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

---

[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)

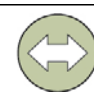
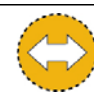
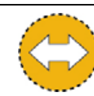
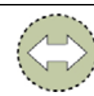
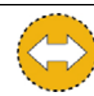
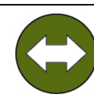
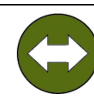
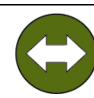
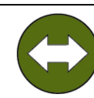
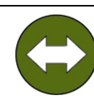
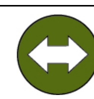
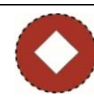
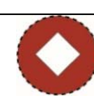
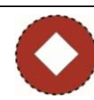
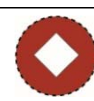
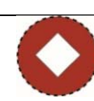
Indicator Reporting Category	Standard	Type of Standard	Indicator
	Relative Abundance - Of the total amount of undisturbed vegetation in the Tahoe Region: 1. Maintain at least four percent meadow and wetland vegetation. 2. Maintain at least four percent deciduous riparian vegetation. 3. Maintain no more 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		

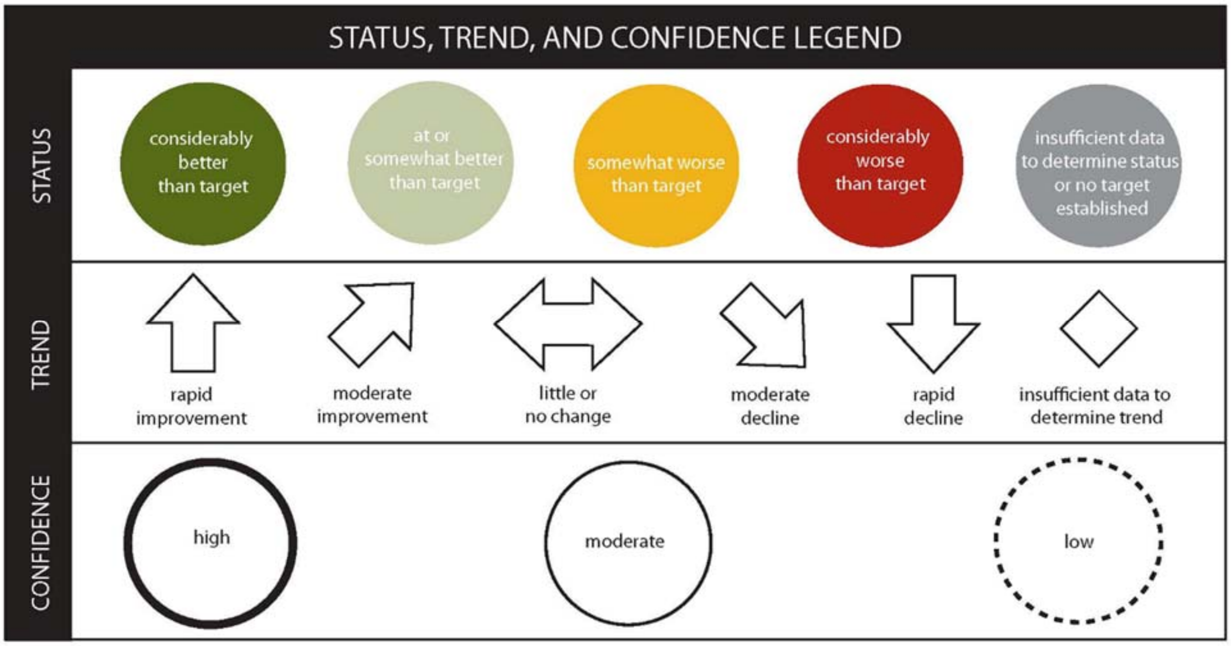


Figure 6-1: *A key to the symbols used to assess status, trend, and confidence levels.*

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.

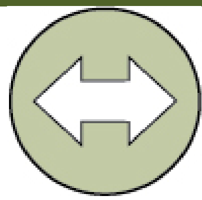
The extensive logging during the Comstock era, livestock grazing, and fire suppression heavily influenced the landscape of today. Most forests in the Region are less than 150 years old and are denser than the forests that occupied the area prior to the Comstock era. Over the past 150 years there has 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.

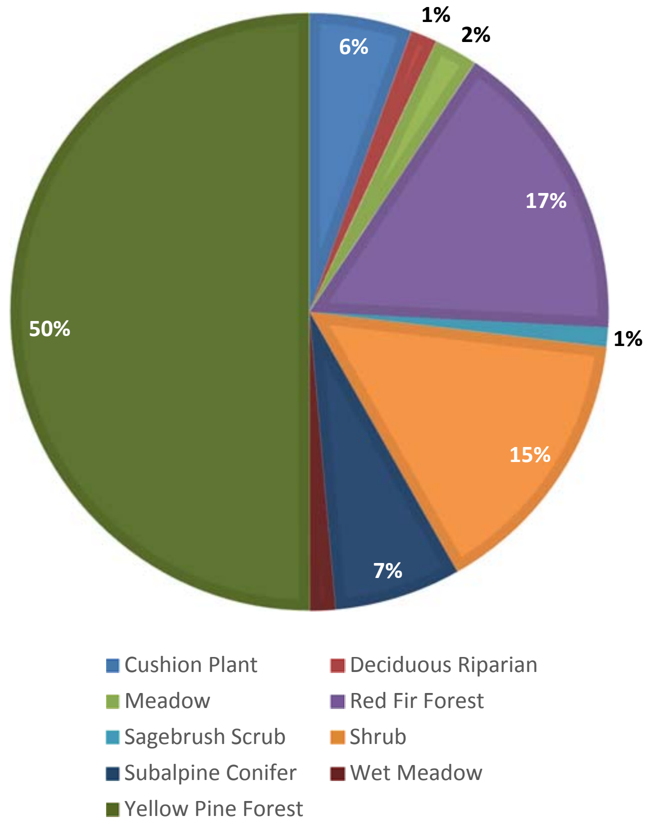
Common Vegetation: **Vegetation Community Richness**

Status	Graph



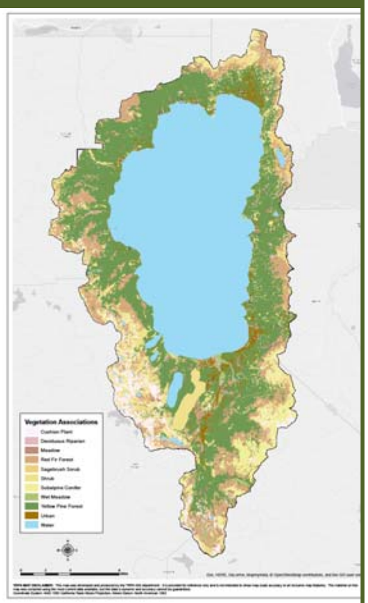
VEGETATION COMMUNITY RICHNESS

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.

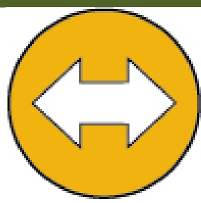
Monitoring Approach – No changes recommended.

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.

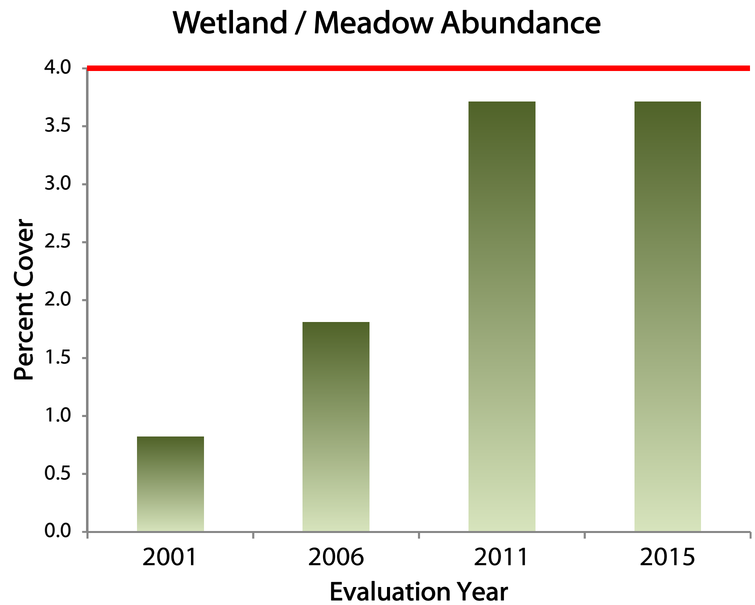
Common Vegetation: **Relative Abundance of Meadows and Wetland Vegetation Types**

