Appendix E: Specific Amendments to the 1980 Yosemite General Management Plan Resulting from the *Tuolumne River Plan*

The Wild and Scenic Rivers Act requires river managing agencies to prepare comprehensive management plans for each Wild and Scenic river. The Act generally provides that river management plans “shall be coordinated with and may be incorporated into resource management planning for affected adjacent Federal lands” (16 USC 1274).

The Tuolumne Wild and Scenic River Comprehensive Management Plan (*Tuolumne River Plan*) will revise portions of the 1980 *General Management Plan* for Yosemite National Park. The *Tuolumne River Plan* provides management direction for the 54 miles of the Tuolumne Wild and Scenic River under the jurisdiction of the NPS. No development or park use of lands in the river corridor shall be permitted that is inconsistent with the Wild and Scenic Rivers Act designation of the Tuolumne River, with this plan, or with the *General Management Plan*.

Accordingly, the *Draft Tuolumne River Plan* would result in the following amendments to the *General Management Plan*.

- The *Tuolumne River Plan*’s river corridor boundaries, segment classifications, Outstandingly Remarkable Values, and corresponding management objectives revise the *General Management Plan* by establishing more detailed land-use prescriptions that must be applied in future site-specific planning.
- The *Tuolumne River Plan*’s Section 7 determination process (as called for in the Wild and Scenic Rivers Act) is a tool that augments the goals of the *General Management Plan*. The Section 7 process will establish specific guidelines for determining appropriate actions within the bed and banks of the Tuolumne River that do not constitute a direct and adverse effect on the river’s free-flowing condition, water quality, or other values.
- The *Tuolumne River Plan*’s specific programs, including user capacity, ecological restoration, and ongoing monitoring revise and augment the previous broad direction provided in the *General Management Plan*.
- The *Tuolumne River Plan*’s management actions and site planning for Tuolumne Meadows would revise previous site planning actions proposed in the *General Management Plan*.

Management Goals

The *General Management Plan* sets forth the purposes of the park and the important resources and values that guide resource management, visitor use, and park operations (NPS 1980: 5-10). The *General Management Plan* establishes five broad goals for managing Yosemite National Park (NPS 1980: 1-4):

- Reclaim priceless natural beauty
- Allow natural processes to prevail
- Promote visitor understanding and enjoyment
- Markedly reduce traffic congestion
- Reduce crowding

The *Tuolumne River Plan* was developed to be in keeping with the five broad goals of the *General Management Plan,* however its overarching goals are also in keeping with the mandates of the Wild and Scenic Rivers Act. Specifically, the *Tuolumne River Plan* defines what the Wild and Scenic Rivers Act calls "outstandingly remarkable values" for the river. These are the unique, rare, and exemplary characteristics of the river that make it stand apart from all other river in the nation. These outstandingly remarkable values—along with water quality and the river's free-flowing condition—are central to the overarching purpose of wild and scenic river management: to protect and enhance these values while allowing public enjoyment, education, and recreation now and in the future. The *Tuolumne River Plan* augments the park's *General Management Plan* by articulating important river-related biological, cultural, and recreation values for the Tuolumne Wild and Scenic River corridor.

Management Objectives

The *General Management Plan* sets forth a number of Management Objectives that guide resource management, visitor use, and park operations (NPS 1980: 5-10). The *Tuolumne River Plan* amends the *General Management Plan* by providing additional detailed guidance to park managers on how to achieve management objectives for the Tuolumne River corridor.

Management elements in the *Tuolumne River Plan* include boundaries, classifications, a definition of outstandingly remarkable values, a Wild and Scenic Rivers Act Section 7 determination process, a user capacity program, an ecological restoration program, an ongoing monitoring program, and management actions needed to protect and enhance river values. Taken together, these elements further guide resource management, visitor use, and park operations within the Tuolumne River corridor.

For example, projects within the river corridor must protect and enhance outstandingly remarkable values and be consistent with the other elements of the *Tuolumne River Plan*. Projects adjacent to the river corridor must protect outstandingly remarkable values, and depending on location, may need to undergo a Section 7 review if they affect the bed or banks of the river.

As a result of the above, the following is to be inserted on page 5 of the 1980 *General Management Plan,* after the first paragraph under "Management Objectives:"

The management objectives for the Tuolumne River corridor focus on protecting and enhancing river values. These objectives, which are worded as conditions to be achieved and maintained over time, are as follows in table E-1.

Table E-1.
Management Objectives for Free Flow, Water Quality, and Outstandingly Remarkable Values

River Value	Management Objectives
Free-Flowing Character	All Segments Above O'Shaughnessy Dam, natural hydrologic processes are preserved and the river remains free of new unnatural impoundments. Below O'Shaughnessy Dam, science-based dam releases mimic to the extent feasible the variation of the seasonal hydrology in order to sustain the aquatic and riparian ecosystems upon which native wildlife species depend.
Water Quality	All Segments Water quality is exceptional. Management of visitor use may be intensive, if necessary, to maintain and protect the integrity of this value.
Biologic Value Subalpine riparian/meadow complex	Segments: Dana Fork (Scenic), Lyell Fork (Wild) , Tuolumne Meadows (Scenic) The subalpine riparian and meadow complex has high ecological integrity. Management of resources and visitor use may be intensive, if necessary, to restore and protect the integrity of this value. The subalpine riparian and meadow complex is sustained by natural hydrologic and biological processes to the extent feasible. The ecological restoration objectives for the meadows are to Protect, maintain, and restore natural hydrologic function of the Tuolumne River and tributaries. Protect, maintain, and restore the function, structure, diversity, and productivity of native riparian and meadow plant communities and wildlife habitat. (See Chapters 5, 7, and Appendix H)
Biologic Value Low-elevation riparian and wetland habitat	Segment: Poopenaut Valley (Wild) The ecological integrity of the riparian and wetland habitat in Poopenaut Valley is as high as possible considering its location below O'Shaughnessy Dam. Management of resources and visitor use may be intensive, if necessary, to restore and protect the integrity of the low-elevation riparian and wetland habitat.
Geologic Value Extensive example of stairstep river morphology	Segment: Grand Canyon (Wild) The character of the Tuolumne River through the Grand Canyon of the Tuolumne is shaped by the extensive stairstep morphology without human interference. Multiple cascades and waterfalls are sustained by natural processes.
Cultural Value Archeological landscape	All Segments Outstandingly remarkable archeological sites are protected at their current levels of integrity, with minimal additional human-caused disturbance. Management of resources and visitor use may be intensive, if necessary, to protect the integrity of this value.
Cultural Value Parsons Memorial Lodge	Segment: Tuolumne Meadows (Scenic) Parsons Memorial Lodge is preserved at its current level of integrity. Elements contributing to the Soda Springs Historic District are protected and restored if necessary to enhance visitor enjoyment and understanding. Historic views are maintained without disrupting the integrity of the natural ecosystem or other biological values or river processes.
Scenic Value Dramatic views and landscape features	Segments: Lyell Fork (Wild), Grand Canyon (Wild) In wild segments, the scenery of the Tuolumne River and the environment through which it flows is shaped by natural processes without human interference. Segments: Dana Fork (Scenic), Tuolumne Meadows (Scenic) In scenic segments (nonwilderness), scenery is shaped by natural processes. Identified vista points are enhanced in a manner that is protective of ecological conditions and archeological values at each viewpoint.
Recreational Value Wilderness-oriented recreation	Segments: Lyell Fork (Wild), Grand Canyon (Wild) Wilderness travelers along the Tuolumne River engage in a variety of activities in an iconic High Sierra landscape, where opportunities for primitive and unconfined recreation, self-reliance, and solitude shape the experience.
Recreational Value Access to high-elevation section of the Tuolumne River afforded by Tioga Road.	Segments: Dana Fork (Scenic), Tuolumne Meadows (Scenic) The quality of the visitor experience is protected by providing safe and efficient access, while protecting other river values from visitor use related impacts

Land Management Zoning

The 1980 *General Management Plan* divided the park into several zones based on management objectives, significance of the resources, and legislative constraints. The zoning plan described the land use policies that management would work to achieve over the life span of the plan.

Much of the Tuolumne River corridor exists within what are referred to as *natural zones (*including Wilderness Subzone, Environmental Protection Subzone, Outstanding Natural Feature subzone, Natural Environment Subzone, etc.). The *Tuolumne River Plan* establishes boundaries and classifications for the river in accordance with the Wild and Scenic Rivers Act. While no additional zoning was established as a management tool in this plan, the management guidance provided in this *Tuolumne River Plan* would remain consistent with the guidance established in these zones.

Policies and Programs

The 1980 *General Management Plan* established a visitor carrying capacity that was based on the capacity of facilities and infrastructure in the park at that time (NPS 1980: 15-19). The plan recommended changes to the kinds and levels of development to fulfill and support the plan's objectives.

Understanding of visitor uses and capacities has expanded and changed since the *General Management Plan* was published; similarly, the Wild and Scenic Rivers system has also expanded to include the Tuolumne (and Merced) Rivers in Yosemite. Subsequent litigation on the Merced Wild and Scenic River Comprehensive Management Plan has resulted in additional directives regarding the establishment of "specific numerical limits" as part of the Wild and Scenic Rivers Act mandate to address user capacity.

For these reasons, the visitor use limits and rationale proposed in the 1980 *General Management Plan* have been revised. The *Tuolumne River Plan* proposes a user capacity program that establishes the kinds and amounts of visitor use that can be permitted while protecting and enhancing river values in the Tuolumne River corridor, including a maximum number of people. The *Tuolumne River Plan* also establishes a program of indicators and standards to assess the condition of river values over time.

This new user capacity program will guide each new planning effort undertaken in the Tuolumne River corridor and will therefore amend the *General Management Plan* for areas within the Tuolumne corridor as regards user capacity. The following specific sections are added to page 15 of the 1980 *General Management Plan:*

- The first paragraph under "Park Policies and Programs" shall have this addition:

  Parkwide policies and programs with respect to visitor use, Indian cultural programs, park operations and visitor protection described in this section have been amended by the Tuolumne River Plan *for all areas within the Tuolumne River corridor*.

