Source: Alice Miller, Pyramid Botanical Consultants.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Pope Marsh occupies roughly 1,500 acres adjacent to the City of South Lake Tahoe, and is managed by U.S. Forest Service Lake Tahoe Basin Management Unit (LTBMU). It was formerly part of the wetland complex at the mouth of the Upper Truckee River, but development of the Tahoe Keys in the 1960s isolated Pope Marsh from the Upper Truckee River and dramatically reduced the size of what was the largest freshwater marsh and meadow complex in the Sierra Nevada (Manley et al. 2000). Pope Marsh is now dependent primarily on rain, snowmelt, and underground flow from Lake Tahoe for its water (Green 1991). Meadows, marshes, and fens have been identified in the Tahoe Science Plan (Manley et al., 2010) as special communities that are small in extent but have great functional importance. Wetland vegetation plays an important role in recycling nutrients, trapping eroding soil, and filtering pollutants (Manley et al. 2000). This filtration capacity is critically important to protect the clarity of Lake Tahoe. Pope Marsh also provides important habitat for numerous species, including waterfowl nesting habitat.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Uncommon plant communities

Adopted Standards – Provide for the nondegradation of the natural qualities of any plant community that is uncommon to the Region or of exceptional scientific, ecological, or scenic value. The threshold standard shall apply, but not be limited to, 1) the deep-water plants of Lake Tahoe, 2) Grass Lake, 3) Osgood Swamp, 4) Hell Hole, 5) Upper Truckee Marsh, 6) Taylor Creek Marsh, 7) Freel Peak Cushion Plant Community, and 8) Pope Marsh.

Type of Standard – Numerical (without numerical target)

Indicator (Unit of Measure) – The status and trend determination was based on a qualitative assessment of the natural qualities of a plant community. The natural qualities of a plant community include the current plant species assemblage, the health, age and ecological condition of those plant species, and the condition of the hydrologic regime.

Human & Environmental Drivers – Pope Marsh was irreversibly altered by the development of the Tahoe Keys (Manley et al. 2000).Since then, human activities outside of the marsh (e.g. groundwater pumping, development, and management of lake water levels) impact hydrology within the marsh (Green 1991). The sandy beach deposits that divide Pope Marsh from Lake Tahoe allow for rapid groundwater flow; therefore, the northern portion of Pope Marsh fills and drains in relation to surface elevation of Lake Tahoe. When the level of Lake Tahoe is low, Pope Marsh drains and becomes dry. Based on the presence and depth of peat within Pope Marsh, it is theorized that historically Pope Marsh received water flow in late summer and fall, and sustained saturated conditions throughout the year even when the lake level of Lake Tahoe was lower (before the dam was built). The southern portion of Pope Marsh is less influenced by lake levels, and relies primarily on snowmelt and upland stream flow processes. These anthropogenic stresses on Pope Marsh increase sensitivity to naturally occurring stressors, and likely will initiate gradual changes in the plant community composition of the marsh, which could dramatically change the effectiveness of the marsh as a filter of nutrients and sediments (Green, 1991). In 2011, a high precipitation year, water from Pope Marsh breached the sand berm and flowed into Lake Tahoe. Other human impacts include the introduction of invasive plants, dogs, and some trampling from hiking and bicycling

Similar to other wetlands, extended drought and climate change pose a threat to the system. Recent California based climate models predict a nine-degree Fahrenheit increase in temperature by 2100, and more conservative models predict a two- to four-degree Fahrenheit increase in winter and four- to eight- degree Fahrenheit increase in summer (Safford et al., 2012a). Models are more variable for precipitation, but recent models for the Sierra Nevada predict similar to slightly less precipitation. Most models predict drier summer conditions, since more of the precipitation is predicted to come as rain, and snow melt-off will occur earlier in spring (Hayhoe et al. 2004, Dettinger 2005, Safford et al. 2012, Drexler et al. 2013). In the Lake Tahoe Region, these changes appear to be happening at an accelerated

pace (Coats 2010). These changes will likely result in decreased stream flow and increased stream temperatures in the summer and fall (Purdy et al. 2014). Climate change may create larger or more frequent flood events if more precipitation comes as rain instead of snow, but will create drier conditions in summer and fall due to lack of slow melting snow pack. Prolonged drought can lower water tables in meadows, increasing the area dominated by drier upland grasses and forbs, and reduce the presence of less resistant and resilient obligate wetland plants (Rejmankova et al. 1999). During the drought of 1988 to 1994, vegetation changes were monitored in Pope Marsh. The results revealed an overall decline in plant production, relative stability in the area dominated by sedge (*Carex* sp.) and rush (*Juncus* sp.) communities, and a decline in Rocky Mountain pond-lily (*Nuphar lutea* subsp. *polysepala*) and hardstem bulrush (*Schoenoplectus acutus*) communities. Most species recovered quickly after the drought, but hardstem bulrush did not. An increase in diversity was observed, as forbs such as common mare's tail (*Hippuris vulgaris*) and other ruderal terrestrial species established in dry pond margins (Rejmankova et al. 1999).

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service Lake Tahoe Basin Management Unit, California Native Plant Society.

Monitoring Approach – The status and trend determinations were based on a qualitative assessment of factors influencing the condition of the site, including historical alterations, ongoing hydrologic impacts, sources of recreation-related disturbance, and surrounding land use and resource management. However, in the future it will be possible to base the evaluation on quantitative vegetation monitoring data. Two permanent plots following the protocol in the Region 5 Range Monitoring Program were installed at Pope Marsh in 2004 (Weixelman 2011). These plots are on the north-east and north west portions of Pope Marsh. The protocol is designed to classify a meadow according to wetland index and plant functional types, which provides a quantitative ecological condition scorecard for that meadow type (Weixelman and Gross In Review). The plots were visited in 2009/2010 and 2014/2015 and the USFS is in the process of analyzing the data (Engelhardt and Gross 2011b; Shana Gross pers. comm.). Distance to meadow edge, distance to stream channel, degree of channel incision, and evidence of Sierra lodgepole pine (*Pinus contorta* var. *murrayana*) encroachment data is collected at each transect.

Analytic Approach – Qualitative assessment of factors influencing the condition of the site. The U.S. Forest Service analysis of meadow monitoring data collected in 2009 and 2014 is under review and unavailable for this assessment.

INDICATOR STATE

Status – Insufficient data to determine status. Pope Marsh is adjacent to Pope Beach, which is one of the most heavily used public recreation facilities at Lake Tahoe in the summer months. Most of the use is concentrated on the beach itself, but a long parking lot separates Pope Marsh from Lake Tahoe and culverts connect the beach area to the marsh. The main impacts to the marsh are related to recreation, including disturbance of vegetation and wildlife by dogs and some trampling from hiking and bicycling. A relatively large infestation of bull thistle (*Cirsium vulgare*) has been present at Pope Marsh for several years, and Eurasian watermilfoil (*Myriophyllum spicatum*) occurs in the standing water. Groundwater pumping from the Tahoe Keys potentially poses a threat to the hydrologic regime, and is likely leading to a gradual change in species composition (Green, 1991).

The potential for decline from increased recreational impacts or an increase in non-native species was noted (TRPA 2007). Management actions in the last five years have focused on facility improvements, hazard tree removal at Pope Beach, and control of known invasive plant populations at Pope Marsh. The location of the wetland in the urban core, and the associated urban run-off and invasive plant infestations suggest that the natural qualities of Pope Marsh are not as intact as more remote wetlands like Hell Hole or Meiss Meadows. Groundwater pumping from the Tahoe Keys is an ongoing threat to the integrity of the marsh plant community (Green 1991). The effects of the recent drought on Pope Marsh are unknown. There is no recent quantitative or qualitative data available, so the status of Pope Marsh is unknown.

Trend – Insufficient data to determine trend. The 2011 Threshold Evaluation Report considered Pope Marsh to be somewhat worse than target. No further evidence is available to indicate a change in the trend in the last four years.

Confidence –

Status – Low. Where insufficient data is available to determine status the confidence is determined to be low.
Trend – Low. Where insufficient data is available to determine trend the confidence is determined to be low.
Overall – Low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA and partners implement regulations and programs related to the protection of stream environment zones and uncommon plant communities. Anthropogenic activities known to impact these areas are prohibited.

Effectiveness of Programs and Actions – Current regulations and protection measures appear effective. However, additional work is needed to control noxious and aquatic weed infestations.

Interim Target – Insufficient data is available at this time to establish an~~d~~ interim target.

Target Attainment Date – Not applicable.

RECOMMENDATIONS

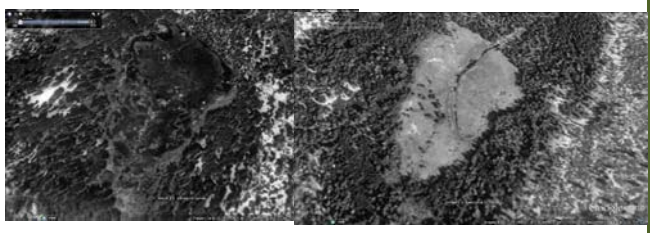
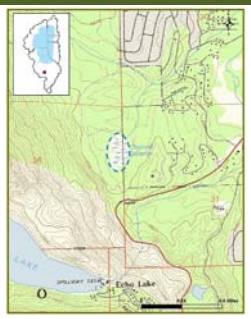
Analytic Approach – Data from the U.S. Forest Service long term meadow monitoring plots are expected to provide a standardized quantitative measure of meadow health and long term trends. Agencies monitor and report on different cycles. Threshold reporting is on a four-year cycle, and the LTBMU is monitoring vegetation plots on a five-year cycle. Synchronization would be beneficial. Web-based reporting in the future will enable more continuous reporting and data analysis.

Monitoring Approach – The U.S. Forest Service long term meadow plots are relevant to a limited area of the marsh. Consideration should be given additional monitoring in the southern area of Pope Marsh influenced by stream flow. One plot could be placed in the southern finger referred to in Green's 1991 study, and another in the broad sedge flats in the south central area (Green, 1991).

Modification of the Threshold Standard or Indicator – No baseline has been established against which the nondegradation of the community standard can be objectively evaluated. Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – TRPA and partners maintain several nondegradation standards supported by policies, regulations, and implementation programs that provide a framework for protecting wetlands and riparian areas within the Tahoe Region. Continue programs to control known invasive weed infestations and prevent new infestations.

Uncommon Plant Communities: **Osgood Swamp**

Status	Trend
 **OSGOOD SWAMP** Status: **Insufficient Data to Determine Status** Trend: **Insufficient Data to Determine Trend** Confidence: **Low**	 **Image 1**. December 1940 **Image 2**. August 1992  **Image 3**. June 2004 **Image 4**. April 2015 Images 1 through 4 are Google Earth historical images of Osgood swamp. Image 1. December 1940: In 1940, Osgood Swamp was a swamp, with observable channels, ponds, and different patches of wetland vegetation. Image 2. December 1992: By 1969, a ditch was constructed to drain the swamp, and a small dam may have been installed during this time. The images remain similar up to 1992. Vegetation appears to be predominantly drier meadow, and there are no signs of ponds. Image 3. June 2004: The entire meadow is flooded and the trees in the center and along the lake margin are dying, trees begin falling by 2007. A series of beaver dams are visible at the lake outlet, and their lodge appears to have been moved from near the outlet to the east side of the lake in 2010 or 2011, perhaps due to the high water year. Image 4. April 2015: Conditions remain similar from 2004 on, but there are periods of near drying and extreme flooding of the "swamp."
Map  Map showing location of Osgood Swamp and surrounding area.	

Data Evaluation and Interpretation

BACKGROUND

Relevance – Osgood Swamp is a lake located near the base of Echo Summit, adjacent to the town of Meyers. Two separate fen sites have been confirmed on the west and south sides of the swamp (Sikes et al., 2011). *Sphagnum* fens are peat-forming wetlands that form when stable hydric soils allow a rate of organic matter production that is greater than the rate of decomposition, which over millennia leads to an accumulation of peat (Patterson and Cooper 2007, Weixelman and Cooper 2009). In environments with low summer precipitation like the Sierra Nevada, fens are sustained by groundwater input rather than precipitation. They are important sites of groundwater discharge and may serve as indicators of

shallow aquifers (Cooper 1990).The conditions required for fens are very limited in mountain ecosystems, and fens occupy only 0.1 to 0.2 percent of the landscape in the Sierra Nevada (Wolf and Cooper 2015). Because fens form slowly over thousands of years, they are not easily restored once destroyed (Cooper et al. 1998), and they provide an important record of prehistoric climate and vegetation (Wolf and Cooper 2015). Fens have been identified by the U.S. Forest Service and in the Tahoe Science Plan, (Manley et al., 2010) as among the most sensitive habitat types in the Sierra Nevada. Fens are hotspots of biodiversity that support rare plants, insects, and small and large mammals. Vegetation in all wetland types, including fens, marshes and meadows plays an important role in recycling nutrients, trapping eroding soil, and filtering pollutants such as nitrates (Cooper and Wolf, 2006). In addition, fens figure prominently in nearly all scenarios of carbon dioxide-induced global climate change because they are major sinks for atmospheric carbon (Chimner and Cooper, 2002).

A quantitative system for ranking the ecological integrity and quality of fens in the Sierra Nevada was used to assess the attainment status of fens at Osgood Swamp (Sikes et al. 2011). In the 2010 Lake Tahoe Region Fen Assessment, the western fen at Osgood Swamp received a conservation significance score of 27 out of 40, while the southern fen was one point lower due to its closer proximity to U.S. Highway 50. Elements that contributed positively to the rankings include the presence of rare plants and vegetation associations, and the uniqueness of the fens in terms of pH, elevation, and geology. Elements that detracted from the score include the presence of rodent burrows at the southern site and prevalent beaver activity around Osgood Swamp that could be affecting the hydrology, and causing higher water levels than in the past. Conservation significance scores of 26 and 27 are considered high when compared to the range of scores for fens in the Tahoe Region (18 to 30 points) and indicate that the natural qualities of the fens exist.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Uncommon plant communities

Adopted Standards – Provide for nondegradation of the natural qualities of any plant community that is uncommon to the Region or of exceptional scientific, ecological, or scenic value. The threshold standard shall apply, but not be limited to, 1) the deep-water plants of Lake Tahoe, 2) Grass Lake, 3) Osgood Swamp, 4) Hell Hole, 5) Upper Truckee Marsh, 6) Taylor Creek Marsh, 7) Freel Peak Cushion Plant Community, and 8) Pope Marsh.

Type of Standard – Numerical (without numerical target)

Indicator (Unit of Measure) – The status and trend determination was based on a qualitative assessment of the natural qualities of a plant community. The natural qualities of a plant community include the current plant species assemblage, the health, age and ecological condition of those plant species, and the condition of the hydrologic regime.

Human & Environmental Drivers – Any condition or activity that disturbs the hydrologic regime, nutrient levels, or alters plant composition, is a threat to the function of that fen (Cooper, 1990). Activities in general that threaten fens in the Sierra Nevada include timber harvest, mechanical fuel reduction treatments, road and trail construction, livestock trampling, off-road vehicles, ground and surface water pumping, and water pollution (Cooper and Wolf, 2006). All are regulated and managed in the Tahoe Region. At Osgood Swamp, illegal snowmobile use is concentrated on existing roads outside of the wetland, and a minimum 100-foot buffer around the water is enforced for adjacent mechanical fuel treatments. Hydrologic modification from beaver activity is also impacting this community.

The two fens at Osgood Swamp are not easily accessible from the decommissioned U.S. Forest Service road on the west side of the swamp or any of the numerous user trails surrounding the swamp. In the summer, light recreational use from local hikers and cyclists is confined to the well-established trail network. In the winter, cross-country skiing and illegal snowmobile traffic have been observed, but generally confined to the roads surrounding the swamp (TRPA 2007). The 2006 Threshold Evaluation

Report first noted high levels of beaver activity increasing water levels across the entire area, which altered the hydrologic conditions of the fen.

Beavers were once thought to be non-native to the Sierra Nevada, but carbon dating of old beaver dams has shown that beavers were in the Sierra Nevada since AD 580 (James and Lanman 2012, Lanman et al. 2012). Beaver trapping eliminated beavers from the higher Sierra Nevada by mid-1800s. Beavers were reintroduced into the Lake Tahoe Region in 1938 in the vicinity of Meiss Meadows (Tappe 1942), and additional introductions may have occurred. Since then populations have expanded to many watersheds around Lake Tahoe. Viewing Google Earth historical images, the first notable beaver activity and extensive ponding in Osgood Swamp occurred before 2004. In 1940 Osgood Swamp was a swamp with observable channels and different patches of wetland vegetation. By 1969, a ditch had been constructed presumably to drain the swamp. Vegetation appears to be predominantly drier meadow. By 1992 a patch of trees had established in the center of the meadow. By 2004, the entire meadow was flooded, and the trees in the center and along the lake margin were dying. By 2007 the trees had fallen, and a treeless margin occurred along the west shore 20 to 120 feet from the lake edge. A series of beaver dams are visible at the lake outlet, and their lodge appears to have been moved from near the outlet to the east side of the lake in 2010 or 2011, perhaps due to the high water year. There is also a man-made structure that dams up water. There have been several years where the soil is exposed in a large portion of the lake (August 2012), and years that the lake has been very full (June 2011). It appears that the lake level fluctuates seasonally as well as annually. It is difficult to determine the desired condition of Osgood Swamp because of these changes. Historically, beaver may have ponded Osgood Swamp, and when it was exposed as a swamp, it may have been a result of the exclusion of the beavers, and now we might be seeing a return to natural conditions. Another theory is that in the process of installing a small dam and creating a deep channel to drain the swamp, human intervention created conditions suitable for beaver habitat, where it did not exist before.

Extended drought and climate change could also negatively impact site hydrology and vegetation (Chimner and Cooper, 2002). Hydrologic change, which will likely be exacerbated by climate change, is predicted to be the largest threat to fen communities. Recent California based climate models predict a nine-degree Fahrenheit increase in temperature by 2100, and more conservative models predict a two to four-degree Fahrenheit increase in winter and four to eight-degree increase in summer (Safford et al., 2012a). Models are more variable for precipitation, but recent models for the Sierra Nevada predict similar to slightly less precipitation. Most models predict drier summer conditions, since more of the precipitation is predicted to come as rain, and snow melt-off will occur earlier in spring (Hayhoe et al. 2004, Dettinger 2005, Safford et al. 2012, Drexler et al. 2013). In the Lake Tahoe Region, these changes appear to be happening at an accelerated pace (Coats 2010). Snowpack is the dominant source of groundwater recharge (Earman et al. 2006), and since Sierra Nevada fen sustainability depends on groundwater, these climatic changes pose a severe threat (Drexler et al. 2013). Further, Sierra Nevada fens have relatively shallow peat depths, which make them highly susceptible to drying effects from increased temperature and/or reduced moisture (Drexler et al. 2013). Drexler et al. (2013) found that five Sierra Nevada fens had shrunk by 10 to 18 percent between 1951 and 2010, while at the same time mean minimum air temperature had increased and snowpack longevity and April 1 snow water equivalent had decreased.

One soil sample collected in 1966 from "the center of the lake" was described in 1971 (Zauderer 1973). The study states: "The lake was approximately 100 meters in diameter, and presumably 1 meter deep before being drained in 1967." The soil sample was composed of 60 cm of soily peat, clayey peat, and peat from rooty debris from surface to bottom of core respectively. A sample from 60 centimeters had a radiometric carbon date of 2,800 to 3,000 years before the present, resulting in a peat accumulation rate of 47 to 50 years/centimeter of peat (Zauderer 1973). The upper 23 centimeters had more mineral soil than the lower horizons, possibly indicating hydrologic changes. The current lake is approximately 190 by 270 meters in size, which is nearly triple the original size estimate. The soil samples and recent photos indicate that Osgood Swamp has fluctuated between a lake and a swamp. The most fibrous peat layers are from 58 to 152 centimeters, which suggests a change occurred just over 1,000 years ago.

MONITORING AND ANALYSIS
Monitoring Partners – U.S. Forest Service Lake Tahoe Basin Management Unit, California Native Plant Society. **Monitoring Approach –** Two recent different monitoring approaches have been implemented at Osgood Swamp. As part of the Region 5 Fen Assessment program, a total of 135 potential fens, including Osgood Swamp, have been assessed within the Lake Tahoe Region since 2006 (Sikes et al., 2011). Of these, a total of 47 locations have been confirmed as fens. In 2010, the U.S. Forest Service collaborated with the California Native Plant Society to develop a quantitative system for ranking the ecological integrity and quality of fens (Sikes et al., 2011). Using this ranking system, surveyors objectively score a fen on eight different criteria on a five-point scale. The criteria include factors such as rarity, biodiversity, impacts, accessibility, and uniqueness. The conservation significance rank is the sum of scores for each criterion and has a maximum value of 40 points. This protocol rates the condition of the fen, but does not provide enough detail to monitor status and trends over time. The second monitoring approach is part of the Region 5 Range Monitoring Program designed to quantify changes in the ecological condition of wetland plant communities (Weixelman et al., 2003). The protocol is designed to classify a meadow according to wetland index and plant functional types, which provides a quantitative ecological condition scorecard for that meadow type. The plots were re-visited in 2009/2010 and 2014/2015 but the data has not been analyzed (Engelhardt and Gross 2011b; Shana Gross, pers. comm.). Distance to meadow edge, distance to stream channel, degree of channel incision, and evidence of Sierra lodgepole pine (*Pinus contorta* var. *murrayana*) encroachment data is collected at each transect. **Analytic Approach –** Qualitative assessment of factors influencing the condition of the site. The U.S. Forest Service analysis of meadow monitoring data collected in 2009 and 2014 is under review and unavailable for this assessment.
INDICATOR STATE
Status – Insufficient data to determine status. There is no recent quantitative data available on Osgood Swamp. The status of Osgood Swamp was reported as somewhat worse than target in 2011, due to increased ponding due to beaver dams. **Trend –** Insufficient data to determine trend. The 2006 Threshold Evaluation Report determined that the condition of Osgood Swamp was declining due to altered hydrology from beaver activity (TRPA, 2007). The 2011 Threshold Evaluation Report also reported a moderate decline due to beaver activity, but the history of beaver in this area and their impact is point of contention. No further evidence is available to indicate a change in the trend in the last four years. **Confidence –** **Status –** Low. Where insufficient data is available to determine status the confidence is determined to be low. **Trend –** Low. Where insufficient data is available to determine trend the confidence is determined to be low. **Overall –** Low.
IMPLEMENTATION AND EFFECTIVENESS
Programs and Actions Implemented to Improve Conditions – TRPA and partners implement regulations and programs related to the protection of stream environment zones and uncommon plant communities. Anthropogenic activities known to impact these areas are prohibited. **Effectiveness of Programs and Actions** – Current regulations and protection measures appear effective at avoiding anthropogenic impacts. **Interim Target** – Insufficient data is available at this time to establish and interim target.

Target Attainment Date – Not applicable.

RECOMMENDATIONS

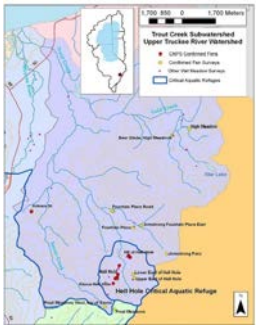
Analytic Approach – Data from the U.S. Forest Service long term meadow monitoring plots are expected to provide a standardized quantitative measure of meadow health and long term trends.
Agencies monitor and report on different cycles. Threshold reporting is on a four-year cycle, and the LTBMU is monitoring vegetation plots on a five-year cycle. Synchronization would be beneficial. Web-based reporting in the future will enable more continuous reporting and data analysis.

Monitoring Approach – The data from the long term monitoring plot is primarily relevant to a small fen south of Osgood Swamp. Consideration should be given additional monitoring in other parts of the swamp. Remote sensing has been effective in detecting change in fens in the Sierra Nevada (Drexler et al., 2013) and its ability to assess status and trend should be evaluated.

Modification of the Threshold Standard or Indicator – No baseline has been established against which the nondegradation of the community standard can be objectively evaluated. Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – No recommended changes.

Uncommon Plant Communities: **Hell Hole (sphagnum fen)**

Status	Trend
 **HELL HOLE (SPAHAGNUM FEN)** Status - **Insufficient Data to Determine Status** Trend - **Insufficient Data to Determine Trend** Confidence – **Low**	 Hell Hole, September 2010, Source: Google Earth Image Photos from the U.S. Forest Service monitoring plots. The photo on the left is from September 2011, and photo on the right is from October 2012.  
Map  Location of fen assessment plots established at Hell Hole in 2010 (Sikes et. al 2010).	

Data Evaluation and Interpretation

BACKGROUND

Relevance – Hell Hole is one of five distinct fens located within the Hell Hole Critical Aquatic Refuge (CAR; a U.S. Forest Service designation), which lies at the western base of Freel Peak (see above Map). At 15 acres, Hell Hole is the largest fen in the CAR and is home to the only known population of mountain yellow-legged frogs (*Rana mucosa*) in the Tahoe Region, an endangered species under the Endangered Species Act. *Sphagnum* fens are peat-forming wetlands that form when stable hydric soils allow a rate of organic matter production that is greater than the rate of decomposition, which over millennia leads to an accumulation of peat (Patterson and Cooper 2007, Weixelman and Cooper 2009). In environments with low summer precipitation like the Sierra Nevada, fens are sustained by groundwater input rather than precipitation. They are important sites of groundwater discharge and may serve as indicators of shallow aquifers (Cooper 1990).The conditions required for fens are very limited in mountain ecosystems, and fens occupy only 0.1 to 0.2 percent of the landscape in the Sierra Nevada (Wolf and Cooper 2015). Because fens

form slowly over thousands of years, they are not easily restored once destroyed (Cooper et al. 1998), and they provide an important record of prehistoric climate and vegetation (Wolf and Cooper 2015). Fens have been identified by the U.S. Forest Service (SNEP 1996) and in the Tahoe Science Plan (Manley et al. 2010b) as among the most sensitive habitat types in the Sierra Nevada. Fens are hotspots of biodiversity that support rare plants, insects, and small and large mammals. Vegetation in all wetland types, including fens, marshes and meadows, plays an important role in recycling nutrients, trapping eroding soil, and filtering out pollutants such as nitrates (Cooper and Wolf 2006). In addition, fens figure prominently in nearly all scenarios of carbon dioxide-induced global climate change because they are major sinks for atmospheric carbon (Chimner and Cooper 2002).

TRPA Threshold Category – Vegetation.

TRPA Threshold Indicator Reporting Category – Uncommon plant communities.

Adopted Standards – Provide for the nondegradation of the natural qualities of any plant community that is uncommon in the Basin, or of exceptional scientific, ecological, or scenic value. The Threshold Standard shall apply, but not be limited to, 1) the deep-water plants of Lake Tahoe, 2) Grass Lake, 3) Osgood Swamp, 4) Hell Hole, 5) Upper Truckee Marsh, 6) Taylor Creek Marsh, 7) Freel Peak Cushion Plant Community, and 8) Pope Marsh.

Type of Standard – Numerical (without numerical target)

Indicator (Unit of Measure) – The status and trend determination was based on a qualitative assessment of the natural qualities of a plant community. The natural qualities of a plant community include the current plant species assemblage, the health, age and ecological condition of those plant species, and the condition of the hydrologic regime.

Human & Environmental Drivers – Any condition or activity that disturbs the hydrologic regime or nutrient levels of a fen or causes drying or changes in plant composition is a threat to the function of that fen (Weixelman and Cooper 2009). Activities in general that threaten fens in the Sierra Nevada include timber harvest, mechanical fuel reduction treatments, road and trail construction, livestock trampling, off-road vehicles, ground and surface water pumping and water pollution (Cooper and Wolf 2006). All are regulated and managed in the Tahoe Region, and none of these activities are present in or around Hell Hole.

Hydrologic change, which will likely be exacerbated by climate change, is likely to be the largest threat to the Hell Hole community. Recent California based climate models predict a nine-degree Fahrenheit increase in temperature by 2100, and more conservative models predict a two- to four-degree Fahrenheit increase in winter and four- to eight-degree increase in summer (Safford et al., 2012a). Models are more variable for precipitation, but recent models for the Sierra Nevada predict similar to slightly less precipitation. Most models predict drier summer conditions, since more of the precipitation is predicted to come as rain, and snow melt-off will occur earlier in spring (Hayhoe et al. 2004, Dettinger 2005, Safford et al. 2012, Drexler et al. 2013). In the Lake Tahoe Region, these changes appear to be happening at an accelerated pace (Coats 2010). Snowpack is the dominant source of groundwater recharge (Earman et al. 2006), and since Sierra Nevada fen sustainability depends on groundwater, these climatic changes pose a severe threat (Drexler et al. 2013). Further, Sierra Nevada fens have relatively shallow peat depths, which make them highly susceptible to drying effects from increased temperature and/or reduced moisture (Drexler et al. 2013). Drexler et al. (2013) found that five Sierra Nevada fens had shrunk by 10 to 18 percent between 1951 and 2010, while at the same time mean minimum air temperature had increased and snowpack longevity and April 1 snow water equivalent had decreased.

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service Lake Tahoe Basin Management Unit, California Native Plant Society.

Monitoring Approach – Several monitoring regimes are in place at Hell Hole:

1. As part of the Region 5 Fen Assessment program, a total of 135 potential fens, including Hell Hole, have been assessed within the Lake Tahoe Region Management Unit since 2006 (Sikes et al. 2011). Of these, a total of 47 locations have been confirmed as fens. In addition to this inventory, the Forest Service collaborated with the California Native Plant Society in 2010 to develop a quantitative system for ranking the ecological integrity and quality of fens (Sikes et al., 2011). Using this ranking system, surveyors objectively score a fen on eight different criteria on a five-point scale. The criteria include such factors as rarity, biodiversity, impacts, accessibility, and uniqueness. The conservation significance rank is the sum of scores for each criterion and has a maximum value of 40 points.
2. The U.S. Forest Service Region 5 Range Monitoring Program quantifies the ecological condition of wetland plant communities (Weixelman et al. 2003, Weixelman and Gross In Review). The protocol is designed to classify meadows and wetlands according to dominant plant species, elevation, and site moisture characteristics, and then use a customized quantitative functional and wetland condition scorecard for that meadow type (Weixelman and Gross In Review). In 2004, two plots and permanent photo points were established at Hell Hole (Engelhardt and Gross 2011b). Plots were re-visited in 2009/2010 and in 2014 (Shana Gross pers. comm.), but the data and results have not been made available.
3. Long-term monitoring of *Sphagnum* spp. and *Meesia triquetra* cover two important mosses at Hell Hole. *Sphagnum* spp. (peatmoss) is a Region 5 sensitive species (watch list) and potential an indicator of climate change. *Meesia triquetra* (three-ranked hump moss) is strongly associated with fens in the Sierra Nevada, and therefore naturally has limited distribution, but was removed from the Region 5 sensitive species list on the most recent revision (McKnight and Rowe 2015). Bryophytes are strongly dependent on wetland habitat, and thus changes in cover and distribution of these dominant species may be indicative of habitat degradation (Engelhardt and Gross 2011c). Permanent transects to monitor moss cover were established throughout Hell Hole in 2012 (Engelhardt and Gross 2011c).

Analytic Approach – Qualitative assessment of factors influencing the condition of the site. The U.S. Forest Service analysis of meadow monitoring data collected in 2009 and 2014 is under review and unavailable for this assessment.

INDICATOR STATE

Status – Insufficient data to determine status. Hell Hole is not accessible by road and the wet conditions and unstable sphagnum substrate deter hikers and cyclists. Grazing was eliminated in the area in 2001 (TRPA, 2007). Recent threshold evaluations reports have assessed the status of Hell Hole as in attainment based on the low levels of potentially threatening activities (TRPA 2002, 2007). In the 2010 Lake Tahoe Region Fen Assessment, Hell Hole received a conservation significance score of 24 out of 40 (Sikes et al. 2011). Elements that contributed positively to the ranking include the presence of rare plants, animals, and vegetation associations, high physical diversity, and a high likelihood of persistence due to its size and proximity to other fens. Elements that reduced the score include its lack of unique features (relative to other fens in the area), relatively homogeneous vegetation, and the presence of the chytrid fungus (*Batrachochytrium dendrobatidis*), which is detrimental to amphibians. While chytrid fungus may be present at other fens in the Tahoe Region, Hell Hole is the only site where presence has been confirmed (Sikes et al., 2011). The conservation significance ranking of the site was 24, midway between the highest (30) and lowest (18) score assigned to fens in the Tahoe Region. Elements that reduced the score (lack of uniqueness, homogeneous vegetation) are not indicative of compromised qualities, and the impact of the fungus on the vegetation quality is unknown. The elements that contributed positively to the ranking, especially the presence of rare species and the high viability, indicate that the natural qualities of the site are being maintained and led to a rating of "at or better than target" in the 2011 Threshold Evaluation Report (TRPA 2012).

Trend – Insufficient data to determine trend. No additional quantitative data is available since the 2011 Threshold Evaluation Report, therefore there is insufficient data to determine trend for Hell Hole.

Confidence –

Status – Low. Where insufficient data is available to determine status the confidence is determined to be low.

Trend – Low. Where insufficient data is available to determine trend the confidence is determined to be low.

Overall – Low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – Hell Hole is designated as a Critical Aquatic Refuge by the USFS. TRPA and partners implement regulations to protection of stream environment zones and uncommon plant communities. Anthropogenic activities known to impact these areas are prohibited.

Effectiveness of Programs and Actions – Current regulations and protections appear effective.

Interim Target – Insufficient data is available at this time to establish and interim target.

Target Attainment Date – Not applicable.

RECOMMENDATIONS

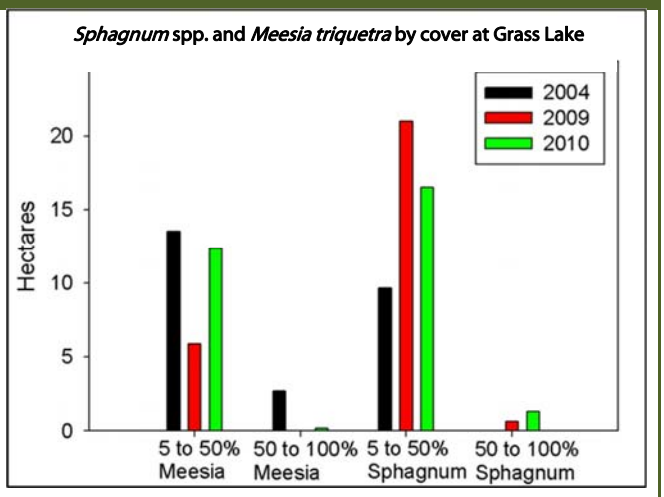
Analytic Approach – Data from the U.S. Forest Service long term meadow monitoring plots are expected to provide a standardized quantitative measure of meadow health and long term trends.
Agencies monitor and report on different cycles. Threshold reporting is on a four-year cycle, and the LTBMU is monitoring vegetation plots on a five-year cycle. Synchronization would be beneficial. Web-based reporting in the future will enable more continuous reporting and data analysis.

Monitoring Approach – The LTBMU monitoring methods (meadow health plots, moss monitoring plots, permanent photo points) appear to be a robust assessment of the status and trends of Hell Hole. Remote sensing has been effective in detecting change in fens in the Sierra Nevada (Drexler et al., 2013) and its ability to assess status and trend should be evaluated.

Modification of the Threshold Standard or Indicator – No baseline or statement of desired condition has been established against which the standard can be objectively evaluated. Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – No recommended changes.

Uncommon Plant Communities: **Grass Lake (sphagnum fen)**

Status	Trend
 **GRASS LAKE (SPHAGNUM FEN)** Status - **Insufficient Data to Determine Status** Trend - **Insufficient Data to Determine Trend** Confidence – **Low**	 Change in the number of hectares occupied by *Sphagnum* spp. and *Meesia triquetra* by cover class at Grass Lake in 2004, 2009 and 2010. Cover classes: Dominant = 50 to 100 percent cover, Intermediate = 5 to 50 percent cover. Source: U.S. Forest Service, LTBMU.
Map	
 Map showing location of Grass Lake and surrounding area.	

Data Evaluation and Interpretation

BACKGROUND

Relevance – Grass Lake lies within the Upper Truckee Critical Aquatic Refuge (CAR; a U.S. Forest Service designation) on the southern boundary of the Lake Tahoe Region. It was established as a U.S. Forest Service Research Natural Area (RNA) in 1991. Grass Lake is roughly 250 acres in size and has long been considered the largest and best example of a *Sphagnum* fen in the Sierra Nevada (Bittman 1985). *Sphagnum* fens are peat-forming wetlands that form when stable hydric soils allow a rate of organic matter production that is greater than the rate of decomposition, which over millennia leads to an accumulation of peat (Patterson and Cooper 2007, Weixelman and Cooper 2009). In environments with low summer precipitation like the Sierra Nevada, fens are sustained by groundwater input rather than precipitation. They are important sites of groundwater discharge and may serve as indicators of shallow aquifers (Cooper 1990).The conditions required for fens are very limited in mountain ecosystems, and fens occupy only 0.1 to 0.2 percent of the landscape in the Sierra Nevada (Wolf and Cooper 2015). Because fens form slowly over thousands of years, they are not easily restored once destroyed (Cooper et al. 1998) and they provide an important record of prehistoric climate and vegetation (Wolf and

Cooper 2015). Fens have been identified by the U.S. Forest Service (SNEP 1996) and in the Tahoe Science Plan (Manley et al. 2010a) as among the most sensitive habitat types in the Sierra Nevada. Fens are hotspots of biodiversity that support rare plants, insects, and animals. Vegetation in all wetland types, including fens, marshes and meadows, plays an important role in recycling nutrients, trapping eroding soil, and filtering out pollutants such as nitrates (Cooper and Wolf 2006). In addition, fens figure prominently in nearly all scenarios of carbon dioxide-induced global climate change because they are major sinks for atmospheric carbon (Chimner and Cooper 2002).

In the 2010 Lake Tahoe Region Fen Assessment, Grass Lake received the highest conservation significance rank of any fen in the Lake Tahoe Region with a score of 30 out of 40 (Sikes et al. 2011). Elements that contributed to the high ranking include its large size, its status as a Natural Research Area, the presence of rare plants and vegetation associations, high species diversity, low levels of disturbance, and a high likelihood of persistence. This high score combined with a qualitative assessment of management and recreation led to a rating of "at or better than target" in 2012 (TRPA 2012).

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Uncommon plant communities

Adopted Standards – Provide for the nondegradation of natural qualities of any plant community that is uncommon to the Basin or of exceptional scientific, ecological, or scenic value. The threshold standards shall apply, but not be limited to, 1) the deep-water plants of Lake Tahoe, 2) Grass Lake, 3) Osgood Swamp, 4) Hell Hole, 5) Upper Truckee Marsh, 6) Taylor Creek Marsh, 7) Freel Peak Cushion Plant Community, and 8) Pope Marsh.

Type of Standard – Numerical (without numerical target)

Indicator (Unit of Measure) – The status and trend determination is based on a qualitative assessment of the natural qualities of a plant community. Natural qualities of a plant community include the current plant species assemblage, the health, age, and ecological condition of those plant species, and the condition of the hydrologic regime.

Human & Environmental Drivers – Any event or activity that disturbs the hydrologic regime or nutrient levels of a fen or causes drying or changes in plant composition is a threat to the function of that fen (Patterson and Cooper 2007, Weixelman and Cooper 2009). Activities in general that threaten fens in the Sierra Nevada include timber harvest, mechanical fuel reduction treatments, road and trail construction, livestock trampling, off-road vehicles, ground and surface water pumping, and water pollution (Cooper and Wolf 2006). All are regulated and managed in the Tahoe Region, and the RNA status protects Grass Lake from these activities. Recreational use is light, and the impacts from cross-country skiing in the winter are likely to be negligible. Runoff from State Route 89 has likely been a source of water pollution, but recent road improvements for stormwater management were designed to divert surface road flow away from Grass Lake.

Hydrologic change, which will likely be exacerbated by climate change, is predicted to be the largest threat to the Grass Lake community (Christensen 2013). Recent California based climate models predict a nine-degree Fahrenheit increase in temperature by 2100, and more conservative models predict a two- to four-degree Fahrenheit increase in winter and four- to eight-degree increase in summer (Safford et al., 2012a). Models are more variable for precipitation, but recent models for the Sierra Nevada predict similar to slightly less precipitation. Most models predict drier summer conditions, since more of the precipitation is predicted to come as rain, and snow melt-off will occur earlier in spring (Hayhoe et al. 2004, Dettinger 2005, Safford et al. 2012, Drexler et al. 2013). In the Lake Tahoe Region, these changes appear to be happening at an accelerated pace (Coats 2010). Snowpack is the dominant source of groundwater recharge (Earman et al. 2006), and since Sierra Nevada fen sustainability depends on groundwater, these climatic changes pose a severe threat (Drexler et al. 2013). Further, Sierra Nevada fens have relatively shallow peat depths, which make them highly susceptible to drying effects from

increased temperature and/or reduced moisture (Drexler et al. 2013). Drexler et al. (2013) found that five Sierra Nevada fens had shrunk by 10 to18 percent between 1951 and 2010, while at the same time mean minimum air temperature had increased and snowpack longevity and April 1 snow water equivalent had decreased. Hydrologic monitoring and climate change modeling scenarios show that a rain dominated precipitation regime would likely lead to desaturation of approximately half of Grass Lake, which would cause aerobic decomposition of peat near the fen's edges and in the western and eastern portions (Christensen 2013). Increasing temperature would accelerate the rate of decomposition.

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service Lake Tahoe Basin Management Unit , California Native Plant Society

Monitoring Approach – Several monitoring regimes are in place at Grass Lake:

1. As part of the Region 5 Fen Assessment program, a total of 135 potential fens, including Grass Lake, have been assessed within the Lake Tahoe Region Management Unit since 2006 (Sikes et al. 2011). Of these, a total of 47 locations have been confirmed as fens. In addition to this inventory, the Forest Service collaborated with the California Native Plant Society in 2010 to develop a quantitative system for ranking the ecological integrity and quality of fens (Sikes et al., 2011). Using this ranking system, surveyors objectively score a fen on eight different criteria on a five-point scale. The criteria include such factors as rarity, biodiversity, impacts, accessibility, and uniqueness. The conservation significance rank is the sum of scores for each criterion and has a maximum value of 40 points.
2. The U.S. Forest Service Region 5 Range Monitoring Program quantifies the ecological condition of wetland plant communities (Weixelman et al. 2003, Weixelman and Gross In Review). The protocol is designed to classify meadows and wetlands according to dominant plant species, elevation, and site moisture characteristics, and then use a customized quantitative functional and wetland condition scorecard for that meadow type (Weixelman and Gross In Review). In 2004, two plots and permanent photo points were established at Grass Lake (Engelhardt and Gross 2011b). Plots were re-visited in 2009/2010 and in 2014 (Shana Gross pers. comm.), but the data and results have not been made available.
3. Long-term monitoring of *Sphagnum* spp. and *Meesia triquetra* cover, two important mosses at Grass Lake. *Sphagnum* spp. (peatmoss) is a Region 5 sensitive species (watch list) and potential an indicator of climate change. *Meesia triquetra* (three-ranked hump moss) is strongly associated with fens in the Sierra Nevada, and therefore naturally has limited distribution, but was removed from the Region 5 sensitive species list on the most recent revision (McKnight and Rowe 2015). Bryophytes are strongly dependent on wetland habitat, and thus changes in cover and distribution of these dominant species may be indicative of habitat degradation (Engelhardt and Gross 2011c). Permanent transects to monitor moss cover were established throughout Hell Hole in 2012 (Engelhardt and Gross 2011c).

Analytic Approach – Qualitative assessment of factors influencing the condition of the site. The U.S. Forest Service analysis of meadow monitoring data collected in 2009 and 2014 is under review and unavailable for this assessment.

INDICATOR STATE

Status – Insufficient data to determine status. Although Grass Lake is located near a major state route, the wet conditions and unstable sphagnum substrate deter hikers and cyclists. In addition, the RNA status protects the site from off-road vehicles, grazing, and water diversions. Recreational use is mainly limited to cross-country skiing in the winter. Recent threshold evaluation reports have assessed the status of Grass Lake as in attainment based on qualitative evaluations of recreation impacts and management actions, rather than any direct measurements of factors that contribute to the integrity of the community (TRPA, 2012e, 2007). Moss monitoring plots showed that plots with intermediate *Sphagnum* spp. (5 to 50 percent cover) decreased between 2009 and 2010 by 30 percent, but plots with high cover (50 to 100 percent) increased. *Meesia triquetra* was present only at intermediate cover in 2009, and this cover class increased

by 31 percent in 2010, and 0.18 hectares was mapped in the high cover class in 2010 (Shana Gross, pers. comm).

Trend – Insufficient data to determine trend. No new quantitative data is available since the 2011 Threshold Evaluation Report.

Confidence –

Status – Low. Where insufficient data is available to determine status the confidence is determined to be low.
Trend – Low. Where insufficient data is available to determine trend the confidence is determined to be low.
Overall – Low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – U.S. Forest Service designation as an RNA and CAR provide protections to Grass Lake. TRPA and partners implement regulations and programs related to the protection of stream environment zones and uncommon plant communities. Anthropogenic activities known to impact these areas are prohibited. Extensive roadwork on State Route 89 was completed in 2011, with the central objective to safeguard water quality in Grass Lake and Lake Tahoe. Fuels reduction treatments in the surrounding area include 100 acres that were mechanically thinned on the west side of Grass Lake in 2008.

Effectiveness of Programs and Actions – Runoff from State Route 89 has likely been a source of water pollution, but recent road improvements were designed to divert surface road flow away from Grass Lake. Current regulations and protection measures appear effective.

Interim Target – Insufficient data is available at this time to establish and interim target.

Target Attainment Date – Not applicable.

RECOMMENDATIONS

Analytic Approach – Data from the U.S. Forest Service long term meadow monitoring plots are expected to provide a standardized quantitative measure of meadow health and long term trends.
Agencies monitor and report on different cycles. Threshold reporting is on a four-year cycle, and the LTBMU is monitoring vegetation plots on a five-year cycle. Synchronization would be beneficial. Web-based reporting in the future will enable more continuous reporting and data analysis.

Monitoring Approach – The LTBMU monitoring methods (meadow health plots, moss monitoring plots, permanent photo points) appear to be a robust assessment of the status and trends of Grass Lake. Remote sensing has been effective in detecting change in fens in the Sierra Nevada (Drexler et al., 2013) and its ability to assess status and trend should be evaluated.

Modification of the Threshold Standard or Indicator – No baseline has been established against which the nondegradation of the community standard can be objectively evaluated. Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – No recommended changes.

Uncommon Plant Communities: **Freel Peak Cushion Plant Community**

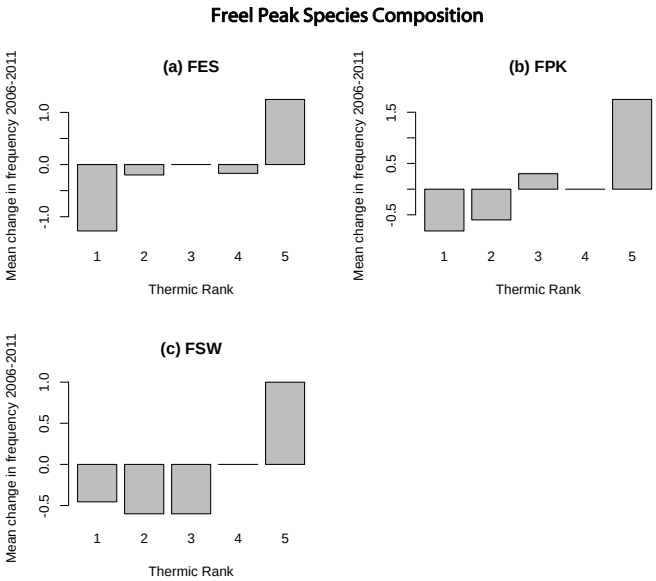
Status	Trend

FREEL PEAK CUSHION PLANT COMMUNITY

Status: **Somewhat Worse than Target**
Trend: **Rapid Decline**
Confidence: **Low**

Photo

Photo credit: Calscape.org, Copyright 2006 Stan Shebs.



Mean change in species frequency of occurrence between 2006 and 2011 in eight summit area sections by thermic rank on the three summit areas of Freel Peak (FES = Freel East Summit, FPK = Freel Peak, FSW = Freel Southwest Summit) where GLORIA (Global Observation Research Initiative in Alpine Environments) plots were established. Thermic rank is based on upper elevation plant elevation zones for the northern Sierra Nevada, based on NRCS land resource units (LRUs): 1. alpine, 2. subalpine, 3. upper montane, 4. mid montane, 5. lower montane. Negative changes in frequency indicate a loss or decline, and positive values indicate an increase in frequency.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Cushion plants have a low, matted growth form that is typical of high elevation environments. This growth form allows them to withstand extreme climates with gusting winds, snow, and huge temperature variation (e.g. Malcolm and Malcolm 1988). The main occurrence of this plant community type in the Region is at elevations above 9,000 feet on the cluster of peaks around Freel Peak (Engelhardt and Gross 2011b). These windblown peaks support a fell-field environment that is largely covered in surface rock fragments and limited to low-statured, long-lived, slow-growing subshrub, forb and grass species. Subshrubs such as cushion buckwheat (*Eriogonum ovalifolium*) are cushion forming, and forbs such as Nevada podistera (*Podistera nevadensis*) are mat forming, while grasses form tight tussock growth forms (Billings and Mooney 1968, Bahn and Körner 2003). These adaptations trap heat, which increases photosynthetic capacity in these cold environments, and limits moisture loss due to transpiration (Billings and Mooney, 1968; Korner, 2003). The Freel Peak cushion plant community supports

a variety of uncommon plant species, including one of the main population centers of Tahoe draba (*Draba asterophora* var. *asterophora*). Tahoe draba is specially designated by TRPA and the U.S. Forest Service to provide this species with increased levels of protection (Engelhardt and Gross 2011a).

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Uncommon plant communities

Adopted Standards – Provide for the nondegradation of the natural qualities of any plant community that is uncommon to the Region or of exceptional scientific, ecological, or scenic value. The threshold shall apply, but not be limited to, 1) the deep-water plants of Lake Tahoe, 2) Grass Lake, 3) Osgood Swamp, 4) Hell Hole, 5) Upper Truckee Marsh, 6) Taylor Creek Marsh, 7) Freel Peak Cushion Plant Community, and 8) Pope Marsh.

Type of Standard – Numerical (without numerical target)

Indicator (Unit of Measure) – The status and trend determination is based on a qualitative assessment of the natural qualities of a plant community. Natural qualities of a plant community include the current plant species assemblage, the health, age, and ecological condition of those plant species, and the condition of the hydrologic regime.

Human & Environmental Drivers – Climate change is considered to be the greatest threat to this alpine community. Prior to the threat of climate change, high elevation cushion plant communities were considered to be a naturally stable type (Malcolm and Malcolm 1988). With climate change a reality, high elevation communities throughout the world are experiencing rapid changes (e.g. Gottfried et al. 2012). Indeed, alpine areas have been called bellwethers for global climate change impacts (e.g. Seastedt et al. 2004), due to a highly specialized flora and fauna that may not compete well with a lessening of harsh environmental conditions, and no higher elevations to retreat. A continental scale study of changes on all of Europe's major mountain ranges found declines in high elevation species and increases in lower elevation species, which were correlated with increasing temperatures between 2001 and 2008 (Gottfried et al. 2012). Microtopographic variation that allows for xeric and mesic species to co-occur may allow for local migration, and confer resilience to climate change (Gibson et al. 2008, Spasojevic et al. 2013). However, areas like the Lake Tahoe Region where true alpine habitat is very limited will likely not have this resilience. Species composition is likely to change, with strictly alpine species likely to be replaced by species with wider ecological ranges. Species richness may increase from species moving upslope, as has already been demonstrated in other alpine environments (e.g. Bahn and Körner 2003, Johnson et al. 2011, Spasojevic et al. 2013). However, these increases in species richness may be offset over time by the extirpation of species that are restricted to the alpine zone and have no upslope environment to move to. A modelling study in the White Mountains of California predicted a six-degree Fahrenheit temperature increase would lead to the extinction of 10 out of 14 alpine forbs modelled. The remaining four species were predicted to lose 99 percent of their current range (Van de Ven et al., 2007). A three-degree temperature increase was predicted to result in the extinction of two species, and lead to severe range restrictions of all others (Van de Ven et al. 2007). Recent California based climate models predict a nine-degree Fahrenheit increase in temperature by 2100, and more conservative models predict a two- to four-degree Fahrenheit increase in winter and four- to eight-degree increase in summer (Safford et al., 2012a). Models are more variable for precipitation, but recent models for the Sierra Nevada predict similar to slightly less precipitation. Most models predict drier summer conditions, since more of the precipitation is predicted to come as rain, and snow melt-off will occur earlier in spring (Hayhoe et al. 2004, Safford et al. 2012).

The rocky, loose, often steep soils of this area are highly susceptible to erosion impacts from trails and trampling and recreational use has the potential to degrade the community. Even light trampling can trigger significant downslope rock movement, which decreases plant production and cover (Bell and Bliss 1973). The erosion of nutrient and moisture poor soils with low propagule availability in these low cover environments may cause significant damage to sensitive, slow-growing plant communities (e.g.

Chambers 1997). Protection from trampling can reverse these impacts (Bell and Bliss, 1973). Trampling of Tahoe draba in the area has been observed (Engelhardt and Gross 2011a).

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service-Lake Tahoe Region Management Unit (LTBMU), Pacific Southwest Research Station (PSW) and the Global Observation Research Initiative in Alpine Environments (GLORIA) network.

Monitoring Approach – Long-term monitoring plots were installed in 2006 on Freel Peak and two adjacent summits following GLORIA protocol. Vascular plant and groundcover are visually estimated in 16 one-meter by one-meter permanent quadrats, and species presence is recorded in eight summit area sections. In addition, continuous soil temperatures are logged in four summit areas, and detailed repeat photography is taken. Plots are re-measured every five years. The U.S. Forest Service Pacific Southwest Research Station has taken the lead in organizing monitoring associated with the GLORIA project throughout the state of California. GLORIA data provide the primary indicator of the status and trend of the cushion plant community. In 2009, the LTBMU installed four permanent plots targeting the Tahoe draba population in the Freel Peak cushion plant community. The plots are visited every three to five years to provide a quantitative and consistent method for evaluating the status and trend of this sensitive species. Data on the status and trend of Tahoe draba are used as a secondary indicator.

Analytic Approach – Changes in the Freel Peak cushion plant community between 2006 and 2011 were assessed in several ways:

1. Change in community composition was assessed using a "thermophilization indicator" (Gottfried et al., 2012). All species occurring in GLORIA monitoring plots were assigned an elevational rank based on northern Sierra Nevada NRCS land resource units (LRUs) and species elevation optimums. Thermic rank categories were: a) alpine (>2897m), b) subalpine (2377-2743m), c) upper montane (1676-2591m), d) mid montane (1097-1798m), and e) lower montane (518-1219m). Species elevation optimums were based on habitat descriptions and elevation ranges in The Jepson Manual (Hickman 1993, Baldwin et al. 2012). An index of vegetation's thermic composition (S) was calculated for each peak as a weighted average based on either species cover (where cover was averaged across the 16 quadrats) and rank, or species frequency (occurrence in the eight summit area sections) and rank (Gottfried et al., 2012). Change (thermophilization indictor, D) was assessed as the difference between the thermic vegetation indictor calculated in 2012 and 2006 ($S_{2012} - S_{2006}$). Using these calculations, a positive D reflects increased frequency/cover of species that are typical of lower elevations, and/or decreased frequency/cover or loss of high elevation species (Gottfried et al., 2012).
2. To test for statistical significance of changes in the plant community, a paired t-test was first used to test for differences in the frequency and cover of species between measurement periods, both overall and for each peak without taking elevation rank into account. Then linear regression was used to test for the effects of elevation rank on changes in frequency or cover, both with data pooled and controlling for peak.
3. The species driving changes in frequency or cover were examined for any consistent patterns.

The general status and trend of the Freel peak population of Tahoe draba was used as a secondary indicator of the status of the Freel Peak cushion plant community.

INDICATOR STATE

Status – Somewhat worse than target. The natural qualities of the Freel Peak cushion plant community declined between 2006 and 2011. Declines included, 1) local extinction, 2) declines of species with the highest elevation affiliations, and 3) colonization and increases of lower elevation species. The declines are consistent with those observed in high elevation communities at GLORIA peaks across the European continent (Gottfried et al., 2012). Declines were observed on all three summits (FES = Freel East Summit, FPK = Freel Peak, FSW = Freel Southwest Summit) when frequency was used for calculations (FES = 0.34,

FPK = 0.35, FSW = 0.40), and for two of three when cover was used (FES = 0.33, FPK = 0.11, FSW = -0.05), indicating that higher elevation species are declining or being lost and lower elevation species are increasing or colonizing. Higher elevation species were more likely to have declined or been lost, and species of the lowest elevations more likely to have increased for all summits (see figure in the trend section of this indicator sheet); F = 5.858, df=116, p<0.0009). Species associated with the alpine zone (elevation rank 1), suffered the greatest losses and declines. Four alpine zone species were lost from at least one summit (though no species were lost from all three summits): Colorado fescue (*Festuca brachyphylla* ssp. *coloradensis*) and Nevada podistera (*Podistera nevadensis*) from FES, and fewseed draba (*Draba oligosperma*) and timberline bluegrass (*Poa glauca* ssp. *rupicola*) from FSW. These are all low-growing, alpine species that are members of, or are often associated with cushion plant communities. Royal penstemon (*Penstemon speciosus*) occurred on all three peaks in 2011, and none in 2006; sanddune wallflower (*Erysimmum capitatum*) and Ross' sedge (*Carex rossii*) occurred on two peaks in 2011 and none in 2006; and Sandberg bluegrass (*Poa secunda*) occurred on one peak in 2011 and none in 2006. Five alpine zone species declined in frequency: Nevada podistera on FPK and FSW, fewseed draba, Lyall's rockcress (*Arabis lyalli* var. *lyalli*), and alpine dustymaiden (*Chaenactis douglasii* var. *alpina*), on FPK, and pygmy fleabane (*Erigeron pygmaeus*) on FES. These species are also all members of the Freel Peak cushion plant community. Four species normally associated with the lowest elevation zone appear to have colonized between 2006 and 2011. Seventeen subpopulations of Tahoe draba occur around Freel peak. The majority of these (11) have had stable plant counts since monitoring began in 2004 and the last available monitoring data in 2012 (McKnight and Rowe 2015). Three subpopulations increased, although increases were likely due to increased search effort. Monitoring of the Freel Peak population occurred in 2015, but the data collected during these surveys are not available at this time.