Status	Trend



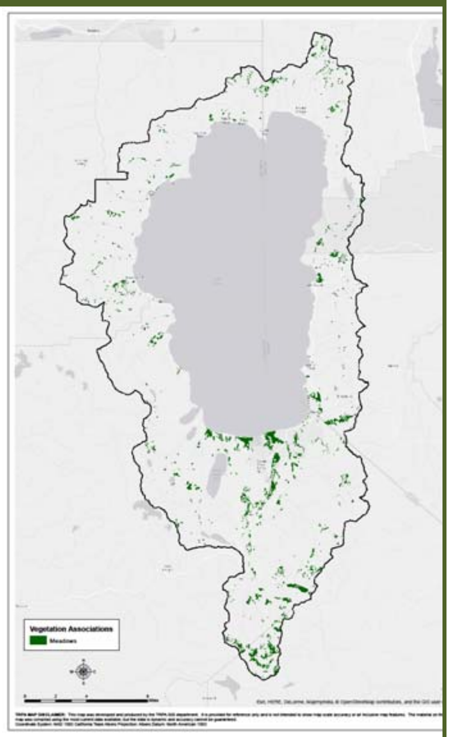
RELATIVE ABUNDANCE OF MEADOWS AND WETLAND VEGETATION TYPES

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*

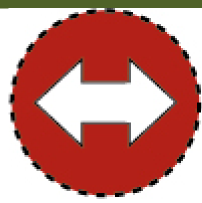
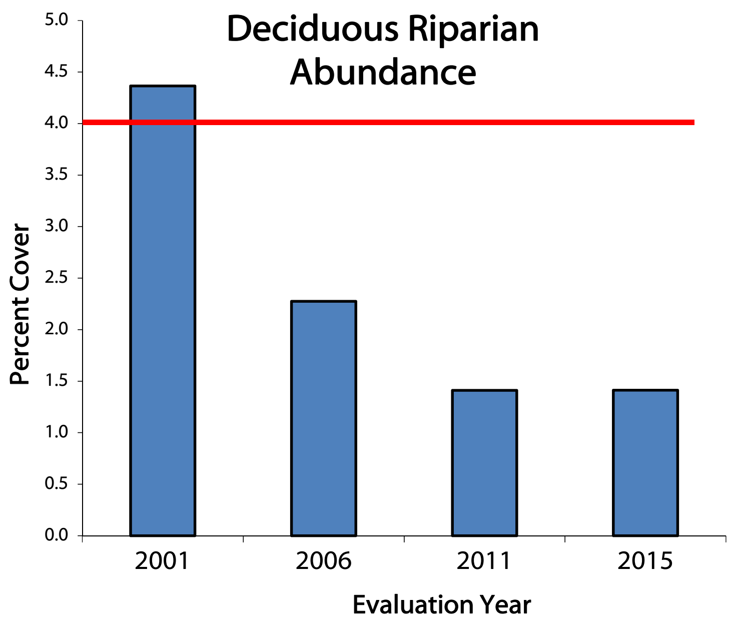
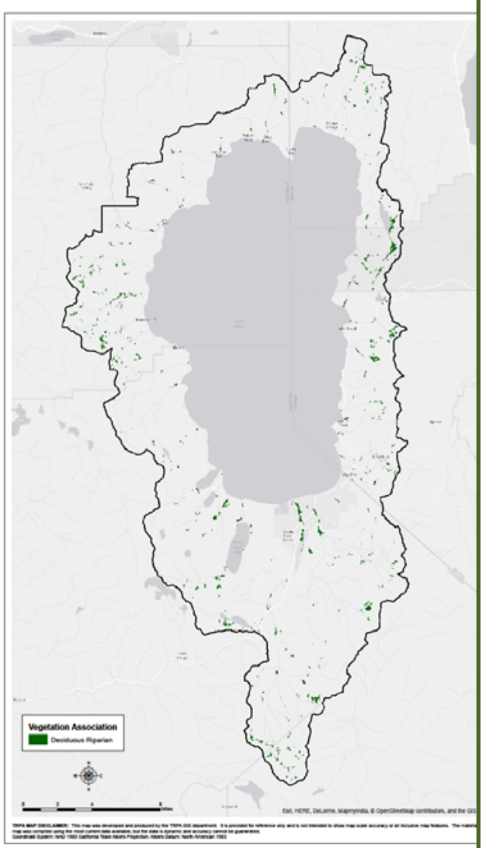
Source	**Target for acres of meadow and wetland vegetation** (based on four percent of total undisturbed vegetation)	**Total acres of undisturbed vegetation** (estimated)
1982 Threshold Evaluation Report	7,180	179,488
1982 Environmental Impact Statement (for 1982 Threshold Evaluation Report)	6,938	173,444
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
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

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.

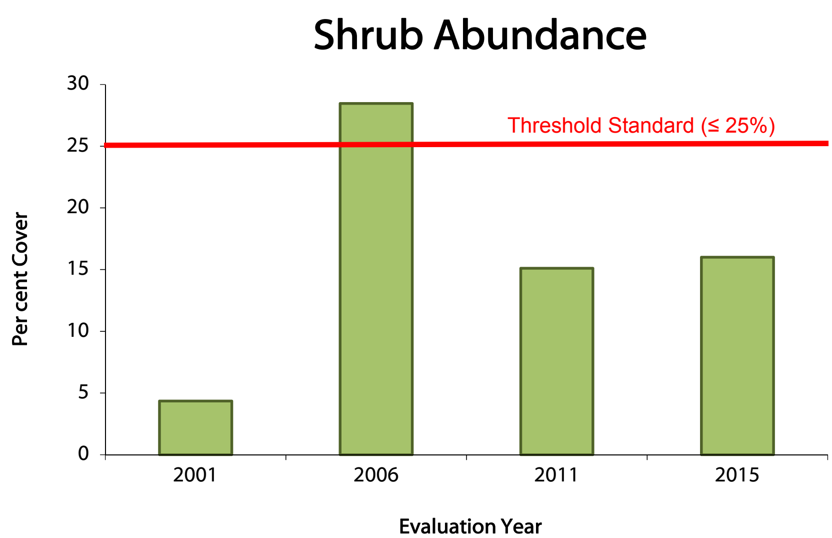
Common Vegetation: **Relative Abundance of Shrub Vegetation Type**

Status

RELATIVE ABUNDANCE OF SHRUB VEGETATION TYPE

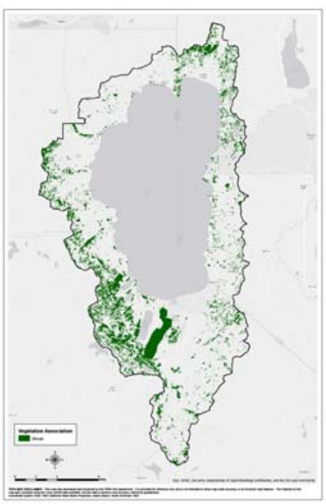
Status: **Considerably Better than Target**
Trend: **Little or No Change**
Confidence: **Low**

Trend



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.

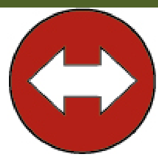
Table 2: *Total acres of "undisturbed" vegetation in the Tahoe Region as reported in prior threshold evaluation reports and studies*

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.

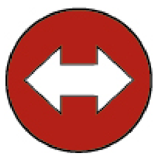
Common Vegetation: **Relative Abundance of Yellow Pine and Red Fir Forest in Seral Stages other than Mature**