- The first paragraph under "Visitor Use" shall have this addition:

  The sections below that address appropriate activities, visitor use levels, visitor facilities and services, overnight accommodations, concessions, regional cooperation, transportation, interpretation, and provisions for special populations will be guided by the management elements of the Tuolumne River Plan. *Visitor use levels and activities are further guided by, and must comply with, the management elements of the* Tuolumne River Plan. *In the event of a conflict between Parkwide Policies and Programs in the* General Management Plan *and specific elements of the* Tuolumne River Plan, *the* Tuolumne River Plan *will control.*

- The first paragraph under "Visitor Use Levels" shall have this addition:

  The section below that addresses visitor use levels, visitor facilities and services, overnight accommodations, and transportation for the Tuolumne River corridor in Tuolumne Meadows is amended by the Tuolumne River Plan. *Specifically,* General Management Plan *visitor use levels for the Meadows are no longer in effect. These visitor use levels are superseded by the user capacity management program in the* Tuolumne River Plan.

In addition, this sentence on page 24 shall be struck from the *General Management Plan*: "A new field office will be developed at Tuolumne Meadows."

Developed Area Plans

The *General Management Plan* contained a Developed Area Plan for the Tuolumne Meadows area, within the Tuolumne River corridor (NPS 1980: 62-65). Future plans for the Tuolumne Meadows area must comply with the management elements of the *Tuolumne River Plan* (boundaries, classifications, Outstandingly Remarkable Values and their protection, Section 7 determination process, user capacity program, restoration program, monitoring program, and management actions). Therefore, the development concepts presented in the *General Management Plan* (pages 62-65) have been amended by the *Tuolumne River Plan*.

The *Tuolumne River Plan* will provide guidance for any future development or redevelopment activities within the Tuolumne River corridor, including the development concepts as described in the 1980 *General Management Plan*. While many of the *General Management Plan's* site planning goals for Tuolumne Meadows are compatible with those established in the *Tuolumne River Plan*, the river plan's range of site planning alternatives has been established for Tuolumne Meadows with particular focus on the protection of river values. To the extent that any development concept presented in the *General Management Plan* would not comply with the elements of the *Tuolumne River Plan*, that development concept is superseded by the *Tuolumne River Plan*. Therefore, the specific actions called for in the Tuolumne Meadows section of the *General Management* Plan are replaced by those management actions called for in the *Tuolumne River Plan*, which has ensured that all actions protect and enhance river values. Actions adjacent to the river corridor but outside of the river boundary must also protect the Tuolumne River's established Outstandingly Remarkable Values.

For this reason, the following paragraph is to be inserted on page 63 of the *General Management Plan*, after the first paragraph under the subheading "Tuolumne Meadows:"

> *Future plans for the Tuolumne Meadows area must comply with the management elements of the* Tuolumne River Plan *(river boundaries, river classifications, Outstandingly Remarkable Values, Section 7 determination process, user capacity management program, ecological restoration program, monitoring program, and management actions). To the extent that any development concepts presented in the* General Management Plan *do not comply with the elements of the* Tuolumne River Plan, *that development concept would be superseded by the* Tuolumne River Plan. *Actions adjacent to the river corridor but outside of the river boundary must also protect the Tuolumne River's established Outstandingly Remarkable Values.*

Backcountry

The Tuolumne Wild and Scenic River and Yosemite Wilderness were both established in 1984, four years after the publication of the park's *General Management Plan*. Although the area was not designated as wilderness at the time, backcountry management objectives were established, along with zones, capacities, and visitor use management strategies.

The *Tuolumne River Plan* would continue to manage the wild segments of the river in accordance with provisions of the Wilderness Act and overarching goals for backcountry management as articulated in the *General Management Plan*. An upcoming Wilderness Stewardship Plan will provide further guidance on wilderness activities in the river corridor.

The *Tuolumne River Plan* would revise and augment management of commercial stock use in upper Lyell Canyon through the establishment of a determination of extent necessary process for commercial use in wilderness (appendix C), grazing capacities (counted in use nights), designated commercial stock camps and approach routes, and a methodology for opening dates.

Appendix F: Revisions to Outstandingly Remarkable Value Statements, 1984-2012

Outstandingly remarkable values were first considered for the Tuolumne River as part of the development of the 1979 *Tuolumne Wild and Scenic River Study Final Environmental Impact Statement and Study Report* (Tuolumne Final Study). That report, prepared cooperatively by the National Park Service and the U.S. Forest Service, established the eligibility of the Tuolumne River for inclusion in the National Wild and Scenic Rivers System. The Tuolumne was designated a wild and scenic river in 1984 based in part on the statements of outstandingly remarkable values included in the Tuolumne Final Study.

Since the completion of the Tuolumne Final Study, the Interagency Wild and Scenic Rivers Coordinating Council (Interagency Council) has issued guidance for identifying and defining a river's outstandingly remarkable values. As part of the comprehensive planning for the river, the National Park Service has followed the Interagency Council's guidance and used the most current scientific and scholarly information available to reevaluate the statements of Tuolumne River outstandingly remarkable values.

Draft outstandingly remarkable value (ORV) statements presented in the 2006 "Tuolumne Wild and Scenic River Outstandingly Remarkable Values Draft Report," and the initial revisions of those statements included in the 2007 Tuolumne Planning Workbook, were based on relatively broad, inclusive interpretations of the criteria that an outstandingly remarkable value must be river related and rare, unique, or exemplary. As the planning for the Tuolumne River progressed, the planning team concluded that the statements were too broad to guide the management decisions that needed to be made, to guide long-term monitoring, and ultimately to ensure that planned management would be effective in protecting and enhancing river values. The Interagency Council confirmed the need to reassess the initial statements using a stricter interpretation of the outstandingly remarkable value criteria. Based on that guidance, the Tuolumne planning team revised the statements to describe a set of specific, generally mappable and measurable, outstandingly remarkable values that met stricter interpretations of being river related and unique, rare, or exemplary. The specific differences in the two sets of statements are shown below in table F-1.

Table F-1.
Revision History of Outstandingly Remarkable Value (ORV) Statements 2007-2012

Draft Outstandingly Remarkable Value (ORV) Statement from the 2007 Tuolumne Planning Workbook	**Revised ORV Statement(s) in the Draft Tuolumne River Plan**	**Reason for Change**
ECOSYSTEM ORVS	*BIOLOGICAL ORVS*	
Exemplary Ecosystems Providing Habitat for a Remarkable Diversity of Species The following biological resources contribute to this value:	None	Statement was too broad and too inclusive to be useful in guiding river management.
▪ Alpine (above 10,500 feet) habitat along the Lyell and Dana Forks, characterized by relatively high plant diversity, is important for numerous plant and animal species, including migratory bird populations and special status plant, amphibian, and small mammal species.	None	Under a tighter interpretation of the ORV criteria, alpine habitat was not considered river related or rare, unique, or exemplary.
▪ Mineral springs habitat for localized populations of special status plant species occurs in Lyell Canyon and Tuolumne Meadows.	None	Under a tighter interpretation of the ORV criteria, rare mineral spring habitat was not considered river related or dependent.
▪ The *subalpine* (8,000 to 10,500 feet) meadow systems at Tuolumne Meadows, Dana Meadows, and the meadows along the Lyell Fork sustain an exceptional diversity of river-related habitat types for plant and animal species, including migratory bird populations and special status plant, amphibian, and bat species.	None	Subalpine meadows were redundant in the earlier ORV statements (see below).
▪ Intact river-dependent habitat types, such as pools, riffles, and steep cliffs, between Tuolumne Meadows and Hetch Hetchy Reservoir support a diverse assemblage of species, including special status bird and bat species.	None	Under a tighter interpretation of the ORV criteria the plants and animal communities in the canyon were not considered unique, rare, or exemplary.
▪ Largely intact low-elevation (below 4,000 feet) riparian and meadow communities provide habitat for an exceptionally diverse assemblage of bird species and several special status bat species at Poopenaut Valley, one of the few undeveloped low-elevation meadow/wetland complexes in the region.	**Poopenaut Valley contains a type of low-elevation riparian and wetland habitat that is rarely found in the Sierra.**	The previous description emphasized the bird diversity. It is instead the wetland habitat that is unusual and most directly linked to the river.
Some of the Most Extensive Subalpine Meadow and Riparian Complexes in the Sierra Nevada	**In Tuolumne Meadows, Dana Meadows, and along the Lyell Fork, the Tuolumne River sustains one of the most extensive Sierra complexes of subalpine meadows and riparian habitats with relatively high biological integrity.**	The revised description places more emphasis on the attributes of the meadows that make them an ORV: their relatively high biological integrity and size.
GEOLOGIC ORV		
Exceptionally Well-Preserved Evidence of Glacial Processes The following geologic resources contribute to this value:	None	Statement was too broad and too inclusive to be useful in guiding river management.
▪ The Tuolumne River corridor represents one of the most extensive examples of stairstep river morphology in the Sierra Nevada.	**Between Tuolumne Meadows and Pate Valley, the Tuolumne River demonstrates classic stairstep river morphology, repeatedly transitioning from calm stretches to spectacular cascades.**	Description was rewritten to emphasize those components most integral to this ORV.

Draft Outstandingly Remarkable Value (ORV) Statement from the 2007 Tuolumne Planning Workbook	**Revised ORV Statement(s) in the Draft Tuolumne River Plan**	**Reason for Change**
GEOLOGIC ORV, CONTINUED		
▪ The geomorphology of Lyell Canyon provides a textbook example of a meandering river through a glaciated U-shaped valley.	None	Under a tighter interpretation of the ORV criteria the glacial topography was not considered to be unique, rare, or exemplary.
▪ Unusual glacial kettle ponds are located along the Dana Fork.	None	Under a tighter interpretation of the ORV criteria the glacial topography was not considered to be river related.
▪ Dramatic evidence of glaciation along the Dana Fork, Tuolumne Meadows, and the Grand Canyon of the Tuolumne includes glacial erratics, moraines, roches moutonnées, striations, hanging valleys, and some of the best examples of glacial polish in the United States.	None	Under a tighter interpretation of the ORV criteria the glacial topography was not considered to be river related.
▪ Poopenaut Valley contains some of the lowest elevation evidence of glaciation found anywhere in the western Sierra Nevada.	None	Under a tighter interpretation of the ORV criteria the glacial topography was not considered to be river related.
HYDROLOGIC ORVS		
Exceptional Water Quality	None	As addressed by the Wild and Scenic Rivers Act, water quality is a river value that is independent of the ORV criteria and should be addressed separately.
Exemplary Diversity of Hydrologic Features The following hydrologic resources contribute to this value:	None	As addressed by the Wild and Scenic Rivers Act, hydrologic processes, principally the fact that the river is free-flowing, is a river value that is independent of the ORV criteria and should be addressed separately.
▪ One of the most extensive examples of stairstep river morphology in the Sierra Nevada creates a series of spectacular cascades and waterfalls between Tuolumne Meadows and Hetch Hetchy Reservoir.	None	Stairstep morphology was redundant in the earlier ORV statements (see above).
▪ A classic and well-known example of an alkaline spring occurs at Soda Springs.	None	Under a tighter interpretation of the ORV criteria, rare mineral spring habitat was not considered river related or dependent.
PREHISTORIC AND AMERICAN INDIAN CULTURAL ORVS	CULTURAL ORV	
Regionally Significant Archeological Evidence of Prehistoric Travel, Trade, Land Use, and Settlement The following archeological sites, eligible for listing on the National Register of Historic Places, contribute to this value:	**The rich archeological landscape along the Tuolumne River reflects thousands of years of travel, settlement, and trade.**	Description was rewritten to be inclusive of all elements related to this ORV.
▪ The oldest known sites in the river corridor, which are found along the Dana Fork, provide evidence of continuous human use and possible environmental change in the region over millennia.	See above	The value of archeological sites throughout the river corridor was combined into a single ORV statement (see above).
▪ Tuolumne Meadows and the Grand Canyon of the Tuolumne are flanked by concentrations of prehistoric archeological sites with excellent integrity and data ORVs. The remote canyon sites retain a level of integrity that is uncommon in the region.	See above	The value of archeological sites throughout the river corridor was combined into a single ORV statement (see above).