Trend – Rapid decline. The disappearance of four alpine affiliated species, the decline of five more, and the colonization of four low elevation species represents significant changes that threaten the Freel Peak cushion plant community. This represents decreases of over 80 percent of the 11 alpine affiliated species. These numbers are alarming; however, two important caveats must be highlighted:

1. 2011 was a very wet year in the Lake Tahoe Region. Snowpack persisted late into the summer. This could have impacted the detectability of high elevation species, and it is possible that the observed declines and disappearances reflect the conditions of the measurement, rather than being true decreases.
2. The GLORIA data needs additional quality assurance by GLORIA personnel, and misidentifications and/or name changes have not been corrected and may have contributed to some of the results (Adelia Barber Pers. Comm.). Although most populations of Tahoe draba in this community have remained stable for up to five monitoring cycles between 2004 and 2012 (McKnight and Rowe 2015), the overall trend is rapid decline.

Confidence – Low. The confidence in the status and trend determination is low because of the caveats above and because the analysis is based on only one GLORIA re-measurement cycle, with the last monitoring date almost five years ago, and on plant demographic monitoring that is four years old.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – A dedicated recreation trail to the top of Freel Peak was completed in 2006 to concentrate recreational use and decrease trampling of the cushion plant community. Additionally, TRPA and partners implement regulations and programs related to the protection of uncommon plant communities.

Effectiveness of Programs and Actions – Tahoe draba has been discovered at three new sites and plant counts have been stable since the installation of the trail improvements which indicate that the trail may have reduced trampling of the cushion plant community.

Interim Target – None set. The primary driver of decline appears to be global climate change.

Target Attainment Date – Not applicable

RECOMMENDATIONS
Analytic Approach – The thermophilization indicator D and analysis of the drivers of D (i.e. which species are declining/disappearing/increasing; climate changes) provides a useful measure for quantitatively assessing changes in this plant community. The average D measured here was of relatively high magnitude compared to D measured across the European continent over a five-year period, indicating that the changes observed here are already significant. It was outside of the scope of the current contract to analyze in more detail the climatic drivers that may have influenced D in Tahoe (e.g. increased summer temperatures, decreased snowpack). In the European study, increased June temperatures were significantly correlated with more strongly positive D (Gottfried et al., 2012). Consideration should be given to the use of a mixed effects model to estimate the significance of observations, with plot and peak included as random effects. Agencies monitor and report on different cycles. Threshold reporting is on a four-year cycle, and the GLORIA monitoring is on a five-year cycle. Synchronization would be beneficial. Web-based reporting in the future will enable more continuous reporting and data analysis. **Monitoring Approach –** No changes are recommended. Evaluation of recreation impacts at the next GLORIA re-measurement is recommended. **Modification of the Threshold Standard or Indicator –** No baseline has been established against which the nondegradation of the community standard can be objectively evaluated. Objective determination of "attainment" status for standards without a specific target is a recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management. Standard revision should also give consideration of the likely impacts of global climate change to what can reasonably be attained with local management action. **Attain or Maintain Threshold** – The climatic changes impacting this community are unlikely to be reversed by local management action. Locally, management could focus on identifying and reducing other stresses on this community. Assisted migration is a limited option in the Tahoe Region.

Sensitive Plants

The Lake Tahoe Region supports a diverse array of plants. Over 1,000 vascular plants and at least 115 species of non-vascular plants have been confirmed, with another 360 species potentially occurring (Murphy and Knopp 2000). The USFS special status[3] plant list includes 22 vascular plants, five non-vascular plants, and one fungus (McKnight and Rowe 2015). The special status plant list includes U.S. Forest Service Region 5 Sensitive Plants, LTBMU Target Species, and TRPA identified sensitive plant species. This list includes 14 species documented in the Region (11 vascular and three non-vascular), and 14 species that may occur but have not been documented (either suitable habitat occurs, or plants are known only from historic records) (McKnight and Rowe 2015). Fourteen additional species occur on a LTBMU 'watch list' (McKnight and Rowe 2015). 'Watch list' species are species that are of conservation concern but have not been designated as 'sensitive' by USFS's regional forester. Of these 42 special status species (special status plant list and watch species list), LTBMU botany and ecology staff monitor 21 species known to occur in the Region. Whitebark pine (*Pinus albicaulis*) is a candidate for listing under the Federal Endangered Species Act. Tahoe yellow cress (*Rorippa subumbellata*) was recently removed as a candidate for federal listing, but is still listed as endangered by the states of California and Nevada.

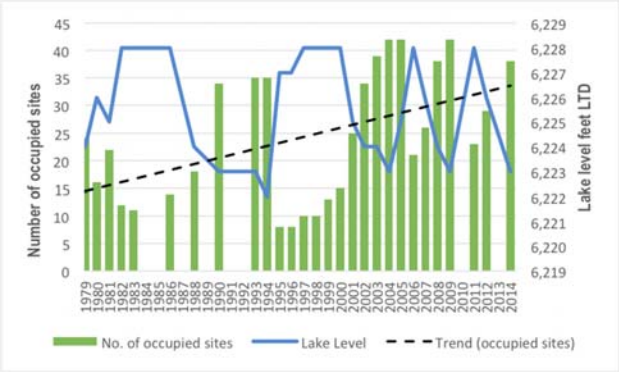
TRPA policy emphasizes conservation of special status plant species. The sensitive plant threshold standard applies to five species: "maintain a minimum number of populations sites" for *Arabis rigidissima* var. *demota* – Galena Creek rockcress, (7), *Draba asterophora* var. *asterophora* – Tahoe draba (5), *D. asterophora* var. *macrocarpa* – Cup Lake draba (2), *Lewisia longipetala* – Long-petaled lewisia (2), and *Rorippa subumbellata* – Tahoe yellow cress (26). TRPA threshold evaluations have interpreted population site as any location where plants have been mapped (TRPA, 2012e, 2007). The current evaluation follows this approach for consistency across reports. Modifying the interpretation of the sensitive plant threshold standard measurement protocol to reflect the biological definition of a plant population should be considered (NatureServe 2004). Distance often determines the degree of interaction between plants, and the standardized Natural Heritage Program methodology uses a minimum default separation distance of one-kilometer for defining and tracking plant populations. Subpopulations can be tracked to gain information in more localized areas, and the population sites discussed in the present evaluation would be considered subpopulations within the NatureServe methodology.

Following the approach of prior threshold evaluation reports, this evaluation assesses attainment based on the number of subpopulations. Four of the five species were determined to be in attainment and considerably better than target (Table 6.2). Galena Creek rockcress, determined to be considerably worse than target, is unlikely to be attainable because the target number of populations have never been observed in the Region.

[3] *Special status species are generally thought of as having low abundance, limited distributions, or small population sizes. Special status plant species are identified through an evaluation of multiple parameters that may include any or all of the following criteria:*

- *Rarity or limited distribution throughout the species' range or the region*
- *Endemism (species endemic to the Basin are found only within the basin and nowhere else)*
- *Presence of threats and perceived vulnerability to local extirpation or extinction*

Sensitive Plants: **Tahoe Yellow Cress (*Rorippa subumbellata*)**

Status	Trend
TAHOE YELLOW CRESS ***(RORIPPA SUBUMBELLATA)*** Status - **Considerably Better Than Target** Trend - **Moderate Improvement** Confidence – **High**	
Photo	The relationship between the number of sites occupied by Tahoe yellow cress and the level of Lake Tahoe as measured in September (USGS Tahoe City gage 103370000) during the survey period from 1979 to 2014. Lake level (blue line) is in feet of elevation, Lake Tahoe Datum (LTD). Fifty sites were surveyed; six years have no survey data, and two years with less than 60 percent survey were excluded. The black dashed line indicates that the number of sites occupied has increased over time. The number of sites surveyed increased from 32 in 1979 to 50 by 2009. Source: Stanton et all. 2015.
 Photo credit: Calscape.org, Copyright 2006 Steve Matson.	

Data Evaluation and Interpretation

BACKGROUND

Relevance – Tahoe yellow cress (TYC, *Rorippa subumbellata)* is a small perennial plant in the mustard family (Brassicaceae) known only from the shores of Lake Tahoe in California and Nevada. Impacts from recreation and development led to conservation concerns as early as 1974 (Smithsonian Institute 1974). In 1982, TYC was listed as endangered by the State of California and as critically endangered by the State of Nevada. Those levels of protection are the highest of any plant species in the Lake Tahoe Region. TYC is also a U.S. Forest Service Sensitive Species. The U.S. Fish and Wildlife Service (USFWS) placed TYC on the candidate list under the Endangered Species Act several times. The first was in 1980, but the USFWS removed TYC from the candidate list in 1996 after a prolonged regional drought exposed large expanses of shoreline habitat and lake-wide surveys indicated high rates of site occupancy. In 1999, after a period of sustained high lake levels in which TYC habitat was inundated and occupied sites declined, USFWS again placed TYC on the candidate list. In October 2015, the USFWS announced a "not warranted" finding and removed TYC from the federal candidate list due to the successful implementation of the Tahoe Yellow Cress Conservation Strategy (Pavlik et al. 2002, Stanton et al. 2015).

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Sensitive plant species

Adopted Standards – Maintain 26 sites Tahoe yellow cress population sites (as depicted on TRPA overlay

maps).

Type of Standard – Numeric

Indicator (Unit of Measure) – The total number of population sites that are maintained as suitable habitat, as determined by a qualified expert.

Human & Environmental Drivers – Knowledge of TYC distribution has been developed through systematic lake-wide surveys that have been completed in targeted parts of the Lake Tahoe shorezone since 1979 (Knapp 1980, CSLC 1994, Pavlik et al. 2002, Stanton et al. 2015). The primary driver of TYC distribution and abundance is the level of Lake Tahoe. The amount of available shorezone habitat for TYC fluctuates widely with changes in lake level such that large amounts of shorezone habitat are exposed at the lowest lake levels, and as Lake Tahoe rises, these areas are inundated due to the geometry of the filling Region (Pavlik et al. 2002). The natural rim of Lake Tahoe occurs at 6,223.0 feet (1,896.8 meters) and the high water line at 6,229.1 feet (1,898.6 meters) Lake Tahoe Datum (LTD). TYC has been found at elevations lower than the natural rim, but occurrences above the high water line are rare (Stanton and TYCAMWG, 2015). Although lake level is controlled in part by the operation of the dam at the outlet of Lake Tahoe in Tahoe City, California, lake level is primarily controlled by environmental factors that increase water input (tributary stream discharge and precipitation) or cause water loss (evaporation and outflow to the Truckee River) (Reuter and Miller 2000). Successive years of high lake levels have the potential to seriously reduce the presence and abundance of TYC as was observed between 1995 and 2000 when the number of occupied Tahoe yellow cress sites declined from 35 in 1993 to only eight in 1995-96, prompting concerns of imminent extinction of the species (Pavlik et al., 2002). The effect of climate change on TYC depends on how climate changes affect the level of Lake Tahoe. The climate-related scenario with the greatest threat to TYC would be a drought-induced period of sustained low lake level followed by a rapid rise in lake level which inundates TYC plants across the entire elevation range of the species (Stanton and TYCAMWG, 2015). If this occurred, species viability would depend entirely on recruitment from the seedbank and re-sprouting of submerged rootstocks after the lake receded.

Recreation and land management practices on the beaches of Lake Tahoe are the primary human drivers of TYC distribution and abundance and constitute the greatest manageable threat to TYC and its habitat (Stanton and TYCAMWG, 2015). Trampling from human foot traffic and dogs may directly destroy plants, roots, and/or seeds and inhibit germination and recruitment of seedlings. Beach raking to remove debris and vegetation can directly destroy plants and decrease the amount of suitable habitat. These human-caused impacts are intensified when the level of Lake Tahoe is high (greater than 6,226 feet) and use is concentrated on smaller amounts of shoreline. Although significant development in the shorezone occurred prior to the adoption of the TRPA Regional Plan in 1987, current TRPA regulations strongly limit the types and amount of development that can occur in the shorezone of Lake Tahoe and the threat to TYC from future development of additional boat launch facilities in the shorezone is expected to remain relatively small (Stanton and TYCAMWG, 2015).

MONITORING AND ANALYSIS

Monitoring Partners – The Tahoe Yellow Cress Adaptive Management Working Group (AMWG) has been meeting quarterly since 2002 under the oversight of the Tahoe yellow cress Executive Committee (Executives). Members include: TRPA, U.S. Forest Service, U.S. Fish and Wildlife Service, California State Parks, California Tahoe Conservancy, California Department of Fish and Wildlife, California State Lands Commission, Nevada Division of State Lands, Nevada Division of State Parks, Nevada Division of Forestry, Nevada Natural Heritage Program, Tahoe Lakefront Owner's Association, and the League to Save Lake Tahoe. Other agencies have also participated including: U.S. Bureau of Reclamation, Natural Resources Conservation Service, Nevada Tahoe Conservation District, and the Tahoe Resource Conservation District.

Monitoring Approach – Lake-wide monitoring for TYC began in 1979 (Knapp, 1980). Surveys prior to 2000 followed a general methodology (Knapp 1979, Knapp 1980), and were completed at various times during the summer (CSLC 1994, 1998, 1999). Beginning in 2001, the AMWG began surveys in the first week of

September and developed a standard protocol (Stanton and TYCAMWG, 2015). Typically, surveyors are assigned to one of four teams that each cover survey sites located within one quartile of the lake. Each team has three to five members that walk the beach in transects parallel to the water looking for TYC. Clonal growth makes it impossible to distinguish an independent individual of TYC, so observers in the field have long referred to the number of TYC "stems" counted as a measure of abundance rather than the number of plants (CSLC, 1998, 1994; Knapp, 1980; Pavlik et al., 2002). Stems are counted in total when possible, but when there are hundreds to thousands of stems, estimates are used. Recreation impacts have also been noted in most surveys, but no quantitative data have been collected. Prior to 2010, lake-wide monitoring was completed on an annual basis with some missed years. In 2010, the AMWG adopted an adaptive survey strategy that emphasizes high lake level monitoring (Stanton and Pavlik 2010). Surveys are now completed every year when Lake Tahoe is at or above 6,226 feet (1,897.7 meters) but only every other year at lower lake levels. Since 1979, the number of survey sites increased from 32 to 55 sites (Figure 1 of this indictor sheet). A survey "site" has been defined as a stretch of public beach, adjacent private parcels grouped by a place name or landmark, or adjacent parcels under a combination of both private and public ownership. The boundaries and names of some of the sites have shifted over time. As of 2015, TYC has been extirpated from five sites for 20 years or longer and these sites are now considered historic and are no longer surveyed.

Analytic Approach – In the original TYC Conservation Strategy (Pavlik et al., 2002) the relationship between lake level and number of occupied TYC sites was evaluated with linear regression. The updated TYC Conservation Strategy (Stanton and TYCAMWG, 2015) repeated the analysis with monitoring data available from 1979 through 2014 for 50 sites (five historical sites were excluded from the analysis) using Spearman's rank correlation because data violated normality rules required for linear regression. No surveys were done in 1984, 1985, 1987, 1989, 2010, or 2013 and two years with less than 60 percent survey were excluded (1991 and 1992). Lake level was presented as a whole integer as measured in September at the USGS Tahoe City gage (gage 103370000).

INDICATOR STATE

Status – Considerably better than the target. As of 2015, there are 50 survey sites and each has been surveyed between 10 and 28 times in the 36-year period from 1979 to 2014 (Stanton and TYCAMWG, 2015). During the survey period, the number of occupied TYC sites fluctuated inversely with the level of Lake Tahoe in September (Figure 2 of this indicator sheet). The number of occupied TYC sites declined significantly with increasing lake levels during the period (Figure 3 of this indicator sheet, Spearman's rank correlation is -0.80, $p<0.0001$). The line in Figure 3 shows an average loss of nine sites for every two-foot rise in lake level (*i.e.*, from 41 sites at 6,222 ft. to 32 sites at 6,224 ft. LTD.). With respect to TYC, the level of Lake Tahoe is characterized as low (≤6,224 ft. (1,897 m) LTD), in transition (6,225 to 6,226 ft. (1,897–1,897 m) LTD), or high (6,227–6,228 ft. (1,898–1,898 m) LTD). The current dataset from 1979 to 2015 includes 28 years when more than 60 percent of the known population sites were monitored and is balanced with an equal number of years of low (11) and high lake level years (11), with six transition years. During this period the average number of occupied sites at low lake levels was 34.5, in transition years it was 26.7, and at high lake levels it was only 13.2 sites. These occupancy rates indicate that it is highly unlikely that the current threshold standard can be met at high lake levels because the greatest number of occupied sites when the lake has been high was 21 in 2006 and 23 in 2011 (it was 15 or less in all other high lake level years). However, the standard is attainable at most lake levels. Across the entire period, the average number of sites occupied is 24.4, lower than the target of 26. However, since

Figure 1: Tahoe Yellow Cress survey sites

the implementation of the conservation strategy in 2002, an average of 34 sites have been occupied by TYC, which is 131 percent of the standard. Furthermore, it was concluded in 2002 that extirpation of TYC populations had occurred three times as often as colonization during the survey period from 1979 to 2000 (Pavlik et al., 2002). The continued collection of data from lake-wide surveys has shown that the number of colonizations is now equal to or greater than extirpations and suggests the species is resilient to fluctuations in lake elevation, by either persisting or re-colonizing when conditions become favorable (Stanton and TYCAMWG, 2015). Therefore, the indicator is considerably better than the target. The location of 55 Tahoe yellow cress survey sites with land ownership are depicted on the map to the right. Nineteen sites are in Nevada and 36 are in California. Twenty-four sites are under private ownership and 31 sites have public/mixed ownership. Five of the sites are considered historical and are no longer surveyed (Stanton and TYCAMWG, 2015).

Trend – Moderate Improvement. The trend for the species in any given period of time depends on fluctuations in lake level. Over the last five years, Lake Tahoe fluctuated from a high level in 2011 to transition in 2012, and has remained low since 2013. The number of population sites occupied by TYC rose from 23 to 29 to 38 (Figure 2). The previous five-year period from 2006 through 2010 showed the same pattern with the number of occupied sites rising from 21 under the high lake level in 2006 to 42 under the low lake level in 2009. The longer term trend for TYC occupancy since the adoption of the conservation strategy in 2002 has shown rapid improvement. The occupancy rate is calculated for each year as a proportion of the number of sites that were surveyed. During the period from 1979 to 2000, on average 32.1 sites were surveyed each year and 17.8 of those sites were occupied (55 percent occupancy). From 2001 to 2014, the average number of surveyed sites climbed to 46.7 and 33.3 of those were occupied (71 percent occupancy). Since there was no change in the short term trend, but a rapid improvement in the longer term trend, the overall trend for Tahoe yellow cress is showing moderate improvement**.**

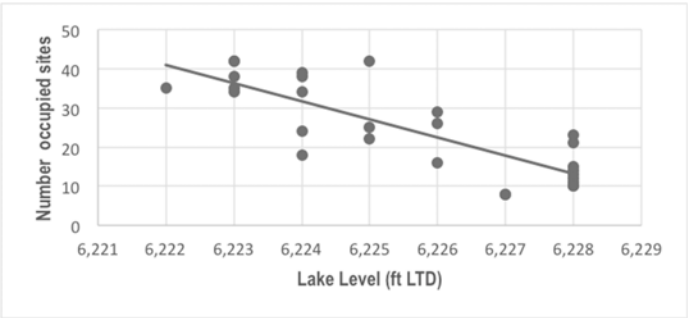


Figure 2: *Number of occupied sites by lake level.*

The number of occupied Tahoe yellow cress sites surveyed from 1979 to 2014 as a function of lake level, as measured in September (USGS Tahoe City gage 103370000). Spearman's rank correlation is -0.80, $p<0.0001$. Fifty sites were surveyed. Six years have no survey data, and two years with less than 60 percent survey were excluded. Source: Stanton et al. 2015.

Confidence – High. There is a high degree of confidence in the status and trend based on the longevity of the monitoring program and the quality of the data collected.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – In response to the placement of TYC on the candidate list under Endangered Species Act in 1999, a multi-agency and private interest group task

force was formed to develop and implement a conservation strategy to promote the recovery and conservation of TYC through adaptive management and cost sharing. The *Conservation Strategy for Tahoe yellow cress* (Pavlik et al., 2002) was finalized in 2002, and in January 2003, the 13 entities listed as monitoring partners above signed a memorandum of understanding/conservation agreement (MOU/CA), agreeing to cooperatively implement the conservation strategy on a voluntary basis. The 2003 MOU/CA expired on January 29, 2013, and a new MOU/CA was signed on June 1, 2013, by all 13 original entities (Stanton and TYCAMWG, 2015). The current MOU/CA is active for 10 years, with an expiration date of June 1, 2023. In 2012, Region executives approved a revision of the 2002 conservation strategy and the revised *Conservation Strategy for Tahoe yellow cress* (CS2015) was completed in October 2015 (Stanton and TYCAMWG, 2015). The AMWG continues to meet on a quarterly basis to coordinate and manage ongoing implementation of the revised strategy. The revised conservation strategy builds upon the previous strategy and represents both a synthesis and significant expansion of TYC information and includes sections on TYC ecology, threats, conservation history, management goals and actions, the stewardship program, and regulatory framework. A field research program from 2003 to 2010 increased understanding of TYC ecology and identified the optimal planting techniques, plant characteristics, habitat conditions, and logistical factors that influence restoration/mitigation success. The suite of management and restoration actions described in the revised conservation strategy provides options for avoiding, minimizing, and mitigating impacts to TYC and its habitat on public and private lands. It also recognizes the critical role of private landowners in ensuring the long-term survival of TYC, and presents the TYC Stewardship Program, which is aimed at gaining landowner participation and implementing strategies that respect private property rights. TYC management goals and objectives in the revised conservation strategy are:

Goal 1: Protect TYC plants and habitat on public lands
Goal 2: Promote stewardship, protection, and awareness of TYC on private lands
Goal 3: Manage TYC populations to promote persistence
Goal 4: Utilize key management questions to direct research that supports management and conservation
Goal 5: Continue long-term monitoring using an adaptive survey strategy
Goal 6: Utilize an adaptive management framework

The stewardship program has been operating under guidance of the AMWG as a cooperative effort of the Tahoe Lakefront Owner's Association, the Nevada Tahoe Conservation District (NTCD), and the Nevada Division of Forestry since 2009 (Stanton and TYCAMWG, 2015). It provides lakefront landowners an opportunity to choose from a range of TYC conservation measures and create a completely customized plan for TYC on their property. Elements of a stewardship plan include a site assessment, approved conservation practices, habitat restoration measures, and monitoring. NTCD has been the primary entity engaging with private property owners. Any lakefront landowner may request a TYC site assessment from NTCD to develop a stewardship plan. Stewardship plans are voluntary and information is kept confidential. TRPA will consider stewardship plans in the permitting process for private landowners with a project that occurs in the shorezone. Information on the stewardship program and other aspects of TYC conservation and management may be found at www.tahoeyellowcress.org.

Effectiveness of Programs and Actions – The first conservation strategy in 2002 was developed with the specific intent of precluding the need to list TYC under the ESA. On October 8, 2015, the USFWS published a 12-month finding that listing TYC under the ESA was not warranted, largely based upon the lengthy track record of the MOU signatories in successful, ongoing implementation of conservation actions that are managing, avoiding, or mitigating identified impacts to TYC and its habitat (80 FR 60834). The 2013 MOU and implementation of CS2015 are intended to continue to ensure long-term conservation of TYC, such that USFWS will not have to re-evaluate the status of TYC under the ESA. Actions to downlist or remove TYC from the endangered species list have not been considered in California or Nevada, but could be pursued in the future. In 2011, NTCD completed 37 stewardship plans and outplantings of TYC on eight properties in Nevada. NTCD also expanded its Backyard Conservation Program to include TYC education and outreach. In 2013, NTCD completed 10 stewardship plans, completed plantings at four of the properties, held volunteer group plantings at four additional

locations (NTCD 2013). NTCD led volunteer groups which collected seeds at the Upper Truckee Marsh enclosure and Baldwin Beach (NTCD 2013). Survival of the plantings in 2013 varied from 0 to over 60 percent.

Interim Target – None, threshold is currently in attainment.

Target Attainment Date – None, threshold is currently in attainment.

RECOMMENDATIONS

Analytic Approach – The number of occupied TYC sites has been assessed in the lake-wide surveys of approximately 50 sites from 1979 to 2014. The measured variables in the dataset include stem counts (Stanton and TYCAMWG, 2015) and lake level in the first week of September. The relationship between lake level and number of occupied TYC sites can be described using a monotonic function, where the number of occupied TYC sites decreases as lake level increases (Figure 2). The analysis approach is highly statistically significant and appropriate. The stem count data has not been utilized in the analysis here, but the revised conservation strategy presents analysis of the relationship between mean stem counts for a site over the survey period, populations persistence (number of years TYC was present/the number of surveyed years*100), and lake level (Stanton and TYCAMWG, 2015). For the period from 1979 to 2014, TYC sites with higher stem counts tended to be more persistent, and sites supported higher stem counts under lower lake levels when there is more habitat available. However, there is an unknown relationship between stem count and population size because of the clonal growth of TYC. Although populations with larger stem counts could be more resilient in the face of fluctuating lake levels, recreation patterns on the beaches probably dampen these relationships because TYC may be trampled under all lake levels. The revised conservation strategy ranks TYC survey sites for purposes of conservation and restoration based on a numeric formula that utilizes persistence, stem counts, and variation in stem count for the dataset (1979 to 2014) to calculate a site viability index. In 2015, 45 of the survey sites were ranked: six core, 11 high, 11 medium, 10 low, and seven ephemeral sites. The ranking categories reflect important differences in the biological character of TYC populations. Core sites have the highest conservation priority because they support relatively large, invariant, and persistent populations of TYC that play an important role in maintaining the species. All six core sites are located at the mouths of large creeks where a high degree of topographic diversity consistently provides favorable habitat conditions across a wide range of lake levels. Many of the high sites have lower recreational pressure and/or high topographic diversity and are capable of supporting large numbers of stems in some years. In contrast, most of the low sites only have habitat in low lake level years, some are very heavily used, and trampling may be an important factor in the variability of stem counts. The revised conservation strategy recommends that the AMWG continue to utilize this analytical approach to assess TYC survey sites.

Monitoring Approach – In 2010, the AMWG adopted an adaptive survey strategy that emphasizes high lake level monitoring. Surveys are now completed every year when Lake Tahoe is at or above 6,226 feet (1,897.7 meters) LTD, but only every other year at lower lake levels. This approach is adequate for assessing the numeric standard of the number of sites occupied by TYC. Goal 5 in the revised conservation strategy is to continue the adaptive survey strategy with the following objectives: 1) maintain this adaptive survey strategy; 2) continue to utilize the survey data to maintain site viability rankings; 3) develop a monitoring strategy to evaluate geomorphic beach processes, especially those at creek mouths or outflows that form berms and swales; and 4) develop a monitoring strategy to evaluate impacts to TYC plants and habitat from recreation.

Modification of the Threshold Standard or Indicator – The number of TYC occupied sites is an appropriate indicator as long as the level of Lake Tahoe is considered in the analysis. Standard review should consider inclusion of a lake level adjusted target for number of occupied sites.

Attain or Maintain Threshold – Maintaining habitat and promoting the persistence of existing TYC populations will require ongoing implementation of the TYC Conservation Strategy and the participation of TRPA and other partners in the AMWG. Successful implementation of the conservation strategy may continue to preclude the need to list TYC under the ESA and may provide grounds for changing the legal

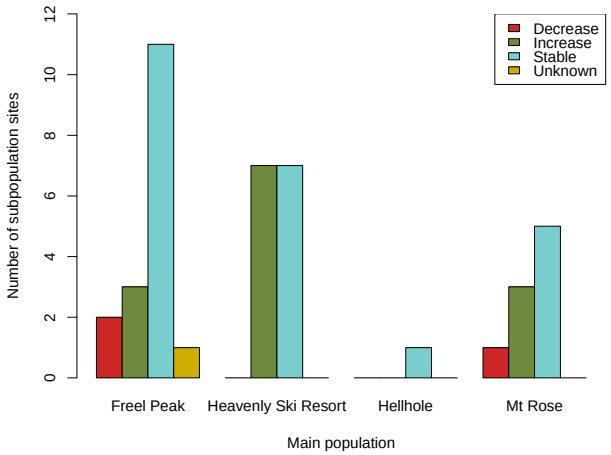
status of the species in California and Nevada. The six goals presented in the original conservation strategy were modified in the revised strategy to incorporate results from the field research program, information derived from a longer survey record, and the professional knowledge of independent researchers and the AMWG members that have been the day-to-day practitioners of TYC conservation for over 12 years. The revised goals and objectives in the revised strategy are not intended to alter the current regulatory requirements of any agency or negatively affect the protection afforded this species through existing policies and guidelines. The six goals have between two to five objectives each that provide measureable targets for the conservation and management of TYC within an adaptive management framework. Many of the 23 total objectives can be implemented within a site-specific management context and may or may not require dedicated funding, depending on the agency landowner. However, funding to implement the conservation strategy ended in 2015 and additional funding is needed to support agency participation in the adaptive management process and also to meet several specific objectives. Funding for the stewardship program ended in 2013 and additional funding is needed to implement the program and also to maintain a supply of TYC seed and container-grown TYC for plantings for population enhancement or creation. Additional funding is also needed to continue the adaptive survey strategy and develop new monitoring strategies that evaluate geomorphic beach processes and impacts from recreation. Finally, the AMWG used a key management question framework to focus the research phase of the TYC adaptive management program from 2003 to 2010 (Pavlik and O'Leary 2002). The process should be initiated again upon adoption of the revised conservation strategy to develop key management questions to address knowledge gaps for TYC decision-making over the next 10 years.

Sensitive Plants: **Tahoe Draba (*Draba asterophora var. asterophora*)**

Status	Trend

TAHOE DRABA (*DRABA ASTEROPHORA VAR. ASTEROPHORA*)

Status: **Considerably Better than Target**
Trend: **Little or No Change**
Confidence: **Moderate**



Number of subpopulation sites within each of the four main population sites of Tahoe draba where plant counts decreased, increased, were stable, or were unknown between 2004 and 2013. Data Source: U.S. Forest Service - LTBMU. The observed increases in population are likely due to more intensive search rather than an actual increase.

Photo

Photo Credit: Calscape.org, Copyright 2002 Steve Matson.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Tahoe draba (*Draba asterophora* var. *asterophora)* is a small alpine perennial plant in the Brassicaceae (mustard) family. The species has small yellow flowers, and is characterized by a pincushion growth form where all the foliage grows close to the ground in a short mound or mat (Baad 1979). The worldwide distribution of Tahoe draba is limited to high elevation (greater than 8,000 feet) steep, north-facing talus slopes in or near the Lake Tahoe Region (Schlesinger and Holst 2000). Two historical populations were reported south of the Region (Mt. Gibbs in Yosemite and near Sonora Pass), but these have not been relocated since they were recorded in 1916 and 1936 respectively (Engelhardt and Gross 2013). Within the Tahoe Region, the species is found in four main populations located around Mount Rose in the north, and the Freel Peak/Jobs Sister and Monument Peak areas in the south, with approximately 41 subpopulations (McKnight and Rowe 2015). A recent genetic study found that the northern and southern populations of Tahoe draba are genetically distinct: northern populations are polyploid while southern populations are diploid (Putnam 2013). The author of this study recommends treating these populations as separate taxonomic entities, along with Cup Lake draba (*Draba asterophora* var. *macrocarpa*) (Putnam 2013). Although there are a few occurrences located adjacent to the Lake Tahoe Region in the Humboldt-Toiyabe National Forest, the largest number of plants occur in

the Tahoe Region populations; thus the status of Tahoe populations is critical to the viability of the entire species. Tahoe draba is a threatened species in California (California Department of Fish and Wildlife 2015) and Nevada, and is considered imperilled globally (Nevada Natural Heritage Program 2015b).

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Sensitive plants

Adopted Standards – Maintain five Tahoe draba population sites.

Type of Standard – Numerical standard

Indicator (Unit of Measure) – The total number of subpopulation sites that are maintained as suitable habitat as determined by a qualified expert.

Human & Environmental Drivers – Human activities that pose direct threats include recreational activities that might trample or uproot plants (e.g., camping, hiking, equestrian use, trail construction, snowmobiles), and the construction and maintenance of ski resort facilities (California Department of Fish and Wildlife 2015). Trampling of Tahoe draba at Freel Peak, a popular hiking destination, has been observed (Putnam 2013, McKnight and Rowe 2015). Snowmobile traffic may increasingly be cause for concern at the Mount Rose and Freel Peak/Jobs Sister areas due to decreased snowpack (Engelhardt and Gross 2011a). Tahoe draba is found at both Heavenly Ski Resort and Mount Rose Ski Tahoe where construction and maintenance of ski facilities have the potential to directly impact population sites. Results from one study indicate that grading of ski runs is correlated with lower plant densities, smaller plant sizes, and higher annual mortality rates (Engelhardt and Gross 2013, Putnam 2013). Changes in precipitation type, timing, and quantity associated with climate change may have significant impacts on Tahoe draba distribution and abundance (Smith et al. 2008). Decreased snowpack and/or earlier snowmelt have the potential to impact populations by altering plant community composition and species interactions, and decoupling plant flowering periods and insect pollinator visitation.

MONITORING AND ANALYSIS

Monitoring Partners – Ecology and botany staff from the U.S. Forest Service – Lake Tahoe Region Management Unit (LTBMU) and Humboldt-Toiyabe National Forest.

Monitoring Approach – Currently, a total of 41 subpopulations of *Draba asterophora* var. *asterophora* are monitored by various partners following standardized protocols developed by U.S. Forest Service botanists. The monitoring protocol can be found in Engelhardt and Gross, 2013. A brief description of monitoring efforts is below:

> *U.S. Forest Service monitoring of Tahoe draba began in 2004 when plants were located and counted at 22 subpopulation sites (Engelhardt and Gross 2013). An additional three sites were added in a limited survey in 2005. All sites were re-surveyed in 2009 and nine new sites were added. In 2013 six sites were revisited and one new site was discovered, and in 2014 14 sites were revisited. All known subpopulations are censused by LTBMU staff every five years at a minimum. A comprehensive long-term monitoring program for Tahoe draba was initiated in 2009 when plots were installed at seven subpopulation sites within three LTBMU populations (Engelhardt and Gross 2011a). Monitoring plots were established at three subpopulations within two populations (Relay Peak and Mt. Rose Ski Area) on the Humboldt-Toiyabe National Forest in 2011. Monitoring occurred two years after plot establishment to collect baseline data, and will occur every three to five years until the species is no longer considered sensitive.*

The monitoring objective is to provide a quantitative and consistent method for evaluating status and trend, especially at sites comprised of large numbers of plants where it is difficult to accurately count individuals. Monitoring in permanent plots allows for more repeatable and efficient surveys.

Demographic data, climate patterns, and associated plant community and site data will help interpret status and trend changes.

Analytic Approach – No formal statistical methods were used to assess the status or trend of this indicator. The indicator standard does not necessarily require formal analysis, as the maintenance of two population sites can be demonstrated by regular stable or increasing population counts. However, formal analysis of population trends and drivers, and habitat quality would improve confidence in the status and trend for this indicator.

INDICATOR STATE

Status – Considerably better than target. Tahoe draba currently exists in four main populations and 41 subpopulations near Freel Peak, Monument Peak, and Mt. Rose. Using subpopulation sites, as has been done for all past evaluations, the current status is 820 percent of the threshold standard. Thus the standard is in attainment and was determined to be considerably better than target.

Trend – Little or no change. U.S. Forest Service monitoring occurred in 2015, but official data was not available in time to be included in this evaluation. Census data and demographic data collected from 2004 to 2008 as part of a PhD dissertation (Putnam 2013) indicate the trend for Tahoe draba is little or no change. Putnam's (2013) monitoring of six sites over a four-year period indicated that populations were stable in the absence of disturbance, but strongly relied on adult survivorship over new recruitment for population maintenance and are thus vulnerable to disturbance impacts (Putnam 2013). Between 2004/05 and 2014, 25 of 41 subpopulation sites (61 percent) were stable, twelve (29 percent) sites increased (although at least six of these increases were probably due to increased sampling effort rather than population growth), three sites (seven percent) decreased, and the status of one site (two percent) was unknown (McKnight and Rowe 2015).

Confidence –

Status – High. There is a high degree of confidence in the status based on the quality of the data collected and the robust nature of the monitoring program. There is a moderate degree of confidence in the trend based on 10 years of U.S. Forest Service population census data, and four years of demographic monitoring (Putnam, 2013).

Trend – Moderate. Variability in sampling effort and inconsistencies in how an individual plant was defined could lead to variation in population census, thus differences between sampling periods cannot be confidently analyzed. However, an overall pattern of population stability from the census data combined with stable population structure measured by Putnam (2013) indicates populations of Tahoe draba are generally stable. The U.S. Forest Service 2015 long-term monitoring data will provide a stronger level of confidence in the trend, and the level of confidence will continue to increase with each data collection cycle.

Overall – Moderate. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA and partners have adopted ordinances, policies, and programs that require that sensitive plants be protected from adverse activities; projects must fully mitigate impacts to sensitive plants, or they will be prohibited. In 2006, the U.S. Forest Service installed an official trail to the top of Freel Peak to concentrate use and direct foot traffic away from Tahoe draba. A memorandum of understanding (MOU) was signed in 2006 between the U.S. Forest Service (Humboldt-Toiyabe National Forest and U.S. Forest Service – LTBMU), Mt. Rose Ski Tahoe, Heavenly Ski Resort, and TRPA (Putnam 2013). The MOU contains specific actions such as developing a long-term monitoring program and initiating development of a conservation assessment/strategy to streamline management of Tahoe draba across its known range. Tthe MOU expired in 2011 and has not been renewed.

Effectiveness of Programs and Actions – The construction of an official trail to the top of Freel Peak appears to have reduced impacts to plants, but a lack of baseline data makes it impossible to quantitatively assess the effectiveness. Translocations of plants prior to lift construction projects at both

Heavenly Ski Resort and Mt. Rose Ski Tahoe have been unsuccessful and are not an effective mitigation strategy (MOU 2006).

Interim Target – None, the threshold standard is currently in attainment.

Target Attainment Date – None, the threshold standard is currently in attainment.

RECOMMENDATIONS

Analytic Approach – Formal analysis of both long-term demographic monitoring data and population census trends would improve confidence in reported trends for Tahoe draba, and improve management of this species. The LTBMU long-term monitoring plan for Tahoe draba (Engelhardt and Gross 2011a) describes analyses planned to assess:

1. Population density and plant size.
2. Demographic structure and reproductive output.
3. Population viability.
4. Climate change impacts.
5. Competition and habitat suitability.
6. Ski area effects.

Consideration should be given to the use of a mixed effects models to assess the impact of climate change, habitat suitability, competition and sampling design.

Monitoring Approach – None. The current monitoring approach provides a comprehensive understanding of the status and trends of Tahoe draba across its range.

Modification of the Threshold Standard or Indicator – The threshold standard could be modified to formally adopt a biologically relevant definition of a population, and to recognize and ensure protection of the genetic diversity in Tahoe Draba populations (Putnam, 2013). A population is defined as occurring at least one kilometer from other populations, and a subpopulation is defined as a discrete occurrence of interacting plants within one kilometer of other subpopulations (NatureServe 2004). In the past the number of subpopulation sites has been used to evaluate the threshold. The threshold standard could be more consistently assessed if measured as three populations, comprised of at least five subpopulations each, with at least one of these subpopulations comprised of a minimum of 1,000 plants. This change would better reflect the biologically important populations for conservation, and increase protection for the species by specifying protection of 15 subpopulations sites. This change was also recommended in the 2011 Threshold Evaluation Report (TRPA 2012). If this new standard were applied to this evaluation, the standard would still have been determined to be in attainment and "considerably better than target."

Attain or Maintain Threshold – To continue long-term monitoring and streamlined management of Tahoe draba, partners should consider reviewing the expired MOU between the U.S. Forest Service (Humboldt-Toiyabe National Forest and LTBMU), Mt. Rose Ski Tahoe, Heavenly Ski Resort, and TRPA.

Sensitive Plants: **Long-Petaled Lewisia (*Lewisia pygmaea longipetala*)**

Status	Trend

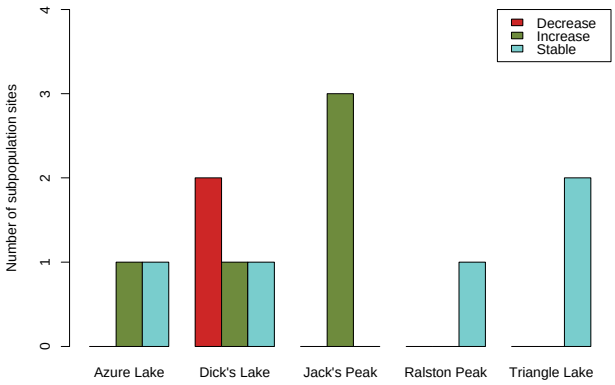
LONG-PETALED LEWISIA (*LEWISIA PYGMAEA LONGIPETALA)*

Status: **Considerably Better than Target**
Trend: **Little or No Change**
Confidence: **Moderate**

Photo

Photo credit: Calscape.org, Copyright 2007.

Long-petaled lewisia population trends



Number of subpopulations at each population site of long-petaled lewisia and subpopulation trend (decrease, increase, or stable) between initial and final monitoring date. Monitoring periods vary by subpopulation. Source: U.S. Forest Service-LTBMU

Data Evaluation and Interpretation

BACKGROUND

Relevance – Long-petaled lewisia *(Lewisia longipetala*) is a low-growing perennial plant in the Purslane (Portulaceae) family. The species has pale pink flowers and fleshy leaves and grows at high elevations (7,874 to 12,500 feet) in moist, rocky habitats directly below persistent snowfields (Halford 1992, Halford and Nowak 1996, McKnight and Rowe 2015). It grows in association with snowbank vegetation communities and optimum habitat is north-facing low gradient gravelly or bouldery slopes with low vegetation cover (Halford and Nowak 1996). The worldwide distribution of long-petaled lewisia is limited to 16 element occurrences in the northern Sierra Nevada crest in El Dorado, Nevada, and Placer Counties, California (McKnight and Rowe 2015, CNPS Rare Plant Program 2016).Within the Lake Tahoe Region the species is found in five populations consisting of 12 subpopulations and approximately 11,000 individual plants (McKnight and Rowe 2015). The species is currently designated as a U.S. Forest Service sensitive species and a TRPA sensitive plant species. It has a California State Rank of S3 (vulnerable), a Global Rank of G3 (vulnerable), and is included in the California Native Plant Society Inventory of Rare and Endangered Plants on list 1B.3 (rare, threatened, or endangered in California; not very threatened in California) and is therefore eligible for state listing (CNPS Rare Plant Program 2016).

The long-petaled lewisia populations in the Tahoe Region are among the largest (CNPS, 2016), and are crucial for maintaining the viability of the species (Engelhardt and Gross 2011b). As a snowbank obligate species (Halford and Nowak 1996), long-petaled lewisia is especially threatened by reduced snowpack in a warming climate. The health of this species is an indicator of climate change impacts on snowbank communities in the Lake Tahoe Region and northern Sierra Nevada.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Sensitive plants

Adopted Standards – Maintain two long-petaled lewisia population sites

Type of Standard – Numerical standard

Indicator (Unit of Measure) – The total number of population sites that are maintained as suitable habitat as determined by a qualified expert.

Human & Environmental Drivers – As a result of climate change there is likely to be a decrease in snowpack and persistence and an increase in rain versus snow predicted for the northern Sierra Nevada (e.g. Mastrandrea and Luers 2012, Safford et al. 2012). This shift poses the most significant threat to this snowfield dependent species. Populations occurring at further distances from persistent snowfields, or on drier south-facing aspects or steeper slopes have lower densities and individual plants are smaller (Halford and Nowak 1996). Dry conditions with few persistent snowfields may have already contributed to observed declines in two populations (McKnight and Engelhardt 2013). Climate change could also lead to competitive exclusion if other plant species are able to expand into areas that previously supported long-petaled lewisia (Halford and Nowak, 1996). Most populations of long-petaled lewisia occur in remote, off-trail areas in designated wilderness; thus direct impacts from human activities are relatively low (Halford and Nowak 1996, McKnight and Rowe 2015). Human activities that pose direct threats include recreational activities that might trample or uproot plants (e.g., camping, hiking, equestrian use, trail construction, snowmobiles) (Halford 1992), horticultural collecting (CNPS Rare Plant Program 2016), and road construction that might alter hydrology and degrade habitat (McKnight and Rowe 2015).

MONITORING AND ANALYSIS

Monitoring Partners – Ecology and botany staff from the U.S. Forest Service – Lake Tahoe Region Management Unit in coordination with Eldorado and Tahoe National Forest staff

Monitoring Approach – Quantitative monitoring of long-petaled lewisia in the Region began in 2004 when plants were located and counted at three population sites (Dick's Lake, Triangle Lake and Azure Lake) in six subpopulation sites (McKnight and Rowe 2015). A new subpopulation was discovered near Azure Lake in 2006, and near Triangle Lake in 2009, and new populations were discovered near Jack's Peak in 2011, and Ralston Peak in 2012, bringing the total number of known populations to five, with 12 subpopulations. All known subpopulations are censused by U.S. Forest Service Lake Tahoe Basin Management Unit (LTBMU) staff every five years at a minimum (typically more frequently), and long-term demographic monitoring occurs every three to five years in permanent plots established at two populations. An extensive survey was completed for long-petaled lewisia in 1991 and two long-term monitoring plots were installed at Region Peak in the Tahoe National Forest and within the LTBMU at Keith's Dome above Triangle Lake (Halford 1992). Using the same methodology, but with additional demographic data collected, LTBMU staff installed long-term monitoring plots above Dick's Lake and above Triangle Lake. Plant populations are visited every three to five years (more frequently when data suggests the population is decreasing). The monitoring objective is to provide a quantitative and consistent method for evaluating status and trend, especially at sites comprised of large numbers of plants where it is difficult to accurately count individuals. Demographic data, climate patterns, and associated plant community and site data will help interpret status and trend changes.

Analytic Approach – No formal statistical methods were used to assess the status or trend of this indicator. The indicator standard does not necessarily require formal analysis, as the maintenance of at least two population sites can be demonstrated by regular stable or increasing population counts. However, formal analysis of population trends and drivers, and habitat quality would improve confidence in the status and trend for this indicator.

INDICATOR STATE

Status – Considerably better than target. Five populations of long-petaled lewisia with 12 subpopulations in the Desolation Wilderness exist in the Lake Tahoe Region (McKnight and Rowe 2015); therefore the status determination is considerably better than target, and the threshold standard is in attainment.

Trend – Little or no change. Long-term demographic monitoring occurred in 2015, but data was not available in time to be included in this evaluation. Based on census data, a conservative interpretation of the trend for long-petaled lewisia is little or no change. Two of the three populations that have been monitored since 2004 have consistently been stable or increasing, two new populations have been added, and the number of subpopulations monitored has doubled. One population has seen declines, with two of the four subpopulations at Dick's Lake declining since 2004. However, the declines occurred between 2004 and 2009, and these subpopulations have been stable or increasing since then, while the other two subpopulations at Dick's Lake are increasing or stable (McKnight and Rowe, 2015).

Confidence –

Status – High. There is a high degree of confidence in the status due to the quality of the data collected and the robust nature of the monitoring program.
Trend – Moderate. There is moderate confidence in the trend analysis because although the majority of populations and subpopulations are stable or increasing, the trend interpretation was based on data from only two to three sample periods, with the Jack's Peak and Ralston Peak populations monitored only since 2011 and 2012 respectively.
Overall – Moderate. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA and partners have adopted ordinances, policies, and programs that require sensitive plants be protected from adverse activities; projects must fully mitigate impacts to sensitive plants, or they will be prohibited.

Effectiveness of Programs and Actions – It is believed that requiring surveys and avoidance measures prior to the implementation of actions known to impact sensitive species is effective at avoiding impacts to sensitive plants.

Interim Target – None, the threshold standard is in attainment.

Target Attainment Date – None, the threshold standard is in attainment.

RECOMMENDATIONS

Analytic Approach – Formal analysis of both long-term demographic monitoring data and population census trends would improve confidence in reported trends for long-petaled lewisia, and improve management of this species. The LTBMU long-term monitoring plan for long-petaled lewisia (Engelhardt and Gross 2011b) proposes the following analysis to assess trends and drivers in the two monitored populations:

1. Density
2. Demographic structure
3. Climate change
4. Interspecific competition

Consideration should be given to the use of a mixed effects models to assess the impact of climate change, habitat suitability, competition, sampling design, and the relationship between plant size and

fecundity.

Monitoring Approach –When long-term monitoring was established, a third site could not be established at Azure Lake due to granite slabs that prevented installation of permanent plot markers (Engelhardt and Gross 2011b). An additional long-term monitoring plot at the fairly large (500-plus individual plants) population discovered in 2012 at Ralston Peak would provide a more comprehensive description of the trends of long-petaled lewisia populations in the Lake Tahoe Region.

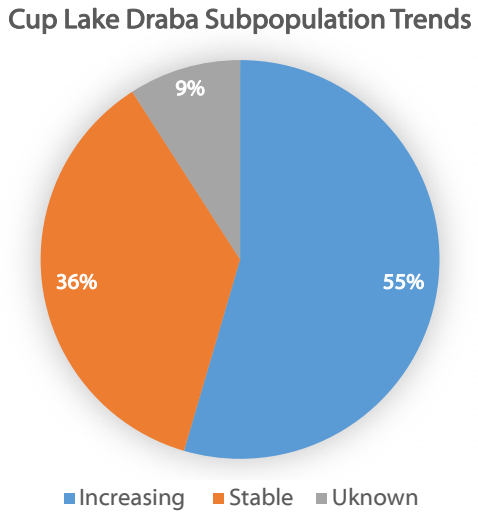
The subpopulation census data could be enhanced with collection (if necessary), description and analysis of subpopulation site characteristics. Following the methods of Halford (1996), characteristics such as slope, elevation, aspect, distance to nearest uphill snowbank, annual climate variables such as date of greatest Snow Water Equivalent (SWE) and date of SWE=0, temperature, and groundcover characteristics could be examined for correlations with population size and changes. Halford (1996) found that plant density and size was lower in populations growing on steeper (drier) slopes or on slopes with southern aspect. Dry conditions in the vicinity of the two subpopulations that declined at Dick's Lake were noted as a possible explanation for the declines (McKnight and Engelhardt 2013); a formal analysis of site characteristics for the known subpopulations would be useful.

Relocation and establishment of a regular monitoring of the population at Keith's Dome/Triangle Lake (Halford, 1992), and the plot outside the Region and Basin Peak, would provide valuable information for assessing longer term trends.

Modification of the Threshold Standard or Indicator – A standard of three populations, with at least two populations comprised of at least two subpopulations, with at least one of these subpopulations comprised of a minimum of 1,000 plants, would better reflect biologically important populations for conservation. This recommendation was also made in the 2011 Threshold Evaluation Report. If this new standard were applied for this evaluation the standard would still have been determined to be in attainment and "considerably better than target."

Attain or Maintain Threshold – No recommended changes.

Sensitive Plants: **Cup Lake Draba (*Draba asterophora* var. *macrocarpa*)**

Status	Trend
CUP LAKE DRABA (*DRABA ASTEROPHORA* VAR. *MACROCARPA*) Status: **Considerably Better than Target** Trend: **Little or No Change** Confidence: **Moderate**	 Cup Lake draba subpopulation trends in the Tahoe Region as classified by the USFS Lake Tahoe Region Management Unit. Six subpopulations were identified as having an increasing number of plants, four subpopulations were identified as stable, and the status of single population was unknown.
Photo  Photo Credit: Mike Taylor. USDA Forest Service	

Data Evaluation and Interpretation

BACKGROUND

Relevance – Cup Lake draba (*Draba asterophora* var. *macrocarpa)* is a small alpine perennial plant in the Brassicaceae (mustard) family. The species has small yellow flowers and is characterized by a cushion growth form where all the foliage grows close to the ground in a short mound or mat (Baad 1979). Cup Lake draba occurs on steep, north-facing talus slopes, chutes and boulder slopes on decomposed granite soils (Hickman 1993). It is found above 8,200 feet in rocky subalpine coniferous forests (CNPS Rare Plant Program 2016). The distribution of Cup Lake draba is extremely limited with only two known populations in the Desolation Wilderness. One population is at Cup Lake on the El Dorado National Forest (outside of the Region), and the other occurs as multiple subpopulations along a ridge between Talking Mountain and Ralston Peak (within the Region). More than half of the known plants occur in the Tahoe Region population. Thus the Region population is critical to the viability of the entire species. Cup Lake draba has a State Rank of S1 (critically imperilled), a Global Rank of G2T1 (critically imperilled), and a CNPS Rare Plant Rank of 1B.1 (rare, threatened, or endangered in California and elsewhere; seriously endangered in California) (CNPS Rare Plant Program 2016).

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Sensitive plant species

Adopted Standards – Maintain two Cup Lake draba population sites.

Type of Standard – Numerical standard

Indicator (Unit of Measure) – The total number of subpopulation sites that are maintained as suitable habitat as determined by a qualified expert.

Human & Environmental Drivers – Human activities that pose direct threats include recreational activities that might trample or uproot plants (e.g., camping, hiking, equestrian use, trail construction, snowmobiles) (CNPS Rare Plant Program 2016). However, the known populations are located in remote, off-trail areas, and potentially of greater concern is the threat of climate change. Climate change may adversely affect Cup Lake draba populations through its influence on precipitation type, timing, and quantity. Decreased snowpack or a change in snowmelt timing could alter plant community composition and species interactions, and/or decouple plant flowering periods and insect pollinator visitation.

MONITORING AND ANALYSIS

Monitoring Partners – Ecology and botany staff from the U.S. Forest Service – Lake Tahoe Region Management Unit (LTBMU), and Eldorado National Forest.

Monitoring Approach – Currently, a total of 10 subpopulations of *Draba asterophora var. macrocarpa* are monitored by various partners following standardized protocols developed by U.S. Forest Service botanists. The monitoring protocol can be found in Engelhardt and Gross, 2013. A brief description of monitoring efforts is below:

> *U.S. Forest Service monitoring of Cup Lake draba began in 2004 when plants were located and counted at five subpopulation sites (Engelhardt and Gross 2013). All sites were re-surveyed in 2009 and one new site was added. In 2011 two new sites were discovered. In 2013 one new site was discovered and an existing site (Drasm 1f) was split into two sites (Drasm 1f and 1k) to bring the total number of monitored subpopulations to 10. A census of all known subpopulations is completed at a minimum of every five years by LTBMU staff. A long-term demographic monitoring program for Cup Lake draba was initiated in 2010 when plots were installed at two subpopulation sites within the LTBMU population (Engelhardt and Gross 2013). Monitoring plots were tentatively scheduled to be added at the Cup Lake population on the El Dorado National Forest, but so far this has not occurred. Monitoring occurred two years after plot establishment to collect baseline data, and will occur every three to five years until the species is no longer considered sensitive.*

The monitoring objective is to provide a quantitative and consistent method for evaluating status and trend, especially at sites comprised of large numbers of plants where it is difficult to accurately count individuals. Monitoring in permanent plots allows for more repeatable and efficient surveys. Demographic data, climate patterns, and associated plant community and site data will help interpret status and trend changes.

Analytic Approach – No formal statistical methods were used to assess the status or trend of this indicator. The indicator standard does not necessarily require formal analysis, as the maintenance of two population sites can be demonstrated by regular stable or increasing population counts. However, formal analysis of population trends and drivers, and habitat quality would improve confidence in the status and trend for this indicator.

INDICATOR STATE

Status – Considerably better than target. There are 10 subpopulation sites in the Region, 500 percent greater than the threshold standard of two. Subpopulation count has been used to assess attainment in all previous threshold evaluation reports. Thus, the standard is in attainment and was determined to be considerably better than target.

Trend – Little or no change. Census data indicate the trend for Cup Lake draba is little or no change. Of the 11 subpopulations, six were found to have increased in size, four were stable, and status on one was unknown. The status of one subpopulation is unknown because it has not been visited since 2004. The subpopulation is located in hazardous terrain and concern for staff safety has precluded a full census. LTBMU long-term demographic monitoring occurred in 2015, but the data was not available in time to be included in this evaluation. The observed increases are likely due to increased survey effort rather than actual increases (McKnight and Rowe 2015).

Confidence –

Status – High. There is a high degree of confidence in the status based on the quality of the data collected and the robust nature of the monitoring program.

Trend – Moderate. There is a moderate degree of confidence in the trend determination, with up to seven years of monitoring data available for some subpopulations. The results of the 2015 demographic monitoring will improve the level of confidence in the trend for Cup Lake draba.

Overall – Moderate. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA and partners have adopted ordinances, policies, and programs that require that sensitive plants be protected from adverse activities; projects must fully mitigate impacts to sensitive plants, or they will be prohibited.

Effectiveness of Programs and Actions – It is believed that requiring surveys and avoidance measures prior to the implementation of actions known to impact sensitive species, is effective at avoiding impacts to sensitive plants.

Interim Target – None, the threshold standard is in attainment.

Target Attainment Date – None, the threshold standard is in attainment.

RECOMMENDATIONS

Analytic Approach – Formal analysis of both long-term demographic monitoring data and population census trends would improve confidence in reported trends for Cup Lake draba, and improve management of this species. The LTBMU long-term monitoring plan for Cup Lake draba (Engelhardt and Gross 2011a) describes analyses planned to assess:

1. Population density and plant size.
2. Demographic structure and reproductive output.
3. Population viability.
4. Climate change impacts.
5. Competition and habitat suitability.

Consideration should be given to the use of a mixed effects models to assess the impact of climate change, habitat suitability, competition and sampling design.

Monitoring Approach – The current monitoring assesses the status and trend of only one of two extant populations of Cup lake draba. While the other population is outside of the Tahoe Region, a holistic approach to species management would also include long-term demographic monitoring plots be established at the Cup Lake population site on the El Dorado National Forest.