Status	Trend



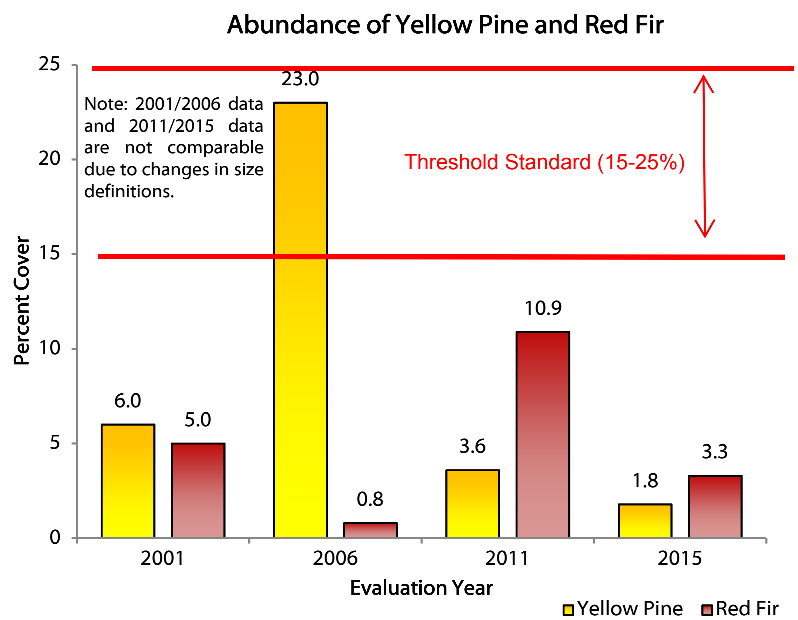
RELATIVE ABUNDANCE OF YELLOW PINE FOREST IN SERAL STAGES OTHER THAN MATURE

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



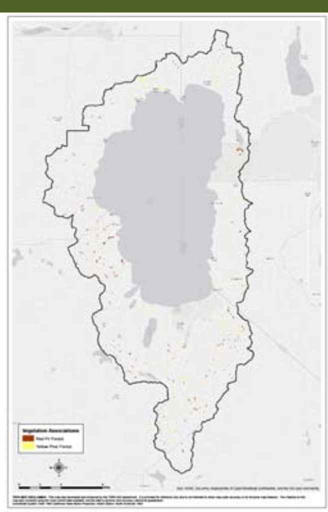
RELATIVE ABUNDANCE OF RED FIR FOREST IN SERAL STAGES OTHER THAN MATURE

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

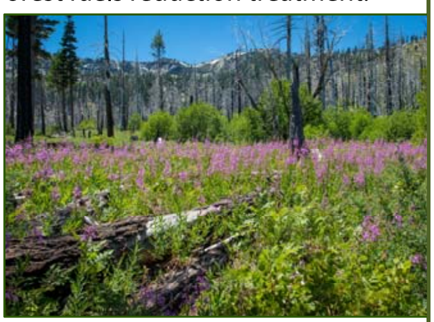
I

JUXTAPOSITION OF VEGETATION COMMUNITIES AND AGE CLASS

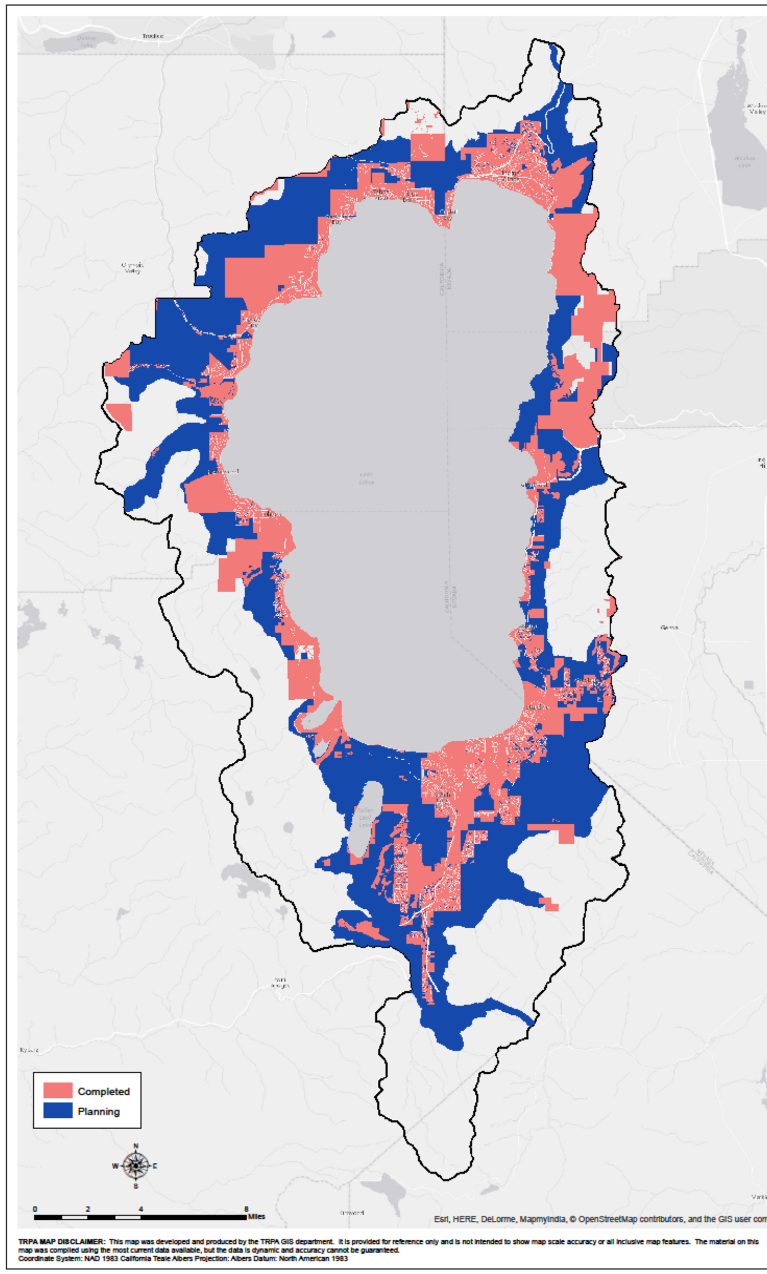
Status: **Implemented**

Image

Forest fuels reduction treatment.



2015 photo of the 2007 Angora burn area.



Map showing the distribution of fuels reduction treatments in the Lake Tahoe Region. Source: U.S. Forest Service, Tahoe Fire and Fuels Team (2015).

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: (

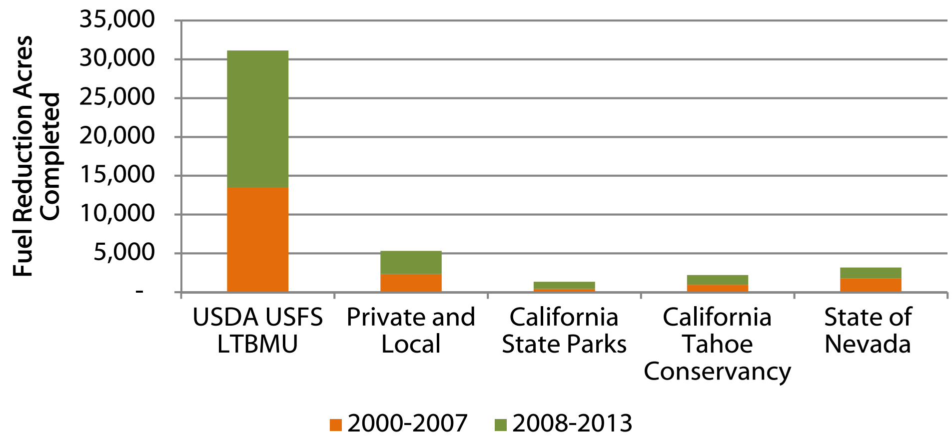


Figure 1: *Forest health/fuels reduction activities in the Region between 2000 and 2013 (Source TFFT 2015)*

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**

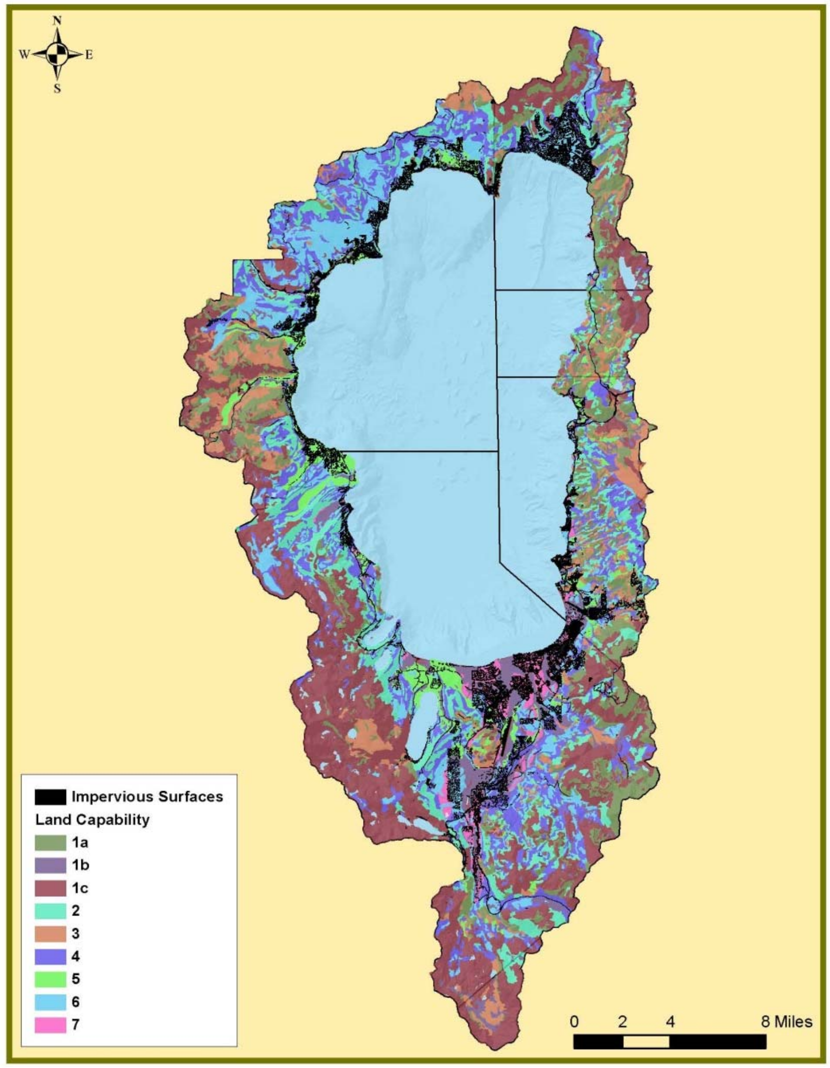
Status	Map

CONSISTENCY WITH BAILEY LAND CAPABILITY SYSTEM

Status: **Implemented**

Image

The land capability system was designed to minimize the impact of development on water resources and ecosystems.



Map showing the extent and distribution of impervious surface in the Lake Tahoe Region relative to Land Capability Districts. Source: TRPA GIS

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

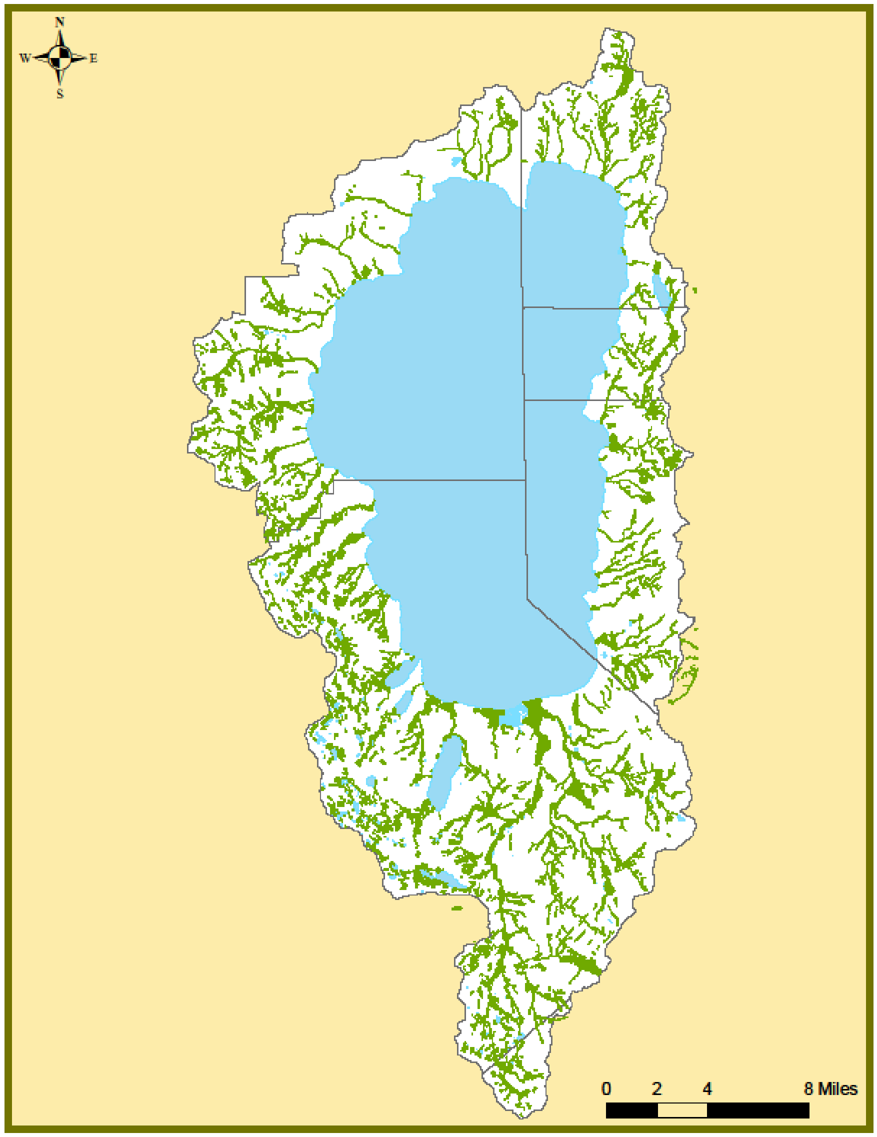
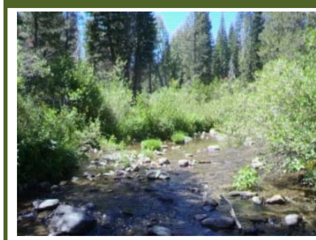
Analytic Approach – No changes recommended.