Draft Outstandingly Remarkable Value (ORV) Statement from the 2007 Tuolumne Planning Workbook	**Revised ORV Statement(s) in the Draft Tuolumne River Plan**	**Reason for Change**
PREHISTORIC AND AMERICAN INDIAN CULTURAL ORVS	CULTURAL ORV	
▪ Prehistoric archeological sites in the low-elevation flats represent possible year-round use by groups of American Indian people.	See above	The value of archeological sites throughout the river corridor was combined into a single ORV statement (see above).
HISTORIC ORV	CULTURAL ORV	
Nationally or Regionally Significant Evidence of Historic Trade, Travel, Recreation, and Early Conservation Activism The following historic resources contribute to this value:	None	Statement was too broad and too inclusive to be useful in guiding river management.
▪ Historic sites along the Lyell and Dana Forks attest to their status as regionally important trade and travel routes between the eastern and western Sierra.	None	Under a tighter interpretation of the ORV criteria these sites were not considered to be river related or unique, rare, or exemplary.
▪ Historic sites at the Soda Springs Historic District in Tuolumne Meadows commemorate the significance of this area as a place inspiring conservation activism on a national scale. Parsons Memorial Lodge is a national historic landmark.	**Parsons Memorial Lodge, a national historic landmark sited near the Tuolumne River, commemorates the significance of this free-flowing segment of the river in inspiring conservation activism and protection of the natural world on a national scale.**	The revised description places more emphasis on Parsons Memorial Lodge, which best fits the unique, rare, or exemplary criterion, of all the Tuolumne Meadows historic sites.
▪ Rustic accommodations at Tuolumne Meadows and Glen Aulin represent the development of a nationally distinctive kind of high-country touring.	None	Under a tighter interpretation of the ORV criteria rustic accommodations were not considered to be river related or unique, rare, or exemplary.
TRADITIONAL CULTURAL ORV		
Resources Important for Maintaining the Cultural and Religious Traditions of American Indian People	See above	The archeological value and traditional cultural value of sites were determined to be so closely related, that they were combined into the single ORV statement above.
SCENIC ORV		
Magnificent Scenery with a Character Unique to the Tuolumne River Corridor The following scenic resources contribute to this value:	None	Statement was too broad and too inclusive to be useful in guiding river management.
▪ The largest glacier on the western flank of the Sierra Nevada is part of the spectacular high-country views from the Lyell Fork.	**Lyell Canyon offers remarkable and varied views of lush meadows, a meandering river, a U-shaped glacially carved canyon, and surrounding peaks.**	Description was rewritten to emphasize those components most integral to this ORV.
▪ Breathtaking views along the Lyell Fork, Dana Fork, and Tuolumne Meadows encompass the meandering river, adjacent meadows, glacially carved domes, and rugged mountain peaks.	**Dana and Tuolumne Meadows offer dramatic views of a meandering river, adjacent meadows, glacially carved domes, and the Sierra Crest.**	Description was rewritten to emphasize those components most integral to this ORV.
▪ The low-relief topography at Tuolumne Meadows and Dana Meadows allows for magnificent skyward views, including some of the best views of dark night skies in the Sierra Nevada.	None	Under a tighter interpretation of the ORV criteria, dark night skies were not considered to be river related.
▪ Views within the Grand Canyon of the Tuolumne include steep canyon walls, hanging valleys, and dramatic cascades of falling water.	**The Grand Canyon of the Tuolumne offers views of a deep, rugged canyon with vast escarpments of granite, hanging valleys, and tall cascades of falling water.**	Description was rewritten to emphasize those components most integral to this ORV.

Draft Outstandingly Remarkable Value (ORV) Statement from the 2007 Tuolumne Planning Workbook	**Revised ORV Statement(s) in the Draft Tuolumne River Plan**	**Reason for Change**
SCENIC ORV, CONTINUED		
▪ The stretch of river below Hetch Hetchy Reservoir offers stunning views of verdant meadows, a glacially carved bedrock valley, large river pools, dramatic canyon walls, and a constricted slot canyon.	None	Under a tighter interpretation of the ORV criteria these views were not considered to be unique, rare, or exemplary.
RECREATIONAL ORV		
Outstanding Opportunities for Experiences Characterized by Primitive, Unconfined Recreation The following recreational resources and opportunities contribute to this value:	**Wilderness travelers along the Tuolumne River engage in a variety of activities in an iconic High Sierra landscape, where opportunities for primitive and unconfined recreation, self-reliance, and solitude shape the experience.**	The recreational ORV was rewritten to express the recreational value of the wilderness river setting rather than specific kinds of activities, which would not necessarily be river-related or unique, rare, or exemplary.
▪ The Pacific Crest Trail, which follows the Lyell Fork and the Tuolumne River through Tuolumne Meadows, offers opportunities to travel one of the country's eleven national scenic trails.	None	See above.
▪ The Grand Canyon of the Tuolumne offers exceptional opportunities for backcountry excursions through a deep, rugged, and seldom-traveled gorge.	None	See above.
▪ The recreational opportunities below Hetch Hetchy Reservoir are unusual due to the relative rarity of low-elevation designated wilderness elsewhere in the Sierra Nevada.	None	See above.
Outstanding High-Elevation Recreational and Educational Opportunities that Are Accessible to People of Various Ages and Abilities The following recreational resources and opportunities contribute to this value:	**The Tioga Road across the Sierra provides rare and easy access to high-elevation sections of the Tuolumne River through Tuolumne and Dana Meadows.**	The recreational ORV was rewritten to express the recreational value of the front-country river setting rather than specific kinds of activities, which would not necessarily be river-related or unique, rare, or exemplary.
▪ A wide range of recreational opportunities attract people of various ages and abilities to Tuolumne Meadows, where many individuals, families, and groups establish traditional ties with the area. The National Park Service and other organizations focus on the river and adjacent meadows as a centerpiece of nature interpretation and education in the Sierra Nevada.	None	See above.
▪ The rustic high-country lodging available at the Tuolumne Meadows Lodge and the Glen Aulin High Sierra Camp is associated with the development of a nationally distinctive High Sierra recreational opportunity.	None	See above.

Draft Outstandingly Remarkable Value (ORV) Statement from the 2007 Tuolumne Planning Workbook	Revised ORV Statement(s) in the Draft Tuolumne River Plan	Reason for Change
SCIENTIFIC ORVS		
Invaluable Opportunities to Examine Natural, Cultural, and Sociological Resources with High Research Value The following resource conditions contribute to this value:	None	The category of 'scientific' ORVs was determined to be redundant with the other categories, such as the biologic and geologic ORVs. Although the specific term *scientific features* is used in section 10(a) of the Wild and Scenic Rivers Act (in the context of giving primary emphasis to protecting "aesthetic, scenic, historic, archaeologic, and scientific features," this category is not included in the ORV-related eligibility criteria developed by the Interagency Wild and Scenic Rivers Coordinating Council.
▪ Relatively intact Sierran river ecosystems provide crucial baseline data and basic information on how components of natural and social systems interact and respond to perturbation (e.g., climate change).	None	See above.
▪ The entire river corridor is either in or surrounded by designated wilderness, which is critical to protecting the integrity and maintaining the scientific value of these resources.	None	See above.
▪ Some of the best evidence of glacial processes in the Sierra Nevada occurs along the river corridor.	None	See above.
▪ Well-preserved prehistoric and historic archeological resources within the river corridor provide outstanding opportunities to research trade, travel, subsistence, and technological change that occurred over thousands of years.	None	See above.
▪ Previous and ongoing human interaction with and visitation to the Tuolumne River and its environs provides outstanding opportunities for social science inquiry.	None	See above.

Appendix G: Characterizing Visitor Use of the Tuolumne Wild and Scenic River

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Introduction

The Tuolumne River passes through the northern, high-country portion of Yosemite National Park. Its setting is shaped by tall peaks, granite domes and meadows (Figure 1). The primary means of access to the river are by vehicle via the Tioga Road and on foot or horseback from other parts of the park and its surrounding backcountry areas. Visitor activities associated with the Tuolumne tend toward the wilderness end of the recreation opportunity spectrum with only some amenities provided in the Tuolumne Meadows area of the corridor. The following is a summary of visitors and their use of the Tuolumne River.

Figure 1. Backpacker in Tuolumne Meadows (NPS Photo)

Visitor Demographics

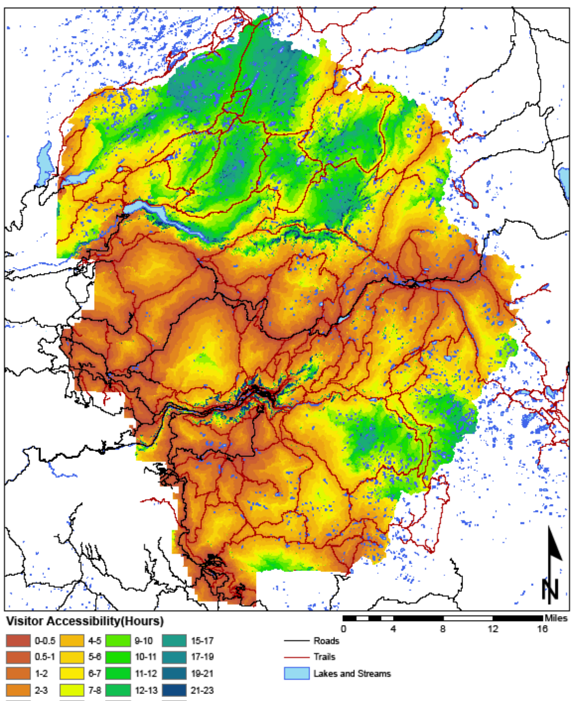
A park-wide, comprehensive study of visitor use in Yosemite was conducted in the summer of 2005 (Littlejohn, et al. 2005). This study provided a variety of visitor-related information including demographic and use characteristics. Data from this study were cut to draw a comparison between Tuolumne area visitors and overall park visitors. A summary of Tuolumne area visitor demographic and use characteristics is shown below (Table 1).