Modification of the Threshold Standard or Indicator – Consideration should be given to changing or interpreting the threshold standard to reflect the biological definition of a population, and ensure protection across the genetic range of Cup lake draba. A population is defined as occurring at least one kilometer from other populations, and a subpopulation is defined as a discrete occurrence of interacting plants within one kilometer of other subpopulations (NatureServe 2004). Only one population occurs in the Tahoe Region. The number of subpopulation sites has been used to evaluate the threshold (TRPA, 2012d, 2007, 2001). It is recommended that the standard be modified to one population comprised of at

least four subpopulations, with at least one of these subpopulations containing 1,000 or more plants. This change was also recommended in the 2011 Threshold Evaluation Report (TRPA 2012). If this new standard were adopted for this evaluation the standard would still have been determined to be in attainment and "considerably better than target."

Attain or Maintain Threshold – No recommended changes.

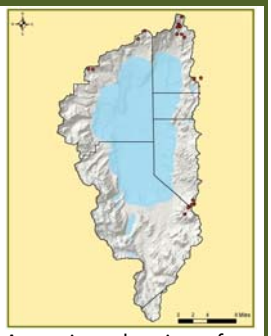
Sensitive Plants: **Galena Creek Rockcress (*Boechera rigidissima* var. *demota*)**

Status	Trend

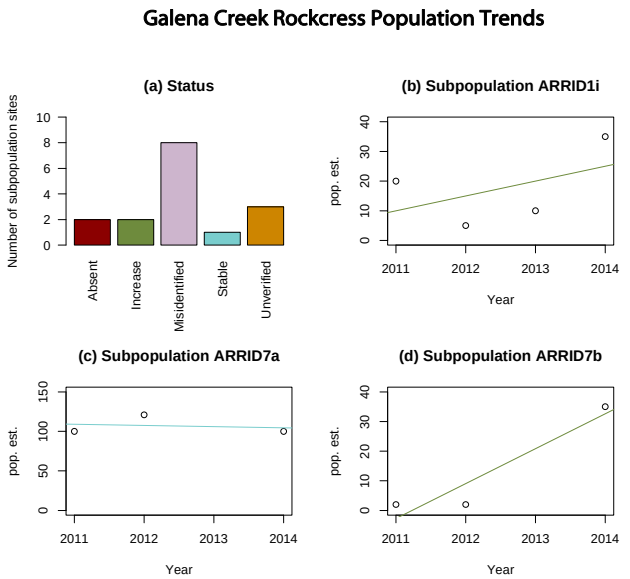
GALENA CREEK ROCKCRESS

Status: **Considerably Worse Than Target**
Trend: **Little or No Change**
Confidence: **Low**

Map



Approximate locations of suspected Galena Creek rockcress in the Lake Tahoe Region, September, 2010. Source: USFS-LTBMU.



(a) Number of LTBMU subpopulations where Galena Creek rockcress plant counts were absent, increased, misidentified, stable, or unverified as of 2014. (b)-(d) Census counts for the three verified subpopulations of Galena Creek rockcress. Source: U.S. Forest Service-LTBMU.

Data Evaluation and Interpretation

BACKGROUND

Relevance – Galena Creek rockcress (*Boechera rigidissima var. demote* formerly known as *Arabis rigidissima var demota)* is a slender perennial plant in the Brassicaceae (mustard) family. The species occurs on sandy to rocky soils or on outcrops derived from granitic or volcanic materials, mostly on moderate to steep terrain with northerly aspects. It often occurs in drainage ways, near meadow edges, or in other moisture accumulating microsites, generally in openings in upper montane coniferous forest (*Abies-Pinus*) and aspen (*Populus tremuloides*) associations (Nevada Natural Heritage Program 2015a, CNPS Rare Plant Program 2016). It is difficult to identify in the field, and often forms hybrids with Elko rockcress (*Boechera elkoensis* = *Arabis platysperma* var. *platysperma*) (McKnight and Rowe 2015). Characteristics for positive identification include auriculate stem leaves, proximally pubescent stems, glabrous pedicels and fruits, narrow fruits (2.5 to 3.5 millimetres) that are erect but not appressed to rachis and basal leaves with branched hairs (2 to 5 rays) (Morefield 2001, McKnight and Rowe 2015). The taxon is classified under Boechera rigidissma in the Jepson Manual and Flora of North America (Al-Shehbaz and Windham 2003, Baldwin et al. 2012), but recent genetic work indicates var. *demota* is a

distinct species of *Boechera* (McKnight and Rowe 2015). Galena Creek rockcress was first recommended for inclusion as a TRPA identified sensitive plant species in the 2001 Threshold Evaluation Report, based on the fact that it was identified as a focal species in the Lake Tahoe Watershed Assessment, and the U.S. Forest Service had listed it as a species of concern (Schlesinger and Holst 2000, TRPA 2001). However, TRPA did not evaluate the species in the 2006 Threshold Evaluation Report, citing concerns over the validity of the species and a lack of information (TRPA 2007). Galena Creek rockcress has a global rank of G3T3Q (vulnerable but has taxonomic questions), a state rank of S1 (critically imperilled), a California Native Plant Society Rare Plant Rank of 1B.2 (rare, threatened or endangered in California and elsewhere; fairly endangered in California), and is on the at-risk list of the Nevada Natural Heritage Program (Nevada Natural Heritage Program 2015, CNPS Rare Plant Program 2016). The species is restricted to Washoe County in Nevada and Placer and Nevada counties in California, with 41 element occurrences reported (Nevada Natural Heritage Program 2015) (seven element occurrences reported by CNPS Rare Plant Program), and an estimated 10,000 individuals are known from private, state and Forest Service land (McKnight and Rowe 2015). Taxonomic confusion and difficult identification have led to misidentification of many occurrences of Galena Creek rockcress (see above figure, part a), and fluctuations in the number of populations reported (McKnight and Rowe 2015). At present there are two populations with three subpopulations of Galena Creek rockcress verified in the Region (McKnight and Rowe 2015). Thus the species is likely more threatened in the Region than originally thought, and the current threshold standard of seven populations is likely not attainable.

Figure 1: Galena rock cress. Photo Credit: Jim Morefield, Flickr: EOL Images

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Sensitive plant species

Adopted Standards – Maintain seven Galena Creek rockcress population sites

Type of Standard – Numerical standard

Indicator (Unit of Measure) – The total number of population sites that are maintained as suitable habitat as determined by a qualified expert.

Human & Environmental Drivers – The primary threat to the species are recreational activities that might trample or uproot plants (e.g., camping, hiking, equestrian use, trail construction, snowmobiles) (McKnight and Rowe 2015). Other direct human threats include forest management such as road construction and maintenance, logging, fire suppression, and fuel reduction treatments (Morefield 2003, CNPS Rare Plant Program 2016). The small population sizes that are typical (e.g. all confirmed LTBMU populations are less than 150 individual plants) make this species susceptible to catastrophic loss from stochastic events. As with other high elevation species, changes in precipitation type, timing, and quantity associated with climate change may adversely affect the species by altering plant community composition and species interactions, and/or decoupling plant flowering periods and insect pollinator visitation.

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring is completed by ecology and botany staff from the U.S. Forest Service – Lake Tahoe Region Management Unit.

Monitoring Approach – This species is included in the sensitive species monitoring program at the U.S. Forest Service - LTBMU. Plant population sites are visited every five years or more frequently when the

occurrence is new or data suggests that the population is decreasing. Recent monitoring has focused on verification of species identity.

Analytic Approach – No formal analysis of the status or trend of this species has occurred.

INDICATOR STATE

Status – Considerably worse than target. Two populations, with three subpopulations, of Galena Creek rockcress have been confirmed in the Region as of 2014. Three potential subpopulation sites remained where identification needed to be confirmed in 2015 (McKnight and Rowe 2015). Eight subpopulations were determined to be misidentified and two additional sites were likely misidentified given their location (McKnight and Rowe 2015). At a minimum there are two known populations with three subpopulations of Galena Creek rockcress in the Tahoe Region. If all three of the remaining subpopulation sites are confirmed to be Galena Creek rockcress there are three populations with six subpopulations in the Region. Either way, the current status of Galena Creek rockcress was determined to be considerably worse than target.

Trend – Insufficient data to determine trend. Two of the three verified subpopulations of Galena Creek rockcress had recorded population increases between 2011 and 2014 and the third (and largest) population was stable (McKnight and Rowe 2015). Of the three unverified subpopulations, one decreased in size between 2009 and 2014, one possibly increased between 2009 and 2011 but had not been revisited since, and one increased between 2011 and 2012. The trend determination of "insufficient data to determine" is based on the issues related to population verification. Based on the confirmed population the trend determination would be "little or no change."

Confidence –

Status - Moderate. There is high confidence in the status of Galena Creek rockcress since nearly all known subpopulations have recently been revisited to confirm identification. However, three additional subpopulations require verification.

Trend – Low. There is low confidence in the trend since reporting data is available only from 2011 for the three verified subpopulations, and for only two sample periods for the remaining three subpopulations that need identification verification.

Overall – Low. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA and partners have adopted ordinances, policies, and programs that require that sensitive plants be protected from adverse activities; projects must fully mitigate impacts to sensitive plants, or they will be prohibited.

Effectiveness of Programs and Actions – It is believed that requiring surveys and avoidance measures prior to the implementation of actions known to impact sensitive species is effective at avoiding impacts to sensitive plants.

Interim Target – Maintain three (if identification is confirmed at the remaining population site, and two populations if not) Galena Creek rockcress populations in the Tahoe Region, with three to six subpopulations (depending on identification verification).

Interim Target Attainment Date – Insufficient data to establish an interim target attainment date.

RECOMMENDATIONS

Analytic Approach – The current data available for Galena Creek rockcress is too minimal for statistical analysis. If changes to the monitoring approach (described below) were adapted, then a range of analytical techniques to evaluate status and trend would be available.

Monitoring Approach – Consideration should be given to the establishment of permanent, long-term monitoring plots for at least two, and three populations if present, to collect quantitative data on trend and drivers for Galena Creek rockcress. Protocols established and in place for monitoring long-petaled

lewisia, Tahoe draba and Cup Lake draba could be followed, which will provide information on basic population trends (density), population demographic structure, climate change impacts, and associated community and habitat. Recording habitat information such as groundcover composition, associated species, slope, aspect, elevation, soil type, and any existing threats (e.g. recreation activities, canopy closure) for all known subpopulations (if not already available) would be beneficial.

Modification of the Threshold Standard or Indicator – Recent genetic analysis indicates that Boechera rigidissima var. demota is a distinct taxonomic entity (McKnight and Rowe 2015). There are currently only two population sites comprised of three total subpopulations of Galena Creek rockcress in the Region. Three additional subpopulations need verification. At a maximum (without discovery of additional populations) there may be three populations with a total of six subpopulations. Thus, without discovery of new populations, or outplanting to create new populations, the current threshold standard of seven populations cannot feasibly be attained Consideration should be given to modifying the target to protect all confirmed populations and subpopulations.

Attain or Maintain Threshold – No recommended changes.

Late Seral and Old Growth Forest Ecosystems

Late seral or old growth forests are generally defined as forests in later stages of development. In the Sierra Nevada, trees that greater than 150 to 200 years old are generally referred to as old growth. Logging during the Comstock era (1860 to 1900) removed up to 60 percent of the large and old trees from the Region (Elliot-Fisk et al., 1996). Approximately four million acres of old growth forest remains in the Sierra Nevada. The remaining stands have been fragmented by human activity, and the majority are now found in protected areas, at higher elevations, or in steep stream canyons (Beardsley et al., 1999).

TRPA adopted numerical threshold standards for old growth in 2001 in response to the Sierra Nevada Forest Plan amendments (USDA, 2001). The U.S. Forest Service (USDA, 2001) environmental impact statement found that old growth forests in the Sierra Nevada were critical habitat for a wide range of wildlife species, including sensitive species (e.g., California spotted owl), and that these systems were in decline as a result of previous land management practices (USDA, 2001). The U.S. Forest Service (USDA, 2001) and the Sierra Nevada Ecosystem Project (Elliott-Fisk et al., 1996) estimated that approximately 55 percent of forests in the Sierra Nevada could be classified as old growth. TRPA used this information to establish numerical targets for the late seral and old growth forest ecosystems threshold standard.

TRPA threshold standards for old growth forests are associated with three elevation zones within the Region; montane (less than 7,000 feet), upper montane (7,000 feet to 8,500 feet), and subalpine (greater than 8,500 feet). The TRPA Code of Ordinances addresses enhancement and protection of late seral and old growth forests, and provides protection for trees larger than 30-inches dbh in westside forests, and larger than 24-inches dbh in eastside forests, while allowing for appropriate management actions. The relative abundance of stands dominated by large trees was evaluated to characterize the overall status of the late seral and old growth forest ecosystem indicator reporting category. For each elevation zone, the Region was determined to be considerably worse than target, with an unknown trend and low confidence, resulting in an overall characterization that mirrored the status of each elevation zone. This should not be surprising as it was acknowledged that it could take 100 years to achieve these threshold standards from the time that they were adopted.

Late Seral and Old Growth Ecosystems: **Relative Abundance of Late Seral and Old Growth Forest Ecosystems Across Evaluation Zones**

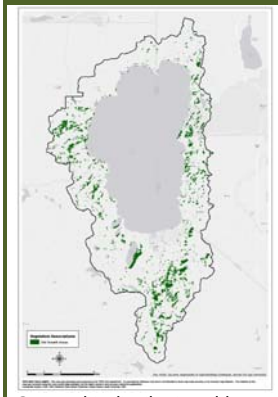
Status

MONTANE ZONE
Status: **Considerably Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**

UPPER MONTANE ZONE
Status: **Considerably Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**

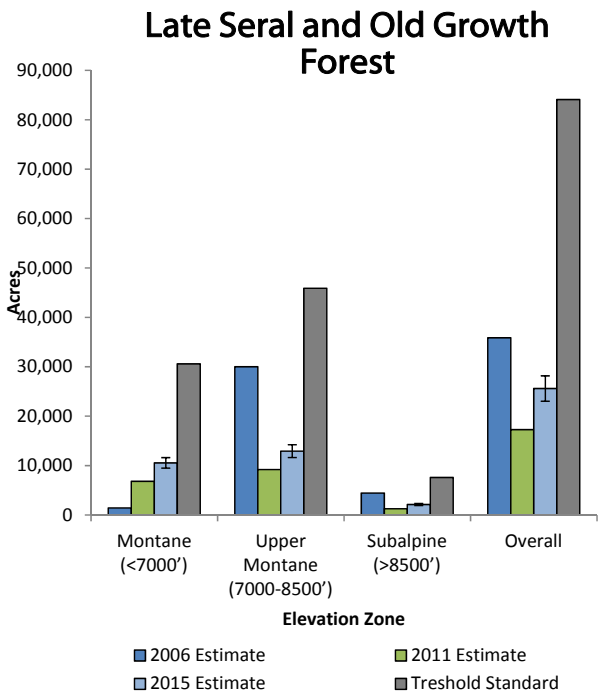
SUBALPINE ZONE
Status: **Considerably Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**

Map



Geographic distribution old growth conifer stands (dominated by trees >24" dbh) in the Lake Tahoe Region. Source: U.S. Forest Service (2007 EVEG).

Graph



Estimated acres of conifer stands dominated by trees greater than 24-inches dbh ("old growth" forest stands) in three elevation zones in the Tahoe Region. Adopted TRPA threshold standard included in grey. Estimated extent in 2015 is bounded by vertical error bars with respect to different assumptions on growth rates (see below). Differences between 2006 and 2011 are largely the result of a modification in the mapping techniques and to a lesser extent the 2007 Angora fire.

Data Evaluation and Interpretation
BACKGROUND

Relevance – This indicator characterizes the proportion of the Tahoe Region dominated by stands of old growth conifers. Old growth forests are valued because they add to Tahoe's ecological integrity by providing a greater diversity of life forms, including a variety of unique lichen, fungi, insects, vegetation and wildlife. Old forests tend to be more structurally complex and resilient to natural disturbances (wildfire) than younger forests, due to tree spacing and fire resistance of bark on mature trees, especially pines. This indicator does not measure the relative condition of this vegetation type.

TRPA Threshold Category – Vegetation

TRPA Threshold Indicator Reporting Category – Late seral and old growth forest ecosystems

Adopted Standards – Attain and maintain a minimum percentage of 55 percent by area of forested lands within the Tahoe Region in a late seral or old growth condition, and distributed across elevation zones. To achieve the 55 percent, the elevation zones shall contribute as follows:

- The subalpine zone (greater than 8,500 feet elevation) will contribute 5 percent (7,600 acres) of the forested lands;
- The upper montane zone (between 7,000 and 8,500 feet elevation) will contribute 30 percent (45,900 acres) of forested lands;
- The montane zone (lower than 7,000 feet elevation) will contribute 20 percent (30,600 acres) of forested lands.

Forested lands within TRPA designated urban areas are excluded from the calculation for threshold attainment. Areas of the montane zone within 1,250 feet of urban areas may be included in the calculation for threshold attainment if the area is actively being managed for late seral and old growth conditions and has been mapped by TRPA. A maximum value of 40 percent of the lands within 1,250 feet of urban areas may be included in the calculation.

Because of these restrictions the following percentage of each elevation zone must be attained to achieve this threshold:

- 61 percent of the subalpine zone must be in a late seral or old growth condition;
- 60 percent of the upper montane zone must be in a late seral or old growth condition;
- 48 percent of the montane zone must be in a late seral or old growth condition;

Type of Standard – Numerical

Indicator (Unit of Measure) – Percent of the forested landscape dominated by large diameter conifer trees greater than 24-inches diameter at breast height (dbh), in three elevation zones.

Human & Environmental Drivers – Soil conditions, aspect, hill slope position, drought frequency, direct sunlight, fire suppression, climate patterns, time and natural disturbance influence the extent and distribution of large-diameter trees (Beardsley et al., 1999; Taylor, 2007; Taylor et al., 2014). Historical land uses, such as clear-cut logging in the late 1800s, dramatically reduced the overall extent of old growth forests in the Region (USDA, 2001). Current forest management emphasizes thinning of overstocked conifer stands, which could result in faster growth rates due to less competition for resources. Changing climate conditions and drought influence growth rates and can increase susceptibility of forest to insect and disease. The Southern Sierra is experiencing a massive die off due to bark beetle. Incidence and outbreak in the Tahoe Region could dramatically alter the conclusions of this evaluation and estimated timelines to attainment.

MONITORING AND ANALYSIS

Monitoring Partners – - U.S. Forest Service, U.S. Geological Survey and TRPA~~TPRA~~.

Monitoring Approach – Every five years, the Tahoe vegetation map is updated with new satellite data (if available) and/or modeled and calibrated using field-based Forest Inventory and Analysis (FIA) data to assess the extent of different vegetation types and associated forest structure characteristics for the Region (USDA, 2009; Warbington et al., 2011). For this analysis, California Wildlife Habitat Relationship (CWHR) vegetation types associated with large diameter trees were queried and enumerated from the most recently available vegetation map (U.S. Forest Service - Remote Sensing Lab Pacific Southwest Region: TMU_Strata_07 [published 2009]).

Analytic Approach – Total acreage of forested land in late seral/old growth within each elevation zone was summed. To estimate change between 2011 and 2015, total acreage of forested land in CWHR size class 4 (dbh 11.0-inches to 23.9-inches) was summed. Transition between size class 4 and old growth was estimated using average expected growth rates. A south side tree with an initial size between 12 and 18-inches dbh would be likely to add 1.5-inches in a decade (R. Mustatia personal communication, 2016), based on recent research (Keyser and Dixon, 2015). Thus based on average growth rates it would take 40 to 80 years for a stand dominated by trees in the 12 to 18-inch dbh size class to grow to exceed 24-inches dbh, the size of "old growth" forest. Assuming that the transition between the smaller size class (CWHR 4) and old growth occurs evenly over the entire period, estimates were developed for each elevation zone (see Table 1). The midpoint of this range (60 years) is used in this evaluation to estimate area expected to be added in old growth. Factors, such as drought, which may influence rates of growth and extend the period of time required to reach old growth status are not included in the estimate below and could lower the average growth rate.

Table 1: *Estimates for each elevation zone*

Estimate (acres)	Years to dbh > 24"	Montane (<7000')	Upper Montane (7000-8500')	Subalpine (>8500')	Total
2011 Extent WHR Size 4 (11.0" - 23.9")	-	53,435	57,200	12,542	123,177
2015 Old growth transition (low)	80	2,672	2,860	627	6,159
2015 Old growth transition (mid)	60	3,562	3,813	836	8,212
2015 Old growth transition (high)	40	5,344	5,720	1,254	12,318

INDICATOR STATE

Status – Considerably worse than target. The status of each elevation zone was determined to be considerably worse than target. This determination was robust to different assumptions on transition rate.

Old Growth Acres: Extent of old growth acres in 2011 and acres expected to transition to old growth by 2015 based on three different assumptions for time required for the next age class to reach old growth.

Table 2: Extent of old growth

Old Growth Acres	Years to dbh > 24"	Montane (<7000')	Upper Montane (7000-8500')	Subalpine (>8500')	Total
2011 Extent	-	6,993	9,116	1,278	17,387
2015 Old growth (low)	80	9,665	11,976	1,905	23,546
2015 Old growth (mid)	60	10,555	12,929	2,114	25,599
2015 Old growth (high)	40	12,337	14,836	2,532	29,705

Percent to target: Table 3 summarizes the percent of current old growth target, based on the 2011 extent as well as the three estimates for area of old growth added in each age class.

Table 3: 2015 percent to target for old growth

2015 Percent to Target	Years to dbh > 24"	Montane (<7000')	Upper Montane (7000-8500')	Subalpine (>8500')	Total
2011 Extent	-	23%	20%	17%	21%
2015 Old growth (low)	80	32%	26%	25%	28%
2015 Old growth (mid)	60	34%	28%	28%	30%
2015 Old growth (high)	40	40%	32%	33%	35%

Trend – Insufficient data to determine trend. The estimates for elevation class transition into old growth are based on average growth rates and the assumption that transition will occur evenly over the 40 to 80 years it is expected for the standard to be in attainment.

Table 4: Percent to target change

Percent to Target Change	Years to dbh > 24"	Montane (<7000')	Upper Montane (7000-8500')	Subalpine (>8500')	Total
2015 Old growth transition (low)	80	9%	6%	8%	7%
2015 Old growth transition (mid)	60	12%	8%	11%	10%
2015 Old growth transition (high)	40	17%	12%	17%	15%

Confidence –

Status – Moderate. The estimated overall accuracy of the map layer used for this evaluation was between 73 percent to 83 percent (USDA, 2009). This level of accuracy equates to a moderate confidence determination for status.

Trend – Low. Estimated change between 2011 and 2015 includes multiple assumptions about forest growth rates in the Region, and has not been field validated.

Overall Confidence – Low. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA and partners have adopted several policies, ordinances and implementing programs designed to promote the conservation and protection of old growth forests (TRPA, 2012e, 1986). Agency partners (such as California Tahoe Conservancy, California State Parks, Nevada Division of Forestry and U.S. Forest Service) affiliated with the Environmental Improvement Program (EIP) have implemented numerous forest restoration and enhancement projects, mostly to thin overstocked conifer stands to reduce the potential for

catastrophic wildfire and restore conifer tree densities consistent with historical conditions. These projects are expected to enhance growth of remaining trees into size classes consistent with achieving threshold standards for old growth forests.

Effectiveness of Programs and Actions – Current regulations appear appropriate and sufficiently flexible to protect late seral and old growth forest ecosystems. Forest fuels reduction projects implemented through the EIP have treated more than 46,000 acres and are expected to contribute to the achievement of the late seral and old growth forest ecosystems threshold standard (TRPA, 2016). Stand density is related to average tree diameter and reducing stand density will promote larger dbh trees (R. Mustatia personal communication, 2016). Changing climate conditions and drought influence growth rates and can increase susceptibility of forest to insect and disease. The Southern Sierra is experiencing a massive die off due to bark beetle. Incidence and outbreak in the Tahoe Region could dramatically alter the conclusions of this evaluation and estimated timelines to attainment.

Interim Target – Demonstrate a measurable increase in the percent cover of stands dominated by large diameter (greater than 24-inches dbh) conifer trees within the forested landscape for each of the elevation zones by 2055.

Target Attainment Date – Target attainment is likely to take 40 to 80 years, 2055 or 2095.

RECOMMENDATIONS

Analytic Approach – No recommended changes.

Monitoring Approach – At average growth or mortality rate assumptions, significant change is unlikely to be observed in this indicator over a four-year period. Future evaluation reports should consider the adoption of a major evaluation interval that better reflects expected change in the indicator. Tree growth rates in the Region are highly variable, dependent on species, elevation, climate, soil, aspect, and density. On average, a south side tree with an initial size between 12 and 18 inches dbh would be likely to add 1.5 inches in a decade (R. Mustatia personal communication, 2016, based on (Keyser and Dixon, 2015). Using average growth rates a stand dominated by trees in the 12 to 18 inch dbh size class would take 40 to 80 years before dbh exceeded 24 inches, the size of "old growth" forest.

Monitoring and reporting should be aligned with the work of other partners in the Region to ensure efforts complement those of the U.S. Forest Service LTMBU Forest Plan Monitoring and Evaluation Plan (USFS LTBMU, 2015).

Modification of the Threshold Standard or Indicator – Consideration should be given to the establishment of alternative criteria to define late seral and old growth forest stands in the subalpine zone. Relative to lower elevation forests, the subalpine forests in the Region have only been marginally subjected to logging, fire suppression or land management. It is generally thought that conditions in subalpine stands are very similar to conditions before Euro-American settlement. Trees grow very slowly in the subalpine zone, and even an 18 inch dbh tree can be very old (up to 200 years old). Since mature trees in the subalpine zone are often smaller than 24 inches dbh, interpretation of the threshold standard for that zone should be considered to more accurately reflect the mature state of species occurring in that zone.

Prior evaluations have noted difficulty in quantifying status and trend of this indicator, because of the lack of a formal definition of what constitutes "Late Seral and Old Growth Forest Ecosystems." Consideration should be given to aligning monitoring and evaluation of the standard with LTMBU. The LTBMU defines early, mid and late seral stages as stands that have quadratic mean diameters of zero to five-inches, five to 25-inches, and greater than 25-inches dbh respectively (USFS LTBMU, 2015). The generally small patch size and mixed age and size of Jeffery pine and white fir stands poses a challenge for identification of stand seral stage (USFS LTBMU, 2015).

Attain or Maintain Threshold – No recommended changes at this time. The forest health and fuels reductions projects in the Region are likely to accelerate attainment of this threshold standard. Lower density stands typically have faster growth rates and are more resilient to bark beetle. Changing climatic conditions and the threat of a bark beetle infestation moving into the Region may require accelerated implementation of existing management prescriptions or alternative management strategies.

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CHAPTER 7
Fisheries

Fish have always been an integral part of the Tahoe's aquatic systems. Fish play in important role in the food webs of the Region's lakes and streams, and fishing is socially important activity. There are two key aquatic environments that support fish in the Lake Tahoe Basin: lakes and streams. These two ecosystems are dynamic in space and time. Combined, lakes and streams provide fish with necessary elements such as water, cover, and spawning and nursery habitat. Both environments play an important role in sustaining fish populations and some fish species use both lake and stream environments in different stages of their life cycles. The combination of chemical, biological, temperature, and physical characteristics of lakes and streams influence the suitability of these environments to sustain different fish populations. Likewise, the physical and biological integrity of the surrounding landscape plays an important role in sustaining aquatic habitats important to fish. Accordingly, degradation of lake and stream habitat and the surrounding landscape can reduce the sustainability of Tahoe's fishery.

The goal of TRPA adopted threshold standards for fisheries resources is to improve aquatic habitat important for the growth, reproduction, and perpetuation of existing and threatened fish resources in the Lake Tahoe Basin (TRPA 1982a). TRPA has adopted one numerical standard (stream habitat condition), one management standard without a numeric target (instream flow), one management standard with a numeric target (lake habitat), and two policy statements (instream flow and Lahontan cutthroat trout) (Table 7-1). There are four indicator reporting categories in the fisheries threshold category: lake habitat, stream habitat, instream flow, and Lahontan cutthroat trout.

The TRPA Regional Plan, including the TRPA Goals and Policies (TRPA 2012c) and the Code of Ordinances (TRPA 2012b), provide relevant policies and regulations for the maintenance of habitat conditions for fisheries threshold standards. The Environmental Improvement Program (EIP) administered by TRPA includes programs that result in the enhancement or restoration of fish habitats in the Basin. For example, EIP projects that reestablish the natural hydrologic regimes, remove impervious cover and enhance vegetation cover in stream zones are widely understood to enhance the quality of stream habitat for various species of fish and aquatic organisms. In addition, erosion control and stormwater treatment projects implemented through the EIP improve water quality and thus improve habitat quality for Tahoe's fishery.

According to the Goals and Policies for fisheries, the overarching goal is to "improve aquatic habitat essential for the growth, reproduction, and perpetuation of existing and threatened fish resources in the Lake Tahoe Basin." Nine policy statements support this goal and include:

1. Mitigating project impacts to fish habitat in streams and lakes.
2. Prohibiting new unnatural blockages and encouraging the removal of existing impediments to fish movement in streams, where appropriate.
3. Developing a maintenance program to inventory and remove stream blockages.
4. Establishing boating standards to reduce associated disturbance in the lake's shallow zone.
5. Encouraging habitat improvement projects in streams and lakes.
6. Maintaining and enhancing stream flows.
7. Transferring existing water diversions from streams to lake withdrawals, whenever feasible
8. Supporting state and federal efforts to reintroduce Lahontan cutthroat trout.
9. Prohibiting the release of nonnative aquatic species and controlling and eradiating existing populations.

The core of TRPA's fisheries regulations are designed to achieve threshold standards as detailed in the TRPA Code of Ordinances, Chapter 63, and applicable regulations for the management of fish habitats can be found throughout the Code of Ordinances (TRPA 2012b). For example, Chapter 30 of the Code of Ordinances restricts urban development within stream environment zones. Chapter 33 governs grading and construction practices and Chapter 53 establishes a framework for grazing livestock. Chapter 63 includes provisions that protect fish habitat and enhance degraded lake and stream habitat. For lake environments, all projects and activities conducted in the shorezone may be prohibited, limited, or otherwise regulated in prime habitat areas (spawning, feed and cover habitats that include submerged substrates comprised of gravels, cobbles, and rocks), or in situations that TRPA found to be vulnerable or critical to the needs of fish. Special conditions of project approval, such as restoring physically altered substrate, limiting construction to designated periods, or implementing shoreline protective measures, may be required for development in the shorezone to mitigate or avoid significant adverse impacts to habitat or fish. Certain activities such as boat beaching may be temporarily restricted in areas where spawning activity occurs. To support the non-degradation standard that applies to lake fish habitat, TRPA's Code of Ordinances prohibits the alteration of substrate in areas of prime fish habitat unless alterations are mitigated and approved by TRPA. Protections for instream habitats are similar. They prohibit channel alterations, permit only stream crossings that allow fish passage, require impacts to fish habitat to be mitigated, and prevent sedimentation and loss of vegetative cover More recently, TRPA adopted additional ordinances to prevent the introduction of new aquatic invasive species by requiring inspections and possible decontaminations of all boats entering regional lakes.

The diversity of Tahoe's fish community has changed considerably since the settlement of Euro-Americans in the Tahoe Basin. Prior to the influence of Euro-American settlement, seven species of fish occurred in the lakes and streams of the Tahoe Basin (Murphy and Knopp 2000; K. L. Ngai et al. 2011). Of the native fish species, Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) and the mountain whitefish (*Prosopium williamsoni*) were abundant and revered by Native Americans because they provided ample food for their people. Since the Comstock era circa 1860, when Lahontan cutthroat trout were extirpated, mountain whitefish populations have declined substantially, and at least 20 additional species of fish have been introduced into Tahoe's aquatic communities (Murphy and Knopp 2000; K. L. Ngai et al. 2011). According to fisheries biologists, several factors have contributed to the alteration of Tahoe's fish species diversity, the decline or extirpation of native fish, and the degradation of aquatic habitats in the Basin. These factors include sedimentation associated with turn of the century logging, livestock grazing, commercial fish harvests, interruption of natural hydrologic regimes resulting from past logging practices, urban development (1950s through 1970s), and the introduction of non-native fish and other

aquatic organisms (Murphy and Knopp 2000; K. L. Ngai et al. 2011; SNEP 1996). Figure 7-1 provides overview of the timeline of introduction of species to Lake Tahoe. Today, stream restoration projects and efforts to reintroduce Lahontan cutthroat trout are underway (R. Al-Chokhachy and Peacock 2009).

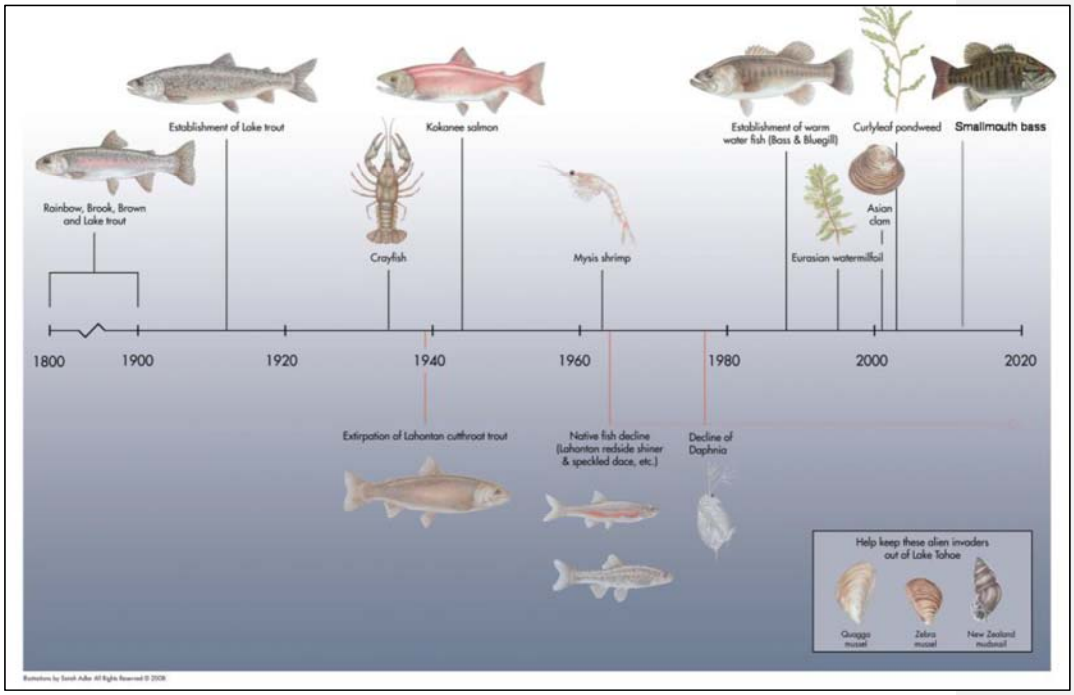


Figure 7-1: *Timeline of species introduction or date first documented in Lake Tahoe. The bottom part of the timeline highlights decline or extirpation of native species* (Wittmann and Chandra 2015).

Table 7-1: TRPA adopted threshold standards for fisheries

Indicator Reporting Category	Standard	Type of Standard	Indicator
Lake Habitat	A nondegradation standard shall apply to fish habitat in Lake Tahoe. Achieve the equivalent of 5,948 total acres of excellent habitat as indicated by the Prime Fish Habitat Overlay Map, which may be amended based on best available science.	Management Standard (with numeric target)	Acres of fish habitat within the nearshore of Lake Tahoe - defined by substrate size
Stream Habitat	Maintain 75 miles of excellent, 105 miles of good, and 38 miles of marginal stream habitat as indicated by the Stream Habitat Quality Overlay map, amended May 1997, based upon the re-rated stream scores set forth in Appendix C-1 of the 1996 Evaluation Report.	Numerical Standard	Miles of stream habitat in different condition classes (excellent, good and poor)
Instream Flow	Until instream flow standards are established in the Regional Plan to protect fishery values, a nondegradation standard shall apply to instream flows.	Management Standard	Evidence of TRPA support for Management Standard
	It shall be a policy of the TRPA Governing Board to seek transfers of existing points of water diversion from streams to Lake Tahoe.	Policy Statement	Evidence of TRPA support for policy statement
Lahontan Cutthroat Trout	It shall be the policy of the TRPA Governing Board to support, in response to justifiable evidence, state and federal efforts to reintroduce Lahontan cutthroat trout.	Policy Statement	Evidence of TRPA support for policy statement

The results of the 2015 assessment are summarized in Table 7-2. The table provides a summary of the status and trend of standards in the fisheries reporting categories for stream habitat, instream flows, Lahontan cutthroat trout, and lake fish habitat, for 2015 as well as the results from the 2011 Threshold Evaluation Report to facilitate comparison. Figure 7-2 and Table 7-2 provide a key to the symbols used to communicate status, trends, and confidence, and a detailed description of each is provided in the methodology section. The indicator sheets that follow contain more detailed assessments of the status and trend of each indicator and provide descriptions of the methods used and recommendations for changes to the standard or the analytic approaches used to assess it.

Table 7-2: Fisheries status & trend summary

Standard	2011	2015
Stream Habitat		
Miles of Stream Habitat in Excellent Condition		
Miles of Stream Habitat in Good Condition		
Miles of Stream Habitat in Marginal Condition		
Instream Flow		
Non-degradation Standard for Instream Flow		
Divert Stream Intakes to Lake Sources		
Lahontan Cutthroat Trout		
Lake Habitat		
Acres of "Prime" Fish Habitat		

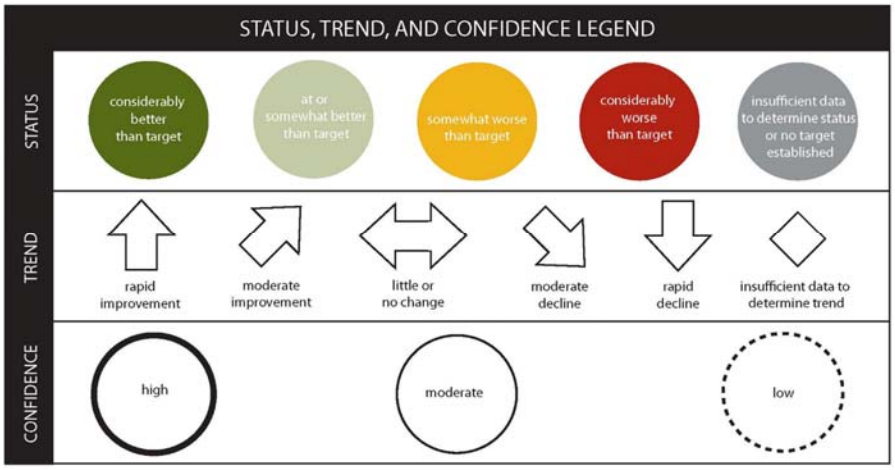


Figure 7-2: A key to the symbols used to assess status, trends, and confidence levels.

Table 7-3. Key to the reporting icon used to characterize the implementation status of management standards and policy statements.

Status Category	Description	Reporting Icon
Implemented	The management standard or policy statement has been integrated into the Regional Plan and is consistently applied to a project design or as a condition of project approval as a result of project review process. Examples of programs or actions can be identified to support the management standard's implementation. Adopted programs or actions support all aspects of the management standard or policy statement's implementation, or address all major threats to implementation.	I
Partially Implemented	The management standard or policy statement has been integrated into the Regional Plan, but is not consistently applied during the project review process. No more than two examples of programs or actions can be identified to support the management standard's implementation and/or adopted programs or actions support some aspects of the management standard or policy statement's implementation, or address some major threats to implementation.	PI
Not Implemented	The management standard or policy statement has not been integrated into the Regional Plan and is not applied during the project review process. No examples of programs or actions can be identified to support implementation.	NI

Stream Habitat

Stream systems are important aquatic resources. Streams are critical to the Lake Tahoe Basin's water cycle by feeding freshwater to lakes and ponds, recharging groundwater, providing habitat for a wide variety of aquatic and terrestrial organisms and corridors for fish and wildlife migration. TRPA refers to the areas surrounding streams as "stream environment zones." Streams also play an important role in connecting fragmented habitats, and thus in conserving biodiversity.

To aid in conserving and enhancing stream habitat in the Basin, TRPA has adopted policies and implements ordinances that limit the types of activities that occur in and adjacent to streams (TRPA 2012c). TRPA administers a basin-wide Environmental Improvement Program (EIP) that facilitates stream restoration on channel segments determined to be disturbed or impaired. Other actions, such as erosion control and stormwater treatment projects, benefit stream habitat as well.

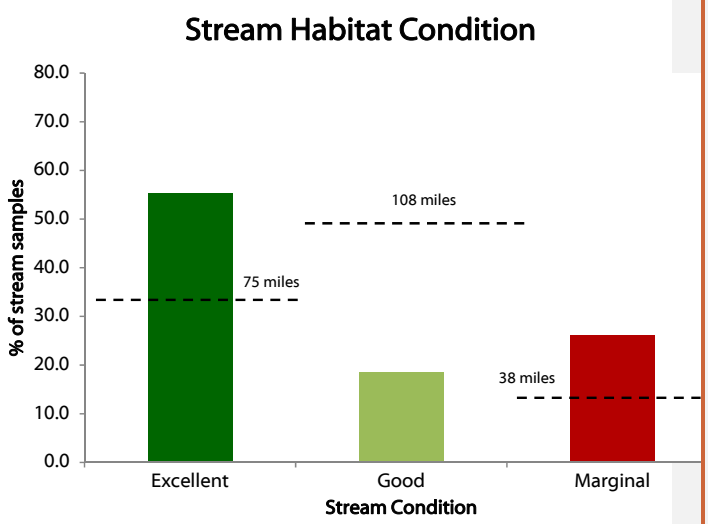
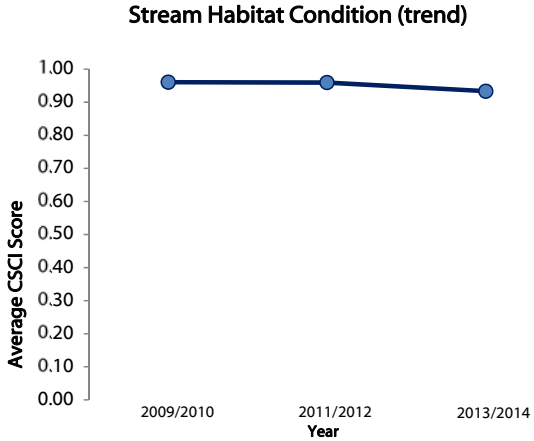
Stream habitats in the Tahoe Basin are similar to streams found throughout the Sierra. High elevation reaches are typically "v-shaped" channels bordered by deciduous and conifer vegetation. Streams at higher elevations typically contain cascades, riffles, runs and pools occasionally interspersed with low gradient meadows. Substrates most common at high elevation reaches are composed of boulder, rocks, cobbles and gravels with smaller diameter sand and silt interspersed. Lower elevation streams typically meander through low gradient flood plains bordered by willow and a variety of meadow wildflowers, forbs, sedges and grasses. Streambed substrates in lower elevation stream reaches are typical of a deposition zone generally dominated by sand and silt.

Recognizing the importance of streams for Tahoe's fishery, TRPA adopted three threshold standards related to the stream habitat indicator reporting category. The stream habitat threshold is a numerical standard to achieve 75 miles of "excellent," 105 miles of "good," and 38 miles of marginal stream habitat for streams classified as residential and migratory. According to Resolution 82-11, the standard can be evaluated based on "*re-rated stream scores set forth in Appendix C-1 of the 1996 Threshold Evaluation Report.*" In response to poorly documented sampling methods in the past (discussed in "monitoring approach"), TRPA, in partnership with Nevada Division of Environmental Protection, Lahontan Regional Water Quality Control Board, California Department of Fish and Game – Aquatic Bioassessment Lab, U.S. Forest Service – Region 5, and Humboldt State University, initiated stream bioassessments in the Lake Tahoe Basin starting in 2009. Benthic macroinvertebrates (BMI) composition and physical stream habitat parameters are analyzed using the California Stream Condition Index model developed by the California Department of Fish and Game – Aquatic Bioassessment Lab (Rehn, Mazor, and Ode 2015).

Results from 2009 through 2014 stream sampling revealed:

- More streams in excellent condition than the standard
- Too many streams in marginal condition
- Standard for streams in good condition was not met
- Because only three monitoring periods exist, there was insufficient data to determine trend and confidence is low.

Stream Habitat: **Miles of Stream Habitat Condition**

Status	Graphs
MILES OF STREAM HABITAT IN EXCELLENT CONDITION Status: **Considerably Better than Target** Trend: **Insufficient Data to Determine Trend** Confidence: **Low**	 Proportion of streams assessed in each condition in the Tahoe Basin based on California Stream Condition Index scores 2009-2014 (status sites only). Threshold standards for stream condition are the dotted lines. There were more excellent streams than the standard, but fewer good streams and too many marginal streams. Source: TRPA.
MILES OF STREAM HABITAT IN GOOD CONDITION Status: **Considerably Worse than Target** Trend: **Insufficient Data to Determine Trend** Confidence: **Low**	 Average CSCI scores of Tahoe Basin streams (trend sites only) from 2009 – 2014. A small decrease in average scores has occurred, but because only three monitoring periods exist, there is insufficient data to determine a trend and confidence is low. Source: TRPA
MILES OF STREAM HABITAT IN MARGINAL CONDITION Status: **Considerably Worse than Target** Trend: **Insufficient Data to Determine Trend** Confidence: **Low**	

Data Evaluation and Interpretation
BACKGROUND
Relevance – Streams and their associated riparian habitats are key components of the Tahoe Basin's aquatic ecosystems and are important to people. Concern for stream water quality and biological condition is embodied in various federal, state, and regional water quality laws, regulations, and ordinances, including the Clean Water Act, 208 Water Quality Plan, TRPA Code of Ordinances, and California/Nevada state water quality standards. Streams and associated environments significantly contribute to the Tahoe Basin's biological diversity and provide recreational opportunities for people in the Basin. The use of benthic macroinvertebrates and associated physical/chemical stream measurements (i.e. bioassessment) to assess overall biotic health of streams is a widely accepted practice used by the EPA and all 50 states in their water quality programs (Davis, Smith, and Jackson 2004; Hodkinson and Jackson 2005; Karr 2006; Karr and Chu 1999). **TRPA Threshold Category** – Fisheries **TRPA Threshold Indicator Reporting Category** – Stream Habitat **Adopted Standards** – Maintain the 75 miles of excellent, 105 miles of good, and 38 miles of marginal stream habitat as indicated by the Stream Habitat Quality Overlay map, amended May 1997, based upon the re-rated stream scores set forth in Appendix C-1 of the 1996 Threshold Evaluation Report. **Type of Standard** – Numerical **Indicator (Unit of Measure)** – Miles of stream habitat in different condition classes (excellent, good and marginal) **Human & Environmental Drivers** – A suite of natural environmental factors including weather and climate patterns, especially drought, and geological context such as geological origin, elevation, topography, and soils influence stream condition and habitat suitability for a variety of fish species. Past resource extraction has contributed to legacy effects on the physical features of streams and their biota. Channel modifications associated with historic logging activities (e.g., dams, water extraction and diversions, flumes, stream channelization, and flood control impoundments) altered stream channel structure and watershed-specific hydrology. Historic grazing damaged stream banks and soils and altered stream channel habitat structure through sedimentation and the simplification of riparian plant structure and composition (Murphy and Knopp 2000). The impact of these activities can be seen in the high percentage of sand and fine sediments from excess erosion in many of the Tahoe Basin streams (Tahoe Regional Planning Agency 2015b; Roll et al. 2013; Purdy, Fesenmyer, and Henery 2014). However, the unique geological features found in the Tahoe Basin can also increase the amount of natural sand and fines found in these streams (Murphy and Knopp 2000). Dams can create barriers to movement and migration of aquatic organisms and alter natural stream flow patterns. Several factors within developed areas contribute to the alterations of key stream features including: 1) the urban transportation infrastructure, 2) land cover and disturbance, 3) urban landscaping practices, and 4) water withdrawal and export. Roads can contribute sediment and chemical inputs, thereby altering streambed conditions and elevating chemical pollutant loads. Road crossings can confine streams from natural meander patterns, resulting in impediments to organism movements, stream bank instability, and channel downgrading. Increased impervious surfaces on the landscape can prevent water from naturally percolating into soils thereby affecting its rate of delivery to streams. As a result, organisms downstream of developed areas can experience more intense flooding events and flashier flow regimes as the water moves faster from the land into the channel. However, in an analysis of Tahoe Basin stream health in relation to impervious cover of the watershed, little correlation was found (O'Dowd and Stubblefield 2013). The study found that less than three percent of all monitoring sites had watersheds with impervious cover greater than five percent. Numerous studies have shown that impacts to streams generally begin to appear when five percent to 10 percent impervious cover is reached, meaning that the majority of Tahoe Basin streams do not exceed this impervious cover threshold. li (Schueler 1994; Booth and Jackson 1997; Wang et al. 1997). However, once there is a more robust stream sample size, it will be worthwhile to reassess the impacts of impervious cover on Tahoe stream health. Forest

structure and fires also impact stream flow and water quality. The forests of the Sierra Nevada today are denser today as result of fire suppression than they were 200 years ago. The result of denser stands is likely reduced stream flow and increased forest thinning could increase annual average streamflow by as much as 6% (Podolak et al. 2015). Fires can also dramatically alter surface dynamics and sediment and nutrient yields from burned areas (Moody and Martin 2009). The Angora fire in 2007, which burned 22% of the watershed area, had a significant but not catastrophic impact on water quality in Angora creek (Oliver et al. 2012).

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service, California Department of Fish and Wildlife, Nevada Department of Wildlife, Nevada Division of Environmental Protection, Lahontan Water Quality Control Board, Tahoe Regional Planning Agency

Monitoring Approach – Streams are monitored using widely accepted bioassessment protocols established by the EPA and further refined by the California Department of Fish & Wildlife (CDFW) (Kaufmann et al. 1999; Ode 2007; Barbour et al. 1999). Specifically, stream monitoring is conducted using *Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California* (Ode 2007). The TRPA stream monitoring program was developed in partnership with the EPA, CDFW, Nevada Department of Environmental Protection (NDEP), Lahontan Water Quality Control Board (Lahontan), and the U.S. Forest Service (USFS) (Fore 2007). Benthic macroinvertebrates (BMIs), as well as physical and chemical stream characteristics, are sampled at 48 streams annually. Of these 48 streams, 16 per year are probabilistic "status" sites randomly selected through EPA modelling (Olsen et al. 1999; Paulsen, Hughes, and Larsen 1998) and 24 are "trend" sites revisited every other year. Eight sites are visited annually as "reference" sites used to determine if any changes in the condition of Tahoe streams is occurring based on environmental factors outside of human influence (Tahoe Regional Planning Agency 2010). The species composition and relative abundance of the BMI in each stream is analysed by a lab. Results of the macroinvertebrates are analysed through the peer-reviewed model developed by the CDFW Aquatic Bioassessment Laboratory called the California Stream Condition Index (CSCI) (Rehn, Mazor, and Ode 2015). The CSCI combines two separate indices that each provides unique information about the biological condition of a stream: a multi-metric index (MMI) that measures ecological structure and function, and an observed-to-expected (O/E) index that measures taxonomic completeness. Metrics in the CSCI include BMI assemblage richness, composition, and diversity, and are chosen based on their responsiveness to human disturbance gradients and/or their ability to discriminate between reference and degraded condition. Unlike previous MMI or O/E indices that were applicable only on a regional basis or poorly represented large portions of California, the CSCI was built with a statewide (plus the Nevada side of the Tahoe Basin) dataset of nearly 600 reference sites that represents a broad range of environmental conditions across California (Rehn, Mazor, and Ode 2015). Sites are organized by elevation, geology, precipitation, temperature, and watershed catchment size so that stream scores are compared against reference sites with similar natural characteristics. For more information on the CSCI, please see Rehn, Mazor, and Ode 2015.

Past threshold evaluations (1991 and 1996) of stream habitat quality used a list of subjective evaluation criteria and a rating system to judge and classify stream habitat conditions (TRPA 2001; TRPA 2007; TRPA 1982b). These assessments were generally qualitative in nature, relying on the best professional judgement of local biologists to assign a score based on various physical habitat conditions to each stream (TRPA 1996). The qualitative nature of these assessments and lack of a standardized protocol made them unrepeatable and not scientifically rigorous. In addition, streams received one rating for their entire length (the whole Upper Truckee River rated as good for example), despite the fact that stream health varies greatly throughout their lengths. A multi-agency partnership including EPA, CDFW, NDEP, Lahontan, USFS and TRPA worked together to develop the more scientifically rigorous methods that are used today (Fore 2007).

Additional monitoring of streams, with a primary focus on characterization of flow and pollutant loads occurs as part of the Lake Tahoe Interagency Monitoring Program (LTIMP). In 2015, ccontinuous flow, temperature, and turbidity monitors were installed on five streams, which account for nearly 50 percent of tributary inflow.

Analytic Approach – The status of stream habitat in the Region is determined by the percentage of sites in excellent, good and marginal condition. The assessment converts the miles of re-rated Stream Habitat Quality Overlay of 1997 into percentage of rated streams (75 miles of excellent = 34.4 percent; 105 miles of good = 48.2 percent; 38 miles of marginal = 17.4 percent). The probabilistic sampling approach used allows us to infer the ratio of streams in different conditional classes without having to monitor every stream mile. The approach is likely to more accurately reflect on-the-ground conditions that vary throughout individual streams, and is a better representation of the fact that it is infeasible to survey all stream miles every threshold evaluation.

In the development of the CSCI, the State of California developed conditional categories for stream health and broke them into four categories of biological condition. These categories were then translated to the TRPA standards as shown in Table 1:

Table 1: *California conditional categories compared to TRPA conditional categories*

California (CSCI) conditional categories	TRPA conditional categories
CSCI Score ≥0.92 = good	CSCI Score ≥0.92 = excellent
0.91 to 0.80 = fair	0.91 to 0.80 = good
0.79 to 0.63 = poor	≤ 0.79 = marginal
≤0.62 = very poor	

Trend assessment averaged all trend site scores in a monitoring period and assessed change in average scores over time. If data is missing from any trend site in any year, that site is excluded from all trend analysis. Because only three monitoring periods exist, confidence in any trend is low. Individual site scores are used to prioritize projects to improve stream health in the basin.

INDICATOR STATE

Status – Results from stream sampling spread out across the entire Basin (n=92) between 2009-2014, indicate that:

- 55 percent of streams are in excellent condition (considerably better than the target of 34 percent)
- 19 percent of streams are in good condition (considerably worse than the target of 48 percent)
- 26 percent of streams are in marginal good condition (considerably worse than the target of 17 percent)

The proportion of the streams in excellent condition well exceeds the target and is encouraging news for stream health in the Basin. The main concern is the proportion of streams in marginal condition. Being below the target for proportion of good streams is less worrisome as most of these streams instead are in the excellent category. The high number of marginal sites is being addressed through stream restoration and stormwater management, among other activities. Low water levels caused by drought are likely the largest contributor to poor biological health of at least four of the 24 marginal sites (4.3 percent of all streams included in the sample). Consequently, if sampling only occurred during normal or above normal water years, the proportion of marginal streams would likely be lower and closer to attainment.

In addition to BMI sampling, physical stream habitat data is collected. Physical habitat is a good indicator of the stream's ability to provide habitat for fish, BMIs, and other aquatic life (Kaufmann et al. 1999). California's Surface Water Ambient Monitoring Program used stream data compiled across California's Sierra Nevada and North Coast regions to assess the linkages between habitat quality and biotic integrity of a stream. Out of all physical stream attributes, the following were deemed to have the closest link to biotic health: percent sand/fines of the substrate, level of human disturbance in the riparian area, intactness of woody riparian cover, and overall fish cover (large woody debris, undercut banks, overhanging vegetation, boulders, etc.) (Rehn 2015). Based on the data, break points were identified where, if below, the streams were very likely (greater than 90 percent) to have poor biological condition (Rehn 2015). Here is a summary of how Tahoe Basin streams sampled by TRPA measured against these attributes:

- Percent sand/fines of substrate: 63 percent of streams were above the break point
- Riparian disturbance: 72 percent of streams were above the break point
- Woody riparian cover: 81 percent of streams were above the break point
- Overall fish cover: 89 percent of streams were above the break point

Figure 1: *A degraded section of the Upper Truckee River that received marginal CSCI scores. This picture shows many of the physical habitat attributes that contribute to poor CSCI scores according to Rehn, 2015: excess fines/sand, riparian human disturbance, lack of woody riparian cover, and lack of fish cover. Photo Credit: Trout Unlimited*

Water temperature also plays a large role in stream health in the Tahoe Basin. Temperatures above 22 degrees Celsius are widely regarded in the literature as an acute stress threshold for salmonid species above which metabolism is impaired, fitness declines, and mortality increases (Purdy, Fesenmyer, and Henery 2014). In a 2012 study, continuous data loggers found water temperatures in the Upper Truckee River from Christmas Valley to Lake Tahoe were found to exceed 22 degrees Celsius for over 300 hours over the summer (Purdy, Fesenmyer, and Henery 2014). These high stream temperatures, in addition to high rates of stream bank erosion and high percent sand/fines of the streambed, likely play a large role in the low CSCI scores observed in the Upper Truckee River. Exposure to elevated temperatures below 22c can result in chronic stress in Salmonids. (Wenger et al. 2011; Isaak et al. 2012; Luce et al. 2014). Climate change is likely to both shift peak flows and increase stream temperatures in the Region, both of which influence the suitability of the Region's streams for Salmonids(Jager, Van Winkle, and Holcomb 1999).

Fish passage is also an important component of overall stream health. One of the limitations of using BMIs to rate stream health is they do not reliably capture fish passage issues such as culverts and dams (Vaughan 2002). In 2010 and 2011, the U.S. Forest Service conducted a basin-wide assessment of fish passage at man-made structures on public lands. Of the 178 structures that were fully assessed, 146 (82 percent) were barriers to at least one life stage of salmonid or sculpin (Vacirca 2010; Gross, S 2014). This does not include the numerous fish passage barriers located on private land. If the status of stream health, for example, counted any inaccessible (blocked by man-made structures) stream habitat as marginal, the standard for streams would be categorized as further degraded. Instead, streams are currently rated based on their biological health and there is a recognized need for projects to improve fish passage and restore stream habitat.