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

APPROPRIATE MANAGEMENT PRACTICES

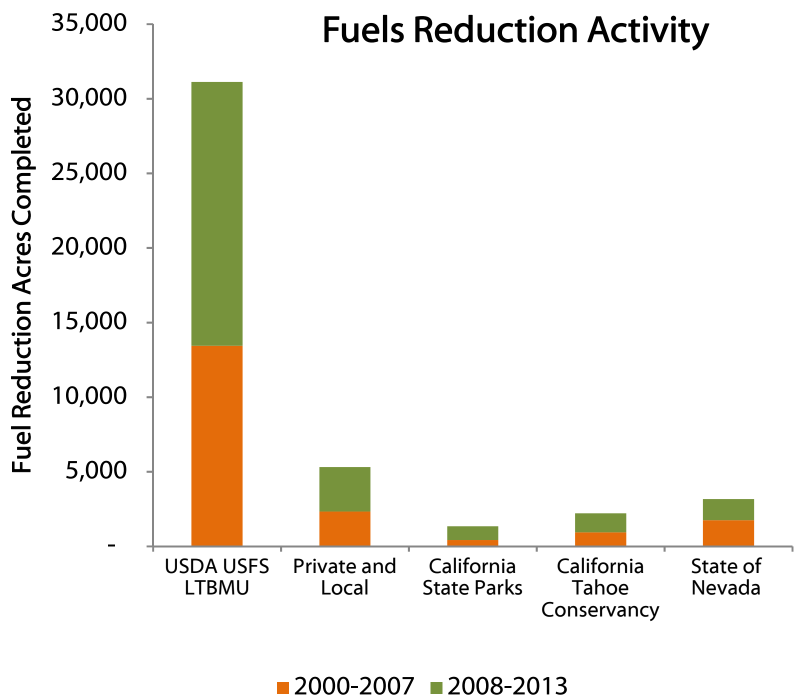
Status: **Implemented**

Photos

Area before fuels reduction treatment.

Same area after fuels reduction treatment.

Chart



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.

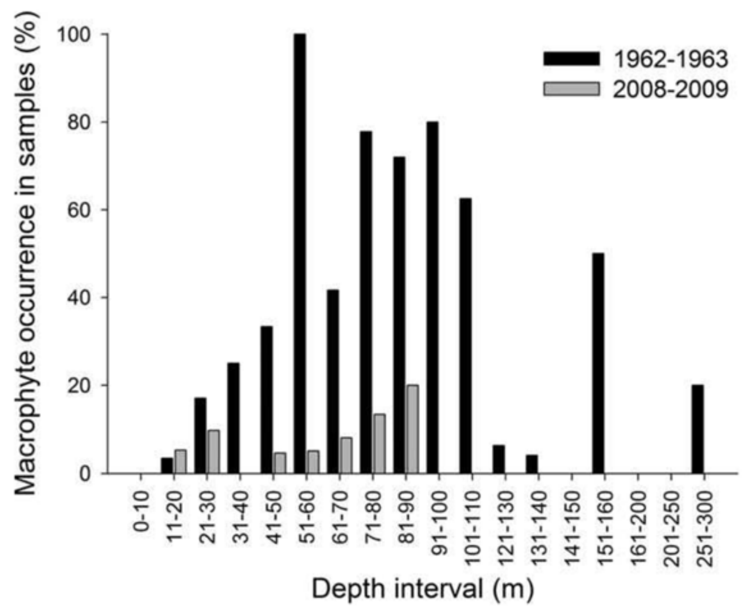
Monitoring data on the deep-water plants of Lake Tahoe is extremely limited. The deep-water plant community was discovered in the 1960s during a study of lake-bottom invertebrates (Frantz and Cordone 1967). Several species of macroalgae, filamentous algae, mosses and liverworts were identified in Lake 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

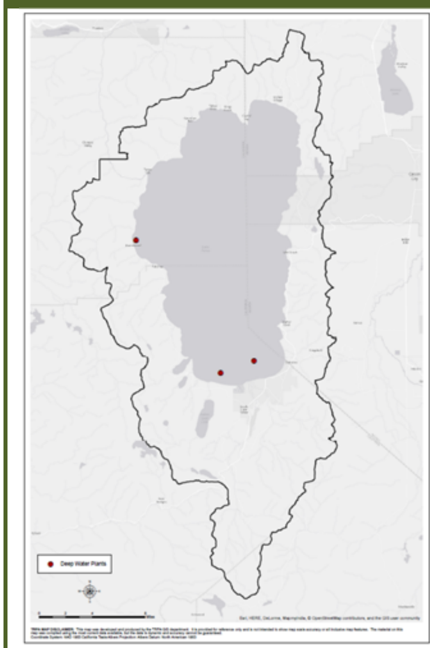
DEEPWATER PLANTS OF LAKE TAHOE

Status: **Considerably Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**



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 surveys 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.

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

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.

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.

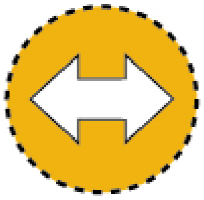
Interim Target – There is insufficient information to establish an interim target at this time.

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



UPPER TRUCKEE MARSH

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

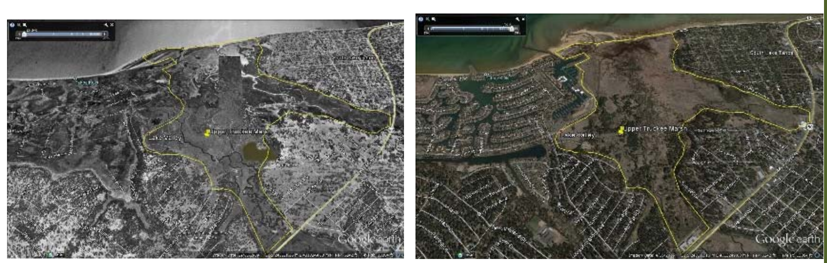
Map

Upper Truckee Marsh as identified in previous threshold evaluation reports. South Lake Tahoe, California

Trend

Photo 1: Trout Creek in the Upper Truckee Marsh. Desired condition. (Source: Marchel Munnecke, Pyramid Botanical Consultants)

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).



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.

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.

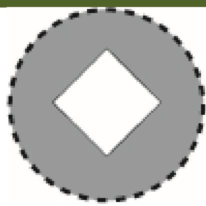
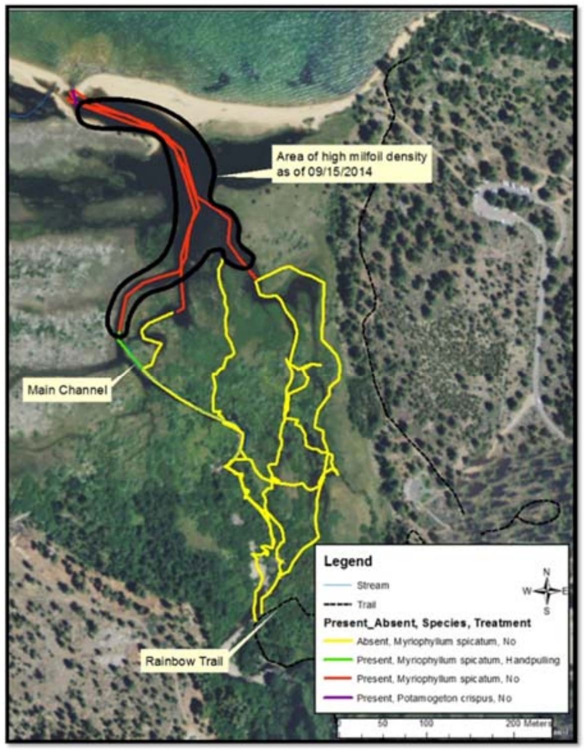
Monitoring Approach – Coordination of multiple monitoring regimes in and around the Upper Truckee Marsh is essential to promoting better understanding of the system and actions taken to manage it. TRPA will continue to collaborate in the design of the long-term monitoring protocol for the Upper Truckee 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.

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.

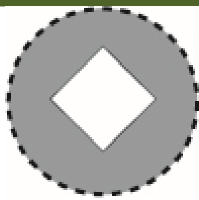
Monitoring Approach - TRPA will continue to be involved with the design of the Tallac and Taylor Creek long term monitoring plan.

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**

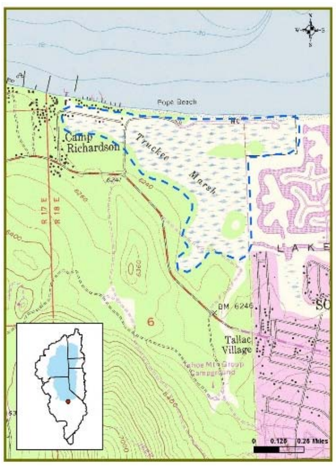
Status



POPE MARSH

Status: **Insufficient Data to Determine Status**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**

Map



Location of Pope Marsh and surrounding area.

Photos

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.