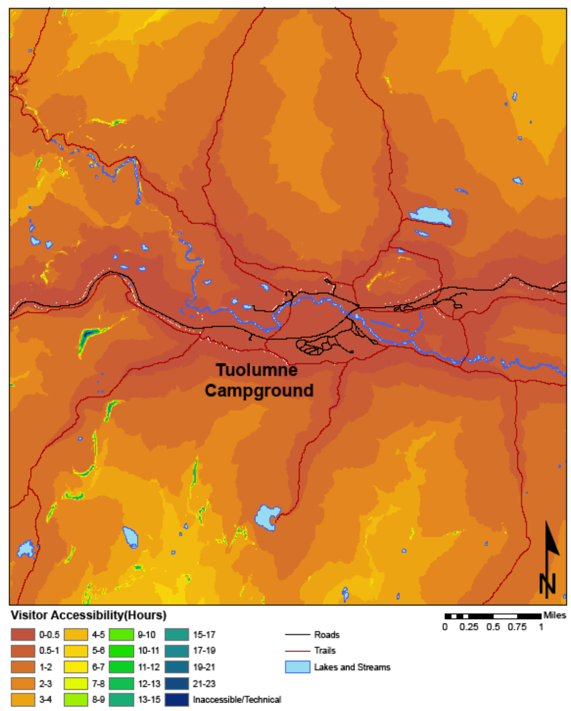
Table 1. Visitor Demographic and Use Characteristics
Gender = 51.5% Male and 48.4% Female
Average age = 32.8 years
Average group size = 3.4 (statistically significant from overall park users at 5.2)
First-time visitors = 51.7%
Average Length of Stay = 7.2 hours
Average Length of Stay in Days = 3.7 days

Visitor Access and Use Patterns

The Tioga Road provides direct visitor access by vehicle to the Tuolumne River corridor. Visitors can view the headwaters of the Tuolumne along the Dana and Lyell Forks easily from their vehicles as they pass along the road. For much of this route federally designated Wilderness lay a mere 200 feet from the centerline of the road. This ease of access to a remote, wilderness area is somewhat unique for the Sierra Nevada and shapes the character of visitor use to the area.

To further understand visitor access and resulting use patterns a model was developed using Geographic Information System (GIS) technology (Pettebone et. al 2007). In this model, visitor use intensity was depicted based on ease of visitor access (Figures 2a and 2b). Accordingly, those areas closest to roads, trails and other access points portray shorter travel times, and by extension suggest areas of potentially higher use intensity. While the model has not been validated with field data, professional experience and judgment indicate that use intensity follows a general pattern as indicated in Figure 2a, suggesting that Tuolumne Meadows is the location of the majority of visitor activities within the Tuolumne River corridor. Further, the model suggests that the majority of day use of Wilderness might extend approximately 4-hours travel time from trailhead areas, given time to return to the trailhead within the same day (Figure 2b). This information is useful in understanding the reaches of visitor day use in Wilderness. All other Wilderness use is overnight and is controlled by a permit system or special use authorization.





Figures 2a and 2b. Maps of Visitor Access and Use Intensity Based on-foot Travel Time

Visitor Activities

Visitors engage in a variety of activities throughout the Tuolumne River corridor. The 2005 study asked visitors which activities they participated in while visiting the park and which of these was their primary activity. Again, this data was split out for Tuolumne area visitors specifically and results are shown below. Visitors participated in a wide variety of activities with sightseeing, visiting the visitor center, leisure pursuits such as painting, drawing, and photography, and day hiking being the most common. Of these, sightseeing and day hiking were the most often reported primary activities participated in for Tuolumne area visitors.

Visitor activities specific to the Tuolumne Wild and Scenic River can be categorized as direct and indirect river recreation. The Secretarial Guidelines pertaining to Wild and Scenic Rivers further characterizes this distinction for designated rivers as primary and secondary contact recreation (DOI 1999). **Primary contact recreation** are those activities in which there is prolonged and intimate contact with the water, (e.g., swimming, water skiing, surfing, kayaking, "tubing," and wading or dabbling by children). **Secondary contact recreation** involves activities in which contact with the water is either incidental or accidental, (e.g., boating, fishing and limiting contact with water incident to shoreline activities). It is important to note that both primary and secondary contact recreational activities take place in the Tuolumne River corridor. Primary contact recreation activities include swimming and fishing. Secondary contact recreation activities are more common and numerous, including a variety of activities as shown below (Tables 2a and 2b).

Table 2a. Summer Activities	%
Sightsee/take a scenic drive	91.9
Visit visitor center	58.9
Paint/draw/take photographs	54.1
Day hike	51.6
View wildlife/bird watching	44.7
View roadside/trailside exhibits	44.3
Shop in park (other than park bookstore)	44.3
Eat in park restaurant	43.5
Picnic	37.8
Shop in park bookstore	33.3
Visit museum	26.4
Camp in developed campground	16.3
Other	14.6
Stay in park lodging	12.6
Attend ranger-led programs	8.9
Climbing	7.3
Overnight backpack	4.5

Table 2b. Primary Summer Activities	%
Sightsee/take a scenic drive	60.0
Day hike	18.7
Paint/draw/take photograph	4.4
Camp in developed campground	4.0
Other (not match with above answer)	4.0
Overnight backpacking	3.6
View wildlife/bird watching	1.8
Climbing	1.3
Other	0.9
View roadside/trailside exhibits	0.4
Attend ranger-led program	0.4
Picnic	0.4

Visitor Use Levels

The following section outlines the methods and assumptions used to estimate current visitor use levels for the Tuolumne River corridor in Yosemite National Park. Multiple estimates were generated each containing a specified set of assumptions, calculations, and corresponding results. Estimates range in scale from daily (per day) to people-at-one-time (PAOT).

Vehicle-based Use Estimates

Yosemite National Park is more than 700,000 acres in size and includes several dispersed sub-districts each containing notable attraction sites. These areas include Yosemite Valley, Wawona, Tuolumne Meadows, Mather, Glacier Point and Hetch Hetchy (Figure 3). More than 95% of the park is designated wilderness. Due to its size and remote landscape, estimating visitor use levels can be challenging.

Nevertheless, vehicle based estimates represent an efficient and effective method for documenting visitor use levels. Two facts are integral to conducting such estimates: 1) the primary means of access to the park is by automobile, and 2) the vast majority of visitors to the park arrive in personal vehicles (Gramman 1992; ORCA 1999; Littlejohn et al. 2005, Le et al. 2008).

Inductive traffic counters are in place at each of Yosemite's five entrance stations including Big Oak Flat, South Entrance, Arch Rock, Tioga Pass, and Hetch Hetchy (Figure 3). These counters have been in place for many years providing the park with estimates of park-wide visitor use levels. Data from these counters are managed by the National Park Service's public statistics office (www.nature.nps.gov/stats). A report is generated from this office each month detailing the park's visitation by entrance station, by month, and by year accumulations. Both recreational and non-recreational visits are estimated. **Estimates included in this document pertain to recreational visits only.**

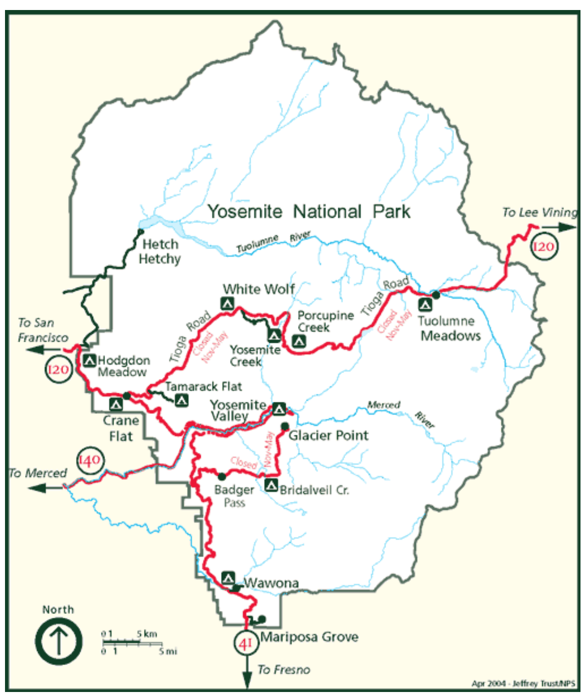


Figure 3. Map of Major Travel Routes in Yosemite National Park

As mentioned above, Tuolumne Meadows and the majority of the Tuolumne River are accessible via Tioga Road/Highway 120. This is a seasonal highway and is closed during winter months. Typically the road is open from approximately May to November representing an average summer season of 174 days per year. Very little backcountry use occurs in the Tuolumne area during the winter. **Estimates included in this document reflect summer season use only.**

Transit and Bus-Based Use Estimates

While the vast majority of visitors to Yosemite National Park arrive by private vehicle, estimates of the total number of people-at-one-time within the Tuolumne River Corridor must also account for those arriving by regional transit service, shuttle bus service within the park, and by privately operated tour buses. Yosemite Area Regional Transit (YARTS) operates a regularly-scheduled, fixed-route transit system providing service into Yosemite National Park and gateway communities located in Merced, Mariposa, Inyo and Mono Counties. During the summer months, YARTS operates a bus along the Highway 120 corridor from Mammoth Lakes to Yosemite Valley and back, stopping at Tuolumne Meadows, with a capacity of 45 passengers. Additionally, the Tuolumne Meadows Tour and Hiker's Bus, operated by the park's concessioner, provides a daily shuttle from Yosemite Valley to Tuolumne Meadows between July and September with a capacity of 45 passengers. The concessioner also operates a Tuolumne Meadows shuttle bus with frequent daily service to destinations and trailheads along Tioga Road between Olmsted Point and Tuolumne Meadows. This shuttle generally serves as an intra-park shuttle and few visitors will use the service to access the Meadows from other destinations along Tioga Road.