Some stream segments identified as marginal would likely have been assessed as excellent if the determination was based solely on an assessment of physical stream habitat assessment. Additionally, some streams scored as marginal in areas that are relatively free from human influence. Some streams may simply be naturally poor fish habitat, while other streams received low scores due to drought or other unknown natural factors. For example, Glen Alpine Creek above Fallen Leaf Lake is widely known as an excellent trout stream and is currently used as the main spawning stream for Lahontan cutthroat trout re-introduction into the Tahoe Basin (R. Al-Chokhachy and Peacock 2009). However, it received a marginal rating using bioassessment. Due to warm water and drought, or

other unknown factors, thick algae (greater than 3 millimeter on average) was present throughout the creek when sampled. This limits the growth and survival of high quality aquatic prey species like stoneflies, mayflies, and caddisflies that would be expected in a mountain stream like Glen Alpine Creek (Mattson 2009). Since the quality and quantity of insects was poor, the stream received a marginal score.

In addition to TRPA stream sampling, The U.S. Forest Service sampled fish populations on 26 of the 63 Lake Tahoe tributaries in the last 10 years. Surveys show high percentages of non-native trout and extremely low numbers of historically important cold-water fish such as Lahontan cutthroat trout and mountain whitefish. Additionally, most streams in the Tahoe Basin have low fish species diversity, with some streams only having one species (Gross, S 2014). Surveys also reveal warm water fish highly tolerant of pollution such as brown bullhead catfish, goldfish, and bluegill present in the Upper Truckee River, Tallac Creek, Taylor Creek, and Trout Creek (LTBMU 2015). This is further evidence of degraded conditions in some stream segments of the Tahoe Basin.

Trend –Insufficient data to determine trend. There are 48 trend sites and each site is sampled every other year (24 each year). For this analysis, there are three monitoring periods. Each monitoring period consists of two years of data collection (beginning in 2009/2010) since half of trend sites are sampled in one year and the other half the following year. The average score for trend sites decreased slightly since monitoring began, with an average CSCI score of 0.96 in 2009/2010 to an average score of 0.93 in 2013/2014 (Tahoe Regional Planning Agency 2015b). However, because only three monitoring periods exist it is determined to be insufficient data to determine trend. Additionally, no statistically significant trends in physical habitat were found during the monitoring period (Tahoe Regional Planning Agency 2015a).

The impact of low flow on stream health is well documented (Mazzacano and Hoffman 2007), and recent drought conditions are likely impacting BMIs and overall stream health. Streams that rely more on snowmelt than groundwater and springs appear to be showing the greatest effects. Four trend and reference sites that went dry (Glen Alpine, Cascade, Ward, and General creeks) during the drought years of 2013 and 2014 saw their average CSCI score drop from 0.925 during the above average water years of 2010 and 2011 to an average score of 0.716 during the drought years of 2013 and 2014, a decrease of 23 percent (Tahoe Regional Planning Agency 2015b). Because human impacts around and upstream of these sites are minimal and are not likely to have occurred during the time period, this drop in biotic integrity is believed to be the result of natural factors. The change in these four sites accounted for 78 percent of decline in average site score. If these sites maintained their above average water year scores during times of drought the overall trend for all sites would be a decrease of 0.3 percent for this monitoring period, as opposed to the decrease of 1.42 percent that was observed. If the drought persists, it is likely the overall trend in stream health will continue to decline.

Confidence –

Status – High. There is high confidence in the status. A large number of sites (92) covering the basin are sampled following well established and published protocols for assessing stream biotic integrity.
Trend – Low. Because there are only three monitoring periods represented, confidence in the trend is low.
Overall – Low. Overall confidence takes the lower of the two confidence determinations.

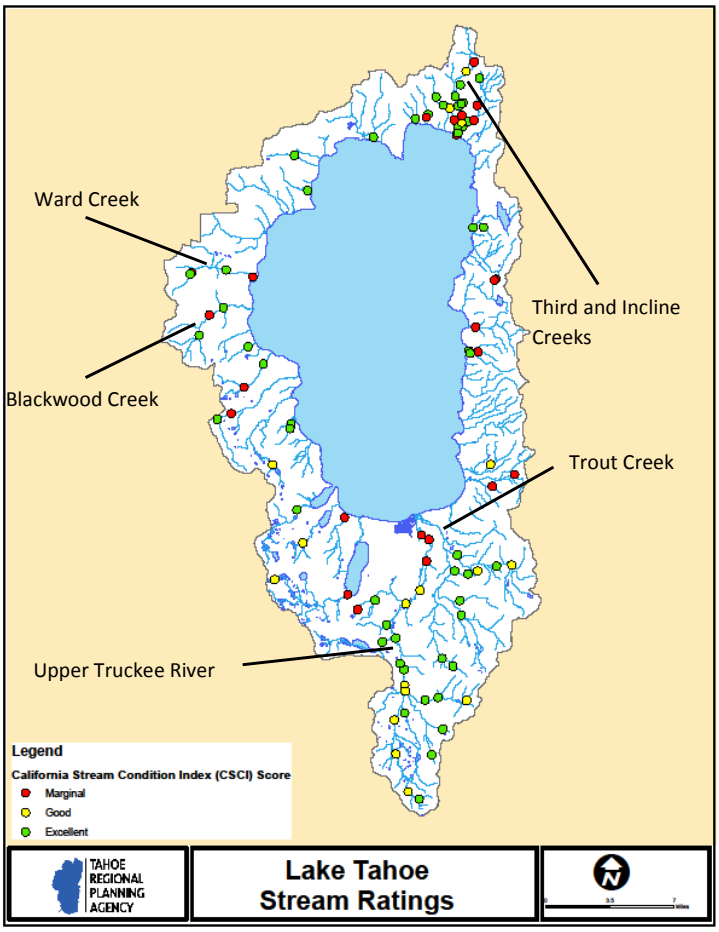


Figure 2: *"Status" monitoring locations and streams in the Tahoe Basin rated as marginal, good, and excellent from 2009-2014 (TRPA 2015).*

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – From 2011 to 2015, nearly 5 miles (26,314 feet) of stream have been restored or enhanced through the Environmental Improvement Program (TRPA 2016). Additionally, several large restoration projects are planned in the lower portion of the Upper Truckee River and elsewhere throughout the next five years. The lower portions of the Upper Truckee River are among the most highly degraded portions of Tahoe Basin streams (Purdy, Fesenmyer, and Henery 2014; Roll et al. 2013), and therefore represent great potential to improve their overall condition and potentially meet the stream habitat threshold standard. Additionally, nine of the 24 monitoring sites that ranked as marginal are located on stream reaches with recently completed or planned restoration projects (see map on right) (TRPA 2016). This suggests that if these restoration projects are successfully completed, the Basin can reach attainment of the stream habitat standard. Additionally, during the threshold reporting period of 2011-2015, eight fish passage improvement projects were implemented, providing access to an additional 7.66 miles of potential habitat (TRPA 2016). Additional fish passage improvement projects are planned beyond 2015.

TRPA and other agencies (e.g., Lahontan Regional Water Quality Control Board, California Department of Fish and Game, US Army Corps of Engineers) regulate projects and activities in the stream environment zones, including activities in the stream itself. Additionally, the Environmental Improvement Program has initiated large-scale BMP construction, reducing pollutant load in stormwater runoff and improving aquatic habitat (TRPA 2016).

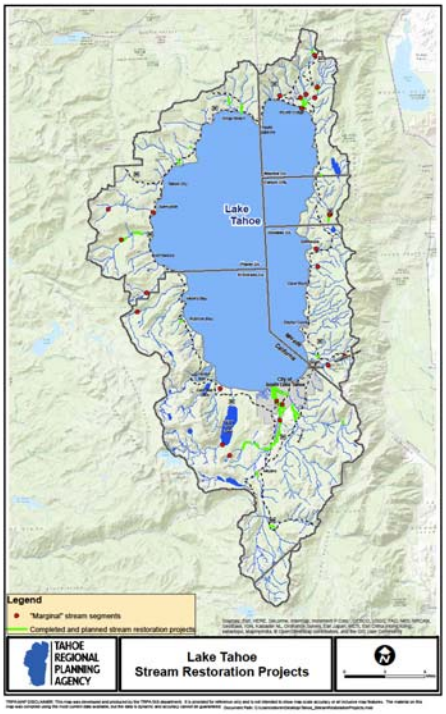


Figure 3: Lake Tahoe steam restoration projects

Effectiveness of Programs and Actions – While Environmental Improvement Program investments have restored nearly five miles of stream habitat in the last five years, the positive effects of these projects on overall stream health have not yet shown up. Likely reasons:

1. The probabilistic nature of TRPA's sampling design means only a small percentage of sampling points are within recently restored stream sections. As the monitoring program continues to select random sites in the future, sampling points will eventually fall in restored sections and capture improvements.
2. Many stream restoration projects have been completed only recently in the last few years. If a project was completed in 2014 or 2015, trend sites in these areas are likely to begin to show improvements in future evaluations.
3. The stream monitoring program assesses trend Basin-wide using 48 sites. The effects of individual restoration projects are often local and can be relatively small when aggregating scores for the whole Basin. Continued large-scale restoration projects and continuation of management practices across broad geographies that benefit stream health are likely required to dramatically improve aggregated regional scores.

Although the current status of stream habitat is below target, current policies and ordinances are appropriate due to their emphasis on protecting fish habitat and surrounding stream environment zones. Additionally, the Environmental Improvement Program's work to reverse legacy impacts to streams and reduce stormwater

pollution intro streams are appropriate and should begin to show effects on the Basin's overall stream habitat over time.

Interim Target – Average stream habitat condition of trend sites is equal to, or better than 0.933 (the average trend site score 2013/2014).

Interim Target Attainment Date – Because limited data exists and a statistically significant trend cannot be established, it is not possible to predict a target attainment date based on trend data. Instead, we can forecast with low confidence when the target will be reached based on projecting conservative implementation progress using already approved and planned stream restoration projects. Currently, the Basin has 19 more miles (9 percent) of marginal stream habitat than the target. Assuming streams in good or excellent condition stay the same or become healthier based on the protective rules and procedures in place for streams, SEZ's, and minimizing stormwater flow to streams, we can assume streams in attainment status remain so and forecast an attainment date for other streams. During the last five years, nearly five miles of stream habitat were enhanced or restored (TRPA 2016). Large stream restoration projects are planned for the immediate future as well (TRPA 2016). If future stream restoration continues at a similar pace of approximately one mile per year, and restored streams with increased CSCI scores would move out of the marginal category, it is expected that 20 miles of marginal streams could be restored by 2035, bringing the marginal stream habitat indictor into attainment. However, if drought conditions persist or worsen, attainment may be pushed out further or may never be reached. Conversely, if wetter conditions and more sustained stream flows return, attainment may be reached sooner.

RECOMMENDATIONS

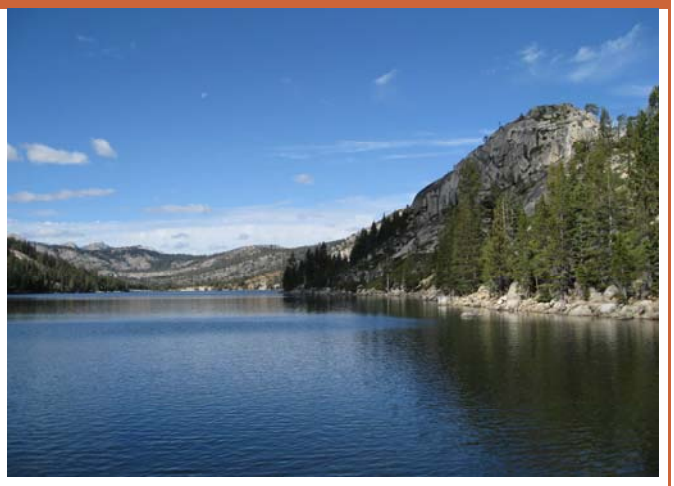
Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – Review or revision of this standard should attempt to clarify its intent. The current standard relates only to the physical habitat within streams, and is only an indirect measure of the health of fish populations in tributaries to Lake Tahoe. Factors such as connectivity between habitats types essential to support different life stages is important to population health, but not currently reflected within the standard. At a minimum, the standard should be revised so that streams moving from a lower category into a higher category would not move one category out of attainment. For example, the way the standard is currently written, if streams move out of the good category and into the excellent category, there would be less streams in the good category (and possibly move out of attainment) even though stream health is improving.

Attain or Maintain Threshold – Climate forecasts suggest a greater proportion of Region's precipitation will fall as rain, which may increase winter runoff, but decrease spring and summer streamflow (U. S. Bureau of Reclamation 2015; Hayhoe et al. 2004). Higher air temperature will also likely mean more frequent and intense droughts(U. S. Bureau of Reclamation 2015). These shifts are likely to result in higher stream temperatures in the Region (Ficklin, Stewart, and Maurer 2013). As stream temperatures increase, riparian protection, shading, and marsh/meadow restoration may be increasingly important to maintaining high quality steam habitat. Prioritization of programs and projects to improve instream fish habitat should consider factors such as connectivity between habitats types essential to support different life stages is important to population health, in addition to the aggregate measures of habitat restored.

Instream Flow: **Non-Degradation Standard for Instream Flow & Divert Stream Intakes to Lake Sources**

Status	Photo
NON-DEGRADATION STANDARD FOR INSTREAM FLOW Status: **Implemented** **DIVERT STREAM INTAKES TO LAKE SOURCES** Status: **Implemented**	 Photo: The Echo Lakes dam is one of the few existing stream diversions in Lake Tahoe. A 2003 Desert Research Institute study (Tracy and Rost 2003) found existing diversions to have a minimal impact on instream flows and overall fisheries habitat. Photo Credit: BrewBooks (https://creativecommons.org/licenses/by-nd/2.0/legalcode)

Data Evaluation and Interpretation

BACKGROUND

Relevance – There are 63 tributaries that drain into Lake Tahoe, and one tributary that drains from the basin. The amount of water flowing through a stream is primarily dependent on the size of its watershed and the amount of precipitation within a given year. Streams provide critical habitat to a diversity of native and non-native fish populations and other riverine dependent organisms. Historic logging, grazing and land uses interrupted the hydrologic integrity of many of the streams and tributaries draining into Lake Tahoe, (Murphy and Knopp 2000) and the results of these legacy activities are evident today (Tracy and Rost 2003; Vacirca 2010). Alteration of stream flow regimes, such as water diversions, can result in adverse impacts to stream habitat diversity, function, and productivity of aquatic ecosystems and organisms (Karr and Chu 1999; Stephens, S.L. et al. 2004). A component of the TRPA Regional Plan is to maintain a healthy functioning fishery through the conservation and restoration of natural flow regimes (TRPA 1986; TRPA 2012c).

TRPA Threshold Category – Fisheries

TRPA Threshold Indicator Reporting Category – Instream flow

Adopted Standards – There are two threshold standards adopted in Resolution 82-11 that address the conservation and restoration of instream flows. The management standard for instream flow states:

"*Until instream flow standards are established in the Regional Plan to protect fishery values, a nondegradation standard shall apply to instream flows.*" The policy standard states, "*It shall be a policy of the TRPA Governing Board to seek transfers of existing points of water diversion from streams to Lake Tahoe.*" A review of TRPA standards (TRPA 1982b) indicates that the original intent was to address concern over the diversion of water from streams for consumptive uses, irrigation and snowmaking. It was believed at the time that TRPA could prescribe minimum flow standards for each stream in the Basin in order to maintain a healthy fishery (TRPA 1982b).

Type of Standard – Management Standard and Policy Statement

Indicator (Unit of Measure) – Three criteria were evaluated to determine the implementation status of the instream flow threshold standards:

1. Has TRPA adopted appropriate policies, ordinances and programs to support the adopted threshold standards?
2. Has TRPA permitted or otherwise allowed for new permanent diversions or alteration of stream flows since 1987?
3. Does available scientific information support the need to adopt instream flow standards for Regional streams?

Human & Environmental Drivers – Weather, climate patterns, geology, elevation, and topography all significantly affect stream flow characteristics. Historic channel modifications associated with logging activities and land uses (e.g., dams, water extraction and within-watershed diversions, urban development and infrastructure, flumes, stream channelization, and flood control impoundments) that preceded the 1987 Regional Plan altered stream channel structure and watershed-specific hydrology.

MONITORING AND ANALYSIS

Monitoring Partners – Management standard. No monitoring exists.

Monitoring Approach – Management standard. No monitoring exists.

Analytic Approach – Not applicable.

INDICATOR STATE

Status – Implemented. Based on the evaluation criteria, the threshold standards are determined to be implemented and in attainment.

Criteria 1: TRPA and other agencies have instituted a number of regulatory actions and restoration projects that support the nondegradation management standard and policy statement set forth under the instream flow indicator reporting category. TRPA regulates projects and activities that have the potential to impact the integrity of stream habitat including impacts to stream flows in the Tahoe Basin (see TRPA 1986 and TRPA 1987a as amended in 2012). In addition, other agencies have established rules that regulate the types of projects and activities that can occur in stream habitats (e.g., California Department of Fish and Game). Under the Environmental Improvement Program, the U.S. Forest Service and other agencies such as the California Tahoe Conservancy have implemented and are planning several large-scale stream restoration projects at Cook House Meadow, Big Meadow Creek, Blackwood Creek, Cold Creek, Angora Creek, Trout Creek and Meeks Creek, as well as the Upper Truckee River. One of the main objectives of these projects is to return streams to a natural flow regime (Vacirca 2010).

Criteria 2: A review of available TRPA permit data indicates that TRPA only permitted temporary stream flow diversion/alterations when the ultimate project objective was stream enhancement and/or restoration. In no instance were permit records found indicating that TRPA permitted new permanent diversion or the extraction of water from streams for consumptive uses. There are at least four dams in the Basin that actively regulate stream flow under historic water rights. These include Echo Creek at Lower Echo Lake, Taylor Creek at Fallen Leaf Lake, Truckee River at the Lake Tahoe outlet, and Marlette Creek at Marlette Lake outlet. Of these dams, only the Echo Lake dam operation diverts stream flow

from the Lake Tahoe Basin as a backup to the El Dorado Irrigation District's water system during drought conditions; in normal water years, no water is diverted from Echo Lake. Each dam is required to provide minimum stream flows necessary to support stream fisheries values as a component of the operating agreements with state and federal regulatory and fisheries management agencies. According to Madonna Dunbar (Tahoe Water Suppliers Association, personal conversation, 2011), waters for consumptive use in the Tahoe Basin are primarily sourced from lake intakes (54 percent) or from groundwater sources (46 percent), and less than one percent is drawn from other sources such as springs or streams.

Criteria 3: The Desert Research Institute (Tracy and Rost 2003) completed the following tasks to assist TRPA in understanding stream flow conditions consistent with the direction provided in the instream flow management standard:

1. A statistical analysis of stream flow rates for tributaries with continuous flow gaging records;
2. A statistical model to predict daily stream flow rates of tributaries with little or no gaging records;
3. A statistical model to predict instream flow needs for salmonid (trout) species in Lake Tahoe's streams; and
4. A field survey to locate and assess the level of anthropogenic disturbance to the hydrology of Lake Tahoe's streams.

The study developed statistical relationships for gauged and ungauged tributaries in the Lake Tahoe Basin to describe their daily flow-exceedance-frequency relationships for each month of the year. These relationships were then compared to published optimal instream flow rates for trout species for several of TRPA's listed threshold tributaries. Comparisons indicated that only a limited number of streams meet defined optimal instream flow requirements (Snider, Kershner, and Smith 1987). Trout Creek and Upper Truckee River showed the greatest potential for meeting optimal instream flow rates for both trout-rearing and spawning periods. A much larger proportion of streams provide suitable, but not optimal, stream flow for trout species and the maintenance of unrestricted stream flows, regardless of flow rates, are important to other aquatic dependent organisms, such as invertebrates, native fishes, amphibians and some reptiles. Tracy and Rost's (2003) analysis also suggested that instream flow rates could be extrapolated to a larger number of tributaries within the basin based on the tributary's physical characteristics. Finally, a field assessment of Lake Tahoe's tributaries showed that about 50 percent of the tributaries have some type of man-induced disturbance (e.g., impoundment, non-functional earthen dams, artificial stream bank stabilization) that could potentially affect the hydrologic characteristics as well as limit organism movement within the stream corridor. However, Tracy and Rost (2003) found that the effect of the majority of man-induced disturbances on stream flow was relatively small, and would likely only affect the tributary's hydrologic characteristics during very low flow conditions experienced during droughts.

Tracy and Rost (2003) found that the flow of the vast majority of streams in the Tahoe Basin is primarily affected by the amount of precipitation occurring within the watershed. Their assessment of stream flow conditions suggested but stopped short of recommending minimum flow standards for streams, largely because only two streams have a high probability to provide optimal flow conditions and because minimum flow requirements would be different for different fish species. Other recommendations include (Tracy and Rost 2003):

- Although there were a number of human instream flow impediments, the effect on stream flow characteristics was negligible. Thus, removal of structures would only marginally improve hydrologic conditions, but would likely improve stream corridor mobility for aquatic organisms during very low stream flow conditions.
- Methodologies for determining instream flow requirements for all of Tahoe Basin's fish species would be needed in order to inform scientifically supported minimum flow standards for different streams. Currently, no published studies could be found that identified instream flow needs for Tahoe's native non-game species. As an important element of the basin's aquatic ecology, their habitat needs should be placed on equal footing with those of the more well-studied introduced trout species.

Tracy and Rost's (2003) evaluation was the basis for an earlier recommendation to establish minimum instream flow conditions. The cost and benefit to the fishery of that recommendation was not evaluated. The finding that stream flow is primarily driven by within-watershed precipitation (which cannot be regulated by TRPA), and that TRPA's existing regulations restrict projects or activities from permanently diverting or impacting flow from streams, suggests that the need to establish minimum flow standards for individual streams may not be feasible or warranted and should be re-considered. It is nonetheless suggested that measures of stream flow should be integrated into stream habitat monitoring protocols as a variable to help explain drivers of stream habitat conditions.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – As stated in evaluation criteria 1, TRPA and other agencies with jurisdictional authority regulate projects that could interfere with the health of fish populations within the Lake Tahoe Basin. Basin partners have instituted a number of actions that implement the non-degradation policy set forth under the instream flow threshold requirements. These actions include restrictions on stream zone encroachment and the funding and implementation of the Environmental Improvement Program's watershed restoration program. Overall, TRPA has permitted temporary actions altering stream flow only when the ultimate objective is improving and restoring natural hydrology, and has cooperated with partner agencies with similar goals. The U.S. Forest Service and other land management agencies have implemented and continue to plan several large-scale stream restoration projects.

Effectiveness of Programs and Actions – Based on the evaluation criteria presented, TRPA and other agencies have been effective at averting new permanent flow diversions from streams in the Lake Tahoe Basin since 1987. Diversions of streams for consumptive water use are extremely limited as the majority of water used comes from either lake or groundwater sources.

RECOMMENDATIONS

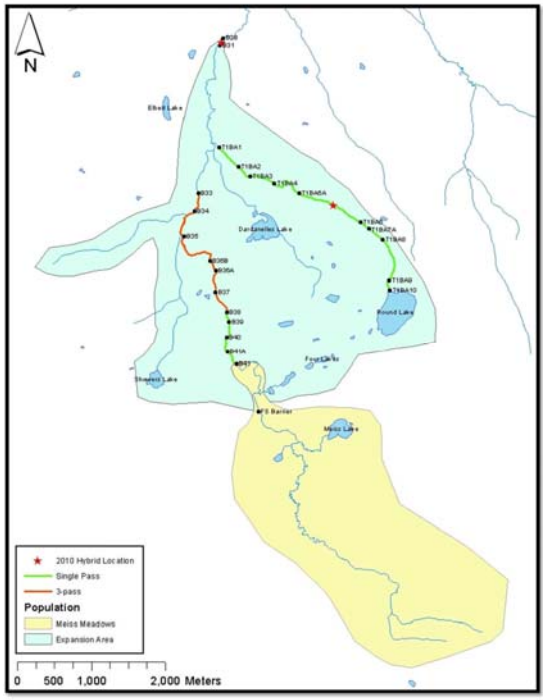
Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – Based on Tracy and Rost's (2003) study, it is questionable whether setting in-stream flow standards would have a measurable benefit on the Tahoe fishery since the primary driver of in-stream flow is precipitation and diversions have a minimal effect on stream flows in the Basin. Current regulations prohibiting new water withdrawals from streams, and only allowing temporary diversions if the ultimate goal of the project is stream restoration, are effective at maintaining instream flows.

Attain or Maintain Threshold –No changes recommended.

Fisheries: **Lahontan Cutthroat Trout**

Status	Map
LAHONTAN CUTTHROAT TROUT Status: **Implemented**	
Photo	
 Photo: Lahontan cutthroat trout (LCT) spawning in Glen Alpine Creek, a tributary of Fallen Leaf Lake. 2012 marked a major milestone as the first observed natural spawning of LCT occurred as part of the Fallen Leaf Lake LCT restoration program. Credit: US Fish and Wildlife Service.	Map shows the project area for the Upper Truckee River Lahontan cutthroat trout (LCT) restoration program in the headwater of the Upper Truckee River. This project is restoring the stream-based strain of LCT while the Fallen Leaf Lake project is restoring the lake-based strain of LCT.

Data Evaluation and Interpretation

BACKGROUND

Relevance – The Lahontan cutthroat trout (LCT, *Oncrhynchus clarkii henshawi*) is the only trout species native to the Lake Tahoe Basin and was once the top predator in Lake Tahoe's aquatic ecosystem (TRPA 2014; Wittmann and Chandra 2015). Due to overfishing, habitat degradation, and the introduction of non-native aquatic species, it was extirpated in the 1930s from the Lake Tahoe Basin (Allen, B.C. et al. 2003). It is listed as threatened under the Federal Endangered Species Act.

TRPA Threshold Category – Fisheries

TRPA Threshold Indicator Reporting Category – Lahontan Cutthroat Trout

Adopted Standards – It shall be the policy of the TRPA Governing Board to support, in response to justifiable evidence, state and federal efforts to reintroduce Lahontan cutthroat trout.

Type of Standard – Policy Statement

Indicator (Unit of Measure) – Two criteria were evaluated to determine the implementation status of the Lahontan cutthroat trout policy statement, including:

1. Has TRPA adopted appropriate policies, ordinances and programs to support the adopted threshold standard?
2. Is there evidence to suggest that at least one self-sustaining population of Lahontan cutthroat trout has been established in the Lake Tahoe Basin?

Human & Environmental Drivers – Due to overfishing, habitat degradation, and the introduction of non-native aquatic species, LCT were extirpated in the 1930s from Lake Tahoe Basin (Allen, B.C. et al. 2003). While overfishing is no longer an issue, degraded stream habitats, fish passage blockages (culverts, etc.), and non-native aquatic species such as rainbow trout, brook trout, and lake trout still pose a significant threat to the reintroduction of LCT. The introduction of mysid shrimp (Mysis diluviana) in the 1960s (Wittmann & Chandra 2015), significantly altered the Lake's food web.

MONITORING AND ANALYSIS

Monitoring Partners – U.S. Forest Service, U.S. Fish and Wildlife Service, California Trout, Trout Unlimited, Nevada Department of Wildlife

Monitoring Approach – Regular monitoring of LCT populations occur through a variety of standard fish population monitoring approaches including electroshocking, fish weirs, etc.

Analytic Approach – Not applicable.

INDICATOR STATE

Status – Implemented. The Lahontan cutthroat trout policy statement has been implemented by TRPA and determined to be in attainment with the adopted policy statement. Support for the Basin's attainment status includes a population of LCT established in the Upper Truckee River including a recently expanded restoration area. Additional restoration is underway to re-establish populations in Fallen Leaf Lake.

Criteria 1: Work is underway to restore the native LCT population into its historic lacustrine (lake) and fluvial (stream) habitats throughout the Truckee River Basin including the Tahoe Basin (TRPA 2007). In April 2007, TRPA joined the Tahoe Basin Recovery Implementation Team (TBRIT), which was formed as part of the ongoing work to develop and implement actions to help recover LCT. TRPA provides support in the TBRIT: TRPA is not a land manger but rather serves to facilitate protection and restoration of LCT habitat through policy, regulation and support of researchers' and implementers' reintroduction work programs (see Chapter 63 of the TRPA Code of Ordinances).

Criteria 2: California Department of Fish and Wildlife reintroduced LCT into the headwaters of the Upper Truckee River near Meiss Meadows in 1989 and 1990. Through years of population management and monitoring, the Meiss Meadows population has become established as the only self-sustaining population of LCT in the Lake Tahoe Basin. The last monitoring occurred in 2013 and determined this area was still free of brook trout and had a self-sustaining population of LCT (Lemmers 2015).

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – In 2008, the U.S. Forest Service began implementing the Upper Truckee River Lahontan Cutthroat Trout Restoration Project downstream of the existing Meiss meadows population referred to as the "expansion area" (Lemmers 2015). Since 2008,

the total number of non-native salmonids species in the expansion area continues to decrease, while LCT populations continue to show signs of successful reproduction and growth. Since 2012, total numbers of LCT have been declined likely as a result of drought and decreased stream flows (Lemmers 2015).

In 2002, the U.S. Fish and Wildlife Service introduced LCT to Fallen Leaf Lake in a pilot project to learn what conditions are necessary for successful restoration of LCT in a lake environment. In 2012, biologists observed successful reproduction in Fallen Leaf Lake's tributary, Glen Alpine Creek (U.S. Fish and Wildlife Service 2013). Additionally, overwintering and multi-year survival has been recently documented. These observations are major milestones for the recovery of the species in the Tahoe Basin. While these results are positive, continuing challenges include adverse interactions with non-native species, including predation by lake trout (*Salvelinus namaycush*), hybridization with rainbow trout (*Oncorhynchus mykiss*), change in the food web as a result of Mysid shrimp and other non-natives, and competition for resources where non-native species are present (Allen, B.C. et al. 2003).

Nascent work toward reintroducing LCT into Lake Tahoe for recreational purposes began in summer 2011. The Nevada Department of Wildlife stocked approximately 22,000 LCT in Lake Tahoe as part of the work to begin stocking native aquatic species for the benefit of anglers. Additional research is needed to improve understanding of reintroduced LCT population dynamics, including seasonal habitat utilization, growth rates, and their interactions with non-native species (Robert Al-Chokhachy et al. 2009) .

Effectiveness of Programs and Actions – Based on observed successful reproduction of both the Upper Truckee River and Fallen Leaf Lake populations, it appears current projects have been initially successful in re-establishing self-sustaining populations of LCT. The health of these populations in upcoming years will determine the success of these projects.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – Objective determination of "attainment" status for standards without a specific target is recurrent challenge both in the Region and in the larger field of monitoring and evaluation (M&E). The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to improve the evaluability of the standard and the information it provides for management.

Attain or Maintain Threshold – No changes recommended.

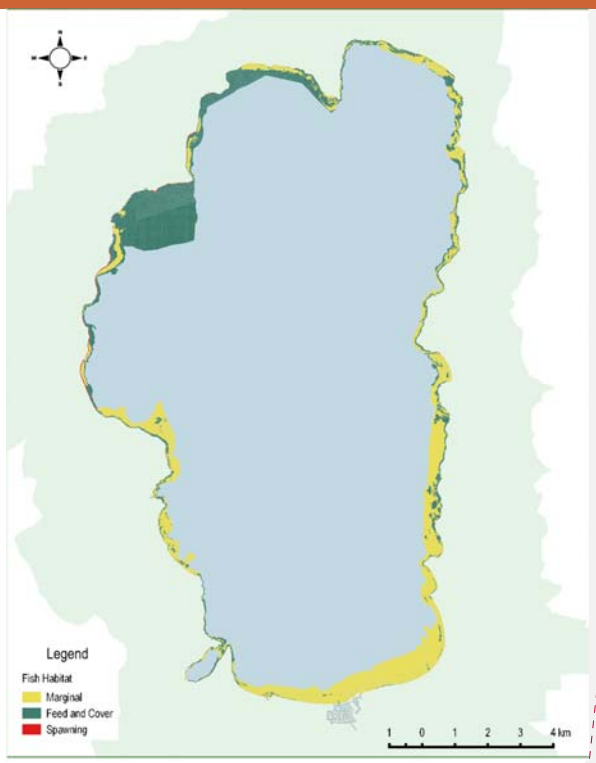
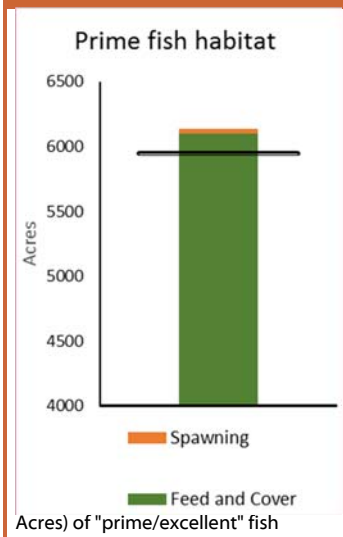
Lake Habitat

There is one threshold standard in the lake habitat indicator reporting category. The lake habitat threshold standard is listed as a management standard with a numeric target to achieve the equivalent of 5,948 acres of "prime" fish habitat. Prime fish habitat includes spawning habitat and feed and cover habitat. Spawning habitats are composed of relatively small diameter gravel substrates used by native minnows for spawning and rearing fry. Feed and cover habitats are composed of larger diameter cobbles, rocks, and boulders, used by fish as foraging habitat and to provide refuge from predation. Marginal habitats are dominated by sand and silt substrates interspersed with occasional willow thickets that establish during low lake levels.

According to TRPA (TRPA 1982a), "The quality of the lake can be evaluated and tested against the threshold using measures of habitat disturbance and substrate conditions." An indicator for the lake habitat threshold standard was identified by TRPA (1996) as "physical disturbance of rocky substrate (acres)." TRPA (1982a) considered moderate to heavy boat traffic as a disturbance that significantly contributed to the decline of lake fish habitat quality. TRPA's 1996 Threshold Evaluation Report further determined that the rearrangement or clearing of near shore substrate to accommodate beach use during low lake levels degraded fish habitat. Since the initial adoption of the threshold standard, studies have revealed that boat activity is not sufficiently frequent in the littoral zone to degrade conditions in "prime" fish habitat (Allen and Reuter 1996). In the 2006 Threshold Evaluation Report, TRPA measured and reported on the extent and distribution of rocky substrates ("prime" fish habitat in the littoral zone) because of the challenges associated with defining and measuring "disturbed rocky substrates." This approach more directly addressed whether the management target of 5,948 acres was achieved.

The indicator for lake habitat showed that the status is "at or somewhat better" than the adopted management targets with an "unknown" trend. Overall confidence in the determination of status and trend is "low" due to changes in mapping techniques. However, the higher resolution imagery and multiple images used to create the substrate map used for the 2015 evaluation offer a significant improvement over prior maps. Evidence from recent research suggests that the populations of many nearshore fish species have declined (K. L. Ngai et al. 2011; Chandra, Caires, and Ryan 2015). However, these population level changes are not detectable using the indicator associated with the existing lake habitat threshold standard. The management provisions embodied in the lake habitat threshold standard have been incorporated into the TRPA Regional Plan and are implemented through the TRPA permit review process.

Lake Habitat: **Acres of "Prime" Fish Habitat**

Reporting Icon	Map
ACRES OF "PRIME" FISH HABITAT Status: At or **Somewhat Better than Target** Trend: **Insufficient Data to Determine Trend** Confidence: **Low**	
Graph	Distribution and extent of nearshore fish habitats in Lake Tahoe (O'Neil-Dunne et al. 2016) based on an evaluation of high-resolution WorldView-2 imagery collected in August 2010 and 2015. "Prime" or excellent habitat includes spawning and feed and cover. O'Neil-Dunne et al. (2016) estimated that there are ~~6,461~~ 6,135 acres of prime fish habitat between an upper elevation of 6,229 feet and a lower elevation 6,199 feet.
 Acres) of "prime/excellent" fish habitat (spawning habitat - orange, feed and cover habitat – green) as estimated by O'Neil-Dunne et al. (2016), relative to TRPA's Lake Tahoe habitat management standard (thick black line = 5,948 acres).	

Data Evaluation and Interpretation

BACKGROUND

Commented [DS1]: Updated the graph and text on Lake Fish Habitat indictor sheet to reflect habitat that would be wetted between lake elevation 6,119- 6,229 (O'Neil-Dunne, Romsos, and Saah 2016). The correction reduced the estimated amount of prime fish habitat from 6,461 to 6,135, but did not alter the status determination.

Relevance –Prime fish habitat is defined as areas that satisfy habitat requirements critical to the distribution of fish or important components of their food chains and life cycles (TRPA 1996). This indicator measures the extent of rocky substrates in Lake Tahoe's nearshore (i.e., littoral zone) known as "prime" or excellent fish habitat. Fish use different diameter rock substrates in Lake Tahoe's nearshore to satisfy different life history requirements such as spawning, growth and feeding. Gravel substrates composed primarily of rocks smaller than 64 millimeters and larger than 2 millimeters in diameter are used for spawning by native minnow species, while substrates primarily composed of larger diameter cobble, rocks and boulders are used for foraging and for cover by a variety of fish species (Beauchamp, D.A., Byron, and Wurtsbaugh 1994). Marginal habitats are primarily composed of sand and silt substrates that measure less than 2 millimeters in diameter. Spawning, and feed and cover substrates together comprise "prime" or excellent fish habitat according to TRPA. TRPA's lake habitat management standard aims to prevent the loss of or disturbance to "prime" fish habitats as a result of shorezone development or other anthropogenic disturbances. This indicator does not measure the abundance of individual fish species, community composition, or trophic structure of Lake Tahoe's nearshore.

Threshold Category – Fisheries

Indicator Reporting Category – Lake Habitat

Adopted Standards – A nondegradation standard shall apply to fish habitat in Lake Tahoe. Achieve the equivalent of 5,948 total acres of excellent habitat as indicated by the Prime Fish Habitat Overlay Map, which may be amended based on best available science.

Type of Standard - Management Standard (with a numeric target)

Indicator (unit of measure) – Acres of "prime" fish habitat. Prime fish habitat is defined by substrate type and includes "spawning" (2 millimeter to 64 millimeter substrates) and "feed/cover" (greater than 64 millimeter substrates) habitat types.

Human and Environmental Drivers – The removal, rearrangement, or covering of littoral zone substrates can influence the status of this indicator (TRPA 1996). Fluctuations in lake level can also significantly affect the availability of "prime" fish habitat, especially spawning habitat (Allen and Reuter 1996). Urbanization along the shorezone, recreational activities , excessive fish harvest , excessive nutrients, increased water temperature associated with global climate change, and presence of non-native fish and other non-native aquatic plants and animals are all factors that can influence the overall quality of Lake Tahoe's fish habitat and fish species composition (K. L. Ngai et al. 2011; Heyvaert et al. 2013).

MONITORING AND ANALYSIS

Monitoring Partners – University of California, Davis; University of Nevada, Reno; California Department of Fish and Wildlife; and Nevada Department of Wildlife.

Monitoring Approach – The monitoring approach used for evaluating the attainment status of this standard involves the mapping and classification of fish habitats in the nearshore (the lake zone that exists approximately between elevations of 6,229 to 6,199). In 1971, a cooperative survey was done by various state and federal fish and wildlife agencies to identify fish and aquatic habitats of special significance. This work produced a Prime Fish Habitat Map that TRPA adopted in 1984. This map, as amended in 1997, is still the map TRPA uses today. Byron et al. (1989) as part of their fish habitat study resurveyed and mapped fish habitat around Lake Tahoe. According to TRPA (1996), the Byron et al. work represented a more accurate picture of the types of fish habitat based on lakebed substrate. The 2006 and 2011 Threshold Evaluations Reports utilized an updated fish habitat map based on satellite imagery collected in 2002 (Metz and Herold 2004; Herold, Metz, and Romsos 2007a). O'Neil-Dunne (2016) followed similar monitoring (mapping) methods used by Metz and Herold (2004) and Herold et al. (2007) to produce higher resolution estimates of fish habitat distribution.

The composite or mixed substrate classes are problematic in that they often contain a mix of habitat types

(e.g., marginal with "feed and cover"). The composite classes are necessary for mapping primarily due to an inability to resolve the individual substrate classes using satellite imagery at the fine scales in which they are present. The result is that the true extent of spawning habitat could be misinterpreted to suggest there is less habitat than truly exists. For example, O'Neil-Dunne et al. (2016) noted numerous examples from field sampling where gravels substrates were commingled with other substrates such as cobble and boulder sized substrates.

Analytic Approach – Early lake fish habitat analyses used field surveys and coarse delineation to estimate fish habitat acreage and are described in Byron et al. (1989). Metz and Herold (2004) and Herold et al. (2007) describe in detail the analysis approach they used for 2002 IKONOS imagery. O'Neil-Dunne et al. (2016) used an analysis that included two primary phases: 1) applying a custom wave detection algorithm to select the best available imagery (imagery was least distorted by wave action) from 2010 and 2015 WorldView-2 datasets and 2) the creation of substrate and fish habitat map. The substrate mapping process consisted of five steps: 1) segmentation of the WorldView-2 imagery into objects, 2) assignment of each object based on the majority class in the 2002 IKONOS derived substrate map, 3) automated refinement of substrate classification using the 2010 and 2015 WorldView-2 imagery, 4) manual review and refinement of the substrate classification, and 5) a comparison of substrate classes into TRPA fish habitat types. Following these steps, attribute data were summarized using pivot tables.

INDICATOR STATE

Status – At or Somewhat Better than Target. Analysis of remotely sensed data collected in August 2010 and 2015 estimated that there are about 6,135 acres of "prime" fish habitat in Lake Tahoe's nearshore/littoral zone (O'Neil-Dunne, Romsos, and Saah 2016), suggesting that the Basin is meeting the adopted management target of 5,948 acres. Note that this acreage estimate included both dry and wet substrate; not the entire habitat was available to fish at the time of the analysis. About 118 acres or 2 percent was dry and not available to fish at the summer 2015 lake level. If only wet habitat was counted, total acreage is 6,098 and the target would still be in attainment. Since 1989, TRPA has regulated construction within Lake Tahoe's littoral zones. TRPA has not permitted the unmitigated construction of piers, boat launches or other developments that would degrade or disturb the littoral substrate. However, efforts to restore "prime" habitat have not occurred since 2002. Consequently, there were likely no substantial changes in the extent of fish habitat since 2002, other than changes that may have occurred as a result of natural littoral drift and fluctuating lake levels. At low lake levels (such as those in summer 2015) available spawning habitat can decrease by more than 85 percent (O'Neil-Dunne, Romsos, and Saah 2016).

Figure 1: *Using aerial imagery along with field verification from a boat, each color spectrum of the Lake is matched to a corresponding habitat type (boulder, gravel, etc.) to estimate distribution of fish habitat around the Lake. This method allows TRPA to track changes over time using satellite imagery.*

As discussed in the 2006 and 2011 Threshold Evaluation Reports and by others (Kamerath, Chandra, and Allen 2008; K. L. Ngai et al. 2011; Heyvaert et al. 2013), additional factors influence the quality of littoral fish habitat, such as the introduction and expansion of aquatic invasive species. Ngai et al. (2011) found that there has been a significant reduction in the abundance and distribution of minnow species in Lake Tahoe's nearshore. Other surveys have documented similar results, including the 2014 survey which estimated native fish abundance in the

nearshore has declined by 57 percent since 1989 (Chandra, Caires, and Ryan 2015).

Trend – Insufficient data to determine trend. The differences between the 2002 (Metz and Herold 2004), 2007 (Herold, Metz, and Romsos 2007a), 2010 and 2015 (O'Neil-Dunne, Romsos, and Saah 2016) habitat mapping efforts should not be interpreted to mean that the substrate has changed, but rather viewed as a refinement of TRPA fish habitat mapping. Consequently, the trend determination for the extent of "prime" fish habitat is "unknown" due to differences in the mapping approach used to establish the management target (TRPA 1982a; TRPA 1982b), and the mapping approach used by Byron et al. (1989), Metz and Herold (2004), Herold et al. (2007) and O'Neil-Dunne et al. (2016).

Confidence

Status – Low. The fish habitat map used in the 2007 and 2001 threshold evaluation reports was estimated to be 86 percent accurate (Herold, Metz, and Romsos 2007b; TRPA 2012a; TRPA 2007). O'Neil-Dunne (2016) compared field data collected in 2015 to both the 2002 and 2015 substrate maps, however, did not complete traditional accuracy assessment because only 240 of the 1,000 field samples needed for a valid accuracy assessment were collected. Nonetheless, the comparison between these datasets provides some meaningful insight into the quality of the data. Principally there were very few hard classification errors in either the 2002 or 2015 mapping efforts. An example of a hard classification error is "boulder" being misclassified as "sand." There are classes with considerable confusion. For example, five locations identified as boulder in the 2015 field data collection were classified as sand/cobble/boulder in both the 2002 and 2015 mapping efforts. This error is an example of a soft classification as boulder was included in the composite class and there is no way to determine if the location observed in the 2015 field collection was part of a larger pure boulder area or just a singular boulder in an otherwise mixed substrate area. Both boulder and sand/cobble/boulder are further classified as "feed and cover" habitat and thus the misclassification does not impact the estimate of fish habitat. Despite these shortcoming reported in the O'Neil-Dunne (2016) mapping effort, their map depicts the highest resolution representation of Lake Tahoe nearshore fish habitat to date.

Trend – Low. The confidence in the trend for "prime" fish habitat is low due to differences in mapping approaches. Recent research suggests high confidence in the reduction of native minnow abundance and distribution because the same sites were sampled in previous efforts.

Overall – Low. Overall, confidence in the status and trend determination is low because of the low confidence in trend information and the lack of a traditional accuracy assessment of mapped habitat in the most recent mapping effort (O'Neil-Dunne, Romsos, and Saah 2016).

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA regulates projects and activities in Lake Tahoe's shorezone and littoral zone that may affect lake fish habitat. TRPA requires habitat mitigation for projects that result in substrate disturbance of prime fish habitat to be restored 1.5 times the area disturbed. Mitigation is generally required in the general vicinity of the disturbance. Pursuant to Chapter 86 of the TRPA Code of Ordinances, fees collected from marina, piers, and boat ramp projects are leveraged for additional research on nearshore impacts and fish habitat restoration (TRPA 2012b). Further measures that benefit fish habitat are found in TRPA Goals and Polices and the TRPA Code of Ordinances, as well as other state and federal laws. Both prevention and control efforts related to aquatic invasive species in the lake help maintain habitat for native species. Watershed restoration work that reduces sediment loads in the basin's lakes and rivers can help prevent spawning substrates from being covered in fine sediment. Water quality improvement projects completed by Environmental Improvement Program partners between 2009 and 2015 have:

- Restored or enhanced 27,150 linear feet of stream channel.
- BMP retrofitted 120.55 miles of road and decommissioned 7.4 miles of road.
- Restored or enhanced 120 acres of disturbed forested uplands.
- Inspected 108.72 miles and maintained 98.2 miles of unpaved non-urban roads
- Issued 18,076 best management practices certificates to commercial, multifamily and single family residential properties.

- Treated over 40 acres for AIS, including the removal of invasive weeds from Emerald Bay. Emerald Bay remains free of Eurasian watermilfoil and curlyleaf pondweed.

Effectiveness of Programs and Actions – There is insufficient data available to assess the effectiveness of individual programs or actions in maintaining lake fish habitat. Programs to prevent the introduction of new aquatic invasive species have been successful and since 2012 no new aquatic invasive species (AIS) have been identified in Lake Tahoe. Greater detail on the AIS management program is included in the assessment of the AIS standard in the Water Quality chapter.

Interim Target – Target is in attainment.

Target Attainment Date – Target is in attainment.

RECOMMENDATIONS

Analytical Approach – No changes recommended.

Monitoring Approach – The substrate map used in this assessment could be improved through an integrated program to map and monitor substrate in Lake Tahoe. Field collection data and additional high-resolution satellite imagery could improve the quality of substrate and habitat maps. Updated bathymetric surveys using the newest generation of LiDAR sensors would help identify the likely extent of wet fish habitat. High-resolution mapping using unmanned aircraft systems could target specific areas of importance to develop more detailed maps and assess changes over time. The current lake habitat indicator measures only one dimension of fish habitat: the extent of physical substrates and associated habitats. Other chemical and biological aspects of fish habitat could be measured, evaluated, and integrated into the existing indicator to provide a more complete assessment of fish habitat and fish populations in Lake Tahoe.

Modification of Threshold Standard or Indicators – Modification of this standard should consider adoption of the 2016 fish habitat map. TRPA has not used the adopted fish habitat map to evaluate the standard since 2001 because of its low resolution. The adopted map for instance was found to extend onshore by up to 50 meters in some areas and overestimate the extent of habitat (TRPA 2007). TRPA adopted its current Prime Fish Habitat Overlay Map in 1997 based on work published in 1989. The standard itself suggests that the Prime Fish Habitat Overlay Map may be amended based on best available science.
The current standard focuses only on physical nearshore fish habitat. The presence of invasive species, pelagic water quality, temperature, and the presence of prey species and food sources all contribute to the suitability of the Lake as habitat and presence of target fish species. In addition, habitat requirements vary between species, and consideration should be given to all target species are addressed. Modification could consider also consider a shift to targets and monitoring of the presence, abundance or status of fish populations. Recent studies have indicated declines of nearly 60 percent in overall native fish species populations in the nearshore (C. K. L. Ngai et al. 2010; Chandra, Caires, and Ryan 2015). Conclusions and recommendations from Heyvaert et al. (2013) and the pilot nearshore monitoring related to indicators of biological community composition (Chandra, Caires, and Ryan 2015) may be helpful in informing and reviewing the lake habitat threshold standard.

Attain or Maintain Threshold - Continue to emphasize the control and prevention of aquatic invasive species as it is suspected that their presence threatens the biological integrity of Lake Tahoe's littoral fish habitats (Kamerath, Chandra, and Allen 2008; C. K. L. Ngai et al. 2010). Consider the possibility of targeting fish habitat mitigation activities in areas where value of restoration effort will be maximized.

Chapter 7 Fisheries References

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CHAPTER 10
Noise

Noise, by definition, is "unwanted sound," and is a subjective reaction to acoustical energy or sound levels. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, sound levels that would go unnoticed in a highly urban or industrial environment outside the basin are likely to be considered noise, and have the potential to negatively impact human health, community ambiance, recreational experience, and wildlife (Francis and Barber 2013; Ware et al. 2015; Laurance 2015).

Based on data from previous research, primary drivers of noise levels in the basin have been attributed to anthropogenic activities and actions. Specifically, vehicular travel in transportation corridors and aircraft activity at the South Lake Tahoe Airport have been identified as the predominant noise sources in the basin. In an effort to address noise impacts to both wildlife and visitors, TRPA Resolution 82-11 established threshold standards for noise, characterized as numerical standards.

Table 10-1 summarizes the assessment criteria for current noise level conditions and trends relative to adopted threshold standards for the basin. The evaluation analyzes two indicator reporting categories for noise: single noise events generated by aircraft and motorized watercraft and cumulative noise events. The threshold standards for each indicator are based on numerical standards using the A-weighted decibel (dBA) as the unit of measure. A-weighting is commonly used for the measurement of environmental and industrial noise, and for assessing potential hearing damage and other noise-related health effects. One adopted policy statement directing the TRPA Governing Board to adopt noise standards for transportation corridors was also evaluated, and was determined to be implemented and in attainment with the threshold standard.

Table 10-1. TRPA adopted and recommended threshold standards for noise[1].

Indicator Reporting Category	Name of Standard	Standard Type	Adopted TRPA Threshold Standard for Noise and Recommended CNELs for Transportation Corridors [1]		Unit of Measure
Single Noise Events	Aircraft	Numerical	80 dBA (Between the hours of 8 AM and 8 PM	Monitoring distance of 6,500 m – start of takeoff roll	Decibel Level (dBA)
				Monitoring distance of 2,000 m – runway threshold approach	
			77.1 dBA (Between the hours of 8 PM and 8 AM	Monitoring distance of 6,500 m – start of takeoff roll	Decibel Level (dBA)
				Monitoring distance of 2,000 m – runway threshold approach	
	Watercraft (Pass-By Test)	Numerical	82 L_{max}[2]	Monitoring distance of 50 ft. – engine at 3,000 rpm	Decibel Level (dBA)
	Watercraft (Shoreline Test)	Numerical	75 L_{max}	Monitoring distance of 5 ft. above water, 2 ft. above curve of shore, dock or platform. Watercraft in Lake, no minimum distance	Decibel Level (dBA)
	Watercraft (Stationary Test)	Numerical	88 dBA L_{max} for boats manufactured before January 1, 1993	Monitoring distance of 3.3 ft. from exhaust outlet – 5 ft. above water	Decibel Level (dBA)
			90 dBA L_{max} for boats manufactured after January 1, 1993		
	Motor Vehicles Less Than 6,000 GVW	Numerical	76 dBA - Less than 35 mph	Monitoring distance of 50 ft.	Decibel Level (dBA)
			82 dBA - Greater than 35 mph		
	Motor Vehicles Greater Than 6,000 GVW	Numerical	82 dBA - Less than 35 mph	Monitoring distance of 50 ft.	Decibel Level (dBA)
			86 dBA - Greater than 35 mph		
	Motorcycles	Numerical	77 dBA - Less than 35 mph	Monitoring distance of 50 ft.	Decibel Level (dBA)
			86 dBA - Greater than 35 mph		

[1] *Consistent with the Policy Statement Standard in Resolution 82-11, Community Noise Equivalent Levels (CNEL) identified for Transportation Corridors have been adopted for Transportation Corridors in the Land Use Element of TRPA (1986) - Goals and Policies.*
[2] *Maximum sound level during a measurement period or a noise event*

	Off-Road Vehicles	Numerical	72 dBA - Less than 35 mph 86 dBA - Greater than 35 mph	Monitoring distance of 50 ft.	Decibel Level (dBA)
	Snowmobiles	Numerical	82 - Less than 35 mph	Monitoring distance of 50 ft.	Decibel Level (dBA)
Cumulative Noise Events	Critical Wildlife Habitat Areas	Numerical	Background noise shall not exceed a CNEL of 45		Decibel Level (dBA)
	Wilderness and Roadless Areas	Numerical	Background noise shall not exceed a CNEL of 45		Decibel Level (dBA)
	Low Density Residential Areas	Numerical	Background noise shall not exceed a CNEL of 50		Decibel Level (dBA)
	Rural Outdoor Recreation Areas	Numerical	Background noise shall not exceed a CNEL of 50		Decibel Level (dBA)
	High Density Residential Areas	Numerical	Background noise shall not exceed a CNEL of 55		Decibel Level (dBA)
	Commercial Areas	Numerical	Background noise shall not exceed a CNEL of 60		Decibel Level (dBA)
	Hotel/Motel Areas	Numerical	Background noise shall not exceed a CNEL of 60		Decibel Level (dBA)
	Industrial Areas	Numerical	Background noise shall not exceed a CNEL of 65		Decibel Level (dBA)
	State Routes 89, 207, 28, 267 and 431 (Transportation Corridors)[1]	Numerical	Background noise shall not exceed a CNEL of 55 (For this threshold evaluation, these CNEL standards are referred to as transportation corridor noise thresholds and this transportation corridor noise threshold overrides the land use CNEL thresholds and is limited to an area within 300 feet from the edge of the road).		Decibel Level (dBA)
	South Lake Tahoe Airport (Transportation Corridor)[1]	Numerical	Background noise shall not exceed a CNEL of 60 (This threshold applies to those areas impacted by the approved flight paths).		Decibel Level (dBA)
	U.S. Highway 50[1]	Numerical	Background noise shall not exceed a CNEL of 65 (For this threshold evaluation, these CNEL standards are referred to as transportation corridor noise thresholds and this transportation corridor noise threshold overrides the land use CNEL thresholds and is limited to an area within 300 feet from the edge of the road).		Decibel Level (dBA)

Table 10-2 summarizes the results of the 2015 assessment. The table provides a summary of the status and trend of standards in the noise reporting categories for single noise events and cumulative noise events today as well as the results from the 2011 Threshold Evaluation Report for comparison. Figure 10-1 provides a key to the symbols used to communicate status, trends, and confidence, and a detailed description of each is provided in the methodology section. The following indicator sheets detail an assessment of the status and trend of each indicator and provide descriptions of the methods used and recommendations to modify the standards and the analytic approaches used to assess them.

The peer review from the 2011 Threshold Evaluation determined TRPA's noise program is "too complex and resource intensive. There are too many indicators, land use categories, and numerical thresholds that need to be monitored to evaluate attainment" (TRPA 2012a). Based on this review, many of the noise monitoring thresholds, especially those related to single noise events, were not analyzed for this evaluation and therefore received a status of "unknown".

Table 10-2: *Noise status & trend summary*

Standard	2011	2015
Single Noise Events		
Aircraft Departures/Arrivals		
Watercraft Shoreline Test		
Watercraft Pass-By Test		
Watercraft Stationary Test		
Motor Vehicles Less Than 6,000 GVW		
Motor Vehicles Greater Than 6,000 GVW		
Motorcycles		
Off-Road Vehicles		
Snowmobiles		

Standard	2011	2015
Cumulative Noise Events		
High-Density Residential Areas		
Low-Density Residential Areas		
Hotel/Motel Areas		
Commercial Areas		
Industrial Areas		
Urban Outdoor Recreation Areas		
Rural Outdoor Recreation Areas		
Wilderness and Roadless Areas		
Critical Wildlife Habitat Areas		
South Lake Tahoe Airport Transportation Corridor		
State Route 28 Transportation Corridor		
Highway 50 Transportation Corridor		
State Route 89 Transportation Corridor		
State Route 207 Transportation Corridor		

Standard	2011	2015
State Route 267 Transportation Corridor		
State Route 431 Transportation Corridor		
Policy Statement Assessment - Adopt noise standards for Transportation Corridors		

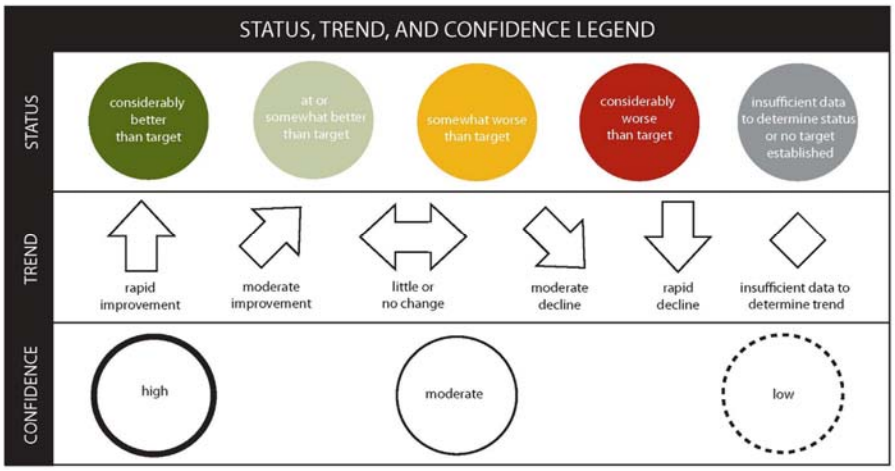


Figure 10-1: *A key to the symbols used to assess status, trends, and confidence levels.*

Table 10-3. Key to the reporting icon used to characterize the implementation status of management standards and policy statements.