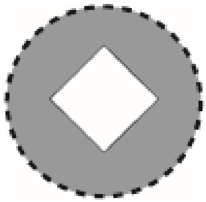
Confidence –

> **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 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**

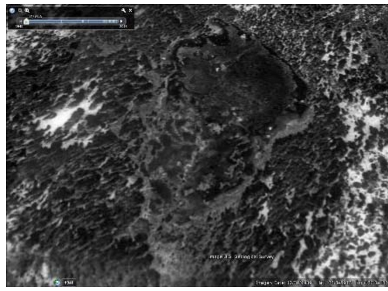


Image 1. December 1940

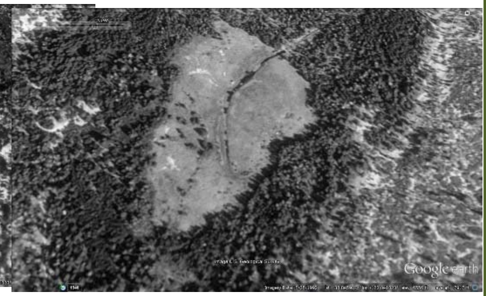


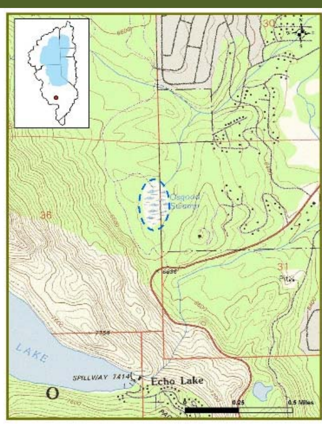
Image 2. August 1992

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.

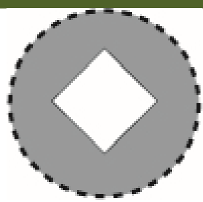
Monitoring Approach – The data from the long term monitoring plot is primarily relevant to a small fen south of Osgood Swamp. Consideration should be given additional monitoring in other parts of the swamp. Remote sensing has been effective in detecting change in fens in the Sierra Nevada (Drexler et 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



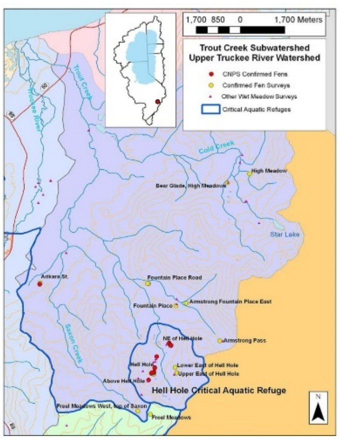
HELL HOLE (SPAHAGNUM FEN)

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.

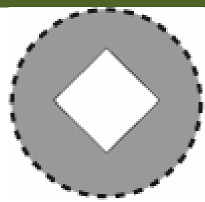
Monitoring Approach – The LTBMU monitoring methods (meadow health plots, moss monitoring plots, permanent photo points) appear to be a robust assessment of the status and trends of Hell Hole. Remote sensing has been effective in detecting change in fens in the Sierra Nevada (Drexler et al., 2013) and 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)**

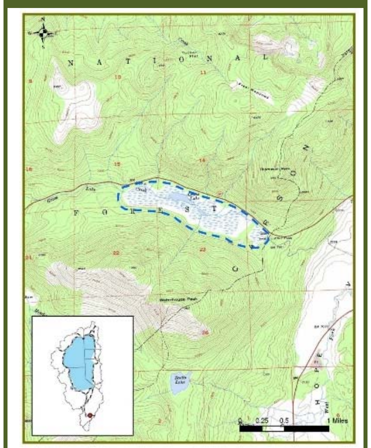
Status	Trend



GRASS LAKE
(SPHAGNUM FEN)

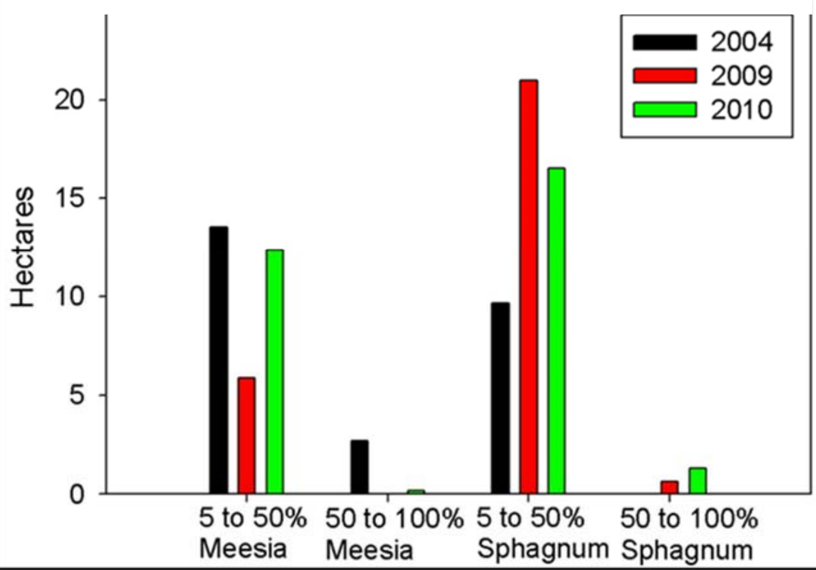
Status - **Insufficient Data to Determine Status**
Trend - **Insufficient Data to Determine Trend**
Confidence – **Low**

Map



Map showing location of Grass Lake and surrounding area.

***Sphagnum* spp. and *Meesia triquetra* by cover at Grass Lake**



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.

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.

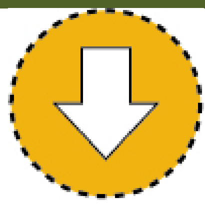
Monitoring Approach – The LTBMU monitoring methods (meadow health plots, moss monitoring plots, permanent photo points) appear to be a robust assessment of the status and trends of Grass Lake. Remote sensing has been effective in detecting change in fens in the Sierra Nevada (Drexler et al., 2013) and 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**

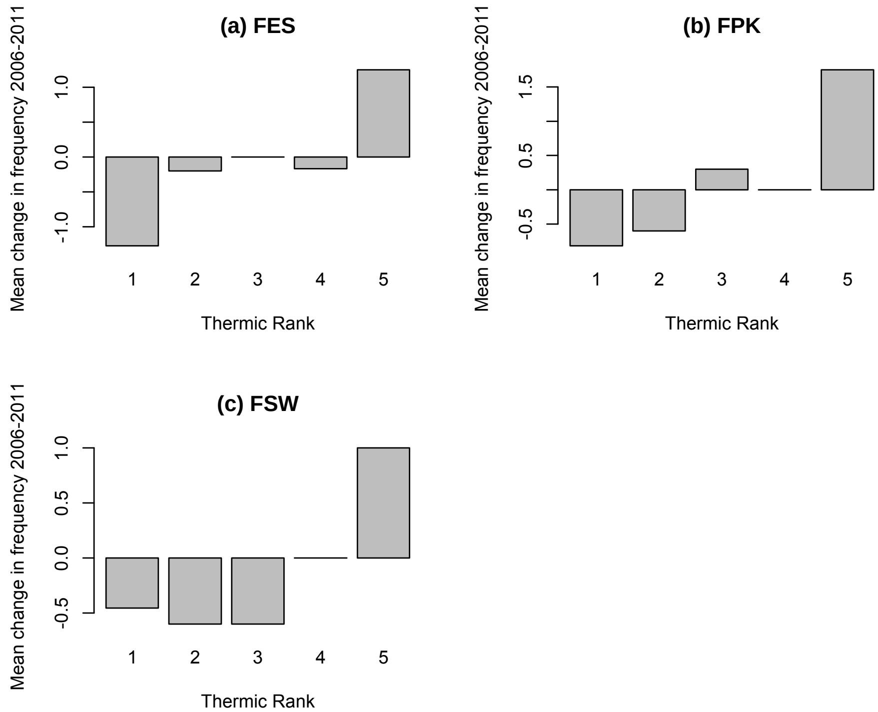
Status	Trend



FREEL PEAK CUSHION PLANT COMMUNITY

Status: **Somewhat Worse than Target**
Trend: **Rapid Decline**
Confidence: **Low**

Freel Peak Species Composition



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.

Photo

Photo credit: Calscape.org, Copyright 2006 Stan Shebs.

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 lyallii* var. *lyallii*), 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.

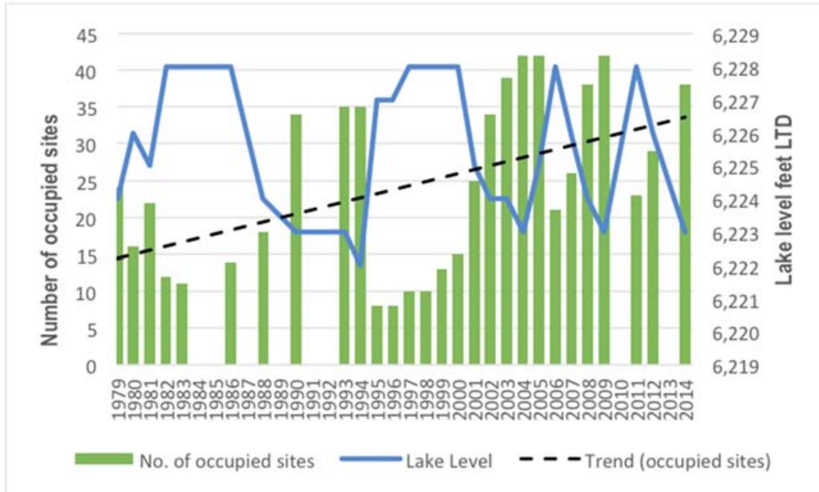
Following the approach of prior threshold evaluation reports, this evaluation assesses attainment based on the number of subpopulations. Four of the five species were determined to be in attainment and considerably better than target (Table 6.2). Galena Creek rockcress, determined to be considerably 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**	 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	
 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

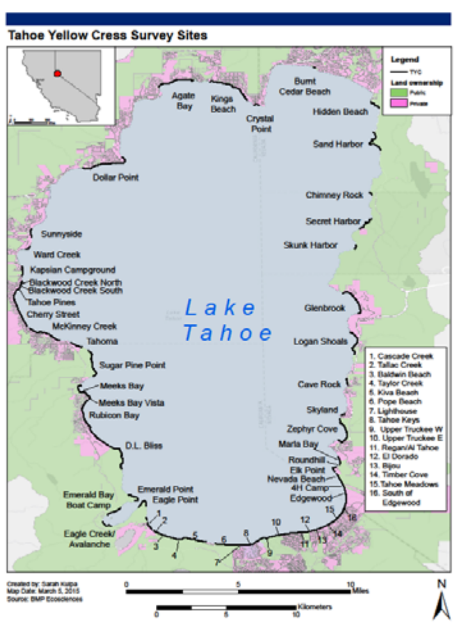


Figure 1: Tahoe Yellow Cress survey sites

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.