Private tour buses also bring visitors to Tuolumne Meadows and park at the Visitor Center, which can only accommodate two buses at a time with a maximum capacity of 45 passengers each. When the private tour bus maximum (90) is combined with the park shuttle (45) and regional transit maximums (90), a maximum of 225 people-at-one-time in Tuolumne Meadows can potentially arrive from outside the corridor by bus.

Trends in Visitor Use Levels

Based on entrance station counts Yosemite National Park has received an average of approximately 3.4 million visitors per year between 1979 (Tuolumne Wild and Scenic River designation) and 2011 (Figure 4 and Table 3). The highest recorded annual visitation occurred in 1996 with a steady decline following the 1997 Merced River flood. However, park-wide use is again on the rise with sharp increases experienced in recent years. Peak visitation generally occurs between May and October with August being the busiest month of the year (approximately 17% of annual visitation alone).

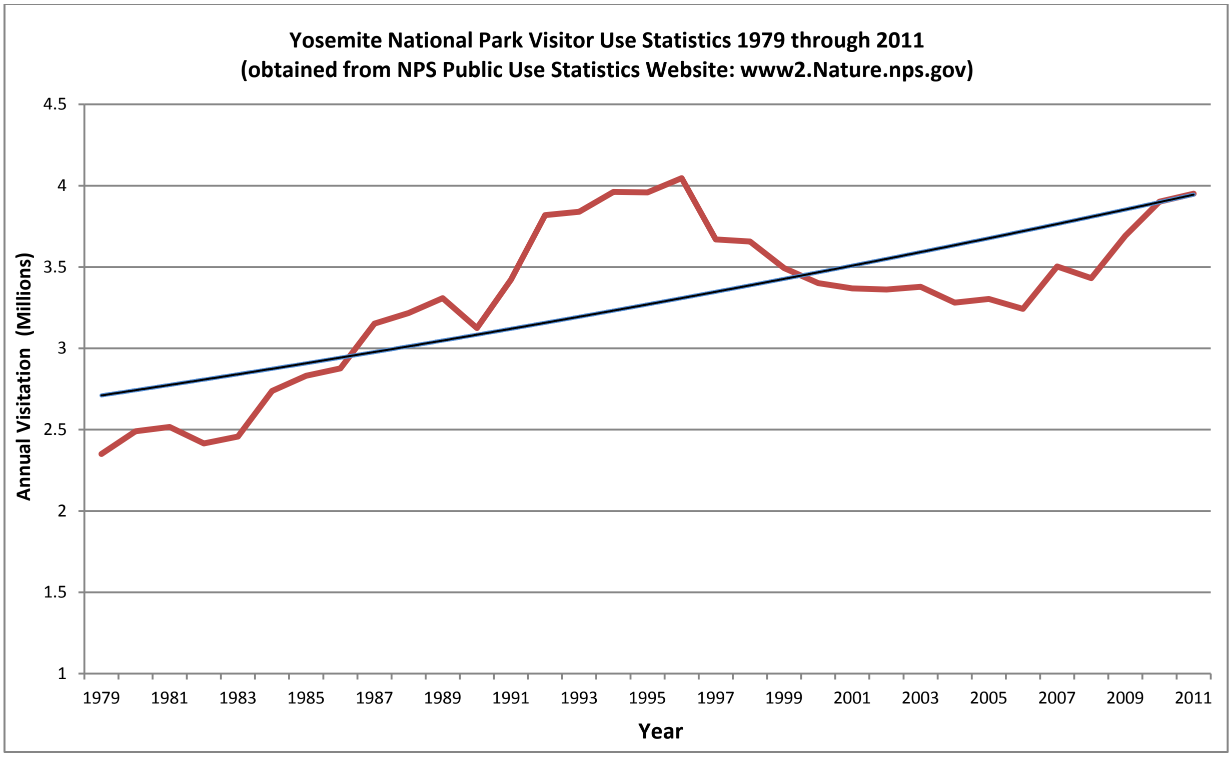


Figure 4. Overall Park Visitation by Year 1982-2011

Yosemite National Park Visitor Use Statistics 1982 through 2011 (obtained from NPS Public Use Statistics Website: www2.Nature.nps.gov)													
Year/Month	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Total**
1982	60,817	68,307	70,702	73,259	254,169	363,303	425,198	432,776	303,673	206,821	85,193	71,369	**2415587**
1983	64,748	64,554	85,104	90,376	214,870	266,832	441,436	473,638	350,841	242,778	87,561	74,726	**2457464**
1984	75,894	83,589	102,049	147,755	276,877	363,876	414,711	494,860	370,899	217,730	101,528	88,699	**2738467**
1985	84,266	86,738	101,035	158,974	314,386	375,841	447,936	498,319	344,277	230,095	105,532	84,553	**2831952**
1986	92,835	74,133	114,441	152,019	291,811	362,173	439,823	522,908	340,843	245,733	151,081	88,917	**2876717**
1987	94,639	98,799	109,617	192,048	373,894	419,479	487,915	526,850	328,866	281,719	146,909	91,540	**3152275**
1988	94,583	109,552	153,436	190,484	362,008	404,321	477,167	502,674	385,509	292,886	144,254	99,807	**3216681**
1989	102,646	96,527	143,858	204,102	377,940	413,068	511,957	524,395	390,364	264,670	163,939	114,693	**3308159**
1990	99,686	101,236	145,037	237,815	364,549	424,933	482,066	367,502	364,838	276,025	162,254	98,998	**3124939**
1991	104,673	111,073	117,735	187,607	354,908	396,841	521,822	587,904	441,553	320,769	164,072	114,144	**3423101**
1992	126,603	120,908	149,651	251,872	425,555	486,890	568,070	586,868	470,798	356,333	163,364	112,606	**3819518**
1993	101,503	105,315	151,472	246,136	378,548	446,235	604,248	634,588	503,629	368,978	171,108	127,885	**3839645**
1994	131,216	127,303	186,008	247,425	384,114	495,097	585,940	666,555	511,954	336,448	146,675	143,382	**3962117**
1995	123,844	151,102	124,710	250,592	279,575	449,511	663,052	656,064	551,886	409,319	210,295	88,456	**3958406**
1996	104,086	135,115	180,709	253,532	347,364	527,284	622,855	679,862	517,934	365,313	172,037	140,116	**4046207**
1997	12,520	64,201	136,476	200,212	319,108	460,459	595,059	697,060	516,567	372,171	168,533	127,604	**3669970**
1998	114,143	109,163	157,257	231,495	307,331	345,916	603,790	672,966	480,941	384,428	142,002	107,700	**3657132**
1999	100,857	102,345	136,795	169,517	335,374	448,560	558,114	625,405	433,178	330,334	150,843	102,285	**3493607**
2000	93,633	103,444	136,523	216,087	317,009	454,638	548,440	546,981	388,707	324,484	144,958	125,999	**3400903**
2001	102,455	101,897	142,141	192,936	315,897	434,014	528,849	591,196	448,519	264,465	137,876	108,486	**3368731**
2002	108,906	113,695	141,766	186,682	295,511	436,862	513,789	570,914	426,684	300,919	149,828	116,311	**3361867**
2003	116,984	111,506	137,550	174,337	280,335	445,887	536,683	604,093	405,605	316,366	136,390	112,928	**3378664**
2004	100,020	106,258	146,876	228,212	326,017	449,566	531,864	508,094	393,437	272,200	121,622	96,745	**3280911**
2005	91,238	103,756	143,335	195,385	304,552	413,124	554,567	485,643	430,134	318,508	152,671	111,231	**3304144**
2006	104,591	101,194	125,556	189,472	309,387	382,972	510,932	528,254	421,502	298,771	165,499	104,514	**3242644**
2007	99892	100941	135925	219854	374184	466054	543235	550172	417882	298122	178846	118321	**3503428**
2008	95124	107729	153735	199592	361193	473186	539874	543799	416918	295547	146837	97,979	**3431513**
2009	101484	78795	132711	230828	399683	438382	586591	643300	471530	346826	151297	110,545	**3691972**
2010	96089	100379	149651	224461	382414	521059	643566	659857	520210	356370	148459	98,893	**3901408**
2011	100718	93588	100433	231372	356588	503741	704553	699749	533502	360449	139079	127,621	**3951393**
Average	**96,690**	**101,105**	**133,743**	**199,148**	**332,838**	**429,003**	**539,803**	**569,442**	**429,439**	**308,519**	**147,018**	**106,902**	**3,393,651**
	January	February	March	April	May	June	July	August	September	October	November	December	Total
TOTAL	**2,703,886**	**2,839,175**	**3,762,210**	**5,518,605**	**9,246,149**	**11,845,304**	**14,845,983**	**15,723,640**	**11,829,468**	**8,538,758**	**4,123,004**	**2,980,539**	**93,956,721**
%	**2.9**	**3.0**	**4.0**	**5.9**	**9.8**	**12.6**	**15.8**	**16.7**	**12.6**	**9.1**	**4.4**	**3.2**	**100**
% of Annual Visitation - May to October					**76.7**								
% of Annual Visitation - June to September						**57.7**							
% of Annual Visitation - July and August							**32.5**						

Table 3. Yosemite National Park Recreational Visits by Month 1982-2011

In order to further understand trends in Tuolumne visitation over time a comparison of recreational visits as recorded by the Tioga Pass Entrance Station traffic counter from 2006 thru 2011 is shown in Table 4 below. This shows that use levels have recently increased when compared to previous years. In particular, use levels have significantly increased in 2009, 2010 and 2011. The highest use has occurred in 2011 at 466,188 recreational visits.

Recreational Visits Thru Tioga Pass Entrance Station 2006-2011 (from NPS public use statistics office at: www.nature.nps.gov/stats)								
Month	2006	2007	2008	2009	2010	2011	07-11 AVG	MAX
July	132,938	117,999	122,065	131,191	132,325	137,058	128,128	137,058
Aug	119,478	125,722	133,268	189,062	189,394	190,931	165,675	190,931
Sept	98,298	94,095	102,095	136,810	136,022	138,199	121,444	138,199
Total	**350,714**	**337,816**	**357,428**	**457,063**	**457,741**	**466,188**	**415,247**	**466,188**

Table 4. Annual Recreational Visits thru Tioga Pass 2006- 2011

Table 5 shows the percent difference in recreational visits from 2006 thru 2011. The percent difference in visitation was calculated and averaged for each month of the core summer season of July to September. The percent difference was also calculated comparing 2006 visitation against 2011 levels directly ("Total %Diff 06-10) resulting in a 24.8% increase in visitation. In order to account for annual variations in use levels, the average % difference was calculated for use increases between the years 2007 thru 2011 and compared against the base year of 2006, resulting in an average increase in visitation over this time period of 15%.