Status Category	Description	Reporting Icon
Implemented	The management standard or policy statement has been integrated into the Regional Plan and is consistently applied to a project design or as a condition of project approval as a result of project review process. Examples of programs or actions can be identified to support the management standard's implementation. Adopted programs or actions support all aspects of the management standard or policy statement's implementation, or address all major threats to implementation.	I
Partially Implemented	The management standard or policy statement has been integrated into the Regional Plan, but is not consistently applied during the project review process. No more than two examples of programs or actions can be identified to support the management standard's implementation and/or adopted programs or actions support some aspects of the management standard or policy statement's implementation, or address some major threats to implementation.	PI
Not Implemented	The management standard or policy statement has not been integrated into the Regional Plan and is not applied during the project review process. No examples of programs or actions can be identified to support implementation.	NI

Single Noise Events

A noise event is defined by TRPA as "an unexpected increase in acoustics." Single noise event threshold standards adopted by TRPA are based on the numerical value associated with the maximum measured level in acoustical energy during an event. This is referred to as the L_{max} of the event. TRPA adopted different single noise event threshold standards for different types of noise sources that were identified as creating the greatest amount of annoyance and/or sleep disruption. TRPA Resolution 82-11, adopting the threshold standards, identified single noise event threshold standards for aircraft, motorized watercraft, cars and trucks, motorcycles, off-road vehicles, and snowmobiles (Table 10-1).

This section reports on single noise events generated by aircraft and motorized watercraft. Other threshold standards have been adopted for this indicator reporting category including motor vehicles, motorcycles, off-road vehicles, and snowmobiles. However, due to insufficient data, these were not evaluated. Generally, TRPA noise threshold standards for these noise sources that represent noise levels from properly maintained and unmodified equipment. Primary factors influencing single noise event exceedances for these types of noise sources include modified exhaust systems, engine type, and user behavior.

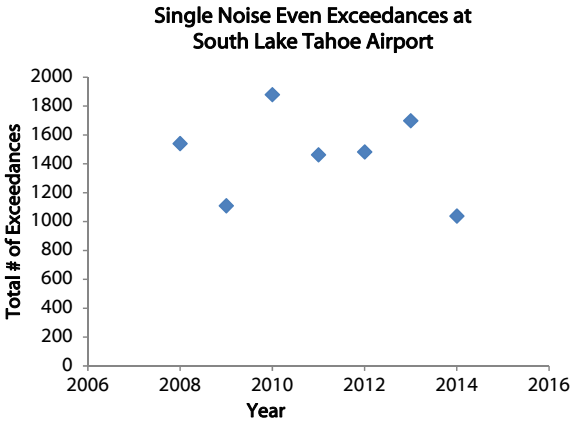
The following section provides an evaluation of the status and trends of the shoreline test for motorized watercraft and the 80 dBA single noise event threshold standards for aircraft, measured between the hours of 8 AM and 8 PM The "shoreline test" approach is one of three approaches related to motorized watercraft-generated single events. Evaluations of the other two watercraft monitoring approaches, the pass-by and stationary tests, are not included in this report due to insufficient data. The "80 dBA departures/arrivals" threshold standard is one of two threshold standards related to aircraft single events. An evaluation of the other threshold standard, "77 dBA departures/arrivals" is not included in this report due to insufficient data.

Single Noise Events: **Aircraft Departures/Arrivals (80dBA/77dBA)**

Status	Trend

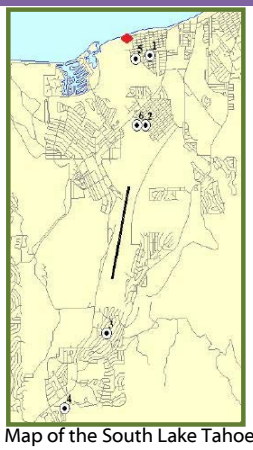
AIRCRAFT DEPARTURES/ARRIVALS (80dBA/77dBA)

Status: **Somewhat Worse Than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**



Total number of documented single noise event exceedances at the South Lake Tahoe Airport from 2008 to 2014. From 8 AM to 8 PM the maximum dBA is 80, and from 8 PM to 8 AM the maximum dBA is 77. Data not corrected for exceedances as the result of aircraft, natural ~~vs~~ or other~~.~~ anthropogenic sources. ~~In addition to the noise monitor an audio recorder on site is activated when noise levels exceed the threshold level that Because the recorder that allows monitors technicians to differentiate between exceedances caused by aircraft versus non-aircraft noise. The recorder was inoperable~~~~While monitoring of exceedances has continued, the ability to differentiate between aircraft and non-aircraft exceedances was not functional for most of the current monitoring period due to various issues, therefore for most of the current monitoring period, data quality is low and only total exceedances are reported and trend is not assessed. Between~~~~From 2008 and~~~~to 2010 when the recorder was operational, an average of 17 percent of exceedances were identified as aircraft. The recorder was fixed in March of 2015.~~ Source: City of South Lake Tahoe

Map



Map of the South Lake Tahoe Airport runway (black line) relative to noise monitoring sites (numbered dots) and TRPA's aircraft noise monitoring site at Barton Beach (red marker).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures noise originating from aircraft takeoffs and landings at the City of South Lake Tahoe Airport. Lake Tahoe Airport supported commercial flights into and out of South Lake

Tahoe from the early 1960s until 2001, when commercial service was ended. Since 2001, the airport has supported aircraft-related operations for one helicopter sightseeing business, occasional military training touch landing exercises, emergency services, and privately-owned general aviation flights only. Aircraft generated noise is most frequently recorded during summer months with most threshold exceedances occurring during the annual celebrity golf tournament and air show each July. TRPA adopted single noise event threshold standards to protect quality of life for residents and visitors and to reduce impacts to wildlife.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Single Noise Event, Aircraft

Adopted Standards – During the hours of 8 AM to 8 PM single noise events generated by aircraft shall not exceed 80 dBA L_{max} (maximum decibel level in a single event) for arrivals and departures. During the hours of 8 PM to 8 AM, the single event standard shall not exceed 77 dBA L_{max} for aircraft arrivals and departures.

Type of Standard – Numerical

Indicator (Unit of Measure) – A-weighted decibel (dBA) measurement used to evaluate the effects of environmental and industrial noise on human health.

Human & Environmental Drivers – The primary factors influencing single noise event exceedances caused by aircraft are aircraft type and frequency of flight (California Department of Transportation - California Aviation Planning 2007). A large percentage of the exceedances recorded by monitoring may be attributed to natural sources (e.g. wind, lightning, wildlife) and other anthropogenic sources other than aircraft. Additional factors influencing aircraft noise levels include wind, temperature, cloud cover, fog, topography, vegetation and man-made barriers such as homes and other buildings. Thermal inversions, a common occurrence in the Tahoe Basin (Tahoe Interagency Management System 2011), and cloud cover can cause noise levels to be perceived as louder than they are (California Department of Transportation - California Aviation Planning 2007).

MONITORING AND ANALYSIS

Monitoring Partners – City of South Lake Tahoe and TRPA. The California Tahoe Conservancy provided access to their lands for monitoring.

Monitoring Approach – Lake Tahoe Airport monitored noise at six sites in the vicinity of the airport (see map above) following an approved monitoring protocol. ~~In order to match noise events to aircraft operations, a recorder separates aircraft noise from other noise types.~~ All exceedances logged by these monitors are documented and categorized in quarterly and annual noise reports sent to TRPA. While monitoring of exceedances has continued, the ability to differentiate between aircraft and non-aircraft exceedances was not ~~functional~~possible ~~for most of the current monitoring period due to various issues~~, therefore data quality is low and only total exceedances (including aircraft, natural sources (e.g. wind, lightning, wildlife) and other anthropogenic sources)~~-~~ are reported and trend is not assessed. ~~Because the recorder that differentiates between aircraft and non-aircraft exceedances was down for the majority of the current monitoring period, only total number of exceedances are reported for this evaluation.~~ Past monitoring data shows that an average of 17 percent of exceedances ~~are~~ were caused by aircraft, however the percent of exceedances per year caused by aircraft varies greatly year to year, making any judgement on how many of the total exceedances are caused by aircraft in any given year inestimable. ~~inappropriate.~~

Analytic Approach – Simple linear regression is used to determine trend.

INDICATOR STATE

Status – Somewhat worse than target. For the current monitoring period where full year data is available, the total number of exceedances ranged from 1,038 to 1,698 (City of South Lake Tahoe 2015). Threshold attainment has historically been evaluated using a ~~Because the threshold standard is~~ zero exceedance~~s~~.

Following ;that convention, -the threshold is out of attainment. Due to the uncertainty regarding the number of exceedances caused by aircraft, the status has conservatively been determined to be "somewhat worse than target" consistent with the 2011 Threshold Evaluation.

Trend – Insufficient data to determine trend. The total number of exceedances shows a decreasing trend from 2008 to 2014**.** However, the trend is not statistically significant ($R^2 = 0.0347$, $P = 0.69$) and exceedances caused by aircraft cannot be differentiated from non-aircraft. The trend means little to understanding the performance of the threshold standard and is given a determination of "insufficient data to determine trend.

Confidence –

Status – Low. Monitoring is conducted following widely accepted protocols, but due to the inability to differentiate between the sources of the exceedances, confidence is low.~~ there is not current cost-effective method to determine the number of exceedances from natural vs. anthropogenic sources~~~~While monitoring is conducted following widely accepted protocols, the recorder was down, and confidence is low.~~

Trend –Low. ~~While monitoring is conducted following widely accepted protocols, because the recorder was down confidence in the trend is low. Additionally, t~~There is low confidence in the trend line of the total number of exceedances ($R^2 = 0.0347$, $P = 0.69$).

Overall – Low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – In the early 1990s, TRPA adopted aircraft type limitations for the Lake Tahoe Airport based on tested arrival and departure decibel levels. TRPA also established noise threshold standards for arrival and departures depending on time of day or night. The City of South Lake Tahoe has published noise abatement guidelines for all pilots located on the Lake Tahoe Airport website.

In 2013, the City initiated an Airport Master Plan Update in order to determine the current and future potential of the airport. Based on the update, the total number of operations are anticipated to increase from 23,540 recorded in 2013 to 29,645 in the year 2033, an overall increase of 17.9 percent over a 20-year period. Aircraft activity at the Lake Tahoe Airport has declined since a peak in 1978 of 63,881 annual operations. Although the existing 65 dB CNEL noise contour does not extend off airport property, proposed projects that could potentially alter aircraft operations, aircraft fleet mix, or change runway use would be subject to further review. The airport currently has an Airport Land Use Compatibility Plan (ALUCP) in place and will be updated after the master plan update and includes opportunities to maintain future noise monitoring of airport operations.

Effectiveness of Programs and Actions – Existing programs do not appear sufficiently effective at achieving adopted threshold standards based on the evaluation of available data.

Interim Target – Due to insufficient data, an interim target cannot be set.

Target Attainment Date – Due to insufficient data, a target attainment date cannot be set.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – Continue to explore options to cost effectively distinguish between natural and anthropogenic sources of noise exceedance events.~~Fix malfunctioning equipment.~~

Modification of the Threshold Standard or Indicator – The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to ensure it reflects the latest science and provides information that is useful for management.~~No changes recommended.~~

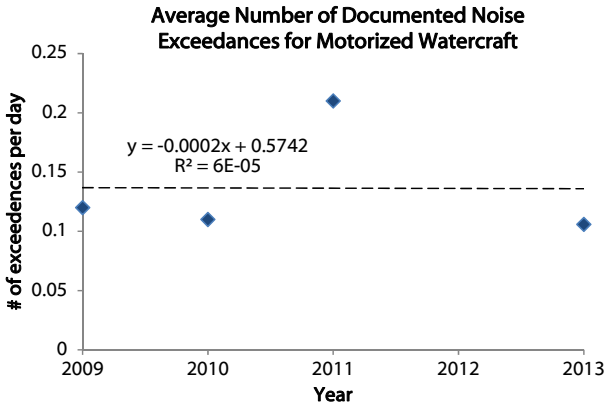
Attain or Maintain Threshold – Further measures may be necessary to achieve existing zero exceedance aircraft noise threshold standards. Alternatively, an investigation may be necessary to determine if existing threshold standards are achievable given today's general aviation aircraft fleet and aircraft noise-reduction technologies. Although there is an established monitoring plan for single noise events for aircraft at the Lake Tahoe Airport, discrepancies of applicable threshold standards exist between the City of South Lake Tahoe and TRPA (i.e., 77 dBA L_{max} vs. 80 dBA L_{max}).

Single Noise Events: **Watercraft Shoreline Test**

Status	Trend

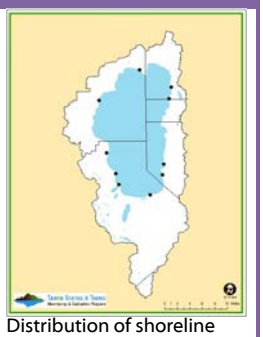
WATERCRAFT SHORELINE TEST

Status: **Somewhat Worse Than Target**
Trend: **Little or No Change**
Confidence: **Low**



The average number of documented exceedances per day for motorized watercraft determined by the shoreline test (greater than 75 dBA) from 2009 to 2013. There was little to no change in the total number of exceedances per day and confidence in trend was determined to be low due to low sample size and annual variations in exceedance rates. Source: TRPA shorezone monitoring data.

Map



Distribution of shoreline noise monitoring sites from 2009 to 2013.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures noise generated from motorized watercraft in the shorezone of Lake Tahoe. Residents and visitors are concerned about the declining serenity of their communities and their enjoyment of the outdoors due to excessive noise from sources such as motorized watercraft (TRPA 2007). Excessive recreational boat noise can also disturb sensitive wildlife. For this reason, TRPA adopted policies and ordinances to reduce noise levels and maintain serenity in Lake Tahoe's shoreline area, while continuing to afford recreational opportunities.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Single Noise Event, Watercraft Shoreline Test

Adopted Standards – Noise from watercraft shall not exceed 75 dBA as monitored at a distance of 5 ft. above water, 2 ft. above curve of shore, dock or platform, no minimum distance.

Type of Standard – Numerical

Indicator (Unit of Measure) – Number of exceedances and exceedance rate (exceedances per day and per year) of the single noise event, watercraft shoreline test threshold standard measured in A-weighted decibel (dBA).

Human & Environmental Drivers – Watercraft-generated single-event noise exceedances are driven by the type of watercraft engine and exhaust system (Lanpheer 2000) and boater behavior (proximity to shore, operating speed, etc.). Shoreline topography, wave slap, and wind can also influence noise levels.

MONITORING AND ANALYSIS

Monitoring Partners – TRPA monitoring with land access granted by the California Tahoe Conservancy, U.S. Forest Service, California Department of Parks and Recreation, and Nevada Division of State Parks.

Monitoring Approach – Watercraft noise levels were measured annually from 2009 to 2013 at 10 shorezone locations for five to six sampling periods (ranging from four to 12 days) from May through September. Sampling periods are comprised of both weekends and weekdays, allowing for analysis of the differences in noise levels or exceedances between days in the week. The monitoring periods include low, medium, and high watercraft use times throughout the day (7 AM to 7 PM). All noise events are individually analyzed and categorized by a trained noise technician.

Analytic Approach – Simple linear regression is used to determine trend.

INDICATOR STATE

Status – Somewhat worse than target. TRPA's maximum allowable noise level from any motorized watercraft in the shorezone is 75 dBA regardless of distance to shore. Measured noise levels in the shorezone from 2009 to 2013 (the last year of noise monitoring) put the Region in non-attainment with the zero-exceedance threshold standard, with watercraft responsible for:

- 47 recorded shorezone exceedances caused by watercraft in 2009 (0.12 exceedances/day, one exceedance every 8.2 days, n=386)
- 51 recorded shorezone exceedances caused by watercraft in 2010 (0.11 exceedances/day; one exceedance every 8.7 days, n=446)
- 91 recorded shorezone exceedances caused by watercraft in 2011 (0.21 exceedances/day; one exceedance every 4.7 days, n=428)
- 48 recorded shorezone exceedances caused by watercraft in 2012 (0.31 exceedances/day, one exceedance every 3.23 days, n=155)
- 12 recorded shorezone exceedances caused by watercraft in 2013 (0.097 exceedances/day; one exceedance every 10.3 days, n=123) (Bollard Acoustical Consultants 2014)

Data from boating surveys conducted in 2009, 2010, and 2011 indicate that 203,821; 188,047; and 193,540 boat trips occurred in those years, respectively. When placed in context of the total number of boat trips undertaken over the same time period, TRPA recorded noise exceedances from boats is 0.0002 percent to 0.0005 percent of the trips undertaken, or greater than 99.999 percent threshold standard compliance rate. Although the Region is not achieving the zero exceedance threshold standard, when viewed in context of the number of boat trips recorded over the same time period, it suggests that the Region is somewhat worse than target.

Trend – Little to no change. A simple linear regression model showed there is little to no change in the exceedance rate from 2009 to 2013.

Confidence –

Status – Moderate. There is a moderate degree of confidence in status because of noise monitoring protocol (SAE 1970), unit accuracy, data integrity, and spatial representativeness of monitoring sites. However, data has not been collected since 2013.

Trend – Low. The confidence in trend for all single event noise exceedances due to watercraft was determined to be low with an analysis of only five data points showing little statistical significance (R^2=0.0938, P=0.616).
Overall – Low. Overall confidence takes the lower of the two confidence determinations.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – TRPA's Watercraft Team enforces a 600-foot no-wake zone for the shorezone to reduce shoreline noise levels.

Effectiveness of Programs and Actions – The existing program or action has not achieved total compliance (i.e., zero exceedances) with adopted threshold standards based on the status and trend evaluation of available data.

Interim Target – Due to a non-significant trend, an interim target cannot be set.

Target Attainment Date – Due to a non-significant trend, a target attainment date cannot be set.

RECOMMENDATIONS

Analytic Approach – No changes recommended.

Monitoring Approach – Re-engage shorezone noise monitoring once a new shorezone plan is implemented.

Modification of the Threshold Standard or Indicator – The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to ensure it reflects the latest science and provides information that is useful for management. Recommendation from the current Shoreline Initiative planning process to modify the threshold standard or comprehensive update of noise threshold standards to respond to recommendations of 2011 Threshold Evaluation Report peer review regarding noise standards.

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Attain or Maintain Threshold – The conditions for this indicator could potentially improve with increased enforcement of the 600-foot no-wake zone regulation or re-enacting the prohibition on boats operating in the lake that have working, aftermarket exhaust bypass systems (invalidated by the 2010 shorezone litigation against TRPA).

Cumulative Noise Events

Cumulative noise or community noise equivalent level (CNEL) is a noise measurement based on a weighted average of all measured noise over a 24-hour period. The CNEL indicator applies a +4.77 dB (decibel) "penalty" or weight to noise levels during the evening period of 7 p.m. to 10 p.m. and a +10 dB penalty to noise levels during the night-time period of 10 PM to 7 AM to account for people's increased sensitivity to night-time noise. TRPA adopted CNEL standards for different zones within the basin to account for expected levels of serenity. Zones included TRPA Plan Areas, land use categories and transportation corridors (Table 10-1).

Adopted CNEL standards range from 45 dBA in critical wildlife habitat and wilderness areas to 65 dBA in highway corridors. The following comparisons provide a generalized practical indication of common sounds to which these standards can be compared:

- 40 dBA: residential area with soft radio music
- 50 dBA: open office area background level
- 60 dBA: normal conversational speech at 5-10 feet
- 70 dBA: small air compressor at 50 feet
- 80 dBA: sports car interior at 60 mph
- 90 dBA: industrial boiler room

In previous threshold evaluations, the number of land use types sampled to characterize Regional CNEL was limited, and the CNEL evaluation was typically based on a single 24-hour sampling effort. In 2011, the monitoring protocol was modified. Multiple plan areas within each individual land use category and transportation corridor were measured over at least seven 24-hour periods to determine attainment status by land use category. This monitoring approach was selected based on recommendations from previous CNEL noise studies and TRPA attempts to increase the statistical rigor and confidence in CNEL monitoring in the Region.

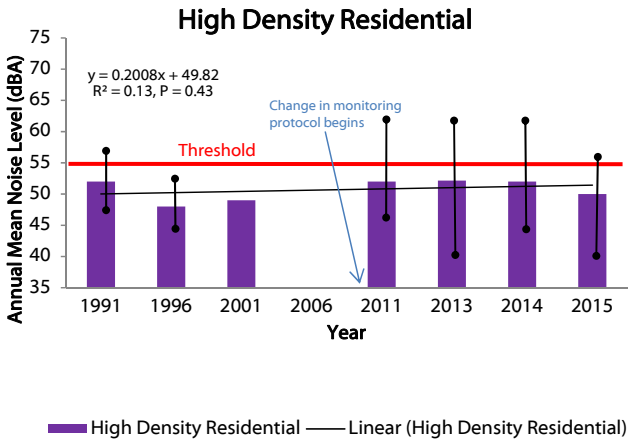
The following section provides an evaluation of the status and trends for the CNEL noise indicator. It includes an evaluation of the 16 adopted TRPA threshold standards for CNEL. Evaluations of these indicators were grouped by numerical standard or maximum allowable CNEL value for a specific area.

Cumulative Noise Events: **High Density Residential Areas (CNEL 55 dBA)**

Status	Trend

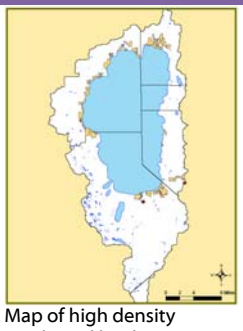
HIGH DENSITY RESIDENTIAL AREAS

Status: **Somewhat Worse than Target**
Trend: **Little to No Change**
Confidence: **Moderate**



Annual mean CNEL (purple bars) with 24-hour high and low CNEL values (black bars) in high density residential land use categories from 1991 to 2015. While a trend exists, changes in monitoring protocol beginning in 2011 lowers the confidence in a trend. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc., Bollard Acoustical Consultants

Map



Map of high density residential land use category areas with monitoring locations (CNEL 55 dBA).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the high density residential land use categories in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels have the potential to negatively impact community ambiance, one's recreational experience and wildlife behavior. In recent years, visitors and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, an effort to address these noise level impacts, TRPA adopted 24-hour noise threshold standards, or community noise equivalent levels (CNEL), for all land use categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 55 dBA, High Density Residential land use categories.

Adopted Standards – For the high density residential land use categories, noise levels shall not exceed a CNEL of 55 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridors are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014).

MONITORING AND ANALYSIS

Monitoring Partners – TRPA monitoring with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample in various land use areas. Threshold standard attainment status was based on a single sample representing each land use type. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol was implemented in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Simple linear regression is used to determine trend**.** The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – Somewhat worse than target. The maximum 24-hour CNEL for the most recent monitoring period,(2015) was 56.2 dBA recorded in the Tahoe Keys, which is approximately 102 percent of the standard (TRPA 2015). Therefore, a status of somewhat worse than target was determined.

Trend – Little to no change. The long term trend line shows a negligible increase in annual mean dBA per year in relation to the standard of 55 dBA (TRPA 2015). Therefore, a trend of little to no change was determined.

Confidence –

> **Status –** High. Taking the recommendation of a reputable noise expert, 1) noise monitoring equipment was calibrated according to manufacturers' specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences about the population of these land uses, and 3) a more robust sampling approach was

deployed beginning in 2011. Therefore, confidence is high.
Trend – Low. $R^2 = 0.13$, $P = 0.43$. Due to changes in sampling protocol beginning in 2011, any confidence in trend significance is low.
Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulations CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potential activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. The North Tahoe Public Utility District has a list of rules that prohibits activities that produce excessive noise levels during park hours. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) is required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears programs are mostly effective in reducing noise in rural outdoor recreation areas.

Interim Target – No interim target set.

Target Attainment Date – No target attainment date set.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

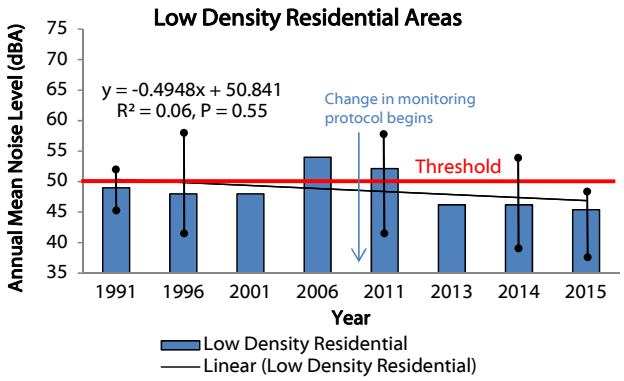
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **Low Density Residential Areas (CNEL 50 dBA)**

Status	Trend

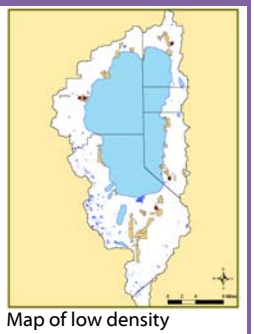
LOW DENSITY RESIDENTIAL AREAS

Status: **At or Somewhat Better than Target**
Trend: **Little to No Change**
Confidence: **Moderate**



Annual mean CNEL (blue bars) with 24-hour high and low CNEL values (black bars) in the low density residential land use categories from 1991 to 2015. While a trend exists, changes in monitoring protocol beginning in 2011 lowers the confidence in a trend. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc.

Map



Map of low density residential land use category areas with monitoring locations (CNEL 50 dBA).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the low-density residential land use areas in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels have the potential to negatively impact community ambiance, recreational experiences, and wildlife behavior. In the past, visitors and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community, and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, TRPA adopted 24-hour noise threshold standards, or community noise equivalent levels (CNEL), for all land use categories and plan areas of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 50 dBA, Low Density Residential areas

Adopted Standards – For the low density residential land use category noise levels shall not exceed a CNEL of 50 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridor are primarily generated from vehicles, roadway traffic, aircraft and recreational activity (Bollard Acoustical Consultants 2014). Other secondary anthropogenic noise influences include noise attributed to construction (Bollard Acoustical Consultants 2014). Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014).

MONITORING AND ANALYSIS

Monitoring Partners – TRPA monitoring with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample in various land use areas. Threshold standard attainment status was based on a single sample representing each land use type. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol was implemented in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Simple linear regression is used to assess trend. The average CNEL across all monitoring locations within a given land use category is averaged for the final annual mean CNEL result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – Somewhat better than target. For the most recent year of monitoring (2015) the maximum 24-hour CNEL was 47.6 dBA recorded at Rubicon Estates which is 95 percent of the standard (TRPA 2015). Based on this, the status is determined to be at or somewhat better than target.

Trend – Little to no change. The long term trend line shows a decrease of 0.145 dBA/year, a 0.29 percent decrease per year in relation to the standard of 50 dBA (TRPA 2015). Therefore, a trend of little to no change was determined.

Confidence –

> **Status –** High. Taking the recommendation of a reputable noise expert, 1) noise monitoring equipment was calibrated according to manufacturer specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences

about the population of these land uses, and 3) a more robust sampling approach was deployed beginning in 2011. Therefore, confidence is high.

Trend – Low. $R^2 = 0.06$, $P = 0.55$. Due to changes in sampling protocol beginning in 2011, any confidence in trend significance is low.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulation CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potentially loud activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) are required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2014). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears programs are mostly effective in reducing noise in this land use category.

Interim Target – Threshold is in attainment.

Target Attainment Date – Threshold is in attainment.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

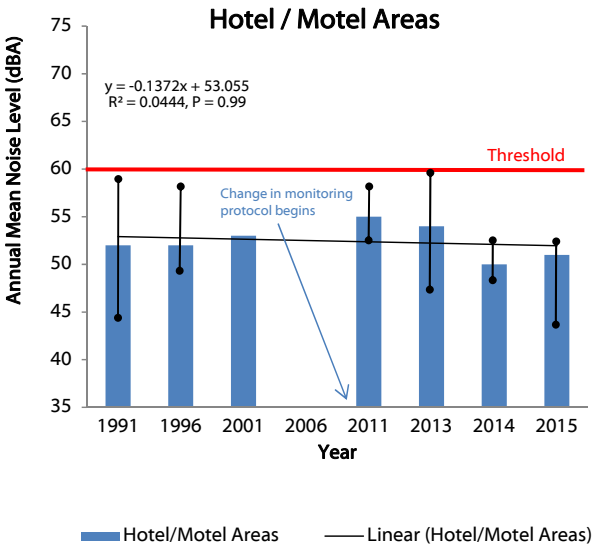
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **Hotel/Motel Areas (CNEL 60 dBA)**

Status	Trend

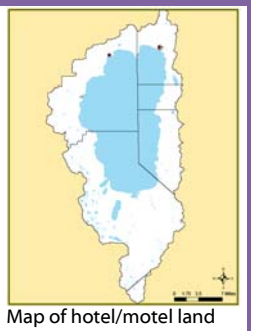
HOTEL/MOTEL AREAS

Status: **At or Somewhat Better than Target**
Trend: **Little to No Change**
Confidence: **Moderate**



Annual mean CNEL (blue bars) with 24-hour high and low CNEL values (black bars) in hotel/motel land use from 1991 to 2015. While a trend exists, changes in monitoring protocol beginning in 2011 lower the confidence in a trend. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc.

Map



Map of hotel/motel land use category areas with monitoring locations (CNEL 60).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in hotel/motel land use categories in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels may negatively impact community ambiance, one's recreational experience, and wildlife behavior. In the past, visitors and residents of the Lake Tahoe Basin have expressed concerns about declining serenity in their community, and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft, and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, TRPA adopted 24-hour noise standards, or community noise equivalent levels (CNEL), for all land use categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events **–** CNEL of 60 dBA, Hotel/Motel

land use categories.

Adopted Standards – For the hotel/motel land use categories noise levels shall not exceed a CNEL of 60 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridors are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample in various land use areas. Threshold standard attainment status was based on a single sample representing each land use type. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol was implemented in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Simple linear regression is used to determine trend**.** The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status –At or somewhat better than target. In the most recent monitoring period (2015) the maximum 24-hour CNEL was 52.2 dBA recorded in the Carnelian Bay tourist district, which is 88 percent of the standard (TRPA 2015). Therefore, a status of at or somewhat better than target was determined.

Trend – Little to no change. The long term trend line for the hotel/motel land use category shows a decrease of .04 dBA per year, a negligible percent decrease per year in relation to the standard of 60 dBA (TRPA 2015). Therefore, a trend of little to no change was determined.

Confidence –

Status – High. Taking the recommendation of a reputable noise expert, 1) noise monitoring equipment was calibrated according to manufacturers' specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences about the population of these land uses, and 3) a more robust sampling approach was deployed beginning in 2011. Therefore, confidence is high.

Trend – Low. $R^2 = 0.0444$, $P = 0.99$. Due to changes in sampling protocol beginning in 2011, any confidence in trend significance is low.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, Code of Federal Regulations CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potential activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. The North Tahoe Public Utility District has a list of rules that prohibits activities that produce excessive noise levels during park hours. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) is required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears current programs are mostly effective in reducing noise in hotel/motel areas.

Interim Target – Threshold is in attainment.

Target Attainment Date – Threshold is in attainment.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

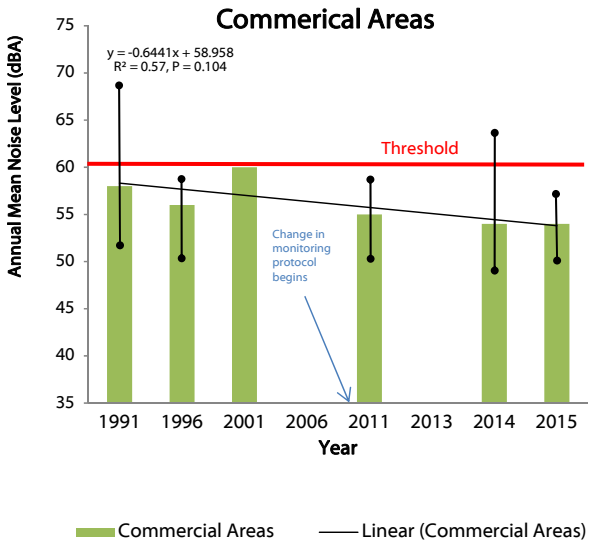
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **Commercial Areas (CNEL 60 dBA)**

Status	Trend

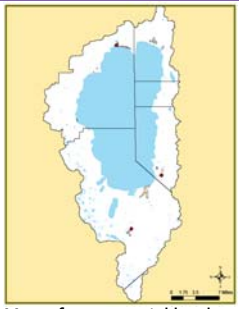
COMMERCIAL AREAS

Status: **At or Somewhat Better than Target**
Trend: **Little to No Change**
Confidence: **Moderate**



Annual mean CNEL (green bars) with 24-hour high and low CNEL values (black bars) in commercial land use categories from 1991 to 2015. While a trend exists, changes in monitoring protocol beginning in 2011 lower the confidence in a trend. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc.

Map



Map of commercial land use category areas with monitoring locations (CNEL 60).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in commercial land use categories in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels may negatively impact community ambiance, one's recreational experience, and wildlife behavior. In the past, visitors and residents of the Lake Tahoe Basin have expressed concerns about declining serenity in their community, and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft, and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, TRPA adopted 24-hour noise standards, or community noise equivalent levels (CNEL), for all land use categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events **–** CNEL of 60 dBA, Commercial land use areas

Adopted Standards – For commercial land use categories noise levels shall not exceed a CNEL of 60 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted Decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample in various land use areas. Threshold standard attainment status was based on a single sample representing each land use type. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol was implemented in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Simple linear regression is used to determine trend**.** The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – At or somewhat better than target. In the most recent monitoring period, 2015, the maximum 24-hour CNEL was 57.1 dBA recorded in the Kingsbury commercial area, which is 95 percent of the target (TRPA 2015). Therefore, a status of at or somewhat better than target was determined.

Trend – Little to no change. The long term trend for the commercial land use category shows a decrease of 0.18 dBA per year, a decrease of 0.3 percent per year in relation to the standard of 60 dBA (TRPA 2015). Therefore, a trend of little to no change was determined**.**

Confidence –

> **Status –** High. Taking the recommendation of a reputable noise expert, 1) noise monitoring equipment was calibrated according to manufacturers' specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences about the population of these land uses, and 3) a more robust sampling approach was deployed beginning in 2011. Consequently, confidence in the status was determined to be high because of the spatial and temporal characterization of CNEL across these land use types.
> **Trend –** Low ($R^2 = 0.57$, $P = 0.104$). Due to changes in sampling protocol beginning in 2011, any confidence in trend significance is low.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulations CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potentially loud activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) are required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears current programs are mostly effective in reducing noise in commercial areas.

Interim Target – Threshold is in attainment.

Target Attainment Date – Threshold is in attainment.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

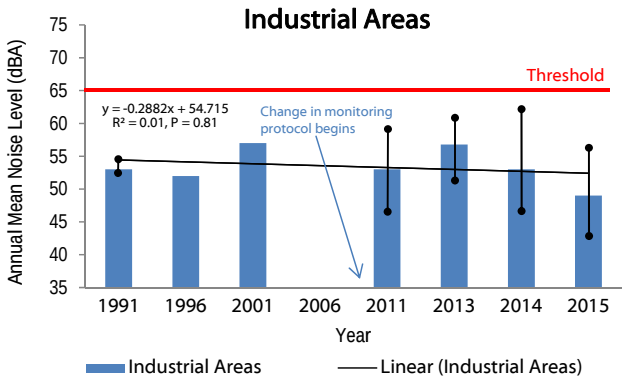
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **Industrial Areas (CNEL 65 dBA)**

Status	Trend

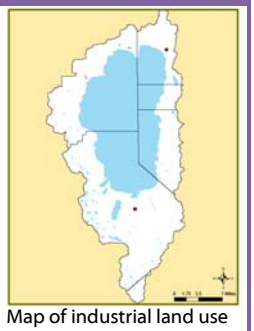
INDUSTRIAL AREAS

Status: **At or Somewhat Better than Target**
Trend: **Little to no Change**
Confidence: **Moderate**



Annual mean CNEL (blue bars) with 24-hour high and low CNEL values (black bars) in industrial land use categories from 1991 to 2015. While a trend exists, changes in monitoring protocol beginning in 2011 lower the confidence in a trend. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc.

Map



Map of industrial land use category areas with monitoring locations (CNEL 65 dBA).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the Industrial land use categories in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, noise management is an integral part of land use planning and environmental improvement processes at Lake Tahoe. Visitors and residents have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, an effort to address these noise level impacts, TRPA adopted 24-hour noise threshold standards, or community noise equivalent levels (CNEL), for all land use categories and plan areas of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Community Noise Equivalent Level - 65 dBA, Industrial Land Use Category

Adopted Standards – For the industrial land use category noise levels shall not exceed a CNEL of 65 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridor are primarily generated from vehicles, roadway traffic, aircraft and recreational activity (Bollard Acoustical Consultants 2014). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample in various land use areas. Threshold standard attainment status was based on a single sample representing each land use type. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol was implemented in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Simple linear regression is used to assess trend. The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – At or somewhat better than target. In the most recent monitoring period (2015) the maximum 24-hour CNEL was 55.6 dBA recorded at the Industrial Tract in South Lake Tahoe, which is 86 percent of the target (TRPA 2015). Therefore, a status of at or somewhat better than target was determined.

Trend – Little to no change. The long term trend line shows a 0.08 dBA per year decrease, a 0.001 percent decrease in annual mean dBA per year in relation to the standard of 65 dBA (TRPA 2015). Therefore, a trend of little to no change was determined.

Confidence –

> **Status –** High. Taking the recommendation of a reputable noise expert, 1) noise monitoring equipment was calibrated according to manufacturers' specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences about the population of these land uses, and 3) a more robust sampling approach was deployed beginning in 2011. Therefore, confidence is high.
> **Trend –** Low. $R^2 = 0.01$, $P = 0.81$. Due to changes in sampling protocol beginning in 2011, any confidence in trend significance is low.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulations CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potentially loud activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. Other restrictions, enforced by the California Highway Patrol (CHP) under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears current programs are mostly effective in reducing noise in this land use category.

Interim Target – Threshold is in attainment.

Target Attainment Date – Threshold is in attainment.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

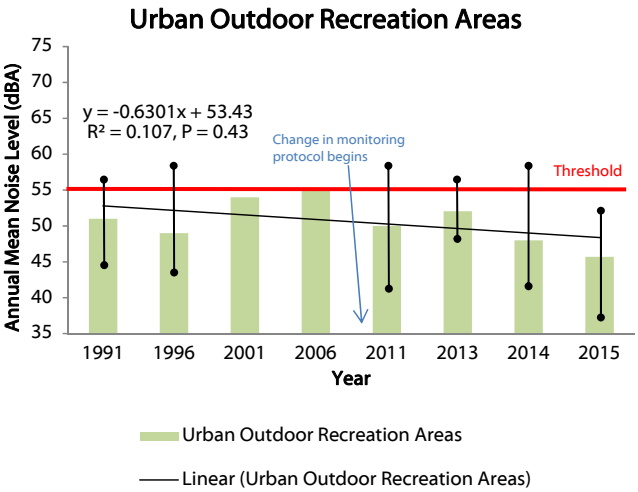
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **Urban Outdoor Recreation Areas (CNEL 55 dBA)**

Status	Trend

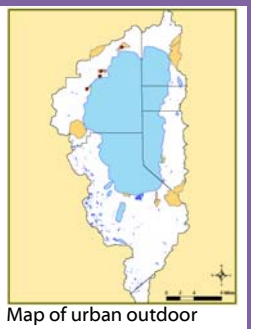
URBAN OUTDOOR RECREATION AREAS

Status: **At or Somewhat Better than Target**
Trend: **Little to No Change**
Confidence: **Moderate**



Annual mean CNEL (green bars) with 24-hour high and low CNEL values (black bars) in urban outdoor recreation land use categories from 1991 to 2015. While a trend exists, changes in monitoring protocol beginning in 2011 lower the confidence in a trend. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc., Bollard Acoustical Consultants

Map



Map of urban outdoor recreation land use category areas with monitoring locations (CNEL 55 dBA).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in urban outdoor recreation land use categories in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels have the potential to negatively impact community ambiance, one's recreational experience and wildlife behavior. In the past, visitors and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, an effort to address these noise level impacts, TRPA adopted 24-hour noise threshold standards, or community noise equivalent levels (CNEL), for all land use categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 55 dBA, Urban Outdoor Recreation land use categories

Adopted Standards – For urban outdoor recreation land use noise levels shall not exceed a CNEL of 55 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridors are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample in various land use areas. Threshold standard attainment status was based on a single sample representing each land use type. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol was implemented in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Simple linear regression is used to determine trend**.** The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – At or somewhat better than target. The maximum 24-hour CNEL for the most recent monitoring period,(2015) was 50.1 dBA recorded at the old fish hatchery site in North Lake Tahoe, which is 91 percent of the standard (TRPA 2015). Therefore, a status of at or somewhat better than target was determined.

Trend – Little to no change. The long term trend line shows a decrease of 0.18 dBA/year, a 0.33 percent decrease per year in relation to the standard of 55 dBA (TRPA 2015). Therefore, a trend of little to no change was determined.

Confidence –

> **Status –** High. Taking the recommendation of a reputable noise expert, 1) noise monitoring equipment was calibrated according to manufacturers' specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences about the population of these land uses, and 3) a more robust sampling approach was deployed beginning in 2011. Therefore, confidence is high.

Trend – Low. $R^2 = 0.107$, $P = 0.43$. Due to changes in sampling protocol beginning in 2011, any confidence in trend is low.
Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulation CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potential activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. The North Tahoe Public Utility District has a list of rules that prohibits activities that produce excessive noise levels during park hours. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) is required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears current programs are mostly effective in reducing noise in urban outdoor recreation areas.

Interim Target – Threshold is in attainment.

Target Attainment Date – Threshold is in attainment.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

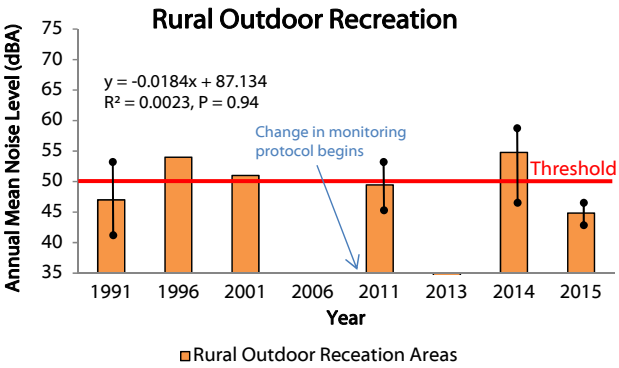
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **Rural Outdoor Recreation Areas (CNEL 50 dBA)**

Status	Trend

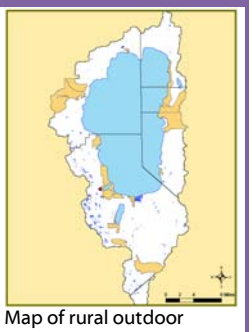
RURAL OUTDOOR RECREATION AREAS

Status: **At or Somewhat Better than Target**
Trend: **Little to No Change**
Confidence: **Low**



Annual mean CNEL (orange bars) with 24-hour high and low CNEL values (black bars) in rural outdoor recreation land use categories from 1991 to 2015. While a trend exists, changes in monitoring protocol beginning in 2011 lowers the confidence in a trend. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc.

Map



Map of rural outdoor recreation land use category areas in the basin, with monitoring locations (CNEL 50 dBA).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in rural outdoor recreation land use areas in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels have the potential to negatively impact community ambiance, recreational experiences, and wildlife behavior. In the past, visitors and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community, and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, TRPA adopted 24-hour noise threshold standards, or community noise equivalent levels (CNEL), for all land use categories and plan areas of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 50 dBA, Rural Outdoor Recreation Areas

Adopted Standards – For the rural outdoor recreation land use category noise levels shall not exceed a CNEL of 50 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014).

MONITORING AND ANALYSIS

Monitoring Partners –TRPA monitoring with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample in various land use areas. Threshold standard attainment status was based on a single sample representing each land use type. In contrast to historic monitoring efforts, a more comprehensive CNEL monitoring effort was implemented in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Simple linear regression is used to determine trend**.** The average CNEL across all monitoring locations within a given land use category is averaged for the final annual mean CNEL result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – At or somewhat better than target. For the most recent reporting period (2015) the maximum 24-hour CNEL was 45.8 dBA recorded at the Eagle Falls parking lot, which is 92 percent of the target (TRPA 2015). Therefore, a status of at or somewhat better than target was determined.

Trend – Little to no change. The long term trend for the rural outdoor recreation land use category shows a negligible decrease in annual mean dBA per year in relation to the standard of 50 dBA (TRPA 2015). Therefore, a trend of little to no change is determined**.**

Confidence –

> **Status –** Low. Taking the recommendation of a reputable noise expert, 1) noise monitoring equipment was calibrated according to manufacturers' specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences about the population of these land uses, and 3) a more robust sampling approach was deployed beginning in 2011. However, only one location was used to sample rural outdoor

recreation, thus confidence is low.
Trend – Low. $R^2 = 0.0023$, $P = 0.94$. Due to changes in sampling protocol beginning in 2011, any confidence in trend significance is low.
Overall - Low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulation CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potentially loud activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) are required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears programs are mostly effective in reducing noise in rural outdoor recreation areas.

Interim Target – Standard is in attainment

Target Attainment Date – Standard is in attainment.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

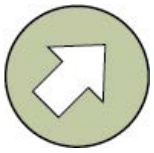
Monitoring Approach – Increase the number of monitoring sites to increase confidence in status.

Modification of the Threshold Standard or Indicator – No changes recommended.

Attain or Maintain Threshold – No changes recommended.

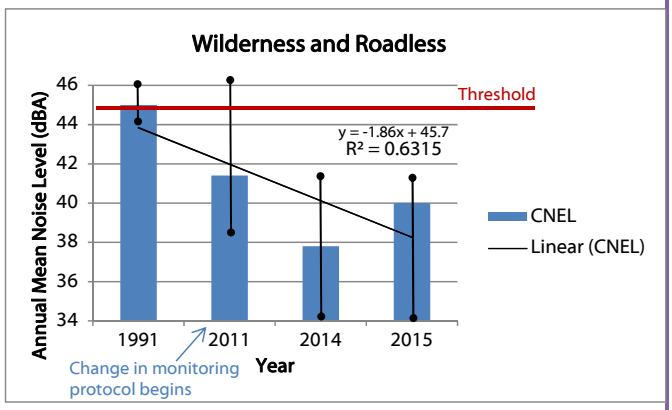
Cumulative Noise Events: **Wilderness and Roadless Areas (CNEL 45 dBA)**

Status	Trend



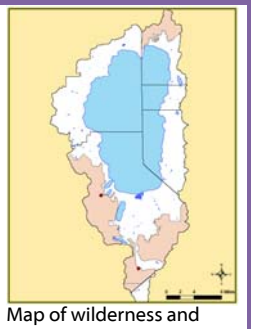
WILDERNESS AND ROADLESS AREAS

Status: **At or Somewhat Better than Target**
Trend: **Moderate Improvement**
Confidence: **Moderate**



Annual mean CNEL (blue bars) with 24-hour high and low CNEL values (black bars) in the wilderness and roadless land use category from 1991 to 2015. While a trend exists, changes in monitoring protocol beginning in 2011 lower the confidence in a trend. Source: TRPA noise monitoring data, Engineering Dynamics, Inc.

Map



Map of wilderness and roadless land use category areas in the basin, relative to monitoring locations.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the wilderness and roadless land use category in the Lake Tahoe Basin. In recent years, visitors to and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). Excessive noise levels, specifically in wilderness areas, can be especially disruptive. In addition to existing federal, state, and local noise control regulations to address impacts of noise on both wildlife and people, TRPA adopted community noise equivalent levels (CNEL) for all land use

categories in the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 45 dBA, Wilderness and Roadless areas

Adopted Standards – For the wilderness/roadless land use category, noise levels shall not exceed a CNEL of 45 Dba

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridors are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (TRPA 2007). Other secondary anthropogenic noise influences include noise attributed to road construction and ambient basin noise (Bollard Acoustical Consultants 2014). Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014a).

MONITORING AND ANALYSIS

Monitoring Partners – TRPA monitoring with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample in various land use areas. Threshold standard attainment status was based on a single sample representing each land use type. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol was implemented in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Simple linear regression is used to determine trend**.** The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – At or somewhat better than target. The wilderness and roadless land use category maximum 24-hour CNEL in the most recent monitoring period (2015) was 42.4 dBA recorded at the Dardanelles site, which is 92 percent of the standard (TRPA 2015). Therefore, a status of at or somewhat better than target was determined.

Trend – Moderate improvement. The long term trend line shows a decrease of 0.52 percent annual mean dBA per year in relation to the standard of 45 dBA (TRPA 2015). Therefore, a trend of moderate improvement was determined.

Confidence –

Status – High. Taking the recommendation of a reputable noise expert, 1) noise monitoring

equipment was calibrated according to manufacturer specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences about the population of these land uses, and 3) a more robust sampling approach was deployed beginning in 2011. Therefore, confidence is high.

Trend – Low ($R^2 = 0.82$, $P = 0.09$). While there is a statistically significant long-term trend line, due to changes in sampling protocol beginning in 2011, any confidence in trend significance is low.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service prohibits the use of all motorized and mechanized vehicles within wilderness areas. Also, the U.S. Forest Service, under Code of Federal Regulation 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). In 2004, the Federal Aviation Administration (FAA) released an Advisory Circular (AC) that addressed flights over or near noise-sensitive areas. This document requested that pilots fly at altitudes higher than the minimum permitted by regulation, and on flight paths that will reduce aircraft noise in such area (U.S. Department of Transportation - Federal Aviation Administration 2004). Specifically, the document stated that pilots operating noise-producing aircraft over noise-sensitive areas should make every effort to fly not less than 2,000 feet above ground level, weather permitting (U.S. Department of Transportation - Federal Aviation Administration 2004). California State Parks restricts the use of off-highway motorized vehicles in the basin. TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears current programs are effective in minimizing noise in wilderness and roadless areas.

Interim Target – Threshold is in attainment.

Target Attainment Date – Threshold is in attainment.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

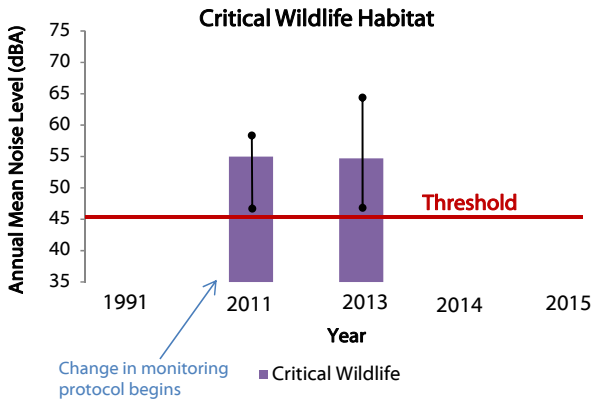
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **Critical Wildlife Habitat Areas (CNEL 45dBA)**

Status	Trend

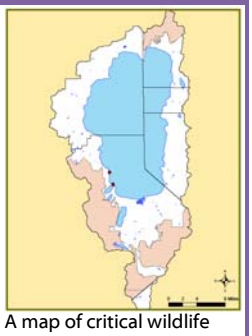
CRITICAL WILDLIFE HABITAT AREAS

Status: **Considerably Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**



Annual mean CNEL (purple bars) with 24-hour high and low CNEL values (black bars) in critical wildlife land use categories from 1991 to 2015. No data was collected in 1991, 2014 and 2015. Source: TRPA noise monitoring data, Engineering Dynamics, Inc.

Map



A map of critical wildlife habitat land use category areas (45 dBA) in the Basin, relative to monitoring locations. The shoreline near Rubicon Point/ Emerald Bay is considered critical wildlife habitat even though it is not shown on the map.

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in critical wildlife land use categories in the Lake Tahoe Basin. In recent years, visitors to and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and

aircraft (TRPA 2007). Excessive noise levels, specifically in critical wildlife habitat areas, can be especially disruptive. Agencies in the basin have adopted specific restrictions and threshold standards to protect sensitive wildlife habitat, and have identified this unique fauna on a special interest species list. In addition to existing federal, state, and local noise control regulations to address impacts of noise on both wildlife and people, TRPA adopted community noise equivalent levels (CNEL) for all land use categories in the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 45 dBA for critical wildlife habitat areas

Adopted Standards – For the critical wildlife habitat land use category, noise levels shall not exceed a CNEL of 45 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Noise sources that affect critical wildlife areas in the Region include automobiles, motorized watercraft, aircraft and other recreational activity (Bollard Acoustical Consultants 2014). Natural events such as thunderstorms, wave slap, and wind can influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014).

MONITORING AND ANALYSIS

Monitoring Partners – TRPA monitoring with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample in various land use areas. Threshold standard attainment status was based on a single sample representing each land use type. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol was implemented in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – Considerably worse than target. Measurements for critical wildlife areas are available only for two years: 2011 and 2013. In those two years, the CNEL far exceeded the standard. In 2013, the most recent year of monitoring, the maximum 24-hour CNEL was 65.3 dBA recorded at Rubicon Point, which is 144 percent of the standard (Bollard Acoustical Consultants 2014a). Consequently, a determination of considerably worse than target was made.

Trend – Insufficient data to determine trend. Only data from 2011 and 2013 is available for critical wildlife areas. Limited data availability precludes an analysis of trends.

Confidence –

Status – Low. Taking the recommendation of a reputable noise expert, 1) noise monitoring equipment was calibrated according to manufacturer specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences about the population of these land uses, and 3) a more robust sampling approach was deployed in 2011. However, because only 2011 and 2013 data is available, confidence is low.

Trend – Low. Insufficient data is available to make a trend determination.

Overall – Low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service restricts the use of all motorized and mechanized vehicles within wilderness areas. Also, the U.S. Forest Service, under Code of Federal Regulation CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). In 2004, the Federal Aviation Administration (FAA) released an Advisory Circular (AC) that addressed flights over or near noise-sensitive areas. The AC requested that pilots fly at altitudes higher than the minimum permitted by regulation, and on flight paths that will reduce aircraft noise in such areas (U.S. Department of Transportation - Federal Aviation Administration 2004). Specifically, the document stated that pilots operating noise-producing aircraft over noise-sensitive areas should make every effort to fly not less than 2,000 feet above ground level, weather permitting (U.S. Department of Transportation - Federal Aviation Administration 2004). In addition, the shorezone of Lake Tahoe has noise-related ordinances and regulations in TRPA code. These include a single event noise threshold of 75 dB, as well as a 600 ft. "no-wake zone" shorezone regulation. California State Parks restricts the use of off-highway motorized vehicles in the basin. TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – While there is limited data available for critical wildlife areas, the data available suggests that programs are not working to decrease noise in critical wildlife areas associated with offshore motorized watercraft.

Interim Target – No interim target set.

Target Attainment Date – Because limited data is available, it is not possible to set a target attainment date.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that, status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

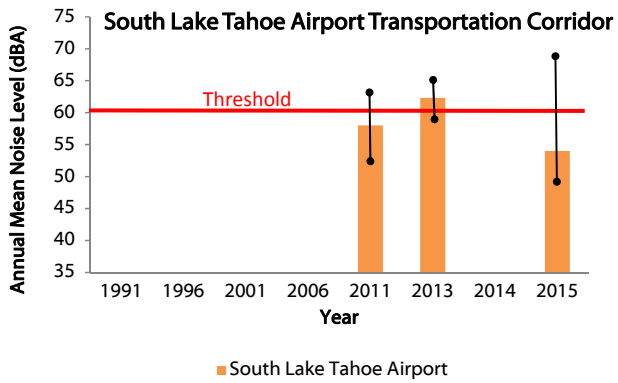
Attain or Maintain Threshold – CNEL for the critical wildlife habitat land use category is out of attainment with the adopted threshold standard. Use management recommendations from the current Shoreline Initiative planning process to move the standard into attainment.

Cumulative Noise Events: **South Lake Tahoe Airport Transportation Corridor (CNEL 60 dBA)**

Status	Trend

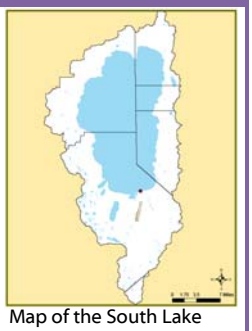
SOUTH LAKE TAHOE AIRPORT TRANSPORTATION CORRIDOR

Status: **Somewhat Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**



Annual mean CNEL (orange bars) with 24-hour high and low CNEL values (black bars) in the South Lake Tahoe Airport transportation corridor from 1991 to 2015. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc.