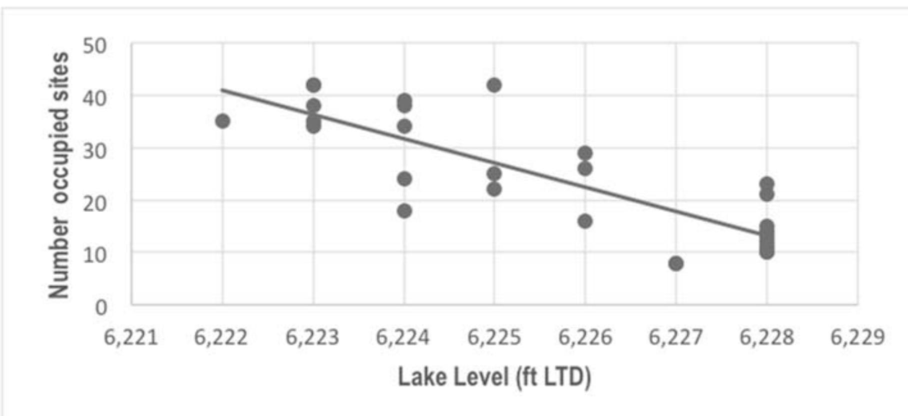


Figure 2: *Number of occupied sites by lake level.*

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.

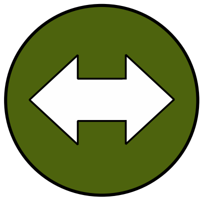
Monitoring Approach – In 2010, the AMWG adopted an adaptive survey strategy that emphasizes high lake level monitoring. Surveys are now completed every year when Lake Tahoe is at or above 6,226 feet (1,897.7 meters) LTD, but only every other year at lower lake levels. This approach is adequate for assessing 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.

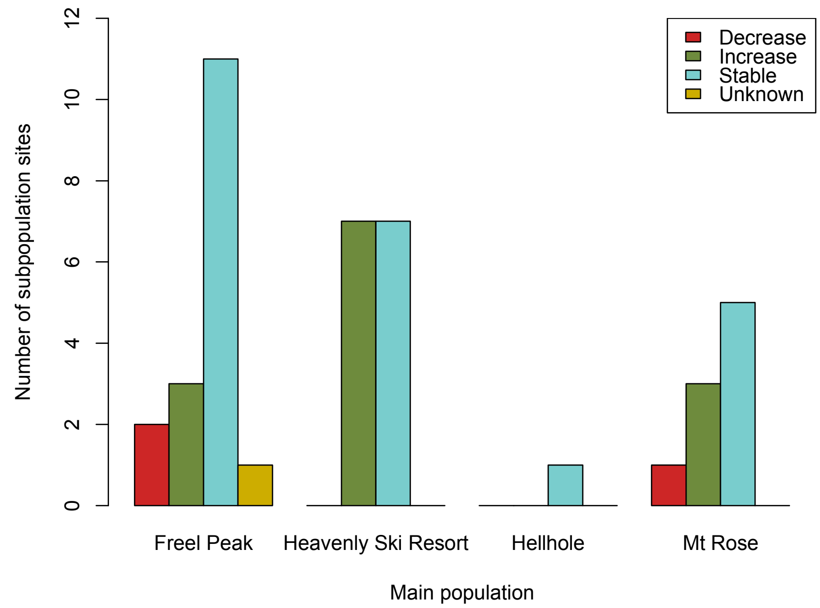
Sensitive Plants: **Tahoe Draba (*Draba asterophora var. asterophora*)**

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.

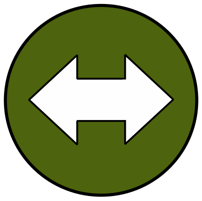
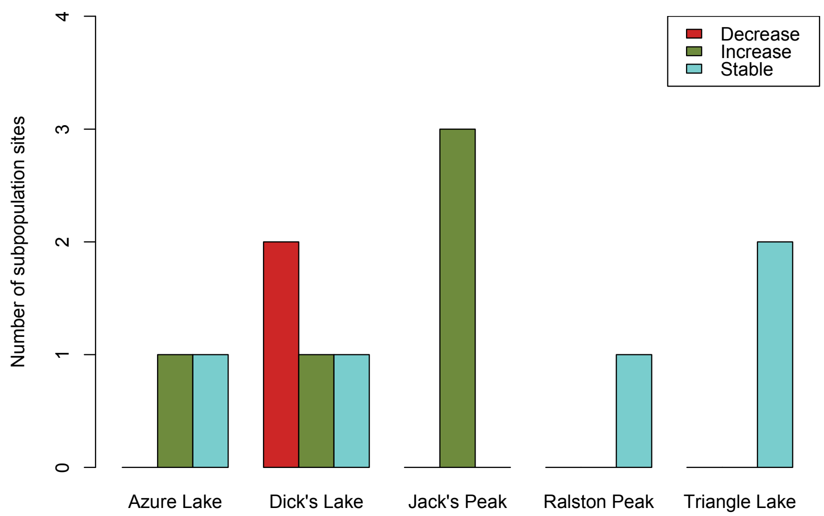
Consideration should be given to the use of a mixed effects models to assess the impact of climate change, habitat suitability, competition and sampling design.

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**	**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
Photo	
 Photo credit: Calscape.org, Copyright 2007.	

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.

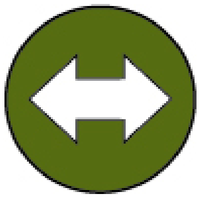
Relocation and establishment of a regular monitoring of the population at Keith's Dome/Triangle Lake (Halford, 1992), and the plot outside the Region and Basin Peak, would provide valuable information for assessing longer term trends.

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



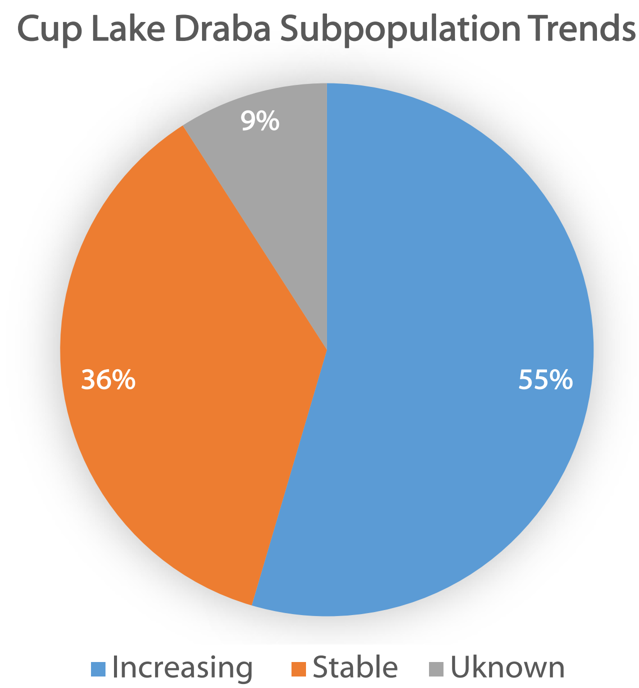
CUP LAKE DRABA (*DRABA ASTEROPHORA* VAR. *MACROCARPA*)

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

Photo

Photo Credit: Mike Taylor. USDA Forest Service

Trend



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.

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.

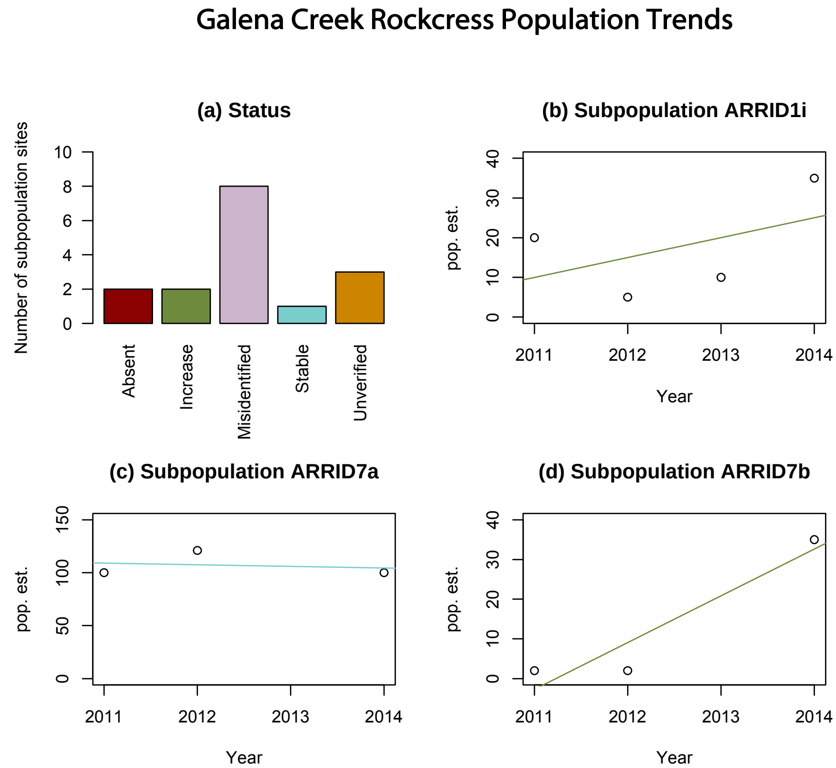
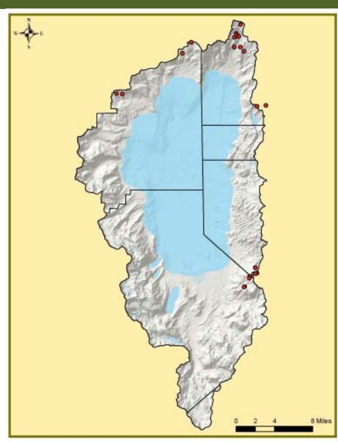
Consideration should be given to the use of a mixed effects models to assess the impact of climate change, habitat suitability, competition and sampling design.