July %Diff 06-11	August %Diff 06-11	September %Diff 06-11	Total %Diff 06-11	%Diff 06 to 07-11 AVG
3.0	37.4	28.9	**24.8**	**15.5**

Table 5. Comparison of Recreational Visits thru Tioga Pass 2006- 2011

Table 6 presents a comparison of the two-way traffic volumes at Tioga Pass for the peak use season in 2009, 2010 and 2011. Overall, the comparison of daily traffic volumes over this three year period shows slowed, but continued increase in visitation in the Tuolumne area. 2010 saw an increase of 8.2% over the previous year and 2011 showed only a 3.7% increase in traffic volumes. For all three years, there has been an average daily traffic volume of 2,939 and a maximum of 4,039 vehicles per day over this period.

YEAR:	2009			2010			2011		
DIRECTION:	Eastbound	Westbound	Combined	Eastbound	Westbound	Combined	Eastbound	Westbound	Combined
SUM:	122,619	129,283	251,902	135,405	138,913	274,318	139,895	144,969	284,864
MEAN:	1,333	1,405	2,738	1,472	1,510	2,982	1,521	1,576	3,096
STDEV:	365	364	697	318	348	618	312	352	609
MAX:	2,053	2,254	3,976	2,151	2,410	4,303	2,280	2,403	4,277
% CHANGE:	-	-	-	9.4	6.9	8.2	3.2	4.2	3.7

Table 6. Comparison of Daily Traffic Volumes at Tioga Pass 2009 - 2011

People-At-One-Time (PAOT)

The maximum number of day users that can be received in the river corridor is expressed as *people at one time* (PAOT). Because day users above Hetch Hetchy Reservoir access the river corridor between Tioga Pass and Tuolumne Meadows, the number of day users depends largely on the number of people entering the river corridor via Tioga Road (the number of visitors who access the river corridor below the reservoir is minimal).

As noted above, the vast majority of visitors to the Tuolumne River corridor arrive by private vehicle. Therefore, the NPS has selected a vehicle-based measure of the maximum PAOT, specifically the number of visitors who could be parked and out of their vehicles, to express the number of day users who are in the Tuolumne River corridor. In addition, the NPS has estimated how many visitors are arriving in the corridor by in-park shuttle, regional transit, and tour buses (see 'Transit and Bus-Based Use Estimates,' above). The current maximum number of day users is calculated by 1) determining the maximum number of vehicles parked in the river corridor, 2) multiplying by an average vehicle occupancy rate, and 3) determining the maximum number of visitors who may arrive by means other than private vehicle.

Parking Supply and Demand

Two parking studies have been conducted in support of this planning effort, 1) a parking study conducted from August 11-13, 2006 and 2) a parking study conducted from July 24-August 20, 2011 (DEA 2007 and DEA 2012). Among other data collected, the 2006 study established the location and type of parking facilities along Tioga Road in within the Tuolumne Meadows area. The two studies also counted the number of parked vehicles in the corridor, from Pothole Dome to Tioga Pass, at various times of day. The parking areas counted in 2006 and 2011 were similar; the primary difference was that some of the roadside pullouts that were separate from one another in 2006 were merged into larger pullouts by 2011 due to increased use.

Based on data collected in 2006 and subsequent analysis by NPS staff, there are 533 designated parking spaces in the river corridor at Tuolumne Meadows (not including the Tuolumne Meadows campground): 340 for day use and 193 for overnight (see Table 7, below). However, the 2006 study did not include overnight parking at the Tuolumne Meadows campground, an overnight facility managed by a reservation system. There is a maximum of two vehicles allowed at each site in the campground. The theoretical maximum parking capacity would therefore be the number of campsites multiplied by 2 vehicles per site, or 651 vehicles.

Table 7. Designated Parking Areas at Tuolumne Meadows (based on DEA 2007)

Parking Location	Parking Type	Primary Use	Number of Designated Spaces
Visitor Center – Oversize Lot	**Lot**	**Day**	**19**
Visitor Center – Main Lot	**Lot**	**Day**	**31**
Gas Station**	**Lot**	**Day**	**15**
Tuolumne Store and Grill	**Lot**	**Day**	**51**
Campground Office	**Lot**	**Day**	**11**
Lembert Dome	**Lot**	**Day**	**29**
Concessionaire Stables	**Lot**	**Day**	**58**
Mono Pass Trailhead	**Lot**	**Day**	**16**
Gaylor Peak Trailhead / Tioga Pass	**Lot**	**Day**	**11**
Dog Lake Trailhead	**Lot**	**Day**	**25**
Elizabeth Lake Trailhead**	**Lot**	**Day**	**11**
Treed parking areas east of Pothole	**Lot**	**Day**	**-**
Pothole Dome Scenic Pull-out and Parking	**Roadside**	**Day**	**16**
Ranger Station**	**Roadside**	**Day**	**7**
Roadside pullouts (13) to Mono Pass	**Roadside**	**Day**	**22**
Dana Meadows Pull-out at Tioga Pass	**Roadside**	**Day**	**18**
Road to Parsons	**Roadside**	**Day**	**-**
Pull-out south of Pothole	**Roadside**	**Day**	**-**
Roadside in front of Visitor Center	**Roadside**	**Day**	**-**
Roadside trail across meadows to Parsons	**Roadside**	**Day**	**-**
Roadside in front of gas station	**Roadside**	**Day**	**-**
Roadside campground office to bridge	**Roadside**	**Day**	**-**
Roadside Lembert to Wilderness Office	**Roadside**	**Day**	**-**
Roadside Wilderness Office to Gaylor Pit	**Roadside**	**Day**	**-**
Roadside Dana Meadows	**Roadside**	**Day**	**-**
Gaylor Pit	**Roadside**	**Day**	**-**
Cathedral Lakes Trailhead	**Roadside**	**Day**	**-**
Tuolumne Meadows Lodge	**Lot**	**Overnight**	**102**
Wilderness Office	**Lot**	**Overnight**	**58**
Dog Lake Trailhead	**Lot**	**Overnight**	**33**
Road to Parsons	**Roadside**	**Overnight**	**-**
Cathedral Lakes Trailhead	**Roadside**	**Overnight**	**-**
Total Day			**340**
Total Overnight*			**193**
Total designated parking spaces at Tuolumne Meadows			**533**

* Tuolumne Campground has a maximum overnight parking capacity of 651 vehicles at 2 per site - this figure is not included in this analysis.

** These locations were not included in the DEA 2007, and were subsequently estimated by the NPS.

The parking study conducted August 11-13, 2006, found parking use was highest from mid-morning through late afternoon, with the exception of the use of the Tuolumne Meadows Lodge parking lots which had their peak occupancy of 115 vehicles at 8 a.m. Most areas had peak use from noon to 2 p.m. During the day, parking occupancy was greatest from the visitor center to the Tuolumne Meadows Lodge. The parking use in this area peaked at 687 vehicles at 1 p.m. (DEA 2007).

The most recent parking study conducted July 24 – August 20, 2011, also found parking use the highest from mid-morning through late afternoon. Again most areas had peak use from noon to 2 p.m. During this study the highest number of parked vehicles, excluding the campgrounds, was 870 at noon on August 13. The two-way daily traffic volume on August 13 was 4,161. There were only two days in 2011 with two-way traffic volumes higher than 4,161: 4,202 on August 5 and 4,277 on August 7. Parking counts were not conducted on those days, but it is likely that more than 870 vehicles were parked during the peak hours on these two days.

A comparison of the designated parking supply in Table 7 and estimated parking demand (based on parking in counts in 2011) suggests that about 40% of the parking in the Tuolumne area is in undesignated or user-created locations. The supply of undesignated parking is generally found in roadside areas and can be primarily associated with visitor day use.

Vehicle Occupancy

The average vehicle occupancy for vehicles traveling along Tioga Road during the three-day collection period in August 2006 was 2.1 (DEA 2007). It is expected that the actual average vehicle occupancy is somewhat larger than this value, because it is assumed that some occupants of vehicles were not visible from the video used to collect the data and were not included. Other visitor studies conducted over the past 20 years have found the average vehicle occupancy to range from 2.6 to 3.4 (Van Wagtendonk and Coho 1980; FHWA 1982; ORCA 1999; Littlejohn et al. 2005; Le et al. 2008). The most recent surveys conducted in Tuolumne during 2010 found an average group size of 2.74 persons (White 2010). Based on this range, an average of 2.9 persons per vehicle is used for estimating visitor numbers for planning purposes in this document.

Visitor Day Use Capacity Calculations

The NPS estimated current peak day use by starting with an actual vehicle count on a peak day during summer 2011 (DEA 2012) and multiplying the number of parked cars attributed to day users by 2.9 persons per vehicle. The maximum number of visitors who currently arrive by tour bus, in-park shuttle, or regional transit was added to this number to reflect the current maximum number of day visitors in the river corridor.

As noted above, both the 2006 and 2011 parking studies (DEA 2007 and DEA 2012) indicate that more cars currently park in the Tuolumne Meadows area than can be accommodated in the available designated parking spaces. A maximum of 870 cars were parked at Tuolumne Meadows on Saturday, August 13, 2011 at the height of the summer season. This includes cars parking in the 340 designated day and 193 designated overnight parking spaces listed above in Table 7, and an additional 337 cars that were crowding into established parking areas and along roadsides. Not including the campground, it is estimated that 340 spaces are needed to accommodate existing overnight users at the lodge, Glen Aulin High Sierra Camp, and wilderness permit holders. Because only 193 spaces are currently designated for overnight users, it is estimated that 147 vehicles belonging to overnight users are currently parking in undesignated areas. The remainder of the cars parked in undesignated areas (190) were assumed to belong to day users.