Map



Map of the South Lake Tahoe Airport transportation corridor with monitoring locations (CNEL 60).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the South Lake Tahoe Airport transportation corridor in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels may negatively impact community ambiance, ~~one's~~ recreational experience, and wildlife behavior. In the past, visitors and residents of the Lake Tahoe Basin have expressed concerns about declining serenity in their community, and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft, and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, TRPA adopted 24-hour noise standards, or Community Noise Equivalent Levels (CNEL),

for all land use categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events **–** CNEL of 60 dBA, South Lake Tahoe Airport Transportation Corridor

Adopted Standards – For the South Lake Tahoe Airport transportation corridor noise levels shall not exceed a CNEL of 60 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridor are primarily generated from vehicles, roadway traffic, aircraft and recreational activity (Bollard Acoustical Consultants 2014). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA and the City of South Lake Tahoe with land access granted by the California Tahoe Conservancy.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample per measured plan area. Threshold standard attainment status was based on a single sample representing a land use type. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol was implemented beginning in 2011. The 2011 monitoring approach was based on recommendations provided by a noise expert (Brown-Buntin Associates 2004). The approach since 2011 monitors the same sites every year for at least seven days during the period of May 15 to October 1. This captures noise levels during construction season and the busiest tourist seasons. ~~Unusual~~ Natural noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise. In addition, CNEL values for the South Lake Tahoe Airport transportation corridor were gathered at the Barton Beach site (see indicator summary "Single Noise Event-Aircraft" for site specifics). ~~in lieu of an established CNEL monitoring site at Lake Tahoe Airport.~~

Analytic Approach – ~~Because only three years of data exists, trend analysis was not conducted. The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis.~~ The highest recorded 24-hour CNEL ~~across all monitoring locations within a given land use or transportation category~~ is used for status analysis. Because only three years of data exists, trend analysis was not conducted.

INDICATOR STATE

Status – Somewhat worse than target. In 2015, the most recent monitoring period, the maximum 24-hour CNEL was 115 percent of the target (TRPA 2015). Therefore, a status of somewhat worse than target was determined.

Trend – Insufficient data to determine trend. While there has been a decrease in mean annual CNEL levels for the airport location since 2011, the limited amount of data results in a trend of insufficient data.

Confidence –

Status – Low. Monitoring is conducted following widely accepted protocols, but due to the inability to differentiate between the sources of the exceedances, confidence is low. ~~Monitoring is conducted following widely accepted protocols, but there is not current cost-effective method to determine the number of exceedances from natural vs. anthropogenic sources.Taking the recommendation of a reputable noise expert, 1) noise monitoring equipment was calibrated according to manufacturers' specifications, 2) sampled land use units and locations within each land use category were randomly selected to improve inferences about the population of these land uses, and 3) a more robust sampling approach was deployed beginning in 2011. However, there is no established monitoring protocol specifically for the airport and the airport's own monitoring devices went in and out of operation during the current monitoring period. Therefore, confidence in the status is low.~~

Trend – Low. Only three years of data exists.

Overall – Low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The City of South Lake Tahoe has published noise abatement guidelines on the South Lake Tahoe Airport website for all pilots. These guidelines pertain to aircraft flight paths and for low altitude departures and approaches over environmentally sensitive and residential areas.

Effectiveness of Programs and Actions – Based on available trend information and the lack of program-specific effectiveness monitoring, it is not possible to characterize the effectiveness of existing regulations and programs with certainty.

Interim Target – No interim target set.

Target Attainment Date – Because there is no established trend, a target attainment data is not possible to estimate.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should be based on annual mean CNEL ~~at all monitoring locations within a given land use category~~, instead of the current practice of using the maximum 24 hour CNEL ~~at all monitoring locations within a given land use category~~.

Monitoring Approach – ~~Although there is an established monitoring plan for single noise events for aircraft at the Lake Tahoe Airport, there is currently no mutually established protocol for evaluating CNEL at the Airport. The d~~Development of a cost-effective monitoring and evaluation methodology ~~plan~~ for ~~the~~ CNEL in the South Lake Tahoe Airport Corridor~~is needed to guide future CNEL monitoring efforts~~.

Modification of the Threshold Standard or Indicator – The standard should be assessed against best practice for the establishment of standards and indicators for M&E, and amended as necessary to ensure it reflects the latest science and provides information that is useful for management. ~~Clarification is needed as to whether attainment is based on annual mean CNEL across monitoring locations, the maximum 24-hour CNEL across all monitoring locations (current approach), or if it is based on the number of exceedances of the threshold standard.~~ Clarification is ~~also~~ needed on whether the threshold will be analysed based on the most current years' data only (current approach) or using a four-year or other periodic average.

Attain or Maintain Threshold – ~~While the CNEL for the South Lake Tahoe Airport transportation corridor was in attainment in 2015, previous years it was out of attainment with the adopted threshold standard.~~ The feasibility of meeting currently adopted CNEL (or single event) noise threshold standards for the

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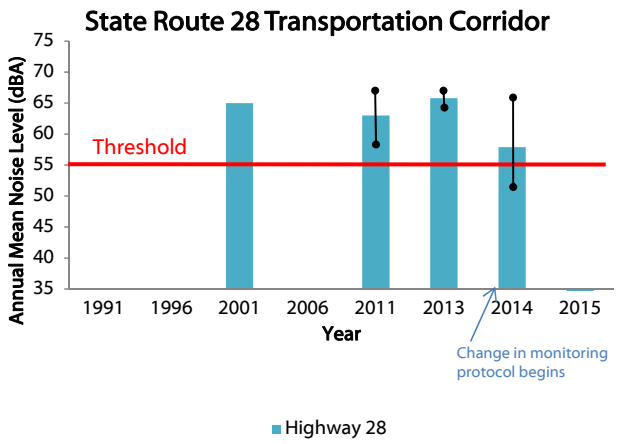
Airport is uncertain and should be evaluated. Based on the evaluation, threshold standards should be considered for adjustment consistent with FAA, TRPA, and airport permit requirements. Modified threshold standards, if any, should be addressed and incorporated in updates to the Airport Master Plan.

Cumulative Noise Events: **State Route 28 Transportation Corridor (CNEL 55 dBA)**

Status	Trend

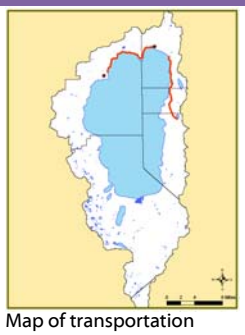
STATE ROUTE 28 TRANSPORTATION CORRIDOR

Status: **Somewhat Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Moderate**



Annual mean CNEL (blue bars) with 24-hour high and low CNEL values (black bars) in the State Route 28 transportation corridor from 1991 to 2015. Trend was not analyzed due to a change from monitoring one location in 2001, 2011 and 2013 to monitoring several locations in 2014. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc., Bollard Acoustical Consultants

Map



Map of transportation corridor State Route 28 with monitoring locations (CNEL 55 dBA).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the State Route 28 transportation corridor in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels have the potential to negatively impact community ambiance, one's recreational experience and wildlife behaviour. In the past, visitors and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, an effort to address these noise level impacts, the Tahoe Regional Planning Agency adopted 24-hour noise threshold standards, or community noise equivalent levels (CNEL), for all land use categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 55 dBA, State Route 28 Transportation Corridor

Adopted Standards – For the State Route 28 transportation corridor, noise levels shall not exceed a CNEL of 55 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridors are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014a). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014a).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample at each transportation corridor. Threshold standard attainment status was based on a single sample representing a transportation corridor. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol for transportation corridors was conducted in 2014. The 2014 monitoring approach was based on recommendations provided by a noise expert (Bollard Acoustical Consultants 2014b). The 2014 approach monitored several sites along each transportation corridor for multiple weeks during the period of May 15 to October 1. This captures noise levels during the construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Because data is not comparable across years due to changes in monitoring approach, trend was not analyzed. The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – Somewhat worse than target. The maximum 24-hour CNEL from 2014, the most current year of data, was 65.2 dBA which is 115 percent of the target (Bollard Acoustical Consultants 2014b). Therefore, a status of somewhat worse than target was determined. Additionally, the 24-hour CNEL was above the standard on 88 percent of sampling days.

Trend – Insufficient data to determine trend. The 2014 monitoring cannot be compared to previous years due to changes in sampling protocol. Therefore, trend analysis was not completed.

Confidence –

Status – High. Based on the recommendations of noise experts a more robust sampling approach was initiated in 2014, including additional instrument calibration and monitoring at

several locations within each transportation corridor.~~Taking the recommendation of a reputable noise expert 1) noise monitoring equipment was calibrated according to manufacturers' specifications and 2) a more robust sampling approach sampling several locations within each transportation corridor was deployed beginning in 2014. Therefore, confidence is high.~~

Trend – Low. Due to the significant change in monitoring approach (one location vs. several locations), trend cannot be analyzed.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulations CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potential activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. The North Tahoe Public Utility District has a list of rules that prohibits activities that produce excessive noise levels during park hours. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) is required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on the fact that State Route 28 has been out of attainment every year it was monitored, and there is no significant trend, it appears current programs and actions are not effective in reducing noise levels on State Route 28.

Interim Target – No interim target set.

Target Attainment Date – Because trend data is not available, it is not possible to set a target attainment date.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

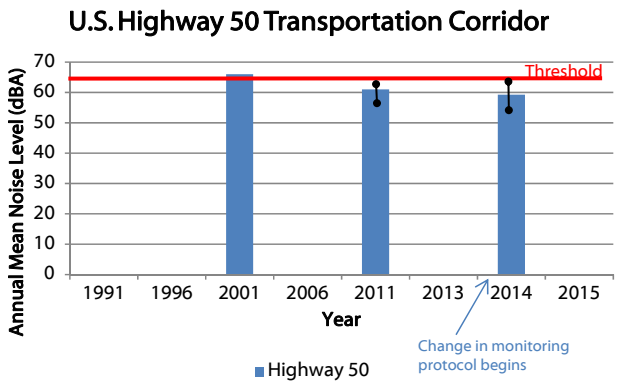
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **U.S. Highway 50 Transportation Corridor (CNEL 65 dBA)**

Status	Trend

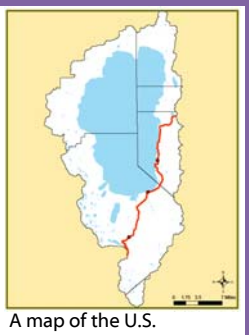
U.S. HIGHWAY 50 TRANSPORTATION CORRIDOR

Status: **At or Somewhat Better than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Moderate**



Annual mean CNEL (blue bars) with 24-hour high and low CNEL values (black bars) in transportation corridor U.S. Highway 50 from 1991 to 2015. Trend was not analyzed due to a change from monitoring one location in 2001 and 2011 to monitoring several locations in 2014. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc.

Map



A map of the U.S. Highway 50 transportation corridor with monitoring locations (CNEL 65 dBA).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the U.S. Highway 50 transportation corridor in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, noise management is an integral part of land use planning and environmental improvement processes at Lake Tahoe. Visitors and residents have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, an effort to address these noise level impacts, TRPA adopted 24-hour noise threshold standards, or Community Noise Equivalent Levels (CNEL), for all land use categories and plan areas of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Community Noise Equivalent Level - 65 dBA, U.S. Highway 50 Transportation Corridor

Adopted Standards – For the U.S. Highway 50 transportation corridor noise levels shall not exceed a CNEL of 65 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridor are primarily generated from vehicles, roadway traffic, aircraft and recreational activity (Bollard Acoustical Consultants 2014a). Other secondary anthropogenic noise influences include noise attributed to road construction and ambient basin noise. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014a).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample at each transportation corridor. Threshold standard attainment status was based on a single sample representing a transportation corridor. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol for transportation corridors was conducted in 2014. The 2014 monitoring approach was based on recommendations provided by a noise expert (Bollard Acoustical Consultants 2014b). The 2014 approach monitored several sites along each transportation corridor for multiple weeks during the period of May 15 to October 1. This captures noise levels during construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Because data is not comparable across years due to changes in monitoring approach, trend was not analyzed. The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – At or somewhat better than target. The maximum 24-hour CNEL for the most recent monitoring period, 2014, was 63.9 dBA, which is approximately 99 percent of the target (Bollard Acoustical Consultants 2014b). Therefore, a status of at or somewhat better than target was determined. In 2014, Bollard Acoustical Consultants were hired to do a comprehensive study of these transportation corridors. This study took data over multiple weeks and at multiple segments. While it does tell us much about the current status, the data is not comparable to previous year's data where data was collected at only one point. For this corridor in 2014, the 24-hour CNEL was never exceeded.

Trend – Insufficient data to determine trend. The 2014 monitoring cannot be compared to previous years due to changes in the sampling protocol. Because only two comparable points exits, a trend of insufficient data to determine trend is given.

Confidence –

Status – High. Based on the recommendations of noise experts a more robust sampling approach was initiated in 2014, including additional instrument calibration and monitoring at several locations within each transportation corridor.~~Taking the recommendation of a reputable noise expert 1) noise monitoring equipment was calibrated according to manufacturers' specifications and 2) a more robust sampling approach sampling several locations within each transportation corridor was deployed beginning in 2014. Therefore, confidence is high.~~

Trend – Low. Due to significant changes in monitoring approach (one location vs. several locations), trend cannot be analyzed.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulation CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potentially loud activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. Other restrictions, enforced by the California Highway Patrol (CHP) under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears programs are mostly effective in reducing noise in this transportation corridor.

Interim Target – Threshold is in attainment.

Target Attainment Date – Threshold is in attainment.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

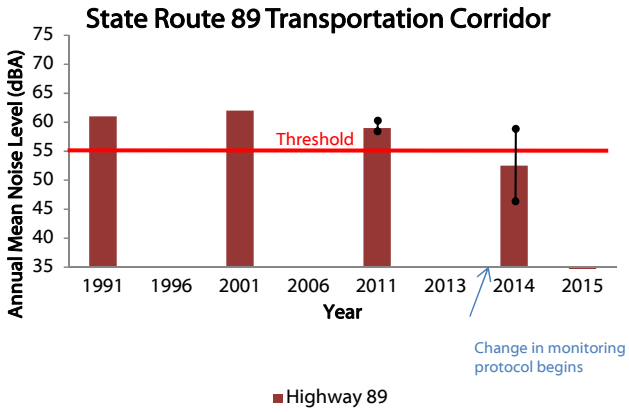
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **State Route 89 Transportation Corridor (CNEL 55 dBA)**

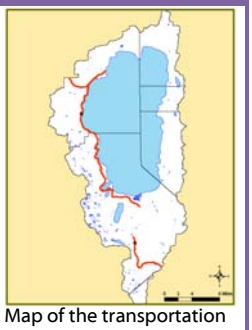
Status	Trend

STATE ROUTE 89 TRANSPORTATION CORRIDOR

Status: **Somewhat Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Moderate**



Map



Map of the transportation corridor State Route 89 with monitoring locations (CNEL 55 dBA).

Annual mean CNEL (red bars) with 24-hour high and low CNEL values (black bars) in transportation corridor State Route 89 from 1991 to 2015. Trend was not analyzed due to a change from monitoring one location in 1991, 2001 and 2011 to monitoring several locations in 2014. Source: TRPA noise monitoring data, Brown and Buntin Associates, Inc., Engineering Dynamics, Inc., Bollard Acoustical Consultants

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the State Route 89 transportation corridor in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels have the potential to negatively impact community ambiance, one's recreational experience and wildlife behavior. In recent years, visitors and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, an effort to address these noise level impacts, the Tahoe Regional Planning Agency

adopted 24-hour noise threshold standards, or community noise equivalent levels (CNEL), for all land use categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 55 dBA, State Route 89 Transportation Corridor

Adopted Standards – For the State Route 89 transportation corridor, noise levels shall not exceed a CNEL of 55 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridors are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014a). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014a).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample at each transportation corridor. Threshold standard attainment status was based on a single sample representing a transportation corridor. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol for transportation corridors was conducted in 2014. The 2014 monitoring approach was based on recommendations provided by a noise expert (Bollard Acoustical Consultants 2014b). The 2014 approach monitored several sites along each transportation corridor for multiple weeks during the period of May 15 to October 1. This captures noise levels during construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Because data is not comparable across years due to changes in monitoring approach, trend was not analyzed. The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – Somewhat worse than target. The maximum 24-hour CNEL recorded in 2014, the most recent year data is available, was 59.4 dBA, which is 107 percent of the target. Therefore, a status of somewhat worse than target was determined (Bollard Acoustical Consultants 2014b). Sampling in 2014 was done at multiple segments as opposed to at one location in prior evaluations, therefore data is not comparable. For this corridor in 2014, the 24-hour CNEL was above the standard on 28 percent of sampling days.

Trend – Insufficient data to determine trend. The 2014 monitoring cannot be compared to previous years due to changes in sampling protocol. Therefore, trend analysis was not completed.

Confidence –

Status – High. Based on the recommendations of noise experts a more robust sampling approach was initiated in 2014, including additional instrument calibration and monitoring at several locations within each transportation corridor.~~Taking the recommendation of a reputable noise expert 1) noise monitoring equipment was calibrated according to manufacturers' specifications and 2) a more robust sampling approach sampling several locations within each transportation corridor was deployed beginning in 2014. Therefore, confidence is high.~~

Trend – Low. Due to significant changes in monitoring approach (one location vs. several locations), trend cannot be analyzed.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulation CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potential activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. The North Tahoe Public Utility District has a list of rules that prohibits activities that produce excessive noise levels during park hours. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) is required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on the fact that State Route 89 has been out of attainment every year it was monitored, and there is no significant trend, it appears current programs and actions are not effective in reducing noise levels on State Route 89.

Interim Target – No interim target set.

Target Attainment Date – Because trend data is not available, it is not possible to set a target attainment date.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

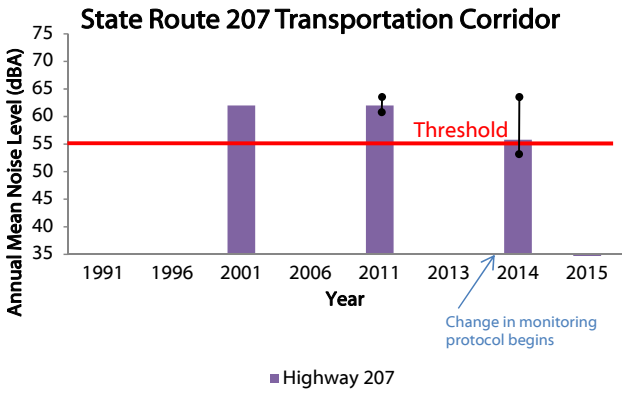
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **State Route 207 Transportation Corridor (CNEL 55 dBA)**

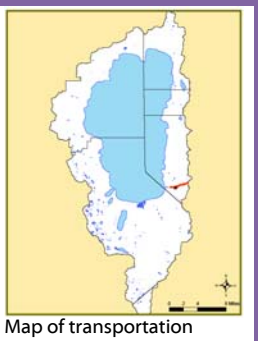
Status	Trend

STATE ROUTE 207 TRANSPORTATION CORRIDOR

Status: **Somewhat Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Moderate**



Map



Map of transportation corridor State Route 207 with monitoring locations (CNEL 55 dBA).

Annual mean CNEL (purple bars) with 24-hour high and low CNEL values (black bars) in transportation corridor State Route 207 from 1991 to 2015. Trend was not analyzed due to a change from monitoring one location in 2001 and 2011 to monitoring several locations in 2014. Brown and Buntin Associates, Inc., Engineering Dynamics, Inc., Bollard Acoustical Consultants

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels on the State Route 207 transportation corridor in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels have the potential to negatively impact community ambiance, one's recreational experience and wildlife behavior. In the past, visitors and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, an effort to address these noise level impacts, the Tahoe Regional Planning Agency adopted 24-hour noise threshold standards, or community noise equivalent levels (CNEL), for all land use

categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 55 dBA, State Route 207 Transportation Corridor

Adopted Standards – For the State Route 207 transportation corridor, noise levels shall not exceed a CNEL of 55 dBA.

Type of Standard – Numerical
Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridors are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014a). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014a).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample at each transportation corridor. Threshold standard attainment status was based on a single sample representing a transportation corridor. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol for transportation corridors was conducted in 2014. The 2014 monitoring approach was based on recommendations provided by a noise expert (Bollard Acoustical Consultants 2014b). The 2014 approach monitored several sites along each transportation corridor for multiple weeks during the period of May 15 to October 1. This captures noise levels during construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Because data is not comparable across years due to changes in monitoring approach, trend was not analyzed. The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – Somewhat worse than target. The maximum 24-hour CNEL in the most recent monitoring period, 2014, was 61.5 dBA, which is 112 percent of the target (Bollard Acoustical Consultants 2014b). Therefore, it received a status of somewhat worse than target. In 2014, Bollard Acoustical Consultants were hired to do a comprehensive study of these transportation corridors. This study took data over multiple weeks and at multiple segments. Therefore, while it does tell us much about the current status, the data is not comparable to previous year's data where data was collected at only one point. For this corridor, the 24-hour CNEL was above the standard on 67 percent of sampling days in 2014.

Trend – Insufficient data to determine trend. The 2014 monitoring cannot be compared to previous years due to changes in the sampling protocol. Therefore, trend analysis was not completed.

Confidence –

Status – High. Based on the recommendations of noise experts a more robust sampling approach was initiated in 2014, including additional instrument calibration and monitoring at several locations within each transportation corridor.~~Taking the recommendation of a reputable noise expert 1) noise monitoring equipment was calibrated according to manufacturers' specifications and 2) a more robust sampling approach sampling several locations within each transportation corridor was deployed beginning in 2014. Therefore, confidence is high.~~

Trend – Low. Due to significant changes in monitoring approach (one location vs. several locations), trend cannot be analyzed.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulations CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potential activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. The North Tahoe Public Utility District has a list of rules that prohibits activities that produce excessive noise levels during park hours. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) is required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on the fact that State Route 207 has been out of attainment every year it was monitored, and there is no significant trend, it appears current programs and actions are not effectively reducing noise levels on State Route 207.

Interim Target – No interim target set.

Target Attainment Date – Because trend data is not available, a target attainment date cannot be established.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

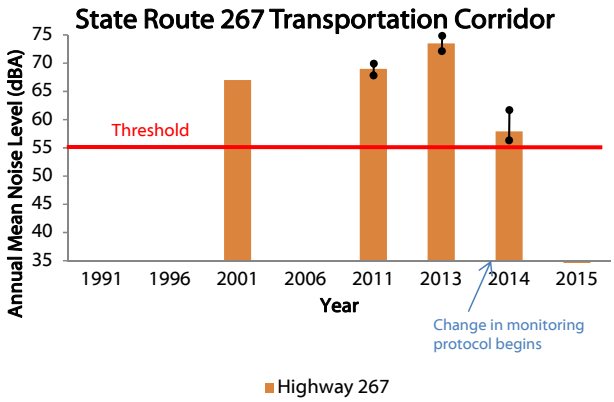
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **State Route 267 Transportation Corridor (CNEL 55 dBA)**

Status	Trend

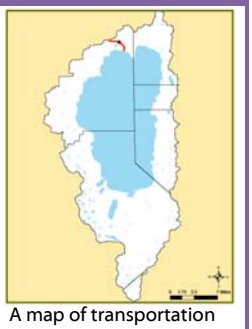
STATE ROUTE 267 TRANSPORTATION CORRIDOR

Status: **Somewhat Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Moderate**



Annual mean CNEL (orange bars) with 24-hour high and low CNEL values (black bars) in transportation corridor SR267 from 1991 to 2015. Trend was not analyzed due to a change from monitoring one location in 2001, 2011 & 2013 to monitoring several locations in 2014. Brown and Buntin Associates, Inc., Engineering Dynamics, Inc., Bollard Acoustical Consultants

Map



A map of transportation corridor State Route 267 with monitoring locations (CNEL 55 dBA).

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the State Route 267 transportation corridor in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels have the potential to negatively impact community ambiance, one's recreational experience and wildlife behavior. In recent years, visitors and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, an effort to address these noise level impacts, the Tahoe Regional Planning Agency adopted 24-hour noise threshold standards, or Community Noise Equivalent Levels (CNEL), for all land use categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 55 dBA, State Route 267 Transportation Corridor

Adopted Standards – For the State Route 267 transportation corridor, noise levels shall not exceed a CNEL of 55 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridors are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014a). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014a).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample at each transportation corridor. Threshold Standard attainment status was based on a single sample representing a transportation corridor. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol for transportation corridors was conducted in 2014. The 2014 monitoring approach was based on recommendations provided by a noise expert (Bollard Acoustical Consultants 2014b). The 2014 approach monitored several sites along each transportation corridor for multiple weeks during the period of May 15 to October 1. This captures noise levels during construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Because data is not comparable across years due to changes in monitoring approach, trend was not analyzed. The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – Somewhat worse than target. The maximum 24-hour CNEL for the most recent monitoring period, 2014, was 61.1 dBA which is 111 percent of the target (Bollard Acoustical Consultants 2014b). Therefore, a determination of somewhat worse than target was made. In 2014, Bollard Acoustical Consultants were hired to do a comprehensive study of these transportation corridors. This study took data over multiple weeks and at multiple segments. While it does tell us much about the current status, the data is not comparable to previous year's data where data was collected at only one point. For this corridor, the 24-hour CNEL was above the standard on 100 percent of sampling days in 2014.

Trend – Insufficient data to determine trend. The 2014 monitoring effort cannot be compared to previous year's efforts. Therefore, trend analysis was not completed.

Confidence –

Status – High. Based on the recommendations of noise experts a more robust sampling approach was initiated in 2014, including additional instrument calibration and monitoring at several locations within each transportation corridor.~~Taking the recommendation of a reputable noise expert 1) noise monitoring equipment was calibrated according to manufacturers' specifications and 2) a more robust sampling approach sampling several locations within each transportation corridor was deployed beginning in 2014. Therefore, confidence is high.~~

Trend – Low. Due to significant changes in monitoring approach (one location vs. several locations), trend cannot be analyzed.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulations CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potential activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. The North Tahoe Public Utility District has a list of rules that prohibits activities that produce excessive noise levels during park hours. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) is required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on the fact that State Route 267 has been out of attainment every year it was monitored, and there is no significant trend, it appears current programs and actions are not effective in reducing noise levels on State Route 267.

Interim Target – No interim target set.

Target Attainment Date – Because trend data is not available, a target attainment date cannot be established.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

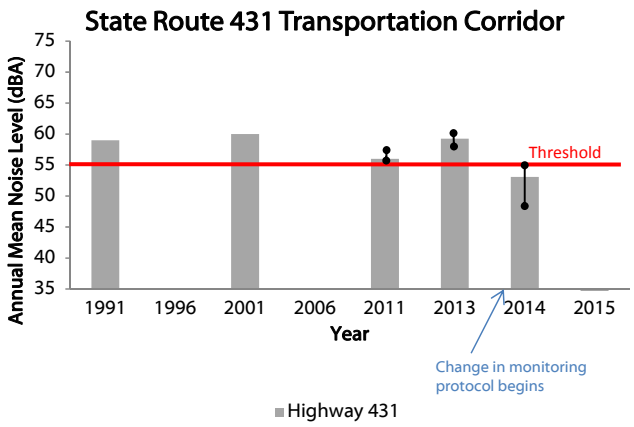
Attain or Maintain Threshold – No changes recommended.

Cumulative Noise Events: **State Route 431 Transportation Corridor (CNEL 55 dBA)**

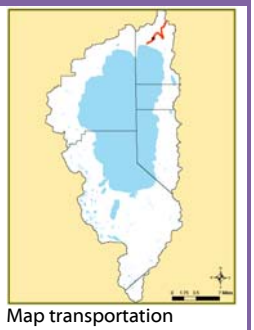
Status	Trend

STATE ROUTE 431 TRANSPORTATION CORRIDOR

Status: **At or Somewhat Better than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Moderate**



Map



Map transportation corridor State Route 431 with monitoring locations (CNEL 55 dBA).

Annual mean CNEL (grey bars) with 24-hour high and low CNEL values (black bars) in transportation corridor SR431 from 1991 to 2015. Trend was not analyzed due to a change from monitoring one location in 1991, 2001, 2011 and 2013 to monitoring several locations in 2014. Brown and Buntin Associates, Inc., Engineering Dynamics, Inc., Bollard Acoustical Consultants

Data Evaluation and Interpretation

BACKGROUND

Relevance – This indicator measures 24-hour noise levels in the State Route 431 transportation corridor in the Lake Tahoe Basin. Due to the rural nature of the communities and the pristine natural areas in the Lake Tahoe Basin, excessive noise levels have the potential to negatively impact community ambiance, one's recreational experience and wildlife behavior. In the past, visitors and residents of the Lake Tahoe Basin have expressed concerns about the decline in serenity of their community and their enjoyment of the outdoors due to excessive noise from sources such as on-highway vehicles, off-highway vehicles, over-snow vehicles, watercraft and aircraft (TRPA 2007). In addition to existing federal, state, and local noise control regulations, an effort to address these noise level impacts, TRPA adopted 24-hour noise threshold standards, or Community Noise Equivalent Levels (CNEL), for all land use categories, plan areas, and transportation corridors of the basin.

TRPA Threshold Category – Noise

TRPA Threshold Indicator Reporting Category – Cumulative Noise Events-CNEL of 55 dBA, State Route 431 Transportation Corridor

Adopted Standards – For the State Route 431 transportation corridor noise levels shall not exceed a CNEL of 55 dBA.

Type of Standard – Numerical

Indicator (Unit of Measure) – The maximum 24-hour CNEL A-weighted decibel (dBA) is used to assess status. The annual mean CNEL is used to assess trend. The A-weighted decibel measurement is used in evaluating the effects of environmental and industrial noise effects on human health.

Human & Environmental Drivers – Anthropogenic noise levels affecting these land use categories and transportation corridors are primarily generated from vehicles, roadway traffic, aircraft, and recreational activity (Bollard Acoustical Consultants 2014a). Other secondary anthropogenic noise influences include noise attributed to construction. Natural events such as thunderstorms and wind influence noise levels as environmental drivers (Bollard Acoustical Consultants 2014a).

MONITORING AND ANALYSIS

Monitoring Partners – Monitoring was conducted by TRPA with land access granted by the U.S. Forest Service, California State Parks, the California Tahoe Conservancy, and several private property owners.

Monitoring Approach – Historical monitoring consisted of gathering a single 24-hour sample at each transportation corridor. Threshold standard attainment status was based on a single sample representing a transportation corridor. In contrast to single-sample historic monitoring, a more comprehensive CNEL monitoring protocol for transportation corridors was conducted in 2014. The 2014 monitoring approach was based on recommendations provided by a noise expert (Bollard Acoustical Consultants 2014b). The 2014 approach monitored several sites along each transportation corridor for multiple weeks during the period of May 15 to October 1. This captures noise levels during construction season and the busiest tourist seasons. Unusual noise such as lightning strikes and animal sounds are discarded from the data. The mean 24-hour dBA from each day is averaged for the final CNEL at each monitoring location. Decibel levels at night ~~are weighted heavier~~are weighted more heavily to account for human's greater sensitivity to night-time noise.

Analytic Approach – Because data is not comparable across years due to changes in monitoring approach, trend was not analyzed. The average CNEL across all monitoring locations within a given land use category is averaged for the final "annual mean CNEL" result and is used for trend analysis. The highest recorded 24-hour CNEL across all monitoring locations within a given land use or transportation category is used for status analysis.

INDICATOR STATE

Status – At or somewhat better than target. In the most recent monitoring period (2014) the maximum 24-hour CNEL was 55.2 dBA, which is 100.2 percent of the target (Bollard Acoustical Consultants 2014b). Therefore, a status of "at or somewhat better than target" was determined. In 2014, Bollard Acoustical Consultants were hired to do a comprehensive study of these transportation corridors. This study took data over multiple weeks and at multiple segments. While it does tell us much about the current status, the data is not comparable to previous year's data where data was collected at only one point. For this corridor, the 24-hour CNEL was above the standard on 25 percent of sampling days in 2014.

Trend – Insufficient data to determine trend. The 2014 monitoring cannot be compared to previous years due to changes in the sampling protocol. Therefore, trend analysis was not completed.

Confidence –

Status – High. Based on the recommendations of noise experts a more robust sampling approach was initiated in 2014, including additional instrument calibration and monitoring at several locations within each transportation corridor.~~Taking the recommendation of a reputable noise expert 1) noise monitoring equipment was calibrated according to manufacturers' specifications and 2) a more robust sampling approach sampling several locations within each transportation corridor was deployed beginning in 2014. Therefore, confidence is high.~~

Trend – Low. Due to significant changes in monitoring approach (one location vs. several locations), trend cannot be analyzed.

Overall – Moderate. Overall confidence takes the middle of the two confidence determinations when high and low.

IMPLEMENTATION AND EFFECTIVENESS

Programs and Actions Implemented to Improve Conditions – The U.S. Forest Service, under Code of Federal Regulations CFR 261.4(d), prohibits causing public inconvenience, annoyance, or alarm by making unreasonably loud noise (USDA 2016). Although this can include a wide range of potential activities, the U.S. Forest Service also has specific regulations for decibel levels generated from motorized vehicles on applicable forest lands. The North Tahoe Public Utility District has a list of rules that prohibits activities that produce excessive noise levels during park hours. Other actions include motor vehicle exhaust system modification restrictions, which the California Highway Patrol (CHP) is required to enforce. These restrictions, under Vehicle Code Section 27151, prohibit the modification of the exhaust system to amplify or increase the noise emitted by the vehicle, making the vehicle noncompliant with Section 27150VC (California Highway Patrol 2006).

TRPA and local jurisdictions review proposed public and private projects to determine if the project would result in increases in existing CNEL that would exceed applicable standards (TRPA 2012b). Projects that would exceed applicable CNEL standards are required to mitigate project-related noise.

Effectiveness of Programs and Actions – Based on available status and trend information, it appears current programs are mostly effective in reducing noise in this transportation corridor.

Interim Target – Threshold is in attainment.

Target Attainment Date – Threshold is in attainment.

RECOMMENDATIONS

Analytic Approach – Noise experts have recommended that status determination for cumulative noise events should either 1) be based on annual mean CNEL at all monitoring locations within a given land use category, instead of the current practice of using the maximum 24 hour CNEL at all monitoring locations within a given land use category, or 2) attainment of CNEL should be based on the percentage of events that exceed the threshold rather than being based on a single exceedance and that TRPA should report on the number of locations that exceed the CNEL standard rather than the magnitude of the exceedance.

Monitoring Approach – No changes recommended.

Modification of the Threshold Standard or Indicator – No changes recommended.

Attain or Maintain Threshold – No changes recommended.

Chapter 10 Noise References

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CHAPTER 12 Implementation and Effectiveness

This chapter summarizes the effectiveness of TRPA's strategic objectives and initiatives, the Regional Plan, compliance measures, and the Lake Tahoe Environmental Improvement Program in moving the Region toward achieving adopted threshold standards. It also provides an overview of improvements in reporting and information systems, cumulative accounting of Regional Plan activities and development rights, and it fulfills reporting requirements established in TRPA Code of Ordinances Sections 16.6, 16.8 and 16.9.

Strategic Direction

TRPA's mission is to cooperatively lead the effort to preserve, restore, and enhance the unique natural and human environment of the Lake Tahoe Region, while improving local communities, and people's interactions with our irreplaceable environment. To realize our vision and to accomplish our mission, the TRPA Governing Board adopted the 2014 Strategic Plan (http://www.trpa.org/wp-content/uploads/Strategic_Plan_2014_June2014_Final_rev1-21-15.pdf) to guide the agency for the next three to five years (TRPA, 2014). The 2014 Strategic Plan includes four key strategic objectives:

- Accelerate Threshold Attainment (ATA)
    - Implement the Regional Plan—Focus on regional issues such as adapting to climate change.
    - Develop and implement new funding strategies for the Environmental Improvement Program—The Agency is confronted with constrained state funding sources and the decline of multiple federal grants that support restoration, science, and monitoring programs.
- Be a Leader in Environmental and Sustainability Programs (BLS)
    - Establish and maintain new cutting-edge, nationally recognized environmental and sustainability programs—The Agency operates on a world stage and the time is ripe for growing TRPA's reputation nationally and internationally as a leader in environmental restoration and sustainability approaches. We will seek best practices and form new strategic alliances.
- Propel the Development and Use of Best Information, Data, and Science for Decision-Making and Accountability (UBS)
    - Provide excellent information for accountability and transparency of policy decisions and operations—TRPA is committed to continuing strong relations with the science community and improving measurement and reporting for programmatic and fiscal accountability.

- Operate as a High Performance Team (OHT)
    - Create an enduring organizational culture of high performance and continuous improvement—The Agency will implement staff development and leadership programs to build capability, ensure accountability, and grow competencies to deliver on performance targets.

These four strategic objectives are the foundation upon which TRPA staff and the Advisory Planning Commission (APC) propose priorities annually. At its annual retreat, the TRPA Governing Board considers these recommendations and selects or updates multi-year strategic initiatives. The seven current strategic initiatives for the next five years (2015 to 2020) that the Governing Board directed TRPA staff to move forward with and the strategic plan objectives they address are:

- Development Rights (ATA)
    - Identify barriers for environmentally beneficial redevelopment and evaluate the effectiveness of the system in implementing the Regional Plan, managing growth, supporting environmentally beneficial redevelopment, and accelerating sensitive land restoration.
- Shoreline (BLS/UBS)
    - Shorezone Plan and Code—update the dated prohibition on new structures in fish habitat and policies governing access and recreation.
    - Nearshore Water Quality—enhance the understanding of the ecosystem dynamics of the nearshore and explore potential policy changes, especially given the alternative climate change scenarios.
- Transportation (ATA/BLS)
    - Update the Regional Transportation Plan and lead implementation efforts to enhance the transportation system including key elements such as the pedestrian and bike trail system around the lake, improving public transit within the Region for those travelling to and from the Region.
- Forest Ecosystem Health (ATA)
    - Support the Lake Tahoe Basin Multi-Jurisdictional Fuel Reduction and Wildfire Prevention Strategy: complete fuels reduction treatments in the wildland urban interface by 2020, and extend forest management actions into the "threat zone" and "general forest" to accomplish watershed-scale multi-benefit restoration through a collaborative, multi-agency process.
- Aquatic Invasive Species Control (ATA)
    - Secure Aquatic Invasive Species (AIS) Control Program funding, prioritize, and implement effective means to push back existing populations of AIS.
- Stormwater Operations and Maintenance Funding (ATA)
    - Establish a sustainable structure and funding source for operations and maintenance of parcel-level, area-wide, and transportation-related stormwater facilities and programs.
- Streamline Monitoring and Update Thresholds (UBS)
    - Consider updates to the thresholds and monitoring systems, working with the new Tahoe Science Advisory Council and science community to 1) create a sustainable, prioritized and relevant monitoring plan, and 2) review and consider modifying the threshold standards to reflect the latest science and the significant values in the Region.

Implementing the Regional Plan

The TRPA Regional Plan (TRPA, 2012a) is the blueprint for attaining and maintaining the threshold standards and securing the Tahoe Region's sustainable future. Major amendments were made to the Regional Plan in 2012 and are now being made on an ongoing basis. The Regional Plan guides community development and redevelopment, enhancing ecosystem functions, creating a more effective transportation network, and revitalizing the basin economy. It pairs ecosystem restoration with redevelopment activities to promote mixed-use town centers where people can live, work, and thrive.

The priorities of the 2012 Regional Plan amendments included:

- Accelerating water quality restoration and other ecologically beneficial projects by supporting environmental redevelopment opportunities and Environmental Improvement Program investments.
- Transitioning to more permitting by local governments to create one-stop-shopping for homeowner improvements in order to return TRPA to the more regional role the Bi-State Compact originally intended.
- Creating walkable communities and increasing alternative transportation options.

To accomplish these priorities, the 2012 Regional Plan amendments established new or revised policies, including:

- Retaining the established regional growth control system. Under this system, rampant overdevelopment was stopped and open spaces preserved. Most of the growth control policies remain in place with the 2012 Regional Plan.
- Creating a more efficient planning system that integrates TRPA requirements into the plans and permits of other government agencies.
- Encouraging property owners to transfer development rights from sensitive or outlying areas to existing town centers, to restore sensitive lands and revitalize town centers.
- Eliminating regulatory barriers to environmentally beneficial redevelopment of rundown buildings.
- Simplifying burdensome regulations for homeowners while achieving threshold gains.
- Integrating with the Regional Transportation Plan to support sidewalk and bike trail projects that reduce automobile dependency and increase walkability and safety.
- Continuing to deliver restoration projects under the Environmental Improvement Program that achieve erosion control on roadways and restore forests and wetlands.

Since the adoption of the 2012 Regional Plan amendments, TRPA and its partners have been executing these policies and programs. Growth controls remain in place, and to date, three area plans have been adopted to integrate the Regional Plan policies into local plans and permits. Environmentally beneficial transfers are facilitating the removal of development from sensitive and remote areas, and property owners are encouraged to restore and redevelop aging properties though reduced regulatory barriers.

The TRPA Governing Board in March 2016 approved an Active Transportation Plan (TMPO, 2016) which envisions a range of options to promote pedestrian and bicycle infrastructure improvements that promote walkable and bicycle friendly communities around the lake. An update to the Regional Transportation Plan is expected to be released for Governing Board

approval in late 2016 or early 2017 for continued improvement of the transportation network. The Lake Tahoe Environmental Improvement Program, now in its 20th year, has completed nearly 500 projects to improve the environmental quality and the recreational experience of the Tahoe Region. These investments are critical to building resiliency in the Tahoe Region and preparing for the challenges posed by climate change, prolonged droughts, and invasive species.

Growth Control

In order to provide for orderly growth, the Regional Plan meters the rate of development right allocations that TRPA releases each year. Under the 1987 Regional Plan, 6,000 residential allocations were released over 20 years (300 allocations per year), 800,000 square feet of additional commercial floor area (CFA) were authorized, and 600 additional tourist accommodation units were made available. While the 2012 Regional Plan amendments authorized some additional development rights, the additional amounts were greatly reduced: 200,000 square feet of additional CFA and 2,600 new residential allocations. No new tourist accommodation units were authorized. The growth controls were also retained, with only 130 residential allocations to be released each year and a requirement that the additional CFA not be released until the remaining CFA from the 1987 Regional Plan (TRPA 1987) amendments is exhausted.

Area Plans

Area plans allow implementation of the Regional Plan through local government planning, permitting, and compliance. And, because each area plan is required to be in conformance with and a component of the Regional Plan, the adoption of area plans ensures the Regional Plan's beneficial effects on the environment are realized.

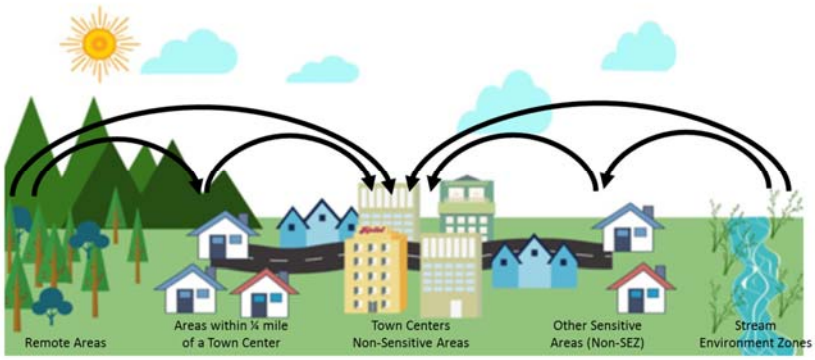
Three communities around the lake have adopted area plans that implement the Regional Plan priorities at the local level. The City of South Lake Tahoe, California has adopted two plans: the Tourist Core Area Plan and the Tahoe Valley Area Plan, which combined include nearly two-thirds of commercial floor area and more than 80 percent of tourist accommodation units in the City. Douglas County, Nevada has adopted the South Shore Area Plan, which includes more than half of the commercial floor area and three-quarters of the tourist accommodation units located within the county's portion of the Lake Tahoe Region.

Four other local area plans are under development, including plans in Douglas County and Washoe County, Nevada, and El Dorado County and Placer County, California.

Transfer of Development Rights and Environmental Redevelopment

A key implementation tool in the Regional Plan is the transfer of development rights (TDR) program. The TDR program provides a range of incentives to relocate development away from sensitive, and remote areas and into highly capable lands in town centers, to create mixed use walkable areas. By transferring the rights from the remote, sensitive sending areas to the town center areas, the TDR program aims to support environmentally beneficial redevelopment that revitalizes town centers and preserves and restores sensitive lands.

Since the adoption of the 2012 Regional Plan amendments, TRPA has approved more than 50 transfer applications. These projects have removed 10,955 square feet of coverage, 97 tourist accommodation units, and 11 residential units from sensitive stream environment zones. Another 41,910 square feet of coverage and seven existing residential units were removed from remote areas and transferred to within one-quarter mile of a town center. In total, 35,000 square feet of coverage and 15,260 square feet of commercial floor area have been transferred into town centers since the adoption of the 2012 Regional Plan.



	Remote Areas	Areas within 1/4 mile of a Town Center	Town Centers/Non-Sensitive Areas	Other Sensitive Areas	Stream Environment Zones
Coverage	-41,910	+6,910	+35,000	+10,955	-10,955
Commercial Floor Area (CFA)	-	-15,260	+15,260	-	-
Residential Units (ERU/RDR)	-7	+7	+12	-1	-11
Tourist Units (TAU)	-	-	+97	-	-97

***Figure 12-1**. Summary of Environmental Benefits from Approved Transfers of Development Since 2012*

Removing Regulatory Barriers

TRPA and its local jurisdiction partners are working to create a more transparent, understandable, and navigable permitting process with increased predictability and regional consistency. Complicated and overlapping permitting processes among multiple jurisdictions can make obtaining permits in the Lake Tahoe Region difficult and time consuming for investors in projects that would remove and replace older, obsolete, legacy development. This initiative will create a coordinated permitting assistance "Welcome Mat" program to enhance consistency and predictability in the permit process and encourage environmental redevelopment. A stakeholder assessment has already been completed and several other tasks are already underway, while other process improvements and tasks will be developed and implemented over the next few years.

Regional Transportation Plan

The Regional Transportation Plan: Linking Tahoe provides the framework for investment in the transportation system that supports community and regional goals set forth in the Regional Plan and the area plans. Linking Tahoe identifies planned transportation projects and programs that will shape the Region's transportation system over the next 20 years, and lays out the funding plan necessary to implement that system. The plan focuses on transit, bicycle and pedestrian, and technology strategies to enhance mobility and the safety of the transportation network, preserve and restore the ecology of the Region, promote economic vitality, minimize the Region's climate footprint, and improve the quality of life for residents and visitors.

Linking Tahoe draws on other approved TRPA plans to identify priority projects that should be incorporated into the Region's future transportation system. These include the Active Transportation Plan (TMPO 2016), which focuses on bicycle and pedestrian infrastructure and

programs, the Intelligent Transportation System Strategic Plan, which focuses on technology solutions for transportation in the Region, and short- and long-range transit plans, which are still being prepared and pending Governing Board approval.

Environmental Improvement

The Lake Tahoe Environmental Improvement Program (EIP) protects the natural and recreational resources of the Region. Since 1997, thousands of feet of stream channels have been restored around the Region, such as projects in the Ward Creek, Blackwood Creek, Third Creek, Incline Creek, and Upper Truckee River watersheds (TRPA, 2016a). These projects have fixed past damage from logging, cattle grazing, and urban development to improve fish and wildlife habitat and reduce erosion and the amount of clarity-robbing fine sediment washing into Tahoe. More detail on the Lake Tahoe Environmental Improvement Program results are on page 12-13 of this chapter.

Improving Accountability through Reporting

History has shown that success is only possible when stakeholders are informed and confident of the direction and results. To this end, across all sectors of government, a clarion call is driving new performance measures, accountability, and transparency. Few are aware that TRPA tracks hundreds of performance measures for the agency and the Region. And, in the search for continuous improvement, we see we can build greater confidence and momentum through more frequent and transparent reporting of what we track and measure that improves accountability and decision making.

TRPA has responded to the call for more transparency and accountability. Beginning in 2013, TRPA committed to delivering annual and quarterly reports on the agency's accomplishments and the implementation progress for all major Regional Plan programs, strategic initiatives, and work priorities. Included within the 2014 and 2015 annual reports are detailed appendices that describe TRPA's progress toward realizing the expected benefits from specific policies of the Regional Plan. These appendices include detailed reports on Regional Plan performance measures, area plan metrics, and sustainability indicators. These reports are available at http://www.trpa.org/reports.

Annual and Quarterly Reports

The TRPA annual and quarterly reports provide a view into the progress that each division within TRPA is making in implementing the Regional Plan and driving toward TRPA's four strategic priorities: accelerating threshold attainment, using best science, being a leader in sustainability and operating as a high performance team.

Regional Plan Performance Measures Report

This annual report measures whether specific regional land use patterns, travel behavior, environmental restoration, and economic measures are responding to the incentive programs and redevelopment goals of the 2012 Regional Plan amendments, and whether the policies of the plan are implemented effectively. The measures include:

Regional Land Use Patterns:

1. Distribution of development for land-use types
2. Annual average number of units transferred to town centers from sensitive and remote land
3. Retirement rate for existing non-residential units of use
4. Housing availability for residents and workers

Travel Behavior:

5. Percentage of all trips using non-automobile modes of travel (transit, bicycle, pedestrian)
6. Automobile vehicle miles traveled per capita (excluding through trips)
7. Construction of pedestrian and bicycle improvements

Environmental Restoration:

8. Coverage removal from stream environment zones and other sensitive lands (privately-funded)
9. Issuance of best management practices (BMP) certificates in conjunction with property improvements and area-wide BMP installations
10. TMDL performance benchmarks
11. Scenic improvement rate on urban roadways

Effective Regional Plan Implementation:

12. Prepare and maintain area plans in conformance with the 2012 Regional Plan
13. Complete mitigation measures identified in the Regional Plan Update EIS

Economic Vitality:

14. Rate of redevelopment

Area Plan Metrics Report

Area plans enable coordinated planning and permitting under TRPA, local, state, and federal requirements. Area plans allow other regulatory agencies in the Region to implement the Regional Plan policies at a smaller scale and with greater flexibility.

The annual area plan report is a required, comprehensive annual review of permitting activity, audit results, corrective actions, coverage changes, and environmental benefits to determine conformance with the TRPA Code of Ordinances and area plan standards.

Sustainability Indicators Report

In 2013, TRPA and other Lake Tahoe Sustainable Communities Program partners and community stakeholders selected a suite of indicators representative of the Lake Tahoe Region's economic, environmental, and community health. This suite of 31 indicators in 11 categories: water quality, forest health, greenhouse gas emissions, aquatic invasive species, income, business environment, employment, housing, transportation, and healthy lifestyle--provides information on status, ongoing efforts and projects, and suggestions on how individuals can get involved.

Developing Transparent Information Systems and Tools

TRPA has also invested in enhancing the reporting capabilities in the Lake Tahoe Region using the https://LakeTahoeInfo.org platform. TRPA and more than 50 partners have developed the reporting platform. The platform provides access to information and resources to improve transparency and accountability for decision-making and public/private investments in projects in the Lake Tahoe Region. The development of the LakeTahoeInfo.org platform has been made possible by generous financial support from the U.S. Environmental Protection Agency, Southern Nevada Public Land Management Act, California Strategic Growth Council, Tahoe Metropolitan Planning Organization, and TRPA general fund.

The tools are hosted under a unified platform and currently include the EIP Project Tracker, Parcel Tracker, Thresholds Dashboard, and Sustainability Dashboard sites. A data center that provides centralized access to data and analytical resources and web services for automated data sharing and communication between LakeTahoeInfo.org and other tools and platforms has also been developed. Additional resources and tools will be created and supported as additional need and funding becomes available.

Figure 12-2. Screenshot of LakeTahoeInfo.org. Source: Tahoe Regional Planning Agency (TRPA 2016b). Lake Tahoe Info.org Accessed 9/2/2016.

EIP Project Tracker: https://eip.laketahoeinfo.org/
Over 50 entities–federal, state, and local agencies, the private sector, non-governmental organizations, and science and research groups–are involved in the restoration and planning efforts in the Lake Tahoe Region through the EIP. A new clearinghouse—the EIP Project Tracker—enables these agencies and organizations to collect, analyze and publish data and reports concerning the environmental health of the Region. The Lake Tahoe EIP Project Tracker was created to efficiently exchange this information between these groups and with the public, to improve EIP transparency and reporting and to better inform the public about these important projects that restore Lake Tahoe's environment

The Lake Tahoe EIP Project Tracker provides EIP managers and funders the project and programmatic level data necessary to understand the environmental return on their investments and secure future funding for environmental improvement in the Tahoe Region. This tool provides

detailed tracking and reporting information needed for programmatic management. Agency management, funders, and the interested public are the target audiences.

Parcel Tracker: https://parcels.laketahoeinfo.org/
Development rights, such as land coverage, tourist accommodation units, commercial floor area and residential units of use, are essential elements of TRPA's Regional Plan policies, growth control framework and regulatory foundation. The 2012 Regional Plan amendments included targeted changes to encourage environmentally beneficial redevelopment and promote change in the existing development pattern of the Region.

To better achieve such transfers of development for threshold attainment, better tracking and reporting of available development right inventories is paramount. In 2013, TRPA launched the Parcel Tracker so that the information necessary to inform the public, assess effectiveness and develop policy improvements was available. The system streamlines the reporting of development right transfers and allocations by permitting authorities. In 2015, the Parcel Tracker was expanded to be able to record banked development rights at the parcel level, track development rights inventories on both public and private parcels, and to capture transactions in real-time, as they occur. This ensures that all parties have access to the latest information. Using this information, property owners, realtors and land banks can use the system to identify opportunities to acquire and relocate development rights and to determine the most environmentally beneficial redevelopment options.

Sustainability Dashboard, https://sustainability.laketahoeinfo.org/
Based upon the Sustainability Indicators that TRPA, other Lake Tahoe Sustainable Communities Program partners and community stakeholders selected in 2013, the Sustainability Dashboard provides a balanced and objective overview of the economic, environmental, and community health indicators for the Lake Tahoe Region.

Each dashboard category provides information on indicator status, ongoing efforts and projects, and suggestions on how individuals can get involved.

Thresholds Dashboard, https://thresholds.laketahoeinfo.org/
The soon-to-be released Thresholds Dashboard will provide an online, user-friendly site to navigate through the more than 170 Threshold Indicators in 9 categories and 34 sub-categories. This site will enable easy review of the status and trend of indicators in each threshold category, while providing access to detailed analysis, background information, monitoring data and insight into reporting methods.

Compliance Measures

Compliance measures are all the actions that TRPA, partner agencies, and private property owners implement to improve environmental quality and socioeconomic conditions in the Region. Implemented actions are discussed in relevant sections of the Regional Plan and can be categorized as: 1) regulations (or controls) or 2) capital improvements (or environmental restoration, public facility investments). There are 186 different compliance measures currently in place and another 47 "supplemental" measures that TRPA plans to implement or that could be implemented if necessary to ensure attainment and maintenance of threshold standards The following summary highlights key programs and policies which have been implemented to promote attainment and maintenance of standards in each threshold category. Appendix I of this

2015 Threshold Evaluation Report contains the detailed list of all compliance measures by threshold category. Furthermore, every indicator summary page includes a discussion in the "Programs and Actions Implemented to Improve Conditions" section or implemented actions that address that indicator.

Water Quality

- 119 compliance measures
- Includes coverage programs, BMP requirements, SEZ encroachment and setbacks, SEZ restoration, land bank acquisition programs, Lake Tahoe TMDL, effluent limitations, marina programs, dredging and filling requirements, Environmental Improvement Program and water quality mitigation programs

Soil Conservation

- 68 compliance measures
- Includes SEZ encroachment and setbacks, SEZ restoration, coverage programs, land capability verification process, BMP requirements, excess coverage mitigation program, land bank acquisition programs, transfer of development programs, and Environmental Improvement Program

Air Quality

- 62 compliance measures
- Includes the Air Quality Mitigation Program, mass transit and shuttle programs, idling restrictions, roadway BMP implementation programs, bike and pedestrian programs, vehicle rental programs, vehicle trip reduction programs, wood heater and stationary source controls, open burning controls, prescribed burning, timber harvesting program, area plans and development right transfer incentives

Vegetation Preservation

- 27 compliance measures
- Includes tree removal requirements, stream restoration projects, vegetation management programs, SEZ encroachment, SEZ restoration, vegetation protections during construction and sensitive species protections

Wildlife

- 39 compliance measures
- Includes SEZ encroachment and setbacks, SEZ restoration, tree removal requirements, stream restoration projects, vegetation management programs, outreach and education programs, noise programs and sensitive species protections

Fisheries

- 45 compliance measures
- Includes fish habitat protections, SEZ encroachment and setbacks, SEZ restoration, BMP implementation, effluent limitations, marina programs, Aquatic Invasive Species programs, fish resources programs, stream restoration projects, vegetation management programs, outreach and education programs, filling and dredging requirements, and sensitive species protections

Noise

- 24 compliance measures
- Includes Community Noise Equivalent Level and single-event noise regulations, transportation corridor design criteria, mass transit and shuttle programs, OHV limitations, and airport noise restrictions

Recreation

- 32 compliance measures
- Includes bike and pedestrian programs, land use planning, mass transit, trolley and shuttle programs, waterborne transit services, hiking and riding facilities, density standards, and public outdoor recreation facilities

Scenic Resources

- 49 compliance measures
- Includes design standards, scenic quality program, historic resources protections, sign requirements, scenic quality improvement program, bike and pedestrian programs, SEZ encroachment and setbacks, vegetation protections, Nevada underground utility line program and public outdoor recreation facilities

Regulatory Controls

Project Review Processes

TRPA and partners implement regulatory compliance measures through their detailed review of project applications and code enforcement programs. The typical project review process begins before a project applicant prepares an application for a TRPA permit. Prior to applying for a permit, the applicant is required to verify the development potential of a subject parcel and most complete an "initial environmental checklist" to disclose potential environmental impacts including impacts related to threshold standards. For projects with the potential for such impacts, TRPA requires that the applicant prepare an environmental assessment or an environmental impact statement to compare project alternatives and disclose potential detrimental and beneficial environmental impacts. Once an application is complete, TRPA project review staff evaluate the proposal and associated application materials against TRPA Goals and Policies, the Code of Ordinances, and applicable area plans, community plans or plan area statements.

Upon permit issuance, the agency is required to add special permit conditions as appropriate to avoid detrimental environmental impacts and make findings that the project will not hamper the Region's ability to achieve and maintain threshold standards. The applicant is then required to acknowledge the requirements of the permit, after which, if all conditions are met, the permit is granted. The applicant has up to three years to initiate construction of the permitted project. Prior to construction of a project, the TRPA Code Compliance Program conducts an on-site pre-grade inspection with the applicant to ensure a clear understanding of the permit conditions. TRPA Code Compliance staff may also conduct intermediate project inspections to ensure permit conditions are being adhered to during the project's implementation. When the project is complete, TRPA staff performs a final inspection to confirm permit conditions are satisfied and the construction conforms to the approved plans.