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**	 (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.
Map	
 Approximate locations of suspected Galena Creek rockcress in the Lake Tahoe Region, September, 2010. Source: USFS-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**

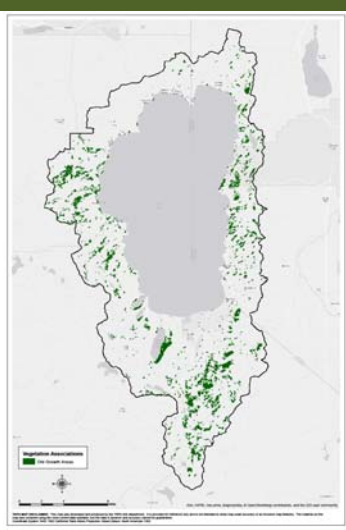
Status

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**

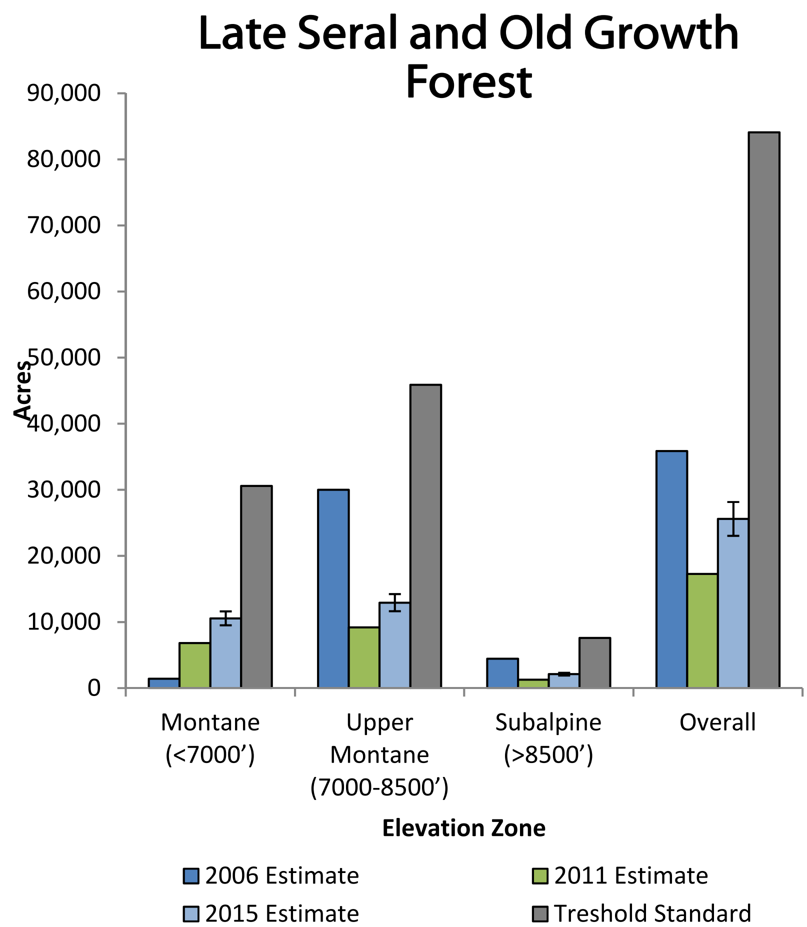
SUBALPINE ZONE
Status: **Considerably Worse than Target**
Trend: **Insufficient Data to Determine Trend**
Confidence: **Low**

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.

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.

Chapter 6 Vegetation Preservation References

Aecom, ENTRIX, C., 2013. Draft Environmental Impact Report Upper Truckee River and Marsh Restoration Project.

Airola, D.A., Barrett, R.H., 1985. Foraging and habitat relationships of insect-gleaning birds in a Sierra Nevada mixed-confier forest. The Condor 87, 205–216.

Bailey, R.G., 1974. Land-Capability Classification of the Lake Tahoe Basin, California-Nevada, A Guide For Planning. USFS, USDA, TRPA, South Lake Tahoe, CA.

Beardsley, D., Bolsinger, C., Warbington, R., 1999. Old-growth forests in the Sierra Nevada: by type in 1945 and 1993 and ownership in 1993. (No. Research Paper PNWRP-516). USDA Forest Service, Pacific Southwest Research Station, Portland, OR.

Bell, K.L., Bliss, L.C., 1973. Alpine disturbance studies: Olympic national park, USA. Biol. Conserv. 5, 25–32.

Billings, W.D., Mooney, H.A., 1968. The ecology of arctic and alpine plants. Biol. Rev. 43, 481–529.

Caires, A.M., Chandra, S., Hayford, B.L., Wittmann, M.E., 2013. Four decades of change: dramatic loss of zoobenthos in an oligotrophic lake exhibiting gradual eutrophication. Freshw. Sci. 32, 692–705. doi:10.1899/12-064.1

Chandra, S., Caires, A., Rejmankova, E., Reuter, J., 2015. Understanding the decline of deepwater sensitive species in Lake Tahoe: What is responsible, eutrophication or species invasions? (No. OSP-1205055 (UNR # 1320-114-23FX)). University of Nevada-Reno, Reno, NV.

Chimner, R.A., Cooper, D.J., 2002. Modeling carbon accumulation in Rocky Mountain fens. Wetlands 22, 100–110.

CNPS, R.P.P., 2016. Inventory of rare and endangered plants (online edition, V8-02) [WWW Document]. URL http://www.rareplants.cnps.org

Cooper, D.J., 1990. Ecology of wetlands in Big Meadows, Rocky Mountain National Park, Colorado. U.S. Fish and Wildlife Service.

Cooper, D.J., Wolf, E.C., 2006. Fens of the Sierra Nevada, California, Report prepared for the US Forest Service, Region 5, Vallejo, CA.

Coppeto, S.A., Kelt, D.A., Van Vuren, D.H., Wilson, J.A., Bigelow, S., 2006. Habitat associations of small mammals at two spatial scales in the northern Sierra Nevada. J. Mammology 87, 335–345.

CSLC, 1998. Tahoe Yellow Cress Draft Biological Assesment. California State Lands Commission, Sacramenta, CA.

CSLC, 1994. Tahoe Yellow Cress Draft Biological Assesment. California State Lands Commission, Sacramenta, CA.

CWHR, 2011. California Wildlife Habitat Relationship System.

Drexler, J.Z., Knifong, D., Tuil, J., Flint, L.E., Flint, A.L., 2013. Fen a whole-ecosystem gauges of groundwater recharge under climate change. J. Hydrol. 481, 22–34.

EDAW, 2005. Biological Setting and Processes, in: Taylor, Tallac, and Spring Creek Watershed EAR. U.S. Forest Service.

Elliot-Fisk, D.L., Cahill, T.C., Davis, O.K., Duan, L., Goldman, C.R., Gruell, G.E., Harris, R., Kattleman, R, Lacey, R., Leisz, D., Lindstrom, S., Machida, D., Rowntree, R.A., Rucks, P., Sharkey, D.A., Stephens, S.L., Ziegler, D.S., 1996. Lake Tahoe case study, Addendum to: Sierra Nevada Ecosystem project, final report to congress. University of California, Davis, Centers for water and Wildland Resources, Davis, CA.

Elliott-Fisk, D.L., Harris, R., Rowntree, R.A., Cahill, T.A., Kattelmann, R., Rucks, P., Davis, O.K., Lacey, R., Sharkey, D.A., Duan, L., Leisz, D., Stephens, S.L., Goldman, C.R., Lindstrom, S., Ziegler, D.S., Gruell, G.E., Machida, D., 1996. Lake Tahoe Case Study, in: Sierra Nevada Ecosystem Project:

Final Report to Congress, Addendum. Davis: University of California, Centers for Water and Wildland Resources, Davis, p. 60.
FGDC, 1997. Vegetation classification standard, FGDC-STD-005. Vegetation subcommittee, Federal geographic data committee, U.S. Geological Survey, Reston, VA.
Frantz, T.C., Cordone, A.J., 1967. Observations on deepwater Plants in Lake Tahoe, California and Nevada. Ecology 48, 6.
Fuller, L., Quine, C.P., 2016. Resilience and tree health: a basis for implementation in sustainable forest management. Forestry 89, 7–19. doi:10.1093/forestry/cpv046
Gottfried, M., Pauli, H., A.Futschik, Akhalkatsi, M., Barancok, P., Alonso, J., Coldea, G., Dick, J., Erschbamer, B., Calzado, M., Kazakis, G., Krajci, J., Larsson, P., Mallaun, M., Michelsen, O., Moiseev, D., Moiseev, P., Molau, U., Merzoiki, A., Nagy, L., Nakhutsrishvili, G., Pedersen, B., Pelino, G., Puscas, M., Rossi, G., Stanisci, A., Theurillat, J.-P., Tomaselli, M., Villar, L., Vittoz, P., Vogiatzakis, I., Grabherr, G., 2012. Continent-wide response of mountain vegetation to climate change. Nat. Clim. Change 2, 111–115.
Green, C.T., 1991. Integrated studies of hydrogeology and ecology of Pope Marsh, Lake Tahoe. Amherst College.
Halford, A.S., 1992. Interim Management Guide for Lewisia longipetala Tahoe and Eldorado National Forests and the Lake Tahoe Basin Management Unit. USDA Forest Service, Tahoe National Forest, Nevada City, CA.
Halford, A.S., Nowak, R.S., 1996. Distribution and ecological characteristics of Lewisia longipetala (Piper) Clay, a high-altitude endemic plant. Gt. Basin Nat. 56, 225–236.
Kattleman, R, Embury, M, 1996. Riparian areas and wetlands, in: Sierra Nevada ecosystem project: final report to congress, vol. 3, assessments and scientific basis for management options. University of California, Davis, Centers for water and Wildland Resources, Davis, CA.
Keyser, C.E., Dixon, G.E., 2015. Western Sierra Nevada (WS) Variant Overview – Forest Vegetation Simulator. Internal Rep comp. 2008 (revised November 2, 2015. U. S. Department of Agriculture, Forest Service, Forest Management Service Cente r.
Knapp, C.M., 1980. Rorippa subumbellata Roll. Status in the Lake Tahoe Basin. U.S.D.A. Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe, CA.
Kondolf, G.M., Kattleman, R., Embury, M., Erman, D.C., 1996. Status of riparian habitat, Sierra Nevada ecosystem project, final report to congress, assessments and scientific basis for management options. University of California, Davis, Centers for water and Wildland Resources, Davis, CA.
Korner, C., 2003. Carbon limitation in trees. J. Ecol. 91, 4–17. doi:10.1046/j.1365-2745.2003.00742.x
Lindstrom, S., Rucks, P., Wigand, P., 2000. A contextual overview of human land use and evironmental conditions, Lake Tahoe Watershed assessment: volume 1, gen. tech. report. U.S. Department of Agriculture, Forest Service Pacific Southwest Research Station.
LTBMU, 2015. USFS AIS Summary Report for 2015.
LTBMU, 2014. Scoping Report for Taylor and Tallac Restoration Project. US Forest Service.
Manley, P.N., Murphy, D.D., Bigelow, S., Chandra, S., Crampton, L., 2010. Chapter 6: Ecology and biodiversity, in: An Integrated Science Plan for the Lake Tahoe Basin: Conceptual Framework and Research Strategies. p. 65.
Manley, P.N., Schlesinger, M.D., 2001. Riparian biological diversity in the Lake Tahoe Basin., Final report for the California Tahoe Conservancy and U.S. Forest Service.
Manley, P.N., Fites-Kaufman, J.A., Barbour, M.G., Schlesinger, M.D., Rizzo, D.M., 2000. Chapter 5: biological integrity, Lake Tahoe Watershed assessment: volume 1, gen. tech. report. U.S. Department of Agriculture, Forest Service Pacific Southwest Research Station, Albany, CA.
McKnight, S., Rowe, C., 2015. LTBMU Rare Botanical Species - 2013-2014 Monitoring Report. USDA Forest Service, Lake Tahoe Basin Management Unit.

Mitsch, W.J., Gosselink, J.G., Anderson, C.J., Zhang, L., 2009. Wetland ecosystems. John & Wiley Sons, Inc., New York.
Murphy, D.D., Knopp, C.M., 2010. Lake Tahoe Watershed Assessment: Volume I (Gen. Tech. Rep. No. PSW-GTR-175). Pacific Southwest Research Station, Forest Service, US Department of Agriculture, Albany, CA.
Muskopf, S., Vacirca, R., Gross, S., Oehrli, C., Cressy, D., 2009. Taylor-Tallac Ecosystem Restoration Plan. US Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe, CA.
Nagel, T.A., Taylor, A.H., 2005. Fire and persistence of montane chaparral in mixed conifer forest landscapes in the northern Sierra Nevada, Lake Tahoe Basin, California, USA. J. Torrey Bot. Soc.
Norman, S., T., Keely, J., 2008. Heavenly Creek SEZ Demonstation Project, 2007 Soil Monitoring Report. USDA Forest Service, Lake Tahoe Basin Management Unit.
Pavlik, B., Murphy, D., Group, T.Y.C.T.A., 2002. Conservation strategy for Tahoe Yellow Cress (Rorippa subumbellata). Tahoe Regional Planning Agency, Zephyr Cove, NV.
Potter, D.A., 2005. Riparian plant community classification: west slope, central and southern Sierra Nevada, California (No. R5-NaN-22). Pacific Southwest Region - Forest Service - U.S. Department of Agriculture, Vallejo, CA.
Putnam, E.R.S., 2013. Ecology, phylogenetics, and conservation of Draba asterophora complex: a rare, alpine, endemic from Lake Tahoe, USA. Brigham Yound University.
Raumann, C.G., Cablk, M.E., 2008a. Change in the forested and developed landscape of the Lake Tahoe basin, California and Nevada, USA, 1940–2002. For. Ecol. Manag. 255, 3424–3439. doi:10.1016/j.foreco.2008.02.028
Raumann, C.G., Cablk, M.E., 2008b. Change in the forested and developed landscape of the Lake Tahoe basin, California and Nevada, USA, 1940–2002. For. Ecol. Manag. 255, 3424–3439. doi:10.1016/j.foreco.2008.02.028
Roby, K., O'Neil-Dunne, J., Romsos, S., Loftis, W., MacFaden, S., Saah, D., 2015. A Review of Stream Environment Zone Definitions, Field Delineation Criteria and Indicators, Classification Systems, and Mapping – Collaborative Recommendations for Stream Environment Zone Program Updates. Spatial Informatics Group, LLC, Pleasanton, CA.
Safford, H., 2013. Natural Range of Variation (NRV) for yellow pine and mixed conifer forests in the bioregional assessment area, including the Sierra Nevada, southern Cascades, and Modoc and Inyo National Forests. (Unpublished report). USDA Forest Service, Pacific Southwest Research Station, Vallejo, CA.
Safford, H.D., North, M., Meyer, M.D., 2012a. Climate change and the relevance of historical forest conditions, in: North, M. (Ed.), Managing Sierra Forests, Gen. Tech. Rep. PSW-GTR-237. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA, pp. 23–45.
Safford, H.D., Stevens, J.T., Merriam, K., Meyer, M.D., Latimer, A.M., 2012b. Fuel treatment effectiveness in California yellow pine and mixed conifer forests. For. Ecol. Manag. 274, 17–28. doi:10.1016/j.foreco.2012.02.013
Sheppard, W.D., Rogers, P.C., Burton, D., Bartos, D.L., 2006. Ecology, biodiversity, management, and restoration of aspen in the Sierra Nevada, Gen. Tech. report RMRS-GTR-178. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.
Sikes, K., Roach, D., Evens, J., Gross, S., 2011. Plant Community Characterization and Ranking of Fens in the Lake Tahoe Basin, California and Nevada. California Native Plant Society / USDA Forest Service Lake Tahoe Basin Management Unit, Sacramento, CA.
Stanton, A., TYCAMWG, 2015. Conservation strategy for Tahoe yellow cress (Rorippa subumbellata). U.S.D.A. Forest Service, Pacific Southwest Research Station.

Taylor, A.H., 2007. Forest changes since Euro-American settlement and ecosystem restoration in the Lake Tahoe Basin, USA, Restoring fire-adapted ecosystems: proceedings of the 2005 National Silviculture Workshop. US Department of Agriculture, Forest Service, Albany, USA.
Taylor, A.H., Vandervlugt, A.M., Maxwell, R.S., Beaty, R.M., Airey, C., Skinner, C.N., 2014. Changes in forest structure, fuels and potential fire behaviour since 1873 in the Lake Tahoe Basin, USA. Appl. Veg. Sci. 17, 17–31. doi:10.1111/avsc.12049
TFFT, 2015. Lake Tahoe Basin Community Wildfire Protection Plan. Tahoe Fire and Fuels Team, Lake Tahoe.
TRPA, 2016. Lake Tahoe Environmental Improvement Program Project Tracker.
TRPA, 2012a. Code of Ordinances. Tahoe Regional Planning Agency, Stateline, NV.
TRPA, 2012b. Regional Plan. Tahoe Regional Planning Agency, Stateline, NV.
TRPA, 2012c. 2011 Threshold Evaluation. Tahoe Regional Planning Agency, Stateline, NV.
TRPA, 2012d. 2011 Threshold Evaluation. Tahoe Regional Planning Agency, Stateline, NV.
TRPA, 2012e. Regional Plan. Tahoe Regional Planning Agency, Stateline, NV.
TRPA, 2007. 2006 Threshold Evaluation Report. Tahoe Regional Planning Agency, Stateline, NV.
TRPA, 2001. Regional Plan for the Lake Tahoe Basin: 2001 Threshold Evaluation Draft. Tahoe Regional Planning Agency, Stateline, NV.
TRPA, 1986. Regional plan for the Lake Tahoe Basin, goals and policies.
U.S. Forest Service, 2016. Forest Service Survey Finds Record 66 Million Dead Trees in Southern Sierra Nevada.
USDA, 2011. Managing shrub habitats for birds in the Sierra Nevada.
USDA, 2009. Lake Tahoe Basin Management Unit Accuracy Assessment - CALVEG Zone 3 [WWW Document]. URL http://www.fs.fed.us/r5/rsl/projects/mapping/accuracies/aa-tmu011409.html
USDA, 2001. Sierra Nevada forest plan amendment, final environmental impact statement, record of decision. USDA Forest Service, Pacific Southwest Research Station.
USFS LTBMU, 2015. Land Management Plan Lake Tahoe Basin Management Unit. USDA Forest Service Lake Tahoe Basin Management Unit, South Lake Tahoe, California.
Van de Ven, C.M., Weiss, S.B., Ernst, W.G., 2007. Plant species ditributions under present conditions and forecasted for warmer climates in an arid mountain range. Earth Interact. 11, 1–33.
Warbington, R., Schwind, B., Brohman, R., Brewer, K., Clerke, W., 2011. Requirements of remote sensing and geographic information systems to meet the new forest service existing vegetation classification and mapping standards.
Weixelman, D., Bakker, G., Fites, J.A., 2003. USFS Region 5 range monitoring project 2003 report. Adaptive Management Services, USDA Forest Service, Nevada City, CA.
Wittmann, M.E., Chandra, S., 2015. Implementation Plan for the Control of Aquatic Invasive Species within Lake Tahoe. Lake Tahoe AIS Coordination Committee, Reno, NV.