Therefore, current maximum day use in the Tuolumne Meadows area and adjacent wilderness is estimated at 1,717 people at one time. This estimate is based upon the data described above as well as the factors described below:

(1) the most current (2011) observed maximum number of parked cars counted on a peak day, presumed to belong to day visitors (530 total vehicles parked at the peak of the summer season) multiplied by an average of 2.9 persons per car, for 1,537 maximum people at one time, plus the maximum number of day visitors who can arrive by in-park shuttles, tour bus, and regional public transportation (225 people per day)

(2) The current maximum day use corridor-wide is estimated to be 1,774: the sum of the Tuolumne Meadows area maximum day use (1,762 people at one time) and the estimated maximum number of vehicles parked below O'Shaughnessy Dam (4 vehicles * 2.9, or 12 people at one time).

Visitor Overnight Use Capacity Calculations

Overnight capacity is calculated by multiplying the number of units by the maximum occupancy of each unit. For camping this is the number of campsites times 6 people per site. For Tuolumne Meadows Lodge and the Glen Aulin High Sierra camp this is the number of tent cabins times 4 people. For overnight wilderness use this equates to the total of all backcountry zone capacities as managed by the trailhead quota and permit system. Collectively, these calculations provide an overall maximum overnight capacity of the river corridor.

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Appendix H:
Ecological Restoration Planning for the Tuolumne Wild and Scenic River Comprehensive Management Plan

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Ecological Restoration Planning for the Tuolumne Wild and Scenic River Comprehensive Management Plan

2010

Ecological Restoration Planning for the Tuolumne Wild and Scenic Comprehensive Management Plan

Division of Resources Management and Science

Yosemite National Park

WRITTEN BY

CHAPTER 1 - ECOLOGICAL RESTORATION PLANNING FOR THE GREATER TUOLUMNE MEADOWS AREA

MONICA BUHLER, SUE BEATTY AND APRIL JOHNSON

CHAPTER 2 - MITIGATION MEASURES TO PROTECT CULTURAL RESOURCES FOR THE GREAT SIERRA WAGON ROAD ECOLOGICAL RESTORATION PROJECT

DANIEL SCHAIBLE

REVIEWED BY

NIKI NICHOLAS AND JUDI WEASER

Cover Photos:

Upper - Photo taken from the west end of Tuolumne Meadows late 1800s

Lower – Photo taken from the west end of Tuolumne Meadows 2008

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INTRODUCTION

This report presents an ecological restoration plan to support the Tuolumne Wild and Scenic River Comprehensive Management Plan (Tuolumne River Plan). It provides a description of sites recommended for ecological restoration in the Tuolumne area, incorporating analyses of the status and integrity of plant communities in Tuolumne Meadows, and a cultural landscape review of the Great Sierra Wagon Road.

The first chapter in this report describes recommended ecological restoration actions throughout the Tuolumne Meadows area and the justification and need for these proposed actions. This chapter focuses on restoration actions associated with the Tuolumne River, Tuolumne Meadows, roads, trails, campgrounds, and lodging.

The second chapter in this report focuses on cultural resource protection of a portion of the Great Sierra Wagon Road. This chapter provides culturally sensitive recommendations for the ecological restoration efforts along the road. It establishes mitigation measures for ecological restoration of abandoned sections of the road, and maps the past alignment(s) of the Great Sierra Wagon Road relative to today's Tioga Road. Ongoing consultation with NPS cultural resources staff will accompany restoration efforts.

Two studies frequently cited in this document provide baseline data on hydrology and vegetation that directs ecological restoration efforts and priorities. Cooper et al. (2006) completed a study focusing on the effects of the Tioga Road on hydrologic processes and lodgepole pine invasion into Tuolumne Meadows. Researchers found incongruence between existing vegetation, hydrology and soils that requires further study. A second study (Ballenger and Acree 2008) focused on the biological integrity of Tuolumne Meadows north of the Tioga Road. Botanists compared vegetation and habitat attributes of Tuolumne Meadows with eight other subalpine meadows in the park with similar plant communities. This study focused on several measures of meadow integrity – community level plant diversity, forb:graminoid ratio, the percentage of areas without functioning vegetation (bare ground), and levels of small mammal activity.

CHAPTER 1. ECOLOGICAL RESTORATION PLANNING FOR THE GREATER TUOLUMNE MEADOWS AREA

By Monica Buhler, Sue Beatty and April Johnson

THE NEED FOR ECOLOGICAL RESTORATION

Meadow and riparian ecosystems are sites of exceptional ecological importance. While highly productive and diverse, riparian and aquatic systems (including meadows) are the most impacted areas in the Sierra Nevada (SNEP 1996). Declining spatial extent and degradation of riparian and wet meadow ecosystems is occurring throughout California at an alarming rate (SNEP 1996). While riparian and meadow ecosystems occupy relatively little land area in Yosemite National Park, they comprise the most biologically diverse areas and are priorities for ecological restoration (Hall 1997).

Tuolumne Meadows represents some of the most extensive subalpine meadow and riparian habitat in the Sierra Nevada (Weixelman, pers. comm.). This meadow/riparian/river complex provides habitat for a diversity of plant and animal species including several special-status species (e.g., slender lupine *(Lupinus gracilentis)*, Yosemite bulrush *[Trichophorum clementis (Scirpis clementis)]*, Yosemite toad *(Bufo canorus)*, several species of bats, and migratory bird populations). In addition, Soda Springs, a natural alkaline spring, supports localized populations of special status plant species (e.g., Buxbaum's sedge (*Carex buxbaumii)* and marsh arrow-grass (*Triglochin spp.*).

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER 2004). Natural processes continue to shape the landscape and the meadow and riparian complex that extends through Tuolumne Meadows, Dana Meadows, and Lyell Canyon. While productivity of these riparian and meadow areas remains high, recent studies document changes in the ecological integrity particularly in parts of Tuolumne Meadows, exemplified by expanding areas of barren ground, atypical plant species, confer encroachment, and diminished willow vegetation along riverbanks (Cooper et al. 2006). In these portions of Tuolumne Meadows, the meadow and associated wetlands and riparian areas exhibit impacts, damage and some degree of degradation. Development such as buildings, roads, trails, and past land management practices (such as ditching) disrupt hydrology, discourage vegetation establishment, and degrade habitat. Many undeveloped portions of the Tuolumne Meadows area are also impacted from past and contemporary activities such as human trampling, old road beds, stock use, invasive plant introduction, vegetation loss, and impacts to river processes.

Through ecological restoration, processes that sustain natural ecosystems, such as hydrology, are restored to provide conditions ideal for the perpetuation of native flora and fauna. Ecological restoration is also appropriate to restore natural conditions if facilities are removed, updated, or relocated. This report describes potential ecological restoration actions for currently impacted areas in the Tuolumne Meadows area, including developed areas that require restoration if infrastructure are moved or removed as well as undeveloped areas that have directly or indirectly been altered by human activities.

Important cultural resources are numerous in the Tuolumne Meadows area and in addition to specific mitigations outlined in Chapter 2, the following programmatic guidance and collaboration with cultural resource staff will ensure protection during ecological restoration. Archeological sites are fragile, non renewable resources and contain important information potential about past life ways and represent tangible heritage resources for park-associated American Indian peoples, as well as the visiting public. Where archeological sites are subject to ongoing impacts through social trails or visitor use, these areas will be carefully assessed for stabilization needs. Social trails will be removed and visitor use of these areas will be discouraged using techniques that retain the data potential of the resource while encouraging native vegetation. Where ecological restoration actions have the potential to affect archeological resources, the actions will be designed to avoid impacts wherever feasible. If avoidance is not possible, archeological site treatments such as controlled testing, and data recovery excavations where necessary, will be employed to reduce the level of impact and thereby avoid adverse effects. All treatments for pre-contact archeological sites will involve close consultation with park-associated American Indian tribes and groups to ensure these treatments incorporate native concerns, issues and perspectives.

Ecological Restoration Goals and Objectives

The goals and objectives of ecological restoration focus on restoring primary processes, particularly hydrology, to maintain the structure and function of a self-sustaining ecosystem. Overall goals of restoration actions are to promote sheet flow in meadows, maintain groundwater levels that reflect landforms without incised channels, and limit continued disruptions to natural hydrology, all of which are linked to maintaining native plant communities. In order to achieve these goals, a combination of restoration actions will provide the best avenue for achieving ecological restoration objectives:

- Protect, maintain and restore natural hydrologic function of the Tuolumne River and tributaries
    - Protect, maintain and restore the hydrologic connectivity between the main river channel and the floodplain (meadows, ponds, wetlands, cutoff channels, oxbows) during regular high water flows
    - Protect, maintain and restore naturally high ground water levels and sheet flow processes to support biotic communities in riparian and meadow plant communities
    - Protect, maintain and restore the ability for the Tuolumne River channel to migrate and change course
    - Improve and protect ecological integrity of Soda Springs
- Protect, maintain and restore the function, structure, diversity and productivity of native riparian and meadow plant communities and wildlife habitat
- Restore areas impacted by the removal or relocation of facilities to natural conditions

THE TUOLUMNE RIVER

Fig. 1-1. Riverbank erosion

Based on a preliminary Proper Functioning Condition Assessment (Pritchard et al. 1998) of the Tuolumne River as it flows through Tuolumne Meadows, a team of hydrologists and river managers determined that several reaches of the Tuolumne River appear to be 'functioning at risk' with an undetermined trend (NPS Roche, personal communication). For example, recent studies indicate that the banks of the Tuolumne River are eroding on outside meanders without concomitant riparian vegetation recruitment on the complementary point bar, likely resulting in channel widening (Cooper et al. 2006). Channel widening produces a shallower channel with a lower river stage for any given flow volume and a concurrent drop of the groundwater level associated with the river (Cooper et al. 2006). A wider, shallower channel also influences the magnitude and frequency of overbank flow. The low vegetation cover on riverbanks, perhaps exacerbated by human trampling, contributes to the rapid bank erosion.

RIVERBANK EROSION

Fig. 1-2. Heavily browsed willow

In general, the riverbanks on the Tuolumne River (particularly on the west end of the meadows) have little to no vegetation, particularly willows *(Salix ssp.)* and are characterized by extensive erosion and riverbank loss (Figure 1-1). Willows typically occur in much greater density along the river and are very effective at anchoring soils and stabilizing eroding riverbanks. Vegetation, particularly woody species, also slows the velocity of water and associated scour while promoting sediment accretion (Mitsch and Grosselink 2007).