The project review process of TRPA and partners is rigorous and multiple control points ensure the process is effective at verifying that approved projects comply with the Regional Plan and the threshold standards, and that projects are constructed in accordance with the approved conditions and requirements in order to ensure threshold attainment. Table 12-1 below summarizes the number and types of applications received between 2011 and 2015. On average, TRPA receives more than 650 project applications each year, not including administrative filings and declarations for work that is exempt from TRPA review. Over the past few years, the number of applications submitted to TRPA has steadily increased as economic conditions have improved and property owners pursue development or redevelopment projects. Many of these applications are

for verifications of existing uses or coverage[1], which are preliminary actions that are required to initiate development or transfer projects.

Table 12-1. *TRPA Project Applications by Calendar Year 2011 to 2015*

	2011	2012	2013	2014	2015
Applications Received [A]	**573**	**588**	**653**	**707**	**736**
Residential Projects [B]	117	101	115	143	134
Commercial Projects [B]	7	10	14	11	9
Recreation/Public Service Projects [B]	34	30	31	23	31
Shorezone/Lakezone Projects [B]	16	11	18	28	22
Grading Projects	22	30	29	23	26
Verifications and Banking [C]	295	353	367	396	397
Transfers of Development	20	11	26	23	29
Other [D]	62	42	53	60	88

Notes:

A. Does not include Exempt or Qualified Exempt declarations or other Administrative applications.
B. Includes New Development and Additions/Modification
C. Includes Soils/Hydrology Verifications, IPES, Land Capability Verifications, Land Capability Challenges, Verifications of Coverage, Verifications of Uses, Site Assessments and standalone Banking Applications
D. Includes Historic, Lot Line Adjustments, Temporary, Scenic, Underground Tank Removal, Subdivision of Existing Uses, Sign, Allocation Assignments, and other miscellaneous project types

Source: TRPA Accela Permit Records

Code Compliance

The Code Compliance Program is responsible for inspecting and monitoring all projects in the Lake Tahoe Region for compliance with the Regional Plan. This includes TRPA-permitted projects, exempt and qualified exempt activities, and unauthorized activities. There are four basic roles of the Code Compliance Program: code enforcement, inspection of TRPA permitted projects, memorandum of understanding (MOU) monitoring, and watercraft program management.

On average, the Code Compliance Program performs more than 800 inspections (see Table 12-2) for permitted projects each year. The program also initiates code enforcement cases for unauthorized activities, complaints, permit non-compliance or other causes. TRPA regularly audits its permitting partners to ensure that the permits issued by other jurisdictions are consistent with the TRPA Regional Plan and Code of Ordinances.

[1] *See TRPA Code of Ordinances sections 30.3.3, Land Capability Verification or 51.5.5, Verification of Existing Residential Units for more information about these types of applications.*

Table 12-2. TRPA Code Compliance Activities by Calendar Year 2013-2015

	2013	2014	2015
Permit Inspections	638	1,009	803
Code Enforcement Cases	76	104	105
Cases Resolved/Referred	43	73	72
Staff-Level Penalties	26	21	33
GB Settlements	7	10	12
MOU Project Audits	100	100	100
Security Return Inspection Audits	50	50	50
Winterization Inspection Audits	50	50	50
Source: TRPA Accela Permit Records			

Capital Improvements: The Lake Tahoe Environmental Improvement Program

Launched in 1997, the Lake Tahoe Environmental Improvement Program (EIP) is the capital improvement arm of TRPA and the Regional Plan. The EIP is a collaborative partnership of federal, state, and local agencies, private interests, and the Washoe Tribe. The EIP was created to not only restore Lake Tahoe's water clarity, but also improve its air quality, forest health, fish and wildlife habitat, and public recreation. The EIP protects the extraordinary natural and recreational resources of the Lake Tahoe Region, advancing the Region toward attainment and maintenance of adopted environmental threshold standards.

To date, nearly 500 EIP projects have been completed and hundreds more are in progress. More than $1.9 billion has been invested in the Tahoe Region since 1997, including $635 million from the federal government, $759 million from California, $124 million from Nevada, $99 million from local government, and $339 million from the private sector.

EIP ACCOMPLISHMENTS (1997 to 2015)

- Nearly 500 projects completed
- 16,343 acres of wildlife habitat restored
- 1,558 acres of stream environment zone restored[2]
- 2,770 feet of shoreline made public
- 65,380 acres of treatment to clear forests of hazardous fuels
- 729 miles of roadways upgraded to reduce erosion and storm water pollution
- 46,853 boats inspected for aquatic invasive species
- 23,502 boats decontaminated
- 152 miles of bike and pedestrian routes constructed
- 39 transit facilities updated
- 41 acres treated for invasive clams and plants

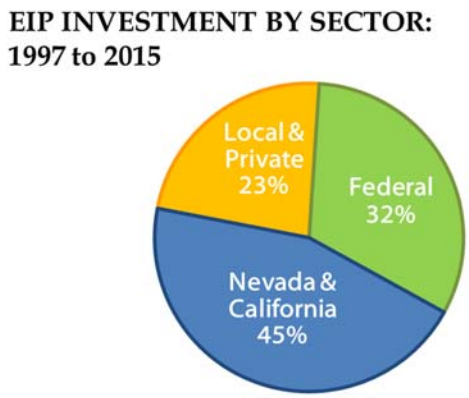


Figure 12-3. Lake Tahoe Environmental Improvement Program Funding and Accomplishments 1997-2015. Source: TRPA 2016a

[2] *This includes the 592 acres of the Upper Truckee River Marsh Restoration Project, which is currently in the planning phase. The project will be one of the largest SEZ restorations undertaken at Lake Tahoe. The Upper Truckee River watershed is the largest contributor of fine sediment to the lake.*

The EIP has six EIP focus areas—Watersheds, Water Quality, and Habitat; Forest Management; Air Quality and Transportation; Recreation and Scenic Resources; Applied Science; and Program Support. EIP projects are prioritized to provide the greatest benefit for multiple threshold categories. The following is an outline of these EIP focus areas and programs and the thresholds standards they support:

- Watersheds, Water Quality, and Habitat
    - Stormwater Management Program: surface runoff, lake and stream habitat conditions, soil conservation, stream environment zones, and water quality
    - Watershed Management Program: deciduous, meadow, and wetland riparian vegetation, uncommon plant communities, habitats of special significance, stream habitat, stream environment zones and impervious coverage, tributary water quality, and scenic quality
    - Threatened, Endangered and Sensitive Species Program: special interest wildlife and fishes, uncommon plant communities, and rare plants
    - Invasive Species Program: lake and stream habitat conditions, water quality, recreation, and non-threshold socioeconomic issues
- Forest Management
    - Forest Ecosystems and Hazardous Fuels Reduction Program: common vegetation and late seral, and old forest ecosystem
- Air Quality and Transportation
    - Air Quality and Transportation Program: ozone, particulate matter, carbon monoxide, nitrate deposition, oxides of nitrogen, and transportation corridor noise
- Recreation and Scenic Resources
    - Recreation Program: recreation quality and public access to recreational opportunities
    - Scenic Program: scenic resources
- Applied Science
    - Monitoring Program: threshold-related monitoring
    - Applied Research Program: agency research needs
    - Data and Information Management and Reporting Program: threshold-related monitoring
- Program Support, Reporting and Technical Assistance Program
    - Public outreach, operations and maintenance, and technical needs and the tracking of expenditures and accomplishments for the EIP

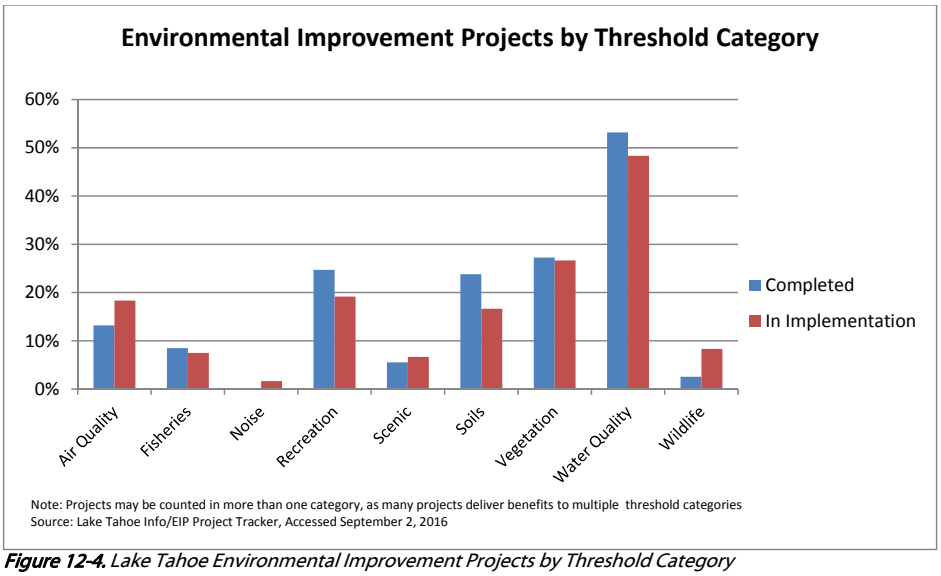


Figure 12-4. *Lake Tahoe Environmental Improvement Projects by Threshold Category*

Major EIP Project Highlights from 2011 to 2015

Water Quality

- Area Wide Stormwater Treatments
  - Bijou Area Erosion Control Project
  - Harrison Avenue Streetscape Improvement & Bike Trail
- Incline Creek/Third Creek restoration projects
- State Route 89 water quality improvement projects
- Lake Tahoe Total Maximum Daily Load (TMDL) implementation
- Upper Truckee River restoration projects
- Emerald Bay invasive species removal and control

Forest Health

- Completion of the Angora Fire Restoration
- Wildland Urban Interface Hazardous Fuels Reduction and Forest Health treatments
- Tahoe Yellow Cress Conservation Strategy

Air Quality & Transportation

- Kings Beach Commercial Core Improvement Project
- 30+ Miles of Bicycle and Pedestrian Facilities: Including Stateline to Stateline, Sawmill, Harrison Avenue Bike Paths

Recreation and Scenic

- Van Sickle Bi-State Park
- Heavenly Epic Discovery Activities
- California and Nevada Land Bank Restoration Activities and Land Acquisitions

Science

- Lake Tahoe Aquatic Invasive Species Management Plan
- Establishment of Bi-State Science Advisory Council
- "Eyes on the Lake" Education and Stewardship Program

Program Support

- Implementation of LakeTahoeInfo.org and the EIP Project Tracker

Cumulative Accounting of Regional Plan Activities

The TRPA Code of Ordinances, Subsection 16.8.2, requires TRPA to maintain a cumulative account of units of use, resource utilization, and threshold attainment and maintenance. The purpose of this accounting is to enable assessment of the cumulative beneficial and negative environmental impacts of the Regional Plan and its role in moving the Tahoe Region toward achieving interim targets and threshold standards. The interim targets (according to Subsection 16.5 of the Code of Ordinances) identify major intervals for each threshold standard, and state and federal air and water quality standards are part of the threshold attainment schedules required in the Code.

The Code of Ordinances states that the cumulative accounting shall include the following items:

A. Units of Use: residential, commercial, tourist, and recreational allocations
B. Resource Utilization: additional vehicle miles traveled, vehicle trip ends, impervious coverage, water demand, sewage disposal capacity, area of stream environment zone (SEZ) disturbance
C. Threshold Attainment and Maintenance: value of investments in water quality, air quality, transportation and coverage mitigation programs; area of SEZ restoration

Unit of Use

The Regional Plan establishes units of use for specific types of development (residential, tourist accommodation, commercial, and recreation). Units of use are essentially rights that allow development of specific project types. Allocations of new or additional units are required to be made by TRPA and local jurisdictions. By metering development, this growth management mechanism ensures that development is consistent with progress toward meeting environmental thresholds. Table 12-3 summarizes the current inventory of existing units of use in the Region, estimated banked units, remaining allocations and total development potential for residential units, commercial floor area and tourist accommodation units. Detailed tables for each type of unit of use follow.

Table 12-3. Summary of units of use, bonus units, and commercial floor area inventory

	Existing[A]	Banked[B]	Remaining Allocations/ Bonus Units/Units of Use	Total Existing and Potential Development
Residential Units	47,183 Existing Residential Units (ERUs)	116 ERUs	3,987 (311 Unused Residential Allocations Released to Local Jurisdictions)[C] (1,474 Residential Bonus Units)[D] (2,202 Unreleased Residential Allocations)[E]	51,286
Commercial Floor Area (CFA) (in sq. ft.)	6,349,051	114,107	569,110 (369,110 Remaining from 1987 Plan) (200,000 Allocated by 2012 Regional Plan)[F]	7,032,268
Tourist Accommodation Units (TAUs)	11,584	523	342 (130 in Area/Community Plans) (90 Reserved for Homewood/Boulder Bay Projects) (122 in TRPA Bonus Unit Pool)	12,449

Notes:

A. Existing as of December 31, 2015. Estimated based on a GIS query of county assessor's data, 2010 Lidar Data and TRPA permit data from 2010-2015. Approved projects that are not yet completed are not counted as existing and their development rights remain in the development potential.

B. Updated Banked totals based on TRPA analysis of file/permit data, communications with CA/NV land banks and local jurisdictions. Banked units in the local jurisdiction lines include public and privately owned parcels with approved banked development rights. Includes units received from transfers but not yet constructed.

C. Includes remaining Residential Allocations from 1987 Regional Plan and remaining Residential Allocations released to local jurisdictions from the 2012 Regional Plan allocations.

D. Includes the 2012 Regional Plan allocation of 600 Residential Bonus Units that shall only be used in Centers.

E. The 2012 Regional Plan authorized 2,600 new Residential Allocations to be released through 2032, with a yearly allocation of units to the local jurisdictions. To date, TRPA has released 398 Residential Allocations from this authorization (see Table 12-7).

F. The 2012 Regional Plan allocation of 200,000 square feet of CFA will not be made available until the remaining CFA from the 1987 Regional Plan is exhausted.

Source: LakeTahoeInfo.org/Parcel Tracker, TRPA Accela Permit Records, TRPA project application files, and local jurisdiction accounting records.

Relation to 2012 Regional Plan Amendments Analysis

The final environmental impact statement (FEIS) for the 2012 Regional Plan amendments, Appendix E, Existing Development, TRPA Code section 50.4, and Goals and Policies DP-2.2, reported on the existing, banked, remaining and total development potential for residential units, commercial floor area and tourist accommodation units as of October 2012. The figures reported in Table 12-3 vary slightly from the 2012 Regional Plan amendments analysis in four areas:

1. TRPA has improved its analysis and tracking of banked development rights, including the identification of some units that were not previously counted as banked in the 2012 analysis. The next section, *Banked Development Rights*, includes more detail on the analysis conducted to identify these banked units.
2. TRPA re-verified the remaining residential allocations through coordination and reconciliation with the local jurisdictions. This process identified 35 additional remaining residential allocations from the 2009 and 2011 releases, for a total of 149 residential allocations remaining from the 1987 Plan, compared to 114 previously reported.
3. The CFA remaining from the 1987 Regional Plan was corrected from the FEIS to reflect the actual balance remaining from the 1987 Regional Plan figure of 383,579 instead of the

rounded figure of 383,600; total existing and potential development from the 2012 Regional Plan amendments changes from 7,011,735 to 7,011,714 as a result.

4. The 2015 evaluation includes development projects that have been constructed since 2012, which changes the existing and banked units of use, including allocations of new development and the removal, restoration and banking of previously existing development. Pending projects that have been approved, but which are not yet constructed are not counted in the existing development totals and any associated allocations remain in the remaining column.

By including these changes rights, the total existing and potential development for each type of unit of use increased slightly—residential units by 0.1 percent, commercial floor area by 0.3 percent, and tourist accommodation units by 0.9 percent.

Table 12-4. *Summary Units of Use Changes from 2012 Regional Plan Amendments to 2015 Threshold Evaluation*

	2012 Regional Plan [A]				2015 Threshold Evaluation				
	Existing	Banked	Remaining Allocations/ Bonus Units/Units of Use	Total Existing and Potential Development [B]	Existing	Banked	Remaining Allocations /Bonus Units/Units of Use	Total Existing and Potential Development [B]	Difference
Residential Units	46,962	87	4,188	51,237	47,183	116	3,987	51,286	+49
Commercial Floor Area (CFA)	6,403,893	24,242	583,579 [C]	7,011,714 [C]	6,349,051	114,107	569,110	7,032,268	+20,554
Tourist Accommodation Units (TAUs)	11,947	48	342	12,337	11,584	523	342	12,449	+112

Notes:
A. Final Environmental Impact Statement for the Regional Plan, Appendix E, Existing Development, TRPA Code section 50.4, and Goals and Policies DP-2.2
B. Includes existing, banked and remaining allocations, bonus units and units of use.
C. Corrected from FEIS to reflect actual balance remaining from 1987 Regional Plan of 383,579 instead of rounded 383,600.

Banked Development Rights

The Regional Plan provides for the verification and banking of several types of legally existing development for use onsite at a later date or for transfer to another parcel. TRPA uses the term "banking" to describe the recording of a particular amount of previously existing development with TRPA that is now available for use. Only development legally established prior to and existing on October 15, 1986 or permitted by TRPA after October 15, 1986 is eligible to be banked. In order to be banked, legally existing development must first be field verified, subsequently removed, and the site restored in accordance with a restoration plan approved by TRPA. The following types of legally existing development are eligible for banking:

- Existing Land Coverage (hard or soft)
- Potential Land Coverage
- Commercial Floor Area
- Tourist Accommodation Units
- Residential Units
- Residential Development Right
- Cubic Volume
- Residential or Tourist Accommodation Floor Area

Over the past year, TRPA has developed tools to better track development rights that have been banked by private and publicly-owned parcels not associated with the existing land banks (California Tahoe Conservancy and Nevada Division of State Lands). These tools improve the

accuracy of the accounting of these banked development rights. To create this accounting, TRPA staff reviewed more than 1,000 files related to banking and verifications. Additional file review was then done to ensure that banked development rights had not been subsequently transferred or used for onsite development projects since the banking was approved by TRPA. Finally, the remaining records were entered into the TRPA Parcel Tracker and are summarized in Table 12-5 below.

Banking is a leading indicator of future development potential, as it is the required first step in transferring development rights. Moreover, because the 2012 Regional Plan provides incentives to relocate development from sensitive and remote areas into town centers, analysis of banked development rights in these areas can provide valuable insight into potential future development. For example, more than 7,100 square feet of banked CFA, 53 TAUs and nearly 380,000 square feet of associated coverage have been banked and removed from stream environment zones and 14,450 square feet of banked CFA and 769,000 square feet of associated coverage has been banked and removed from remote areas.

Table 12-5. *Estimated banked development rights[A] by location as of December 31, 2015*

Development Rights	Total Banked	Stream Environment Zones [B]	Remote Areas [B,C]
Commercial Floor Area	88,644	7,119	14,454
Tourist Accommodation Units	314	53	5
Existing Residential Units	63	3	20
Residential Development Rights	66	1	63
Coverage [D]	910,982	379,634	769,346

Notes:
A. Includes private- and publicly-owned parcels not associated with the existing land banks.
B. *Stream Environment Zones* and *Remote Areas* are not mutually exclusive; some parcels may qualify in both categories.
C. Remote Areas include all areas greater than ¼-mile from a town center.
D. Coverage includes banked hard and soft coverage (potential coverage is not included).
Source: LakeTahoeInfo.org/Parcel Tracker; TRPA and Local Jurisdiction Tracking as of May 6, 2016.

Residential

The Lake Tahoe Region is approaching full build-out for residential development, and TRPA's growth controls will meter out most of this remaining development over the next two decades. As of December 31, 2015, 92 percent of the maximum allowable residential development exists within the Region. Less than 1 percent of the remaining residential development potential is currently available for construction; including previously existing residential units that have been removed, restored and banked for future use; and remaining unused residential allocations that have been released to the jurisdictions. The remainder of the residential units are to be metered out over the next 17 years or are to be used as bonus incentives for the construction of affordable housing, sensitive lot retirement, or the transfer of residential development to town centers.

Existing Residential Units and Residential Allocations

As of December 31, 2015, there were 47,183 existing residential units within the Region. In addition, 116 previously existing residential units have been banked for future use onsite or for transfer to another site.

TRPA regulates the rate and timing of new residential growth by issuing a limited number of residential allocations each year to local jurisdictions. The 2012 Regional Plan amendments authorized 2,600 new residential allocations to be released through 2032, with a yearly allocation

of 130 units to be released based on achievement of environmental and permit compliance performance measures. Since 2012, TRPA has released 368 residential allocations to local jurisdictions, of which 44 percent have been subsequently assigned to new residential development projects. TRPA has also placed 30 residential allocations into the TRPA Incentive Pool, for the assignment of bonus units to projects that result in sensitive lot retirement, affordable and moderate-income housing, or the transfer of residential development from remote areas into town centers. The maximum development potential for residential units in the Region is 51,286 units.

Table 12-6. *Residential units accounting as of December 31, 2015*

Jurisdiction	Estimated Total Existing Residential Units [A]	Banked Existing Residential Units [B]	Remaining Unused Allocations Released to Local Jurisdictions[C]	Remaining Unreleased Residential Allocations[D]	Residential Bonus Units	Total Development Potential
City of SLT	15,559	30	27	-	109	15,725
Douglas Co.	4,359	7	21	-	67	4,454
El Dorado Co.	8,690	9	56	-	0	8,755
Placer Co.	11,215	10	88	-	53	11,366
Washoe Co.	7,359	7	97	-	120	7,583
Carson Co.	1	0	-	-	-	1
TRPA Incentive Pool	-	-	22	2,202	1,125 [E]	3,349
California Tahoe Conservancy	-	53	-	-	-	53
Nevada Division of State Lands	-	0	-	-	-	0
TOTALS	47,183	116	311	2,202	1,474	51,286

Notes:

A. Estimated based on a GIS query of county assessor's data, 2010 Lidar Data and TRPA permit data from 2010-2015.

B. Updated Banked totals based on TRPA analysis of file/permit data, communications with CA/NV land banks and local jurisdictions. See Banked Development Rights section, Page 12-18, Table 12-5. Banked units include public and privately owned parcels with approved banked development rights.

C. Includes remaining residential allocations from the 1987 Regional Plan and remaining residential allocations released since 2012 (see table 12-7).

D. The 2012 Regional Plan authorized 2,600 new Residential Allocations to be released through 2032, with a yearly allocation of 130 units. Remaining unreleased residential allocations will be given out to local jurisdictions annually, which will increase the future development potential for each jurisdiction by the corresponding amount.

E. Includes the 2012 Regional Plan allocation of 600 Residential Bonus Units that shall only be used in Centers.

Source: LakeTahoeInfo.org/Parcel Tracker, TRPA Accela Permit Records

Commented [JM1]: Updatde the residential bonus units allocated to the former North Stateline Community Plan (50 RBUs), into the California North Stateline Community Plan (13 RBUs) and Nevada North Stateline Community Plan (37 RBUs).

Table 12-7 shows the number of residential allocations provided to local jurisdictions between 2009 and 2015. As of December 31, 2015, there are 311 unused residential allocations remaining that have been released to the jurisdictions and are available for use (see Table 12-6).

Table 12-7. Residential Allocations Provided to Jurisdictions

Jurisdiction	2009	2010 [A]	2011	2012 [A]	2013	2014	2015
City of SLT	32	0	14	0	18	20	33
Douglas Co.	15	0	7	0	8	9	10
El Dorado Co.	69	0	27	0	45	47	30
Placer Co.	50	0	20	0	26	31	37
Washoe Co.	40	0	18	0	22	22	10
TRPA Incentive Pool [B]	0	0	0	0	9	1	20
Total	**206**	**0**	**86**	**0**	**128**	**130**	**140**

Notes:
A. Estimated TRPA did not release Residential Allocations to the local jurisdictions in 2010 or 2012.
B. Per TRPA Code Subparagraph 50.5.1.D, the TRPA Incentive Pool may be used for sensitive lot retirements, moderate income housing or development right transfers to centers.
Source: LakeTahoeInfo.org and TRPA Governing Board reports.

Commercial

The Tahoe Regional Planning Agency regulates commercial structures in the Lake Tahoe Region by issuing commercial floor area (CFA) and tourist accommodation units (TAUs) to local jurisdictions in accordance with Sections 50.6 and 50.7 of the TRPA Code of Ordinances.

Commercial Floor Area

Commercial floor area is based on the square footage within the outer wall of a commercial building, not including stairwells and airshafts. Accessory features such as parking areas, driveways, outside stairways, and walkways are not included in the calculation of CFA. CFA is allocated by TRPA through the Regional Plan and local jurisdictions primarily through an adopted area plan or community plan.

As of December 31, 2015, approximately 6.35 million square feet of CFA, or over 90 percent of the maximum development potential, is built within the Region. In addition, more than 114,000 square feet of previously existing CFA has been removed, restored, and banked for future use or transfer. These figures do not include more than 92,000 square feet of CFA that has been allocated and/or transferred to permitted projects that were not yet constructed as of December 2015.

Table 12-8: Commercial floor area accounting as of December 31, 2015

Jurisdiction	Total Existing CFA[A]	Banked CFA[B]	Remaining from 1987 Plan and 2012 Allocation	Total Existing and Potential Development
City of SLT	2,869,065	9,481	40,170	2,918,716
Douglas Co.	700,935	5,572	33,520	740,027
El Dorado Co.	329,044	1,550	33,395	363,989
Placer Co.	1,292,176	23,570	68,441	1,384,187
Washoe Co.	1,157,831	48,471	10,000	1,216,302
TRPA Pool	-	-	383,584 [C]	383,584
California Tahoe Conservancy	-	25,463	-	25,463
Nevada Division of State Lands	-	0	-	0
TOTALS	**6,349,051**	**114,107**	**569,110**	**7,032,268**

Notes:

A. Estimated based on a GIS query of county assessor's data, 2010 Lidar Data and TRPA permit data from 2010-2015. Approved projects that are not yet completed are not counted as existing and their development rights remain in the development potential.

B. Updated Banked totals based on TRPA analysis of file/permit data, communications with CA/NV land banks and local jurisdictions. See Banked Development Rights section, Page 12-18, Table 12-5. Banked units include public and privately owned parcels with approved banked development rights.

C. The 2012 Regional Plan allocation of 200,000 square feet of CFA will not be made available until the remaining CFA from the 1987 Regional Plan is exhausted.

Source: LakeTahoeInfo.org/Parcel Tracker, TRPA Accela Permit Records, TRPA project application files, and City of South Lake Tahoe accounting records.

Table 12-9. Existing commercial floor area by land capability and land use district as of December 31, 2015

		ESTIMATED EXISTING CFA BY LAND CAPABILITY			ESTIMATED CFA BY LAND USE DISTRICT		
Jurisdiction	Total Existing CFA[1]	Stream Environment Zone (Class 1b)	Sensitive Lands (Classes 1a, 1c, 2 & 3)	Non-Sensitive Lands (Classes 4, 5, 6 & 7)	Town Centers	Areas within 1/4 Mile of a Center	Remote Areas (More than 1/4 mile away from a town center)
City of SLT	2,869,065	1,226,811	19,110	1,623,144	1,882,559	542,997	443,509
Douglas Co.	700,935	12,588	542,929	145,418	389,323	26,900	284,712
El Dorado Co.	329,044	89,406	69,868	169,770	120,800	61,993	146,251
Placer Co.	1,292,176	477,703	21,022	793,451	690,369	29,754	572,053
Washoe Co.	1,157,831	9,855	138,281	1,009,695	973,321	15,843	168,667
TOTALS	**6,349,051**	**1,816,363**	**791,210**	**3,741,478**	**4,056,372**	**677,487**	**1,615,192**

Notes:

A. Estimated based on a GIS query of county assessor's data, 2010 Lidar Data and TRPA permit data from 2010-2015.

Source: LakeTahoeInfo.org/Parcel Tracker, TRPA Accela Permit Records, TRPA project application files, and City of South Lake Tahoe accounting records.

Under the Regional Plan, new allocations of CFA are made by local jurisdictions based on the availability of CFA in adopted community plan and area plan pools. Additional bonus pools of CFA are held by TRPA and can be used for certain projects that result in significant environmental improvements, such as EIP projects and community enhancement projects. Finally, existing CFA may be banked onsite for use by projects in the future on the same parcel, or for transfers to other parcels.

Table 12-10 summarizes CFA allocations from local jurisdictions from 2011 through 2015.

Table 12-10. *Commercial Floor Area Allocations [A,B] (in square feet)*

Jurisdiction	2011	2012	2013	2014	2015
City of SLT	0	0	8,847	0	11,429
Douglas Co.	0	0	0	2,730	0
El Dorado Co.	0	2,500	255	0	0
Placer Co.	0	0	5,104	0	4,375
Washoe Co.	0	0	0	0	-8,000 [C]
Total	**0**	**2,500**	**14,206**	**2,730**	**7,804**

Notes:
A. Does not include minor CFA additions per TRPA Code 50.6.1.B (2).
B. All CFA associated with project approvals are reported. Allocations of CFA to projects with expired permits are returned to TRPA allocation pools.
C. 8,000 sq.ft. was returned to the Washoe County CFA pool from an expired project in 2015.

Source: LakeTahoeInfo.org/Parcel Tracker, TRPA Accela Permit Records, TRPA project application files, and City of South Lake Tahoe accounting records.

Tourist Accommodation Units

TAUs are defined as units with one or more bedrooms and with or without cooking facilities that are primarily designed to be rented by the day or week and occupied on a temporary basis[3]. TAU bonus units are reserved for special projects[4] that transfer existing units from sensitive lands that have been restored, as incentives for the transfer of existing development to centers[5], or as incentives for the removal and retirement of excess coverage[6].

As of December 31, 2015, there are 11,584 existing TAUs within the Region, over 94 percent of the maximum development potential for tourist units. In addition, 329 previously existing TAUs have been removed, restored and banked for future use or transfer. These figures do not include 393 units that have been allocated and/or transferred to permitted projects which are not yet constructed. Since 2000, no TAUs or TAU Bonus Units have been allocated to projects by TRPA or local jurisdictions.

TRPA has approved one project (Boulder Bay in Washoe County) that will receive an allocation of 31 TAUs from Washoe County, however these units are not counted as the project permit has not yet been acknowledged. Additionally, the Boulder Bay and Homewood Mountain Resort projects have been approved to receive an allocation of 40 units and 50 units respectively from the TRPA bonus unit pool (previously the Community Enhancement Program Pool); these units are similarly not counted as neither project permit has been acknowledged.

[3] *TRPA Code section 90.2*
[4] *TRPA Code subsections 50.6.4.D and 50.7.1.C.*
[5] *TRPA Code subsection 51.5.3*
[6] *TRPA Code subsection 30.6.3*

Several projects have been approved that used banked or transferred TAUs. For example, in 2014 TRPA approved the Edgewood Lodge and Golf Course Improvement Project. This project will result in a new lodge building, which is proposed to include 194 TAUs. These units will be sourced from transfers of previously existing, banked units, including 97 TAUs approved for transfer from an environmentally non-compliant motel located within a stream environment zone. A dilapidated motel was demolished within a SEZ and the site restored prior to the approval of this transfer.

Table 12-11. *Tourist accommodation units accounting as of December 31, 2015*

Jurisdiction	Total Existing TAUs [A]	Banked/Received TAUs [B]	Remaining from 1987 Plan and 2012 Allocation	Total Development Potential
City of SLT	6,674	240	25	6,939
Douglas Co.	2,651	194[C]	25	2,870
El Dorado Co.	113	0	10	123
Placer Co.	1,329	69	37	1,435
Washoe Co.	817	5	33	855
TRPA Pool	-	-	212 [D]	212 [D]
California Tahoe Conservancy	-	15	-	15
Nevada Division of State Lands	-	0	-	0
TOTALS	**11,584**	**523**	**342**	**12,449**

Notes:

A. Estimated based on a GIS query of county assessor's data, 2010 Lidar Data and TRPA permit data from 2010-2015. Approved projects that are not yet completed are not counted as existing and their development rights remain in the development potential.

B. Updated Banked totals based on TRPA analysis of file/permit data, communications with CA/NV land banks and local jurisdictions. See Banked Development Rights section, Page 12-18, Table 12-5. Banked units include public and privately owned parcels with approved banked development rights.

C. Includes 194 units transferred to Douglas County for the Edgewood Lodge project, which is not yet constructed.

D. The TRPA Pool includes 90 Bonus TAUs that have been permitted for projects at Homewood Mountain Resort (50 units) and Boulder Bay (40 units) but are not yet acknowledged.

Source: LakeTahoeInfo.org/Parcel Tracker, TRPA Accela Permit Records, TRPA project application files, and City of South Lake Tahoe accounting records.

Table 12-12. Existing tourist accommodation units by land capability and land use district as of December 31, 2015

		ESTIMATED EXISTING TAUs BY LAND CAPABILITY			ESTIMATED TAUs BY LAND USE DISTRICT		
Jurisdiction	Total Existing TAUs [A]	Stream Environment Zone (Class 1b)	Sensitive Lands (Classes 1a, 1c, 2 & 3)	Non-Sensitive Lands (Classes 4, 5, 6 & 7)	Town Centers	Areas within 1/4 Mile of a Center	Remote Areas (more than 1/4 mile of a center)
City of SLT	6,674	1,772	188	4,714	5,730	554	390
Douglas Co.	2,651	289	560	1,802	2,493	0	158
El Dorado Co.	113	0	93	20	0	0	113
Placer Co.	1,329	400	50	879	646	98	585
Washoe Co.	817	0	38	779	787	30	0
TOTALS	**11,584**	**2,461**	**929**	**8,194**	**9,656**	**682**	**1,246**

Notes:

A. Estimated based on a GIS query of county assessor's data, 2010 Lidar Data and TRPA permit data from 2010-2015. Approved projects that are not yet completed are not counted as existing and their development rights remain in the development potential.

Source: LakeTahoeInfo.org/Parcel Tracker, TRPA Accela Permit Records, TRPA project application files, and City of South Lake Tahoe accounting records.

Recreation

TRPA regulates the rate and distribution of new recreation facilities in the Region by issuing PAOT, which are defined as "people at one time." PAOT is a measure of recreation capacity specifying the number of people that a developed recreation facility can accommodate at any one time. PAOT are assigned to three categories of facilities: summer day use, winter day use, and overnight use. The TRPA Code of Ordinances section 50.9 establishes maximum allowances for these categories: 6,114 PAOT in overnight facilities, 6,761 PAOT in summer day-use facilities, and 12,400 PAOT in winter day-use facilities. Projects that require additional PAOT must receive an allocation approved by TRPA. Table 12-13 shows the current inventory of PAOT categories and the remaining balances for each category.

Table 12.13: Cumulative accounting of PAOT allocations

PAOT Categories	Regional Plan Allocations	Assigned as of 2011 Evaluation	Assigned 2011 to 2015	PAOTs Remaining	Percent of All PAOTs Assigned
Summer Day Use[A]	6,761*	1,192	530	5,039	25.5%
Winter Day Use[B]	12,400	5,267	0	7,133	42.5%
Summer Overnight[C]	6,114	394	0	5,720	6.4%
Total	25,275	6,853	530	17,892	29.2%

Notes:

A. Per TRPA Code Subsection 50.9.3.C.2, 2,000 PAOTs are reserved for marina and boat launching facility expansion pursuant to a master plan. These PAOTS apply to all marinas, boat launching facilities, rural sports, golf courses, visitor information centers, off-road vehicle courses, and tour boat operations. PAOTs apply when a federal agency or state department of parks and recreation (or their permittees) operate a recreation center, participant sports facility, sport assembly facility, or beach recreation or day use area.

B. For downhill ski areas pursuant to a master plan pursuant to TRPA Code Subsection 50.9.3.c.3.

C. These PAOTs apply to certain developed campgrounds, group facilities, and RV parks.

Source: TRPA Accela Permit Records, Prior TRPA Threshold Evaluations

TRPA allocated 470 summer day-use PAOT to Heavenly Ski Resort (under lease with U.S. Forest Service, Lake Tahoe Basin Management Unit) for the Epic Discovery project, and 60 PAOT to the Beach Shack project in Placer County during the reporting period (Table 12-14).

Table 12-14. Recreational allocations in Persons At One Time (PAOTS)

	2011	2012	2013	2014	2015
All Jurisdictions	0	470	0	60	0

Source: TRPA Accela Permit Records

Resource Allocations

Additional Vehicle Miles Traveled and Vehicle Trip Ends

TRPA measures changes in highway traffic by measuring vehicle miles traveled (VMT) and daily vehicle trip ends (DVTE). VMT represents the total miles traveled by vehicles during a given period within the Lake Tahoe Region. In 2014, the most recent year for which traffic modeling data were available, there were an estimated 1,937,070 VMT in the Lake Tahoe Region[7] (see VMT indicator sheet in the Air Quality chapter of this evaluation). Trip ends are the total of all trips entering plus all trips exiting a project area during a given period of time; one daily vehicle trip end is counted each time a vehicle enters or exits a property.

As Table 12-15 indicates, DVTE and VMT have fluctuated annually during the five-year reporting period. Overall, the change in DVTE and VMT indicate 236 fewer daily trip ends and 21,991 fewer vehicle miles travelled during the period. As indicated in the air quality chapter of this report, overall VMT levels are at or somewhat better than target.

7 Based on TRPA TransCAD model using California Department of Transportation and Nevada Department of Transportation traffic counts.

Table 12-15. Change (Δ) in Daily Vehicle Trip Ends (DVTE) and Vehicle Miles Traveled (VMT)

Jurisdiction	2010	2011	2012	2013	2014	Total Δ by Jurisdiction
Douglas						
DVTE	800	1,259	-1,549	-2,732	3,724	**1,502**
VMT	3,200	11,353	-14,628	-12,649	15,082	**2,358**
Washoe						
DVTE	0	251	-892	-378	981	**-38**
VMT	0	6,171	-14,495	-1,908	6,565	**-3,667**
El Dorado						
DVTE	-1,500	4,200	-200	0	-7,900	**-5,400**
VMT	-5,643	13,935	-10,840	0	-33,866	**-36,414**
Placer						
DVTE	-800	1,000	-500	0	4,000	**3,700**
VMT	-4,040	14,477	-12,185	0	17,480	**15,732**
Annual Δ						
DVTE	**-1500**	**6,710**	**-3,141**	**-3,110**	**805**	**-236**
VMT	**-6,483**	**45,936**	**-52,148**	**-14,557**	**5,261**	**-21,991**

Notes: Based on traffic counts collected by Caltrans and NDOT. VMT is calculated by TRPA using average trip length, survey data and modeling.

Source: TRPA, Caltrans and NDOT Annual Traffic Count Programs

Impervious Land Coverage and Area of Stream Environment Zone Disturbance

Additional impervious land coverage for the 2011-2015 reporting period is shown in Table 12-16. New land coverage in this table was calculated using water quality mitigation fee collection data for TRPA approved projects, including projects approved by local jurisdictions though delegation memorandums of understanding.

Table12-16. New impervious land coverage acres [A] by evaluation period

Jurisdiction	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
	Acres	Acres	Acres	Acres	Acres
Douglas	7.0	6.0	6.5	3.4	0.5
Washoe	29.7	17	15.7	5.6	10.9
El Dorado	32.1	40.4	46.1	28.1	4.2
Placer	25.5	28.7	35.1	15.3	3.3
Total	**94.4**	**92.1**	**103.4**	**52.4**	**18.9**

Notes:
A. Acres are calculated from underlying square feet; totals may not sum due to rounding.
B. This figure does not account for reductions of land coverage for environmental restoration projects or excess land coverage mitigation (pursuant to Chapter 30 of the Code of Ordinances).

Source: TRPA Threshold Evaluations and Water Quality Mitigation Fee collection data from TRPA Accela Permit Records

New land coverage is different from "transferred" and "relocated" land coverage, which is not considered "new" by definition in Chapter 90 of the Code of Ordinances and is not reflected in Table 12-16 for this reason. Similarly, Table 12-16 does not account for decreases in land coverage

that have occurred due to coverage removal for banking purposes; nor does the table reflect decreases in land coverage that occurred pursuant to TRPA's excess land coverage mitigation programs included in Chapter 30 of the Code of Ordinances.

As Table 12-16 indicates, there was a significant decrease in the amount of new land coverage created from 2011 to 2015 compared to prior periods. This decrease is likely related to the overall economic conditions during this period and a decrease in developable vacant land in the Region as it approaches "build-out."

Total new land coverage created from 1991 through the end of 2015 equaled 361 acres or 15.7 million square feet. This figure does not account for reductions of land coverage for environmental restoration projects or excess land coverage mitigation.

Table 12-17 summarizes the placement of impervious cover in Lake Tahoe Region using the Bailey (Bailey 1974) land capability classes. This table summarizes the data from Table 5-5 in the soils conservation chapter of this report for impervious coverage in each category. Based on these findings, impervious coverage in land capability class 1b (SEZ) and class 2 are estimated to exceed allowable coverage limits while all other land capability classes are below the allowable levels. However, this analysis shows that more than 10 acres of impervious coverage in class 1b (SEZ) were removed between 2010 and 2015.

Table 12-17. *Total area and estimated impervious cover within each land capability class in 2015.*

Land Capability Class	Total Area Within Class (Acres)	Allowable Impervious Cover (Acres/% Impervious)	Estimated Impervious Cover 2010 (Acres/% Impervious)	Change August 2010-August 2015 (Acres)	Estimated Impervious Cover 2015 (Acres/% Impervious)
Class 1a	23,558	236 (1%)	175 (0.7%)	0.82 removed	174 (0.7%)
Class 1b	11,304	113 (1%)	783 (6.9%)	10.39 removed	773 (6.8%)
Class 1c	53,957	540 (1%)	505 (0.9%)	0.17 added	505 (0.9%)
Class 2	23,648	236 (1%)	279 (1.2%)	0.03 removed	279 (1.2%)
Class 3	16,920	846 (5%)	358 (2.1%)	0.06 added	358 (2.1%)
Class 4	32,386	6,477 (20%)	1,263 (3.9%)	2.42 added	1265 (3.9%)
Class 5	10,347	2,587 (25%)	1,099 (10.6%)	4.90 added	1104 (10.7%)
Class 6	24,308	7,292 (30%)	2,214 (9.1%)	6.93 added	2221 (9.1%)
Class 7	5,525	1,658 (30%)	1,283 (23.2%)	3.52 added	1287 (23.3%)
Total	**201,953**	**19,984 (9.9%)**	**7,959 (3.9%)**	**6.75 added**	**7974 (3.9%)**

Source: *Land capability data is based on the 2007 NRCS Soil Survey (USDA-NRCS 2007). Impervious cover estimates based on evaluations of high resolution LiDAR and multispectral data collected in August 2010 and permitted development between August 2010 and August 2015.*

Water Demand

Water rights in the Lake Tahoe Region are controlled by the Truckee River Operating Agreement (TROA), which was signed on September 6, 2008 and went into effect in 2015. The TROA formalizes, regulates and monitors water rights and water use in the Tahoe Region, the Truckee River watershed, and the final outflow areas of Pyramid Lake and the Carson River in Nevada. Under the TROA, total water extractions in the Tahoe Region are capped at 34,000 acre feet per year, limiting each state as follows:

California: 23,000 acre feet per year
Nevada: 11,000 acre feet per year

The Tahoe Region has numerous public water systems, including large-scale and small-scale (i.e., less than 200 households) systems. In addition, there are many single-use intake lines along Lake Tahoe's shoreline and wells. The large-scale water and wastewater treatment systems in the Tahoe Region are provided by public utility districts (PUDs) and general improvement districts (GIDs). On the California side of the Region, PUDs may acquire, construct, own, complete, use, and operate a variety of services, including water, electricity, recreational facilities, drainage facilities, street lighting, and fire protection. Similarly, Nevada GIDs oversee the development, maintenance, and use of public facilities such as water and sewer systems, streets and sidewalks, and parks and open space. Since 1968, all wastewater in the Tahoe Region has been treated and pumped out of the Region to avoid discharge into the lake. Districts are bound by service areas and directed through boards created by local governments.

The following PUDs and GIDs operate within the Tahoe Region:

Cave Rock Estates GID	Oliver Park GID
Incline Village GID	Round Hill GID
Kingsbury GID	South Tahoe PUD
Lakeridge GID	Tahoe City PUD
Logan Creek Estates GID	Zephyr Cove GID
Marla Bay GID	Zephyr Heights GID
North Tahoe PUD	Zephyr Knolls GID

The Tahoe Water Suppliers Association (TWSA, 2015) consists of public water suppliers in the Lake Tahoe Region that use Lake Tahoe as their source of drinking water. TWSA consists of:

Cave Rock Water System (Cave Rock; Douglas County)
Edgewood Water Company (Edgewood)
Glenbrook Water Cooperative (Glenbrook)
Incline Village General Improvement District (IVGID)
Kingsbury General Improvement District (KGID)
Lakeside Park Association (LPA)
Cave Rock Water System (Cave Rock; Douglas County)
North Tahoe Public Utility District (NTPUD)
Round Hill General Improvement District (RHGID)
Skyland Water Company (Skyland; Douglas County)
South Tahoe Public Utility District (STPUD)
Tahoe City Public Utility District (TCPUD)
Zephyr Water Utility (Zephyr; Douglas County)
North Tahoe Public Utility District (NTPUD)

In 2015, TWSA suppliers served approximately 20,597 service hookups, supplying water to approximately 34,410 residents. The average daily water flow for TWSA suppliers ranges from 100,000 gallons per day (gpd) to 2,690,000 gpd. Peak daily water flow ranges from 424,000 gpd to 5,945,000 gpd (TWSA, 2015).

Numerous water purveyors distribute water from groundwater sources throughout the Region, including South Tahoe Public Utility District, Lukins Brothers Water and the Tahoe Keys Water Company.

Water demand in the Lake Tahoe Region varies year to year due to changes in resident and/or visitor populations, length of summer growing seasons (for outdoor irrigation), and drought conditions (which can lead to local water restrictions imposed by local utility districts). Water conservation is encouraged by many Lake Tahoe water purveyors. The South Tahoe Public Utility District (STPUD), for example, provides a lawn turf buy-back program, water-efficient appliance rebates, leak detection assistance, and irrigation efficiency evaluations.

Sewage Disposal

The Porter-Cologne Act in California, and an executive order by the Governor of Nevada dated January 27, 1971, prohibit discharges of domestic, municipal or industrial wastewaters to Lake Tahoe, its tributaries, groundwater, or the portion of the Truckee River within the Tahoe Region.[8] As a result, Tahoe Region wastewater is generally collected, treated, and discharged to locations outside of the Region in one of the following four sewer export systems:

1. South Tahoe Public Utility District – Wastewater for the City of South Lake Tahoe and unincorporated portions of El Dorado County (south of Emerald Bay) is exported to Alpine County, California, via a sewer export line over Luther Pass (California State Route 89).
2. Douglas County Sewer Improvement District – Wastewater for Douglas County is exported to the Carson Valley in Nevada, via a sewer export line over Daggett Pass (Nevada State Route 207, Kingsbury Grade).
3. Incline Village General Improvement District – Wastewater for Washoe County is exported to the Carson City/Stewart area, Nevada, via a sewer export line over Spooner Summit (U.S. Highway 50).
4. Tahoe City and North Tahoe Public Utility Districts – Wastewater for Placer County and the portion of El Dorado County north of Emerald Bay is exported to the town of Truckee, California, via a sewer export line in the Truckee River Canyon (along California State Route 89).

Exceptions may be granted to discharges under alternative plans (for wastewater disposal authorized by state law, and approved by a state agency with appropriate jurisdiction). TRPA may also approve sewage holding tanks or other no-discharge systems in accordance with Subparagraph 60.1.3.C of the TRPA Code of Ordinances as a temporary measure, or as a permanent measure in remote public or private recreation sites, where a sewer system would create excessive adverse environmental impacts.

The California Water Quality Control Board, Lahontan Region, has authority to issue wastewater discharge waivers in the California portion of the Lake Tahoe Region. In Nevada, this authority rests with the Nevada Department of Environmental Protection (NDEP). Exceptions have been given to cabins in remote summer home tracts on the California side of the Region (including Upper and Lower Echo Lakes, Fallen Leaf Lake, Lily Lake, Glen Alpine, and Emerald Bay). Some summer homes are allowed to discharge "gray water" to leach field systems, but are also required to contain and transport "black water" sewage to an approved sewer dump station for treatment in a sewer plant.

[8] *See section 60.1, TRPA Code of Ordinances*

There are five sewer treatment plants located in the Tahoe Region, each of which exports treated sewage into one of the four export lines noted above. Existing sewage capacity for these plants, including "reserved" capacity, is summarized in Table 12-18, below. As the table indicates, none of the five Tahoe sewer treatment plants are near their total capacity. In discussions with sewer plant officials, all five sewer plants were originally designed for a much larger population than currently expected at Lake Tahoe. Excess plant capacity is a result of a number of factors, including TRPA growth controls and localized population decreases, combined with water conservation efforts, and public purchases of environmentally sensitive lands.

Table 12-18. *2015 Sewage Disposal Capacity in Millions of Gallons per Day (MGD)*

Sewer Collection District	Approximate 2015 Peak Sewer Flow	Approximate Capacity[1]	Approximate Reserve Capacity
North Tahoe PUD	0.65[3]	6.00	5.35
Tahoe City PUD[2]	1.16	7.80	6.64
South Tahoe PUD	4.93	7.70	2.77
Incline Village GID	1.61	3.00	1.39
Douglas County SID	2.31	3.75	1.44

Notes:
1. The North Tahoe and Tahoe City Public Utility Districts share a common North Shore sewer export line to Truckee, where sewage is combined with four other sewer collection districts for treatment by the Tahoe-Truckee Sanitation Agency (T-TSA). Sewer plant capacity for NTPUD and TCPUD is, therefore, a factor of export line capacity and total capacity of the T-TSA treatment facility (9.60 million gallons per day).
2. TCPUD's sewer collection is split between a North Shore and a West Shore collection system. TCPUDs portion of the shared TCPUD-NTPUD North Shore export line has a capacity of 3.5 MGD. TCPUD's West Shore collection system has a capacity of 4.3 MGD, and is "fixed" by pumping capacity at their Sunnyside pump station.
3. Equals 2015 average sewer flow. A peak flow estimate was not available from NTPUD.

Source: Tahoe Region Sewer Districts

Area of SEZ Restoration

Stream environment zones are defined in Chapter 90 of the TRPA Code of Ordinances and include marshes and meadows that are critical filters for water flowing into Lake Tahoe. Significant SEZ disturbance, especially in urbanized areas close to Lake Tahoe, is allowing sediments and nutrients to flow into the Lake above natural levels, and is contributing to water quality decline.

All stream environment zones in the Region are protected from additional development, and legacy development in SEZs is acquired and restored where possible. As described in the soil conservation chapter of this report and detailed in Appendix E, the U.S. Forest Service, California Tahoe Conservancy, and Nevada Division of State Lands acquire and protect SEZs (TRPA 1988), and TRPA's permit review process and development restrictions prevent the degradation of non-protected SEZs. Approximately 924 acres of SEZ have been restored in the Lake Tahoe Region since 1980. This accounting of SEZ restoration projects does not include restoration projects completed by the U.S Forest Service in the mid-1980s, which included restoration of 680 acres between 1984 and 1987 (TRPA 1988). By including these additional acres, the total area of SEZ r

Threshold Attainment and Maintenance

Investments in Water Quality, Air Quality, Transportation, and Coverage Mitigation Programs

Subparagraph 16.8 of the TRPA Code of Ordinances requires the agency to report the value of investments in water quality, air quality, transportation, coverage mitigation programs, and the area of stream environment zone (SEZ) restoration. To satisfy this requirement, Table 12-19 incudes

the balances, contributions to, and expenditures from the various mitigation funds maintained for this purposes from 2010 through 2015.

Table 12-19: *TRPA capital improvement expenditures 2010-2015*

TRPA Trust Fund Account	Beginning Balance July 1, 2010	Contributions and Interest July 1, 2010 through June 30, 2015	Expenditures [A] July 1, 2010 through June 30, 2015	Ending Balance, June 30, 2015
Water Quality Mitigation	$1,884,850	$2,480,477	$2,409,002	$1,956,326
Stream Zone Restoration Program	$1,597,897	$567,665	$1,051,012	$1,114,551
Air Quality Mitigation	$2,024,101	$1,932,224	$2,621,254	$1,335,070
Operations & Maintenance	$553,434	$443,022	$76,909	$919,547
Excess & Offsite Land Coverage Mitigation	$10,918,318	$3,566,559	$13,652,048	$832,829
Total	$16,978,600	$8,989,948	$19,810,226	$6,158,324

Notes:
A. Includes refunds and approved transfers between funds.

Source: TRPA Mitigation fund accounting records.

TRPA collects mitigation fees for projects approved by the agency or one of its partners (through memoranda of understanding) in place of physical mitigation incorporated into approved projects. Priority for release of "in-lieu" mitigation funds is given to restoration projects or capital improvement needs listed in the Environmental Improvement Program (EIP) in accordance with Chapter 15 of the TRPA Code of Ordinances. The types of projects that were allocated these funds between 2010 and 2015 are listed in Table 12-20 for each mitigation category.

Table 12-20: *Project type by mitigation fund source (percent of funds expended and obligated)*

Expenditures & Obligations July 1, 2010 through June 30, 2015	Air Quality Mitigation	Water Quality Mitigation	Stream Zone Restoration Program	Operations & Maintenance	Excess & Offsite Land Coverage Mitigation
Bike and Pedestrian Lane Improvement Projects	73%	-	-	6%	-
Erosion Control Projects	-	29%	100%	-	-
Fire Rehabilitation	-	19%	-	-	-
Roadway Capital Improvement Projects	3%	8%	-	55%	-
Street Sweepers	20%	6%	-	16%	-
Transit Services Equipment Purchase	4%	-	-	-	-
Water Quality Maintenance and Operational Support	-	39%	-	23%	-
Land Bank and Operational Support	-	-	-	-	100%
Total	100%	100%	100%	100%	100%

Water Quality Mitigation Funds

The TRPA Water Quality Mitigation Fund was established to provide local jurisdictions with funding to implement water quality improvements, erosion control or stream environment zone restoration projects. Water quality mitigation fees are required to be paid for any new land coverage that is created by projects.

From July 1, 2010 through June 30, 2015, TRPA allocated water quality mitigation fund expenditures totaling $2.4 million. Of these expenditures, 29 percent were invested in water quality treatments, including erosion control and source runoff improvements, and the implementation of best management practices on developed properties. An additional 39 percent was allocated for water quality maintenance and operational support. Combined, roadway capital improvement projects and the purchase of street sweepers accounted for 14 percent of expenditures. The remaining 19 percent was invested in forest fuels reduction and thinning to reduce fire risks and improve forest health (Table 12-20).

From July 1, 2010 through June 30, 2015, TRPA has approved Stream Zone Restoration Program expenditures and obligations totaling nearly $1.05 million. All of these funds were invested in water quality treatments, including erosion control and source runoff improvements, and the implementation of best management practices on developed properties (Table 12-20).

Air Quality Mitigation Fund

The TRPA Air Quality Mitigation Fund is used to offset the regional and cumulative traffic and air quality impacts of additional development, typically projects that add commercial floor area or otherwise increase daily trips. These funds are distributed to local jurisdictions or the Tahoe Transportation District (TTD) for expenditure consistent with the Regional Transportation Plan or 1992 Air Quality Plan, in accordance with Section 65.2.6 of the Code of Ordinances. In general, these mitigation funds are used to build bicycle trails, improve intersections, purchase and operate street sweepers, and enhance public transportation systems.

From July 1, 2010 through June 30, 2015, TRPA has allocated air quality mitigation fund expenditures totaling $2.6 million. Of these funds, 73 percent was invested in pedestrian and bike trails supporting air quality improvements and enhanced recreation. Seven percent was invested in transit fleet buses and equipment, and roadway improvements and 20 percent was invested in street sweepers (Table 12-20).

Operations and Maintenance Mitigation Fund

The TRPA Operations and Maintenance Fund was established to fund the repair and maintenance of EIP projects, such as bike lane/path restriping or surface repairs, and water quality treatment facility maintenance, or EIP project related operations of either a one-time or limited duration, such as project effectiveness monitoring, project implementation management, and expanded transit operations. Up to 25 percent of the air and water quality mitigation funds received into the accounts above may be set aside for EIP project/program related administration, operations and maintenance, or effectiveness monitoring expenditures.

From July 1, 2010 through June 30, 2015, TRPA allocated operations and maintenance fund expenditures totaling nearly $77,000. Of these funds, 55 percent was invested in roadway maintenance and capital improvement projects, 16 percent was invested in the operation and maintenance of street sweepers, 23 percent went to the maintenance and operation of water quality improvements, and 6 percent went to pedestrian and bike trail maintenance (Table 12-19).

Excess and Offsite Land Coverage Mitigation Fund
The TRPA Excess Land Coverage Mitigation Fund is established in Subsection 30.6 of the Code of Ordinances, and is collected in lieu of on-site or off-site land coverage reductions for projects with excess land coverage. Excess land coverage is the amount of legally created land coverage existing within s project area that exceeds the area's base allowable land coverage. Excess land coverage can be mitigated several ways: 1) through the payment of an excess coverage mitigation fee; 2) by reducing land coverage onsite or offsite; or 3) by expanding the project area.

Excess and Offsite Land Coverage Mitigation Funds are provided by TRPA to land banks operated by the California Tahoe Conservancy (Conservancy) and Nevada Division of State Lands (NDSL) to provide land coverage/impervious surface reduction. Land banks achieve land coverage reductions through the purchase of vacant parcels with development potential and placement of deed restrictions on them, or the purchase of properties with coverage and subsequent removal of coverage. Reducing land coverage has been demonstrated to improve water quality and habitat quality because it allows water to infiltrate the soil rather than flow directly into surface waters, and allows for the reestablishment of native vegetation important for wildlife.

From 2007 to 2011, the Conservancy withdrew approximately $500,000 per year from the excess and offsite land coverage mitigation fund. However, in recent years, these withdrawals increased significantly, with nearly $10.8 million in reimbursements to the Conservancy occurring between 2011 and 2015, primarily to compensate the Conservancy for previously unreimbursed land purchases and coverage retirements. NDSL withdrew more than $2.4 million between 2011 and 2015. Incoming contributions and interest totaled more than $3.5 million during this period. As a result of these withdrawals, the fund balance was $832,829 at the end of fiscal year 2015.

Other Mitigation Funds

Shorezone Mitigation Funds
Mitigation fees collected for certain shorezone projects are used to fund studies assessing existing or potential impacts created by shorezone structures, methods for achieving restoration within the shorezone, or to fund fish habitat restoration projects (Subparagraph 86.6, Code of Ordinances). Currently there is approximately $97,000 in this fund.

Rental Car Mitigation Fund
Chapter 65.4 of the Code of Ordinances establishes a Rental Car Mitigation Program, which is intended to assist the achievement and maintenance of threshold standards for air, and water quality. TRPA collects and transfers funds from its Rental Car Mitigation Program fund to the Tahoe Transportation District (TTD) when it finds that the expenditure is consistent with the Regional Transportation Plan and Air Quality Plan (RTP-AQP 1992). The TTD primarily uses these funds to support public transportation systems and the administration of TTD. Revenue and expenses for the TRPA Rental Car Mitigation Program from fiscal years 2011 to 2015 are summarized in Table 12-21, below. The net differences between revenues and expenses are related to the timing of the receipt of funds and subsequent distributions to TTD.

Table 12-21: *Rental car mitigation fee revenue and expenses (by fiscal year, in dollars).*

	2011	2012	2013	2014	2015	Total
Revenue	$81,641	$67,130	$91,312	$76,147	$82,363	$398,591
Expenses	$89,725	$92,922	$141,482	$77,577	$71,154	$472,859
Net	-$8,084	-$25,792	-$50,171	-$1,430	$11,209	-$74,269

Source: Tahoe Transportation District

Chapter 12 Implementation and Effectiveness References

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CHAPTER 13
Conclusions
and Recommendations

This chapter examines the findings of the 2015 Threshold Evaluation and places the details in the broader context of the Lake Tahoe Region's suite of management objectives. It is an opportunity to look outside the resource silos that house individual standards and identify larger patterns, themes, and emerging issues that cut across individual disciplines. The recommendations included in this chapter have the benefit of being informed by the thoughtful comments of 15 independent scientific experts who peer reviewed draft versions of this report, the seven peer reviewers of the 2011 Threshold Evaluation Report, and the five threshold evaluation reports that preceded this report.

The results of the 2015 Threshold Evaluation Report suggest that the policies and on-the-ground restoration and redevelopment projects implemented by TRPA and partners under the Regional Plan continue to move the Region in the right direction. Of the 110 standards for which status determinations could be made in this evaluation, 77 (70 percent) were found to be "at or better than target" or "considerably better than target." That number is up from 58 (63 percent) in the 2011 evaluation. In addition, just two indicators were found to be declining relative to target in 2015, down from five indicators in 2011. These findings are broadly consistent with earlier evaluations, which have each shown that incremental, but measurable progress continues to be made.

It is important to place these findings in the broader context of the Region's long term goals for recovery from legacy impacts. Logging, grazing, and unregulated development shaped the landscape for 150 years. When the threshold standards were adopted, it was widely acknowledged that many represented goals of long duration for recovery and restoration of the Region that would not be attained quickly or even within a decade. Within water quality this is explicitly stated in the text of the standard, "*These numeric threshold standards for Pelagic Lake Tahoe are currently being exceeded and will likely continue to be exceeded until full implementation of the pollutant loading reductions prescribed by the Lake Tahoe Total Maximum Daily Load program are implemented by the State of California and Nevada*." In fact, the implementation plan laid out in the Total Maximum Daily Load (TMDL) framework for restoring the historic clarity of the lake establishes pollutant load reduction over 65 years (Lahontan & NDEP 2010).

Threshold evaluation reports therefore serve as a check-in on the course to recovery. Incremental progress towards attainment has been reported in each of the five threshold evaluation reports, and this one is no different. Along with gains in important areas, the report also highlights areas of emerging concern that require additional attention. For example, the observed decline in deep

water plant communities and apparent declines in high elevation cushion plant communities are findings that may warrant research to understand the drivers or additional management consideration. The continued increase in pelagic primary productivity suggests the lake ecosystem continues to change, and additional research is needed to determine what the trend means for lake health and to understand its underlying drivers. Standards for which no status determination was possible continue to stymie the report. Status determinations were not possible for 38 percent (68 standards) of the 178 standards because of ambiguity in the standard, reference to an unknown historic baseline, or insufficient data. The proportion of standards for which status determinations could not be made, decreased from the 2011 evaluation which did not assign status to 39 percent of standards (59 standards). This is nonetheless an area where critical assessment in the threshold update initiative of those unmeasurable standards themselves and the value of the information they intend could ultimately improve the overall evaluation system.

Programmatic Recommendations

Following the 2011 Threshold Evaluation Report and the 2012 Regional Plan Update, the TRPA Governing Board identified priority areas where additional environmental gains could be achieved, gains that the 2015 report also flags for attention. In response to those emerging trends, the Board directed TRPA to work on seven strategic initiatives between 2015 and 2020; 1) Development Rights, 2) Shoreline, 3) Transportation, 4) Forest Ecosystem Health, 5) Aquatic Invasive Species Control, 6) Stormwater Operations and Maintenance Funding, and 7) Streamline and Update Monitoring and Thresholds. The findings of this report reinforce that those identified initiatives are focusing on the right areas and also flags some new linkages within the seven initiatives and their areas of concern.

As examples, the nearshore is impacted by the presence of aquatic invasive species and stormwater runoff. Development rights transfers and where development is located in the Region impacts sensitive land restoration and the transportation network required to move people around the region. The forest ecosystem health initiative is closely tied with the threshold monitoring and update initiative, because it highlights the disconnect between the metrics presented in the threshold evaluation report and the information forest managers most need to effectively manage the forests. The threshold update initiative is closely tied with all other initiatives and everything the agency does because it asks, “are we aimed at the right targets?” and “do we have the best information necessary to make good management decisions?”

The seven ongoing initiatives are comprehensive, touching virtually every part of the Region, from large landscape forest management in remote areas to development and transportation in urbanized environments and the ecosystem of the lake at the center of it all. In every corner of the Tahoe Basin, partnerships are asking the same question, “can we do better?” The findings of the report and recommendations of the peer reviewers suggest the question is properly framed and that we should continue to focus on this diverse set of resource areas.

In addition, the report suggests some new areas for adaptive management. A clear example of the interconnectedness of the system is the threat that increased on road parking near recreation sites poses to the trending improvements in the scenic thresholds. The problem reflects increasing numbers of visitors, which implicates the transportation system and recreation site management, which touches the recreation standards and metrics. Cross-cutting effects like this suggest that we should continue to ask about the ties that bind the initiatives and how the work of one initiative can deliver outcomes in another.

Both the observed successes and causes for concern documented in this report informed the development of two types of recommendations included in this chapter. The first are programmatic recommendations to promote standard attainment. The second focus on the threshold update initiative and taking a comprehensive look at the threshold standard system to ensure that it continues to reflect the most important values of the Region, is based on the latest science, and provides managers with the information they need to effectively manage this natural treasure.

The next sections identify themes for action by TRPA or within the larger basin partnership to advance further threshold gains needed in response to the report's findings.

Partnerships and Progress

TRPA is charged with coordinating the many partners in the Region to achieve shared goals that cut across jurisdictions, organizations, and governments. None of the agency's daily work or the seven strategic initiatives can be accomplished in isolation by TRPA alone. Recognizing the complex landscape in which threshold progress and restoration occur is essential to the basin's collective impact. And in the Region, partnerships are how we develop and implement the plans that transform our aspirational goals into reality.

The report highlighted two facts about the Region: 1) partnerships drive progress in the Region, and 2) as emerging issues have been flagged (in threshold evaluation reports and elsewhere) new partnerships have emerged to respond and established partnerships have evolved to meet the challenges. The number of partnerships successfully promoting attainment of our shared objectives are too numerous to count. Below are some notable successes and these and others like them are the means to respond to threshold report findings:

Aquatic Invasive Species - When the threat of quagga mussel invasion at Lake Tahoe became apparent 10 years ago, TRPA and partners convened to set the direction and guide AIS management for the Region. The Aquatic Invasive Species Coordinating Committee (AISCC)is comprised of representatives from 14 agencies – federal, regional, state – and is further supported by local governments and private NGOs. The AIS program now also reaches outside the region to a larger western states and national coalition to leverage legislative influence, funding, and best practices. Building and maintaining an environment where these types of far-reaching and robust partnerships are possible and successful is the first step toward the actions needed in response to evaluation reports like this one. The AISCC is a recent example of how continually growing partnerships leads to successful responses to emerging issues.

Lake Tahoe TMDL – In response to the observed decline of a third of the lake's clarity over several decades, local, state and national agencies joined together to develop the Lake Tahoe Total Maximum Daily Load (TMDL), which charts a course of action to restore the historic clarity of the lake. The TMDL, signed in 2011, is a science based framework for reducing pollutant loads in the lake. Coupled with TRPA's work, the TMDL partnerships provide unprecedented collaboration, science, and added muscle to the regional efforts to restore clarity. Because the research that went into the TMDL revealed the specific pollutants and their sources that are most adversely affecting the lake, TRPA and its' partners can now zero in on programs that have the biggest positive impact on clarity.

Tahoe Yellow Cress – The Tahoe Yellow Cress Adaptive Management Working Group began 15 years ago to prevent the disappearance of this unique and rare Lake Tahoe wildflower. The group guided the study of the plant's ecology and developed the first comprehensive

conservation strategy in 2002, and has been actively implementing it ever since. In October 2015, the U.S. Fish and Wildlife Service announced its decision not to list Tahoe Yellow Cress as a federally endangered or threatened species after an extensive review found previously identified habitat threats no longer pose significant risk to the health and well-being of the species. That decision was a direct result of the collaborative partnership in the Region working to ensure the species survives.

New and similar partnerships are now being built and nurtured in response to emerging ecosystem conditions of concern. Far-reaching coalitions are being built to address interregional transportation, large forest and vegetation landscapes, recreation and visitor engagement management, and nearshore water quality conditions. We do not have to wait for a report every four years to act, and as soon as the need for building new partnership initiatives becomes apparent, we start organizing around actions that are already underway. It is these new associations of partners collaborating on solutions to emergent issues that will account for continued progress toward our regional shared goals.

As part of the commitment to adaptive management, TRPA is continually asking itself how it can be a better partner. As part of the threshold review process, opportunities emerged for TRPA to foster new partnerships and better support existing partnerships in the Region to promote threshold attainment.

1. Continue to Invest in Retooling Communication

   The foundation of successful partnership is communication. Nearly six years ago the agency set new strategic goals for improved information access and transparency. The goal was to shorten the adaptive management lifecycle and promote engagement with stakeholders. The peer reviewers of 2015 Threshold Evaluation Report encouraged the agency to continue to rethink how it presents and shares information.

   A range of suggestions were offered by the 2015 peer review panel. Some suggested structural modifications such as combining the presentation of individual standards to reduce redundancy and enhance the readability of the report. Others suggested that reorganizing the report's presentation would better illuminate the interdependencies and linkages between thresholds standards. Another reviewer suggested a greater focus on data accessibility and making the raw information presented in the report available to researchers and the general public.

   TRPA and partners continue to explore how to more effectively turn the vast amounts of information collected into knowledge and to share that knowledge in ways that inform adaptive management in the Region. The Lake Tahoe Info web platform (https://laketahoeinfo.org) is emerging as a central repository for all Lake Tahoe based information. The platform was born out of collaboration between TRPA, the U.S. Environmental Protection Agency, the U.S. Forest Service, and the California Strategic Growth Council. The platform was initially intended to house only sustainability and Environmental Improvement Program (EIP) information. However, the early success of the website has led to its intentionally incremental expansion focused on filling specific voids and targeted needs identified and accepted by the partnership.

   In late 2016, TRPA will launch a beta-version of the thresholds reporting platform on the Lake Tahoe Info website (Figure 13-1). The agency plans to experiment with the organization and presentation of the website to provide those interested with better

access to the information about the lake and its ecosystem. The goal is for future threshold evaluations to be reported continuously in real time through this information and reporting platform as new best data and information becomes available rather than waiting for periodic comprehensive compilations on a 4-year cycle.

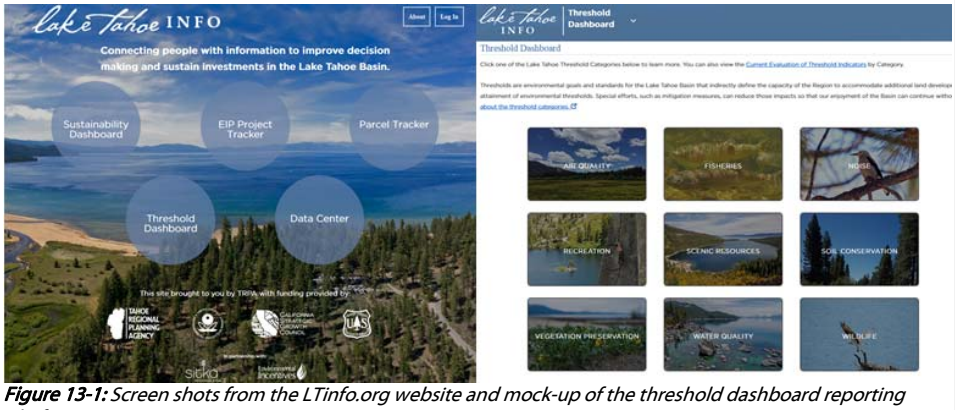

Figure 13-1: *Screen shots from the LTinfo.org website and mock-up of the threshold dashboard reporting platform.*

2. **Target Attainment Dates** - The TRPA Code of Ordinances requires an interim target to be identified for each standard that is identified as out of attainment. Each threshold evaluation report has diligently listed interim targets for standards, even when no specific commitments or secured funding source was in place to achieve them. To establish interim targets, authors generally looked at past program implementation or historic rates of change and assumed a similar trajectory going forward. The limitations of establishing interim targets based on this methodology have been noted in past threshold evaluations and was again questioned by the peer reviewers of this evaluation.

   Unlike the detailed studies and modelling of pollutant load reductions of the TMDL, the interim targets listed in threshold evaluation reports have rarely been founded on scientifically modelled projections or firm commitments tied to specific funding. A peer reviewer of the 2015 report expanded the critique more broadly and suggested the practice of setting interim targets should be abandoned in the absence of a specific plan to achieve the target, saying, *"I doubt that the "estimated attainment date" will have much meaning for most indicators. Unless they're tied to a concrete, funded plan or program, it's almost silly to use what I assume would be a linear extrapolation of prior trends to "calculate" a date. Absent firm legally and/or financially obligated commitments, just don't do it."* The sentiments were echoed by other peer reviewers and struck a chord within TRPA.

   Establishing goals for each threshold standard in isolation is an outdated approach that fails to consider the interconnectedness of resources or the network of partners that collectively manage those resources and make restoration projects happen. Over the last 20 years, the 100-plus partners of the EIP have implemented nearly 500 projects in the Region that have protected environmentally sensitive lands, improved water quality, and enhanced recreational opportunities. These programs and projects are the building

blocks for bringing about threshold gains. The establishment of realistic interim targets requires extensive engagement and coordination with the many agencies that implement projects and regulate in the Region. Each agency has its own mission and priorities and the process of aligning those missions and priorities and reaching consensus on scope, scale, timing, funding, and feasibility of next actions requires significant investment of time and resources. The Tahoe Interagency Executive Steering Committee (TIE-SC) oversees implementation of the EIP and is leading the discussion on priorities. The TIE-SC has been actively engaged in facilitating the discussion on EIP goals and action plans for the next five years of EIP programs and projects.

3. **Closer link between monitoring data and decision making** - While it is often repeated that additional information leads to better decisions, not all information is equally useful. Within the field of decision theory, value of information (VOI) refers to the fact that different pieces of information have different value and different levels of influence on a decision (Sato 2011; Trainor-Guitton 2014). The notion that the highest value monitoring or research efforts are those that help distinguish between management alternatives resonated with TRPA, its partners, and the peer reviewers of this report.

   Recent work has suggested that like other types of investments, there are diminishing returns from investing in the collection of additional monitoring data after a certain point (Grantham et al. 2008). Here diminishing returns result not from the information collection itself, but because the additional information is less likely to significantly influence a necessary decision. Understanding the value of individual pieces of information for management decisions is critically important to allocating scare resources and helps avoid unnecessary expenditures.

   Regional partners are already rethinking how we invest in monitoring. For several years, the Nearshore Agency Working Group (Lahontan Regional Water Quality Control Board, Nevada Division of Environmental Protection, U.S. Environmental Protection Agency, and TRPA) has been developing a coherent framework for guiding investments in nearshore science and monitoring efforts. Through the Nearshore Resource Allocation Plan (NRAP), the group is taking a fresh look at how Tahoe's agencies invest in nearshore monitoring and nearshore science and is seeking to improve coordination and return on investments in the allocation of scare monitoring dollars. The goal of the process is to think through how information collected through monitoring feeds into the management decisions in the Region and ensure that the information collected is actively informing management.

   By beginning with how information will be used to inform decisions, we can identify and prioritize gathering information that is most likely to inform decision making and promote threshold attainment. A draft of the NRAP is expected to be released for discussion and review in late 2016.

   Better information for decision-making could also be generated with increased focus on project and policy effectiveness and understanding system drivers and their influence on threshold status and trend. The decisions made daily by the partners in the Region are based on their knowledge of the effectiveness of their actions. There are over 200 compliance measures currently used by TRPA and its partners to attain or maintain threshold standards (see Appendix I). Efficient management requires making tough choices about the relative merits or contributions of each compliance measure to those

goals, and understanding the marginal cost and benefit of investing more or less in any one of the measures. This allocation is complicated by the diversity of goals for the region and the number of compliance measures that contribute to attaining or maintaining multiple threshold standards.

A greater focus on impact evaluation and causation research would likely be both more challenging and more expensive than simply reporting on status and trends, but it could also be more useful. Understanding which policies or projects are the most cost-effective mechanisms to promote threshold attainment is ultimately what enables better decision making. Building this knowledge base is also an essential component for the effective implementation of TRPA's adaptive management system (plan–do–check–adjust). Adaptive management requires the generation of knowledge that enables decision-makers to better understand project and program effectiveness and more efficiently allocate resources to achieve desired outcomes. Understanding the success of existing investments and the incremental benefit of investing more in a program or project is a key to more efficiently allocating resources.

4. **Better Coordination of Monitoring and Reporting** – In some instances, status determination was not possible because data analysis was still in process and not available for inclusion in the report. The threshold evaluation report, like most work in the Region, is only possible because of the contributions of numerous partners. The report continues to rely on those contributions. Better aligning the scheduling of reporting, monitoring and attendant analysis could lead to more complete information in future reports. Even more effective would be the successful implementation of continuous real time reporting through LT Info outlined above.

Manage Systems Not Symptoms

The partnership's effectiveness depends on shifting our emphasis from silos to systems. As with the 2011 report, the siloed evaluation approach of the current threshold system was again questioned by the 2015 scientific experts in the peer review. They suggested greater emphasis be placed on the inter-relatedness of the individual elements of the threshold system and on understanding the drivers of change in the context of the broader ecosystem (TRPA 2012).

The guidance is consistent with the direction that other large restoration efforts in the country have taken. For example, the South Florida Ecosystem Restoration Task Force that oversees the multi-billion dollar restoration of the Everglades recently developed and implemented 11 system wide ecological measures of restoration efficacy (Doren et al. 2009). And, the Expert Scientific Panel assembled by the United States Government Accountability Office to review indicators of program success for restoration of the Chesapeake Bay offered similar guidance (GAO 2005). The GAO stressed the need to be able to integrate information from individual indicators in order to say something about the state of the system as whole.

This threshold evaluation report highlights the need for the agency and partners to continue to look outside the individual threshold categories and indicator silos and think about broader drivers. A clear and pressing example is the nexus among threshold standards for scenic, recreation, and air quality. Visitation to the Region may be growing and visitation patterns changing. This evaluation found that increasing visitation also poses a challenge for the recreation experience and scenic quality. As visitors frequent Lake Tahoe, the roadsides are increasingly cluttered with parked cars. Roadside parking is an emerging stressor on scenic resources. And use of the individual auto affects other threshold standards as well. TRPA recently

commissioned the development of a recreation travel study to better understand how visitors are getting to and moving around the Region. Understanding visitor systems dynamics is increasingly important to adaptively managing transportation, recreation access, quality of recreation experience, and air and water quality. The Regional Transportation Plan Update recognizes these linkages and will propose solutions to better link these areas. Development of new partnerships and metrics around recreation management and visitor engagement may also be needed to fully manage the systemic effects of growing visitation expected from population increases outside the region and greater demand for the Tahoe experience.

In an environment where resource managers are increasingly being asked to administer programs and projects that deliver multiple benefits across a range of objectives, it is of growing importance that we actively consider and address the linkages within the interconnected systems we manage. Ecosystem-based management is an approach that promises to deliver those multiple benefits through a more holistic management approach. Ecosystem-based management is the term used to describe management actions that focus on systems and processes, in contrast to historic approaches that focused on managing individual species or specific parts of an ecosystem (Ruckelshaus et al. 2008). Numerous challenges have been identified in implementing systems based approaches, including the cost, lag between implementation and response timeframes, transaction costs of coordinating across disciplines, difficulty in communicating ecosystem objectives to stakeholders, and evolving understanding of drivers and linkages at the ecosystem scale (Wasson et al. 2015).

Nonetheless, the basin partnerships are already engaging the ecosystem management approach more fully. The newly formed Lake Tahoe West Restoration Partnership is a local example of a partnership that is designed to take a more holistic approach to forest management for multiple goals. The partnership aims to restore the resiliency of the West Shore's forests, watersheds, recreational opportunities, and communities by accelerating the pace of project implementation and expanding the scale of ecosystem management particularly in light of the dynamics of changing climate conditions. The core partnership, which includes the National Forest Foundation, California Tahoe Conservancy, U.S. Forest Service Lake Tahoe Basin Management Unit and Pacific Southwest Research Station, California State Parks, and TRPA, aims to address forest and watershed health issues over 70,000 acres of federal, state, local, and private lands, from Emerald Bay to Squaw Valley.

Acknowledge Uncertainty and Incorporate It: Climate Change

Both the 2015 report and peer review comments point to a growing body of knowledge we have been urged to bring into our standards and evaluations. Globally, 2015 was the warmest year on modern record. Temperatures in 2015 were over 1.5 °F (0.8 °C) warmer than the average temperatures of the 20th century, breaking the record set just a year earlier (NOAA & NASA 2016). The fingerprints of climate change are already visible in the Region. Average minimum air temperature has increased by 4.3 °F (2.4 °C) over the last hundred years. With rising temperatures there has been a correspondent decrease in the number of days with below freezing temperatures, which have declined by almost 30 days in the last 100 years (UC Davis - TERC 2016).

These changes are also evident in the Region's waters. Lake Tahoe has steadily warmed since regular measurements began in 1970, and the volume averaged temperature of the lake is now nearly a 0.8 °F (0.24 °C) higher (UC Davis - TERC 2016). The rate at which the lake is warming has increased in recent years (UC Davis - TERC 2016). A warmer lake is likely to alter species

composition, potentially altering the food web of the lake (Winder et al. 2009) and make it more hospitable to invasive species (TRPA 2014a).

The fraction of the Region's precipitation that fell as snow in 2015 (6.5 percent) was the lowest ever recorded (UC Davis - TERC 2016) and the studies suggest a future with significantly less snow in the Region. Tributary inflow from snowmelt is cooler than rain driven streamflow and the cooler waters generally sink to the bottom of the lake as they flow in. Higher temperatures of the inflowing waters in 2015 is one plausible explanation for the decline in clarity between 2014 and 2015 despite the relatively dry year (UC Davis - TERC 2016).

On land, rising temperatures and more frequent and intense drought events will increasingly pose a challenge for forest management (Thompson et al. 2009). While evidence from the historic record suggests that extended droughts are relatively common in the Region, climate change will likely increase the frequency and intensity of future droughts and require us to revisit forest management practices and other ecosystem dynamics in a warmer world.

These are only some of the system effects expected to flow from changing climatic conditions. While the full impact of these changes is not known, partners are already working to understand and plan for the likely shifts. For example, global climate change likely poses a threat to the integrity of the Region's vegetation communities and plant species and threatens to exacerbate existing stressors. Forecasts suggest high elevation areas such as the Lake Tahoe Region may experience range shifts, re-sorting of species associations, extirpations, and extinctions (e.g. Seastedt et al. 2004, Loarie et al. 2008, Tomback and Achuff 2010). The current prolonged drought, likely exacerbated by climate change (Diffenbaugh et al. 2015), has contributed to the bark beetle epidemic that the southern Sierra is experiencing. The outbreak has left tens of millions of dead trees on the landscape. The Tahoe Region is also experiencing increased beetle activity, but it is unknown yet whether we will experience infestations on the scale observed to the south. Drought and overcrowding reduce trees' ability to fend off beetle attacks and increases the risk of large scale infestations and tree die-offs.

While there is still much uncertainty and areas where management adaptations have yet to be defined, regional partners have already begun important planning and management adaptations. Partners have worked for over a decade on fuels reduction and forest health projects in the wildland urban interface (WUI) with the primary goals of protecting communities from wildfire and improving forest health. Regional partners are now actively exploring forest health treatments beyond the WUI to increase the resilience of Tahoe's forests. The forest health strategic initiative will take the last decade of adaptive management actions even further. It seeks to support the U.S. Forest Service and other land management partners as they work to address growing system stressors and consider multi-benefit restoration and management through a collaborative, multi-agency process. The group recognizes the potential impact of warmer temperatures and more frequent drought and is asking difficult questions about how best to manage the forest in the face of multiple threats. The science of forest management has begun to focus on landscape level forest resilience or "the capacity of the system to resist damage and recover quickly when challenged by environmental pressures" (Fuller and Quine 2016).

The strategic initiative to address shoreline development policy in the Region and the recreational experience along Lake Tahoe's shore is also actively incorporating uncertainty and the potential impacts of changing climate into planning and recommendations for new codes and ordinances. The natural rim of lake Tahoe sits at 6,223 feet (1,897m), and the dam at Tahoe City enables 6.1 feet (1.9 meters) of water storage, bringing the maximum elevation of the lake to 6229.1 feet (1,899m).

Since the dam in Tahoe City was installed, the lake's elevation has averaged about 6225 feet (1,897.4 meters). Climate forecasts for the Region suggest that warmer temperatures and more variable rainfall are likely to lead to more frequent and dramatic fluctuations in lake level (U. S. Bureau of Reclamation 2015) and observations from the last 15 years suggest that this is already the case (UC Davis - TERC 2016).

While the shoreline and forest health initiatives are at the forefront of climate policy in the Region, they are not the only ones addressing these challenges. The lessons learned through these initiatives will provide an invaluable platform that supports future efforts.

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Adaptive Management and the Threshold & Monitoring Update Initiative

Because change is happening all around us and the need to iterate more regularly to adapt to changing needs and conditions is essential, we have made the goal of continual adaptive management intentional. And the additional uncertainty associated with drivers largely beyond local control (eg. climatic change, population growth) makes management systems that can incorporate uncertainty even more valuable. Nearly 10 years ago, TRPA embraced more fully the "plan-do-check-adjust" adaptive management approach. We made it the foundation not only of the Regional Plan but also TRPA's Strategic Plan Objectives, Strategic Initiatives, internal initiatives, ongoing annual activities, and even reorganized to build it into TRPA's organizational division structure and reinforce it in our operating model (Figure 13-1). The model shifts the emphasis from creating the perfect plan and actions for all time towards creating good plans that can be more regularly and continually adapted and improved using new best information as it becomes available to deliver on objectives.

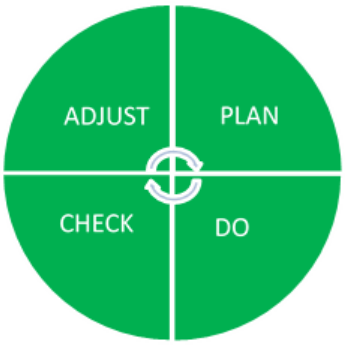

Figure 13-2 *The "Plan-do-check-adjust" approach utilized by TRPA and the basin partnership for adaptive management and continuous improvement.*

While both TRPA and the basin partnership are getting better at mobilizing to make adaptive improvements to programs in response to evaluative information, such as this threshold report, the area where we have not adapted as well is in keeping our evaluation standards and measures of effectiveness up to date. The peer reviewers' recommendation in this respect is to create an adaptive management cycle for goals (threshold standards) to ensure that the plans and projects are continually aimed at the right target. The 2015 Threshold Evaluation Report peer reviewers acknowledged this and challenged the agency and its partners to ask: Is the information we collect and analyze generating knowledge that leads to better decision making? In the executive summary of the 2015 peer review, Conservation Science Partners, the lead of the peer review, writes, "Improvements to the Monitoring Program section will be easier to implement once the recommendations on improving the threshold standards themselves have been carried out."

The TRPA Governing Board's strategic initiative, endorsed in 2015, to review and update the threshold standards is charged with the task of taking a comprehensive look at the standards to ensure that they continue to reflect the most relevant values of the Region and are supported by the latest science. The next section of this chapter outlines a recommended first step in that process.

Recommendations for the Review and Modification of Thresholds Standards: Phase I - Assessment of Threshold Standards

The programmatic recommendations focus on how the things that are already in motion can be made more effective. In short, how can we do what we do better? But in the comments of the peer reviewers of the 2011 and 2015 threshold evaluations, a much larger question loomed. Are we focused on the right things? Are ~~all of~~ the programs and policies that are continuously being adjusted and refined still focused on the right goals? And, is the information that guides those adjustments the best that can be offered? The latter questions are the focus of the threshold update initiative, and the comments of the peer reviews have further reinforced its central importance to the success of the other initiatives and the restoration of the Region.

The majority of the threshold standards were adopted in 1982 and are now nearly 35 years old. The scientific basis for many of the threshold standards dates back to the 1970s. Recognizing a widely acknowledged consensus, the TRPA Governing Board identified the review and update of the threshold standard system as a strategic initiative for the agency to engage in over the next five years. The threshold standard system includes both the threshold standards themselves and the monitoring, evaluation, and reporting structure that supports the system.

The initiative to review the threshold standard system enjoys robust support in the two states. In 2014, California and Nevada signed a memorandum of understanding to establish the Tahoe Science Advisory Council (TSAC), a 14-member panel of scientific experts from the leading institutions in the two states, to provide scientific guidance and inform management decisions in the Region. In establishing the TSAC, the states identified providing science-based recommendations on threshold standards as among the first tasks of the council. The TSAC role in the review process was reaffirmed at the first meeting its executive committee in July 2015 and at the first meeting of the TSAC in May 2016, and also supported by the Tahoe Interagency Executive Steering Committee at its meeting in April 2016. This chapter outlines the first phase in a process designed to capitalize on this broad support base to review and strengthen the threshold standards system.

The establishment of standards that can be objectively evaluated is the most frequent recommendation for modification included in the individual indicator sheets in the 2015 threshold evaluation. Moving from narrative standards towards specific numeric standards is a challenge that is not unique to the agency or the Tahoe Region. Over the last 20 years the U.S. Environmental Protection Agency has consistently encouraged states to transition from narrative to numeric criteria, which it describes as "ultimately necessary for effective state programs" (EPA 2011). This is clearly an important priority, but in reflecting on the recommendations in this and previous threshold evaluations it was clear that simply substituting numeric criteria for the existing standards might not be sufficient to address the issues identified. The peer reviewers of the 2011 Threshold Evaluation Report suggested a need to move away from a system that silos environmental values towards a more holistic landscape perspective. A more comprehensive approach is required to address concerns of that nature.

Reviewing and updating the standards that establish the goals for the restoration of the Tahoe Region will require a phased approach over multiple years. The proposed first phase is an assessment of the existing threshold standards against national and international best practices. The assessment (outlined in greater detail below) is designed to take a comprehensive look at the existing standards and establish the knowledge base necessary for informed review and possible

revision of the threshold standard system. To provide context for the proposed assessment, a brief background of the existing threshold standards is included below.

Origin of TRPA Environmental Threshold Carrying Capacities

Congress amended the Bi-State Compact (Compact) in 1980 (PL 96-551; December 19, 1980) with a directive and a Compact definition (Article II (i)) to adopt standards it termed "environmental threshold carrying capacities." The Compact defined the standards 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. Such standards shall include but not be limited to standards for air quality, water quality, soil conservation, vegetation preservation and noise".*

The definition included in the Compact bears little resemblance to the notion of "carrying capacity" as it is generally understood. The disconnect between and potential for confusion has been repeatedly identified and was again called out by the peer reviewers of the 2015 threshold evaluation report. One suggested changing the name entirely:

"..simply refer to "Threshold Standard" instead. The term "carrying capacity" has very specific meanings depending on context, and could lead to unintended interpretation."

To avoid this confusion TRPA and partners routinely refer to "threshold standards" in keeping with the Compact definition.

The Compact directed TRPA and partners to identify appropriate environmental ~~threshold carrying~~standards ~~capacities~~ within 18 months of signing (PL 96-551, Article V(b)), and to develop and implement a Regional Plan to assure attainment or maintenance of those ~~environmental threshold carrying capacities~~standards (PL 96-551, Article V(b)). TRPA initiated a 10 step process that included public comment and an environmental impact statement with an objective of developing recommendations for ~~environmental threshold carrying capacities (Box 1, TRPA 1982a~~adopting the required standards ~~)~~(Box 1, TRPA 1982a).

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In October 1982, TRPA released a report based on the best available science at the time detailing suggested environmental threshold standards (TRPA 1982b) ~~(TRPA 1982b)~~. The report, completed within the ~~short~~ time frame mandated in the 1980 Compact, provided a rationale for each proposed threshold standard, summarized relevant scientific information related to the proposed standard, and provided guidance on how

Steps used to identify and establish TRPA Environmental Threshold Carrying Capacities ~~*(TRPA 1982a)*~~***.***

1. Select environmental components
2. Develop value or goals statements
3. Identify environmental variations
4. Model relationships of variables to the environment
5. Select Alternative Threshold Sets
6. Determine implication of alternative thresholds
7. Prepare and circulate EIS
8. Prepare draft study report
9. Conduct public hearings
10. Governing Board certify EIS and adopt thresholds

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Figure 13-3: *Steps used to identify and establish TRPA Environmental Threshold Carrying Capacities (TRPA 1982a)*

attainment would be achieved (TRPA 1982~~b~~). The TRPA Governing Board unanimously adopted the proposed ~~environmental threshold carrying capacities~~standards via Resolution 82-11 in December 1982. The resolution established nine threshold categories that have been retained to this day and adopted multiple standards in each: air quality, fisheries, noise, recreation, scenic resources, soil conservation, vegetation preservation, water quality, and wildlife.

Historical Context

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The conceptual basis for the threshold standards traces its origin to the agencies involved in the 1970s, and federal and state environmental quality legislation of the time, such as the Porter-Cologne Act in California (1969), Clean Air Act (1970), Clean Water Act (1972), Noise Control Act (1972), Endangered Species Act (1973), and Safe Drinking Water Act (1974). These national regulations along with the 1969 TRPA Compact agreement between Nevada and California (PL 91-147; December 16, 1969) likely framed the approach for standard development in Tahoe. In 1974, the EPA published a report entitled "*The Lake Tahoe Study*" which introduced the "environmental threshold" concept as a means to protect environmental quality in the Tahoe Region. According to that report, environmental thresholds would be represented by a set of parameters that specify the numerical value beyond which undesirable ecological damage occurs. In 1978, the Western Federal Regional Council (WFRC), a coalition of 11 federal agencies, signed a consensus federal policy statement for the Tahoe Region. The statement encouraged federal agencies to promote the establishment of "environmental threshold controls" to guide decision making in the Region. The federal agencies committed to policies to enhance coordination of National Forest land use planning to emphasize outdoor recreation and protection of water quality, threatened and endangered species, cultural resources, scenery, air quality, and the health of natural communities.

In 1979, the WFRC published the "*Lake Tahoe Environmental Assessment*" summarizing existing environmental and socioeconomic conditions at Lake Tahoe and exploring the feasibility of applying the environmental thresholds concept to the Tahoe Region. Chapter 7 of that assessment presented ~~the~~ a framework for integrating environmental thresholds ("socially desirable levels of environmental quality") with the carrying capacity concept. ~~The concept of a carrying capacity emerged from the field of ecology, where it is used to describe limits on a species' population size imposed by the environment.~~ The WFRC report proposed application of the carrying capacity concept to human populations and suggested that carrying capacities could be defined based on the environmental impacts of human activities (WFRC 1979a)~~(WFRC 1979)~~. The WFRC suggested integrating the carrying capacity and environmental thresholds concepts by starting with the desired environmental conditions in the Region (environmental thresholds) and then ~~working backwards~~to achieve ~~from~~ those conditions by~~, and~~ defining levels of development and human activity (carrying capacities) to ensure the desired environmental conditions are maintained (WFRC 1979a)~~(WFRC 1979)~~.

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~~The report recognized that environmental impacts from human activity are not necessarily linear with population size or level of human activity. Drawing from an earlier report on *"A conceptual framework for defining Environmental Thresholds and Carrying Capacities for the Lake Tahoe Basin,"* the WFRC noted, "a small population with environmentally damaging development and activity can have the same environmental impact as a larger population undertaking less environmentally damaging development and activity" (WFRC 1979). In applying the carrying capacity concept to human activity in the Region, the report recognized that people have the ability to mitigate environmental impacts, but doing so comes at a cost. The report suggested that~~

~~determination of the carrying capacity for human activities in the Region is a function of the willingness to pay to mitigate the environmental impacts of those activities. This implied an iterative process for defining carrying capacity, where "the level of urban activity each end state [environmental threshold] or the aggregate end state [environmental thresholds] would allow is a function of the mitigation strategies employed" (WFRC 1979).~~

~~Congress amended the Bi-State Compact (Compact) in 1980 (PL 96-551; December 19, 1980) with a directive to identify and adopt "environmental threshold carrying capacities" for the Region. The Compact (Article II (i)) defined "environmental threshold carrying capacities" 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. Such standards shall include but not be limited to standards for air quality, water quality, soil conservation, vegetation preservation and noise".*~~

~~The definition included in the Compact more closely aligns with that of environmental thresholds than with the notion of human carrying capacities.~~

The inclusion of the term "carrying capacity" in the Bi-State Compact, likely originated out of the work of the WFRC. However, the WFRC treated "Environmental Thresholds" and "Carrying Capacities" as distinct, but related, ideas and never merged the terms together in the way they appear in the Bi-State Compact.

The WFRC report suggested definitions for both "environmental thresholds" and for "carrying capacity." Environmental thresholds were defined as "end-states" for a resource (e.g., air quality, wildlife), or socially desirable levels of environmental quality. The concept of a carrying capacity emerged from the field of ecology, where it is used to describe limits on a species' population size imposed by the environment. Carrying capacities for the Tahoe region, the report suggested, should be defined as, "the maximum population and associated urban activity that a region can accommodate without exceeding environmental thresholds and without exceeding the infrastructure and mitigation cost limitations."

The WFRC suggested the "carrying capacity" and "environmental thresholds" concepts could be integrated to manage the Region by defining both the desired environmental conditions ("environmental thresholds") and levels of development and human activity ("carrying capacities") to ensure the desired environmental conditions are maintained (WFRC 1979). Thus then was the approach ultimately made explicit in the Compact, to adopt environmental standards (Compact Article II(l)) and an implementing Regional Plan with levels of development defined as growth caps and management actions designed to achieve the adopted standards (Compact Article V(c)). The Regional Plan regulates human activities and provides a vision for desired changes in those activities (e.g., a different regional development pattern, non-auto mobility, scenic improvements, etc.), while prescribing standards that must be met to ensure that the desired environmental conditions (e.g., water quality, air quality, etc.) are attained and maintained

Using the example of carbon monoxide, the WFRC report suggests that the desired end-state for carbon monoxide concentration could be achieved by a suite of management and mitigating actions; a) reducing the number of vehicle trips, b) increasing road capacity, c) cleaner burning automobiles, or some combination of all three (WFRC 1979b). Within this framework, the determination of carrying capacities for impacts from human activities in the Region is a function

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of action to manage and mitigate the environmental impacts of those activities versus an absolute numerical limit on a given human activity. "Carrying capacity" in this context refers to the policies and programs that govern development and human activities to ensure the desired conditions are achieved.

The peer reviewers of the draft 2015 Threshold Evaluation pointed out that since its introduction, when it focused primarily on the number of people, the application of the carrying capacity concept for management of people in ecological systems has evolved substantially. A broad body of scientific study has now developed over the last four decades, generally in the field of recreation management, giving the concept robust and more nuanced meaning. Years of management experience that found that total capacity limits were "seldom the most effective way to deal with most management problems (Cole & Carlson 2010)." Today, capacity limits are no longer viewed as the preeminent management strategy, but rather one of many strategies (Marion 2016). That shift in thinking was summarized in a recent policy guidance document on the use of visitor capacity as a management tool, *"..research and managerial experience have revealed that managing the number of visitors in an area is only one tool within a suite of strategies that can be used to achieve and maintain desired conditions. Effective visitor use management is often more about managing factors such as the types, timing, and location of visitor activities and associated visitor behaviors* (IVUMC 2016a)." Current best practice is consistent with the conceptual approach defined in the Compact that look to varied environmental standards and required management actions to achieve those standards (IVUMC 2016b).

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Modification of the Environmental Threshold ~~Carrying Capacities~~Standards

TRPA Resolution 82-11 instructs that the threshold standards:

> *"…shall be reviewed by staff and the Governing Body at the time of adoption of the Regional Plan to assure that the Regional Plan and the environmental threshold carrying capacities are consistent, and shall be reviewed at least every five years thereafter by the most appropriate means. After such review, the pertinent environmental threshold standards shall be amended where the scientific evidence and technical information indicate:*
>
> *a) two or more threshold standards are mutually exclusive; or*
> *b) substantial evidence to provide a basis for a threshold standard does not exist; or*
> *c) a threshold standard cannot be achieved; or*
> d) *a threshold standard is not sufficient to maintain a significant value of the Region or additional threshold standards are required to maintain a significant value."*

The TRPA Regional Plan Goals and Policies and Code of Ordinances provide no specific process for the revision of threshold standards. Since 1987, selected threshold standards have been amended eight times with the most recent amendments occurring in 2012. The process for amending Resolution 82-11 has typically included the following steps:

1. Developing ~~rationale and~~ a proposed action for the amendment and administrative record evidence;
2. Vetting and refining proposed threshold standard amendments with partners and stakeholders;
3. Preparing ~~a staff report and~~ environmental documentation and making findings according to the TRPA Regional Plan (Code of Ordinances– Chapters 2, 3, and 4) and Resolution 82-11 (using reasons for amendment as listed above);
4. Holding public hearings (at Advisory Planning Commission and Governing Board); and,
5. If approved, incorporating new or revised standard into Exhibit 1 of Resolution 82-11.

Assessing the Threshold Standards: A Proposed Methodology

> *"If we could first know where we are, and whither we are tending, we could then better judge what to do, and how to do it."*
>
> *- Abraham Lincoln*

As Lincoln suggests, to know where to go next we first need a firm understanding of where we stand today. Extensive guidance and numerous national and international examples exist for the establishment and review of indicators and standards. Where existing standard and goals exist, the starting point for revision is generally an assessment of the existing system. While there are many models for best practice, there is no universally agreed upon set of criteria. The recommendations for this assessment are the product of a review of over 20 national and international models for standards and the development of monitoring and evaluation systems to identify the criteria most relevant to an assessment of the threshold standard system.

The assessment methodology proposed here is defined by a set of questions designed to identify strengths and weaknesses in the current threshold standard system. Each standard would be subjected to each question of the assessment. The questions emerged from a synthesis of both the academic and applied monitoring and evaluation literature. These sources ranged from guidance documents published by the most recognizable international environmental and development organizations such as the United Nations, Centers for Disease Control and Prevention, Global Environment Facility, and Conservation Measures Partnership, to leaders of national professional organizations such as the American Evaluation Association and major restoration programs such as those managed by U.S. Environmental Protection Agency. The proposed assessment does not include all criteria identified in any of the individual models. Rather it seeks a balance between the comprehensiveness of the assessment and redundancy in the information gained through applying the criteria in conjunction with the other criteria in the assessment.

The assessment would consist of two parts. The first would assesses the individual standards against criteria drawn from the SMART framework commonly used to set goals and evaluate progress in project and employee management. The second set, "standard categorization," would provide additional context for individual standards and provide insight into how the standard fits into the larger threshold system framework.

The SMART acronym was coined in 1981 to describe desirable qualities for management objectives. SMART stands for Specific, Measurable, Achievable, Realistic, and Time-bound (Doran 1981). While the SMART criteria emerged from the human resources management field, they have become common in the conservation and environment field and have been adopted by the Global Environment Facility, the International Union of Concerned Nations, and the United Nations Evaluation Group.

The SMART framework is designed to enable objective and informative evaluation of the effectiveness of programs and actions. Goals that are SMART enable the development of reporting structures that:

1. Promote accountability for the achievement of objectives through the assessment of outcomes and the effectiveness of activities and policies.
2. Accelerate attainment through improved resource allocation and decision making and promotion of learning and knowledge sharing among partners.

TRPA is committed to collaborative adaptive management of regional programs through the Plan-Do-Check-Adjust cycle (PDCA). At the heart of effective implementation of the PDCA is understanding how effective the implemented actions have been in facilitating the desired outcomes. The provision of high quality information that informs management is a primary objective of the threshold evaluation reporting process.

How the application of SMART principles helps support more effective management is best illustrated with an example, the one below is drawn from *Measures of Success* (Margoluis & Salafsky 1998):

> *Original goal: Reduce incidents of harvesting of undersized marine resources.*

Assessing the above goal against the SMART criteria, we identify that the original goal does not meet the SMART criteria for being specific, measurable or time-bound. The goal is ambiguous (not-specific) because "undersized marine resources" is not formally defined and there is no specified target for the desired reduction in incidents of harvesting. This ambiguity could cause different evaluators or stakeholders to reach different conclusions about whether the goal has been attained. The ambiguity could also confound measurement of the goal. The goal also specifies no timeline against which to assess progress towards attainment.

> *Revised goal: By the end of the third year of the project, reduce incidents of harvesting snappers, groupers and conch in violation of community council defined size limits to fewer than 15 per month.*

The revised goal addresses the issues identified in assessing the original goal against the SMART criteria by formally defining the previously ambiguous parts of the original goal and specifying a formal target and desired attainment date. By addressing the ambiguity in the goal, the revisions ensure that evaluation of the goal will provide decision makers with the information they need to track progress towards attainment.

While the SMART framework includes "time-bound" as an attribute, time-boundedness is not included in the assessment framework proposed here. Criteria such as "time-bound" may be essential for evaluation of projects or establishment of goals for individuals, but may not be applicable to the establishment of standards for ambient environmental conditions. Air and water quality standards of the EPA, the State of California, and the State of Nevada detail desired conditions, but the rules themselves do not include a "time-bounded" element. This approach is also consistent with guidance from institutions like the Global Environment Facility (GEF) that apply the full SMART framework to their monitoring and evaluation criteria, but require only that project and programs objectives be specific and measurable (GEF 2010).

The threshold standards are a mixture of environmental standards, restoration goals, directives to engage in specific action, broad guidance, and narrative statements. This fusion of types poses a challenge for the design of an assessment framework that is relevant to all of the standards. The assessment framework outlined below is intended to be comprehensive in its coverage, but in creating a comprehensive assessment framework the relative importance of individual criteria varies across standard types.

For example, consider the differences between three standards below:

1. Carbon monoxide - M*aintain carbon monoxide concentrations at or below 6 parts per million (7 mg/m3) averaged over 8 hours*

2. Littoral loading - *reduce the dissolved inorganic nitrogen loading to Lake Tahoe from all sources by 25 percent of the 1973-1981 annual average*
3. Nearshore attached algae - *support actions to reduce the extent and distribution of excessive periphyton (attached) algae in the nearshore (littoral zone) of Lake Tahoe*

The carbon monoxide standard establishes a limit and specifies a desired environmental condition in a manner similar to a regulatory standard. The littoral loading standard specifies a load reduction target, ~~but not desired ambient conditions, that is closer to a project level goal~~but not specify desired ambient conditions. The attached algae standard provides general direction, but establishes neither a specific target nor the desired ambient state of the system.

While the intent of all three standards may be appropriate, because of the nature of each, no single set of criteria is universally applicable to the assessment of all three. Differentiating between the types has implications for the relevance of individual criteria within the assessment and for design of larger monitoring and evaluation systems. Because of the importance of understanding the focus of each element in the threshold standard system, type differentiation is included as part of the assessment framework to provide decision makers insight into which criteria are most relevant for which types of standards.

After assessing each of the standards against the SMART framework based criteria, a second set of questions is proposed, which are referred to as standard categorization questions. These questions are intended to group standards in ways that provide additional insight into the basis of individual standards and how the standard fits into the larger threshold system. Categorization questions are intended to be combined with the SMART based criteria to help decision makers strengthen the threshold standard system and the information provided by the threshold evaluation. For example, the first question in the standard categorization assessment classifies standards based on where they fit in a simplified results hierarchy. Application of this assessment question to the aforementioned carbon monoxide, littoral loading, and attached algae standards would result in the identification that each was directed at different levels of the results hierarchy. The attached algae standard is directed at inputs, the nearshore loading standard is directed at intermediate results, and the carbon monoxide standard is outcome based.

Assessment Frameworks

The assessment frameworks are outlined in detail in tables 13.1 and 13.2 and each follow a common format. The first column, "assessment questions," briefly conveys what is being assessed to a general audience. The "description" column provides technical details for engaged audiences to understand the rationale, usefulness, and applied or academic source of the question. The "rating" provides discrete groupings to help general audiences quickly discern the assessment of the standard. The "rating definitions" column provides the technical detail that defines each rating or category.

By working through the questions in tables 13.1 and 13.2, TRPA, partners, and stakeholders will gain insight into the evaluability of the existing threshold standards. The assessment is designed to transparently identify issues and opportunities to strengthen individual standards and the threshold system as a whole. The assessment will also provide the comprehensive information necessary to scope the magnitude or breadth of threshold standard review that decision makers can use to prioritize areas of inquiry and inform choices. The outcomes of the assessment are not prescriptive in nature; there is no single solution to address any issue highlighted during the assessment.

The recommended assessment questions are the product of a detailed review of national and international best practice and guidance for the establishment of the environmental goals and standards and guidance for development of monitoring and evaluation programs as well as reflection on the specific context and history of the threshold standards. The assessment process will allow TRPA and partners to assess the degree to which standards individually or as a system are consistent with best practice, can be objectively evaluated, or could benefit from additional review and strengthening.

The completion of the assessment is not an end point in and of itself. It is intended to provide information on the evaluability of the current threshold standards and to lay the foundation for the multi-phased initiative to review and update the threshold standard system. This information, in combination with the findings of the threshold evaluation report, guidance from the peer review, and input from partners and stakeholders, will be used to develop a process to strengthen the threshold standards system. The proposed assessment does not delve into why an individual standard exists or explore the merits of a standard relative to alternative standards with similar aims. Subsequent phases of the initiative are likely to address those questions and include wider inquiry that considers how well the standards in aggregate represent the values, concerns, and goals for the Region today.

The threshold standard system plays a critical role informing the design of policies, programs, and projects that impact Lake Tahoe's environment, recreation, and economic opportunities. This assessment is the first step to create baseline information for strengthening the threshold system, and is aimed at integrating the best available science with the efficient allocation of resources to achieve the shared objective of preserving and protecting a national treasure.

Table 13.1: SMART-based criteria. *Questions to assess the extent to which the existing threshold standards are consistent with criteria based on the SMART framework for objective setting. SMART represents important criteria that have proven useful in defining indicators, however, organizations often ascribe slightly different definitions for each component of the SMART criteria.*

SMART-BASED CRITERIA			
ASSESSMENT QUESTION	**DESCRIPTION**	**RATING**	**RATING DEFINITION**
1. Is the standard **specific?**	This question identifies where a lack of clarity in a standard may lead to misunderstanding or disagreement around attainment or progress towards attainment of a standard because the desired outcome is not clear. (Doran 1981; US EPA 2004; Stufflebeam & Shinkfield 2007; CDC 2009; GEF 2010; CMP 2013; IUCN 2015)	YES	The standard has a specific numeric target and baseline values are documented where necessary.
		NO	The standard has an unclear target or lacks a documented baseline value. Narrative standards receive this rating or standards that contain multiple sub-standards receive this.

SMART-BASED CRITERIA			
ASSESSMENT QUESTION	DESCRIPTION	RATING	RATING DEFINITION
2. Is the standard **measurable**?	This question identifies standards where measuring progress towards attainment is a complicated by a lack of clarity on what should be measured, or where there are no practical ways to measure the indicator. (Doran 1981; US EPA 2004; DRI 2006; Stufflebeam & Shinkfield 2007; CDC 2009; GEF 2010; CMP 2013; IUCN 2015)	YES	Indicators are unambiguous, clearly linked to the standard, and there are practical ways to measure them.
		NO	Appropriate indicators are not well specified, are impossible or impractical to monitor using existing methods, or questions surround monitoring methods.
3. Is the standard **attributable**?	This question identifies standards less likely to provide information that informs local management decisions, because the desired outcomes cannot reasonably be credited to the activities anticipated. (Doran 1981; US EPA 2004; GEF 2010; CMP 2013; IUCN 2015)	YES	There is a clear link between actions being undertaken and changes in the standard indicator.
		NO	There is no clear link between management decisions in the Region and change in the standard indicator.
4. Is the standard **achievable**?	This question identifies standards that are not likely to be achievable by the anticipated actions in a reasonable timeframe. (Doran 1981; US EPA 2004; GEF 2010; CMP 2013; IUCN 2015)	YES	It is likely that current actions or reasonably expected action will attain or maintain the standard or interim target.
		NO	It is unlikely that the standard or interim target can be achieved.
5. Is the standard **relevant**?	This question identifies standards that have drifted from top level priorities of stakeholders or not providing information that informs management decisions. (US EPA 2004; DRI 2006; Stufflebeam & Shinkfield 2007; GEF 2010; CMP 2013; IUCN 2015)	YES	The standard is highly relevant to current concerns in the Region, and the information derived by assessing the standard is regularly used to direct management in the Region.
		NO	The standard is not relevant to current concerns in the Region, and the information provided by assessing the standard does not regularly inform management.

Table 13.2: Standard categorization questions. *Standard categorization questions are intended to group standards in ways that may be insightful to decision makers but do not always have an innate positive or negative quality. These categorization questions are intended to be combined with SMART-based criteria to provide additional insight into standard content and help focus on attention.*

STANDARD CATEGORIZATION			
ASSESSMENT QUESTION	DESCRIPTION	RATING OR CATEGORY	RATING DEFINITION
1. **Focus:** What is the standard designed to measure (Activities, intermediate results, or ultimate outcomes)?	This question groups standards by type to provide additional insight about the chain of cause and effect, allowing a better understanding of the use and need for the standard. To provide strong program evaluation it is crucial to measure outcomes but it may be difficult to measure these end points due to time lag or challenges in attributing results to management activity. In these cases, it can be valuable to establish standards for intermediate results or activities completed. (DRI 2006; GEF 2010; CMP 2013; IUCN 2015)	Activity/Strategy/ Input	An activity standard defines a target for an activity or strategy that is expected to positively contribute to an outcome of intermediate result. Miles of roads treated (an Environmental Improvement Program performance measure) is an activity based measure that is expected to reduce pollutant load in stormwater, which will improve water quality in the lake.
		Intermediate Results	An intermediate result standard refers to a product that occurs along a chain of cause and effect that is expected to eventually lead to the desired outcome. Stormwater pollutant load is an intermediate result which is expected to lead to improved water quality.
		Outcomes	An outcome standard measures the environmental condition or other result that is the desired end point. Secchi depth indicator of lake clarity is an outcome standard of water quality threshold category.
2. **Science-based:** Is the standard well supported by settled science or the most recent evidence?	This question assesses the strength of evidence for the existing standard. Many standards were adopted in 1982. New evidence and scientific research has emerged since then. In some cases, there is support for the standard, in other cases the evidence suggests a modification of the	YES	The latest science supports the standard.
		NO	Since the standard was adopted additional research has emerged that suggests the standard needs to be revisited. Partner agencies managing similar resources have amended

STANDARD CATEGORIZATION			
ASSESSMENT QUESTION	DESCRIPTION	RATING OR CATEGORY	RATING DEFINITION
	objective establish in 1982. (DRI 2006)		their standards/goals more recently than the TRPA standard and the two standards are not consistent.
3. **Redundant:** Do other standards measure similar content?	This question looks at the individual standard in the context of the whole threshold standards system to assess if multiple standards that relate to the same entity or objective. Redundancy can increase reporting costs and lead to confusion on goals and objectives. (DRI 2006)	YES	~~This standard relates to a unique entity.~~ Other standards relate to the same entity.
		NO	~~Other standards relate to the same entity.~~ The standard relates to a unique entity.
4. **Reliable and Credible:** Can reliable and credible information be gathered to assess the standard?	This question relates to the information available to assess status and trend of conditions relative to the standard and the extent to which information is reliable and credible. (DRI 2006; Stufflebeam & Shinkfield 2007)	YES	The information sources used to evaluate the standard are well documented, impartial and quality assured.
		NO	The information sources used to evaluate the standard are not available, likely contain bias, or quality assurance is inadequate.
5. **Cost Feasible:** How costly is it to monitor the standard?	A categorization of the total costs to monitor the standard for the time interval for each threshold evaluation (four years). Costs include rough estimates of personnel, supplies, analysis and reporting.	High	More than $150,000[1]for each threshold evaluation.
		Med	$20,000 to $150,000[1] for each threshold evaluation.

[1] *Cost range categories may be subject to revision.*

STANDARD CATEGORIZATION			
ASSESSMENT QUESTION	DESCRIPTION	RATING OR CATEGORY	RATING DEFINITION
	This question provides decision-makers with a general understanding of the cost to monitor standards. (DRI 2006; GEF 2010; CMP 2013; IUCN 2015)	Low	Less than $20,000[1] for each threshold evaluation.

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