Existing willows in Tuolumne Meadows are heavily browsed (Figure 1-2), precocious (flowering on the previous season stems), or have no reproductive structures at all (Cooper et al. 2006). Deer browsing suppresses the plants to heights of less than 0.5 m in species that are typically 1-2 m tall. Heavy browsing can also limit the extent of willow stands, as well as willow regeneration as deer favor tender, young shoots. Willows provide important nesting habitat for many birds and cover for other wildlife. The lack of willow establishment on sandbars and riverbanks contributes to the net river channel widening. The absence of vegetation allows water to flow unimpeded, increasing velocity and altering scour and deposition relationships. The reason for the absence and heavy browse of willows along the Tuolumne River is not entirely understood but the condition of the riverbanks indicates that this has been occurring for some time.

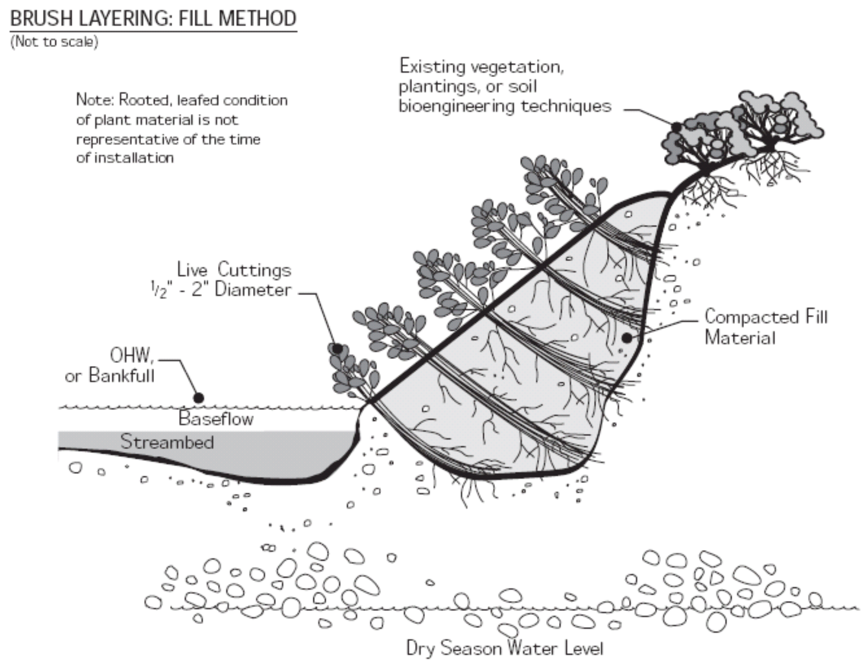
Fig. 1-3. Trampled vegetation on riverbanks

Vegetation loss and the subsequent riverbank erosion can be exacerbated by visitor trampling (Madej et al. 1994; Milestone 1978), (Figure 1-3). Certain reaches of the Tuolumne River experience high levels of visitor use and are devoid of vegetation, facilitating more erosion. Protection of riverbanks in sensitive areas can help promote vegetation establishment and improve riverbank stability. If further studies indicate that riverbank conditions are exacerbated by current and past human actions, ecological restoration may be warranted.

Because of the dynamic nature of river processes and gaps in knowledge, it would be shortsighted to focus riverbank restoration in isolated areas. Therefore, a holistic approach for riverbank restoration and willow establishment will be considered for the entire stretch of the Tuolumne River including both the Dana and Lyell Forks, and as it flows through Tuolumne Meadows. Further research on willow establishment, recruitment and persistence, and sediment dynamics will refine restoration techniques. The following restoration actions are proposed to mitigate impacts and restore riverbanks and natural river processes:

- Protect, maintain and restore the function, structure, diversity and productivity of native riparian and meadow plant communities and wildlife habitat
- Apply bioengineering techniques (e.g. brush layering, anchor logs, intensive planting of vegetation) to stabilize riverbanks, promote sediment accretion, and minimize further riverbank loss
- Establish willows (using hydrodrilling techniques) along riverbanks
- Protect impacted riverbanks from further trampling using temporary fencing or natural obstructions, such as logs, so vegetation can establish
- Install temporary exclosures to protect willow regeneration from deer browsing
- De-compact, seed, mulch and plant to encourage vegetation establishment on denuded riverbanks
- Protect and document any cultural resources

Examples of bioengineering techniques commonly used for riverbank restoration include willow hydrodrilling, brush layering (Figure 1-4), willow wattles and anchoring logs to anchor soils and accrete sediment. To establish willow, cuttings are taken from established plants and placed deeply into the soil to promote establishment and to prevent them from washing away during high water events. Because riverbank areas are often rocky or compacted, a hydro-drill (a pump with a high-powered stream of water) can create deep holes into which cuttings are placed. Willows may also be bundled into wattles and partially buried and anchored along riverbanks.



Brush Layering

Brush layering is the technique of laying cuttings on horizontal benches that follow the contour of either an existing or filled bank (slope). Branches serve as tensile inclusions or earth-reinforcing units to provide shallow stability of slopes.

The cuttings are oriented more or less perpendicular to the slope face. The portion of the brush that protrudes from the slope face assists in retarding runoff and reducing surface erosion. When used on a fill slope, this technique is similar to vegetated geogrids without the geotextile fabric.

Applications and Effectiveness

- Breaks up the slope length into a series of shorter slopes separated by rows of brush layer.
- Dries excessively wet sites.
- Works where the toe is not disturbed.
- Works on a slump and as a patch.
- Reinforces the soil with the unrooted branch stems.
- Reinforces the soil as roots develop, adding significant resistance to sliding or shear displacement.
- Traps debris on the slope.
- Aids infiltration on dry sites.
- Adjusts the site's microclimate, aiding seed germination and natural regeneration.
- May cause flow to wash soil from between layers.
- Does not work on outside bends.

Construction Guidelines

Brush layering can be installed on an existing or filled slope. On an existing slope, a bench is cut 2- to 3-ft. deep and angled slightly down into the slope. On a fill slope, brush layers are laid into the bank as it is filled.

Live material

- Branch cuttings should be 0.5 to 2 in. in diameter and long enough to reach the back of the bench and still protrude from the bank.
- Side branches should remain intact.
- Mix easy-to-root species such as willow, dogwood, and poplar.

Fig. 1-4: From *A Soil Engineer's Guide* (Eubanks et al. 2006)

TUOLUMNE MEADOWS

Humans have used the Tuolumne Meadows area for thousands of years, but in the last century the level and intensity of use has increased and changed dramatically. Meadows link the main Tuolumne River channel with neighboring terrestrial systems and regulate the entry of water, nutrients, and organic material into the river channel (Gregory et al. 1991). Human alterations in Tuolumne Meadows range from historic actions such as digging ditches to drain ponded areas of the meadow, building roads in the meadow, and extensive sheep grazing from 1860-1905, to contemporary impacts from trampling, development, and fragmentation. Other impacts result from parking area edge effect or parking creep leading to soil compaction, soil loss, and vegetation loss. Tuolumne Meadows is not only ecologically important but also is a treasured resource for visitors and highly valued by traditionally associated people as it contains sacred areas and provides traditionally used ecological resources. Efforts to sustain the integrity of the Tuolumne River ecosystem are likely to be more effective over the long term when considering the integrity of the meadow and associated riparian areas.

VEGETATION

Most of the greater Tuolumne Meadows comprises subalpine meadow vegetation with pockets of subalpine forest dominated by lodgepole pine *(Pinus contorta).* It must be recognized that existing vegetation communities are influenced by hydrologic and climatic conditions as well as past (intensive grazing, fire suppression, tree removal) and current (tree removal, infrastructure, fire suppression, trampling) human activities. Changes in hydrology from a variety of perturbations including ditching, road and trail building, water diversions, livestock grazing, visitor foot traffic, fire suppression, and imbalances in the mammal herbivore populations, have altered the plant and animal communities that once occupied the meadow (WRD 2010). These disturbances alter hydrologic conditions including water delivery (primarily through channelization rather than sheet flow), sediment dynamics, lowered groundwater levels, and changes in the amount and timing of ground and surface water availability for plants (Loheide et al. 2007).

A study completed in 2008 (Ballenger and Acree) compared several attributes of meadow integrity in Tuolumne Meadows with eight other subalpine meadows in Yosemite. All other meadows in the study have also experienced grazing or other perturbations and are not considered reference or pristine, but provide a range of meadow condition for comparison. Assessments focused on indicators of meadow function and structure including community level plant diversity, forb:graminoid ratio, the percentage of areas without functioning vegetation (bare ground), and levels of small mammal activity. Tuolumne Meadows had a much greater proportion of plots with bare ground as well as a much higher occurrence of plots with bare ground greater than 50%. Tuolumne Meadows study plots had four to eight times the proportion of plots dominated by forbs compared to the other meadows (Ballenger and Acree 2008). In terms of the forb:graminoid ratio, study plots in Tuolumne Meadows had two to eight times the proportion of plots dominated by forbs compared to six of the other meadows (Ballenger and Acree 2008). Areas in Tuolumne Meadows that have a high forb:graminoid ratio are of particular importance, especially in areas with high organic content in the soil. High organic content levels in meadow soils were likely generated by centuries of organic matter contributed from deep-rooted graminoids. If graminoids are missing from the floral composition, the plant composition may have changed. In addition, shallow- or tap-rooted forbs do not grow as densely as long-lived rhizomatous and clonal plants, and they do not grow into and reduce the areas of bare ground in the same manner as the graminoid species (Ballenger and Acree 2008). Because tap- or shallow-rooted forbs lack the soil stabilizing characteristics of graminoids and do not contribute significantly to soil organic matter, areas with a high proportion of forbs are also at higher risk of soil erosion and loss of soil organic matter (Cooper et al. 2006). Areas with high forb:graminoid ratios and high levels of bare ground are not likely to re-vegetate on their own, and soils may be losing organic matter.

Tuolumne Meadows was the only meadow surveyed with areas dominated by big sagebrush (*Artemisia tridentata*) shrubs (Ballenger and Acree 2008). Related meadow studies found that expansion of sagebrush into meadows might be stemming from livestock grazing-related disturbances, which can compact soil, increase the aridity of soils, and cause changes in meadow hydrologic processes, such as stream incision (Magilligan and McDowell 1997; Vavra et al. 1994). Berlow et al. (2002) found that intact moist meadow vegetation effectively prevents sagebrush germination and subsequent seedling survival, while small disturbances (such as gopher activity) can decrease competition with other vegetation and promote sagebrush invasion (Burke and Grime 1996). The fact that Tuolumne Meadows has areas dominated by big sagebrush is another indication that the biological integrity of this meadow is in a compromised state (Ballenger and Acree 2008).

Mammal burrowing activity did not differ greatly between Tuolumne and the eight other meadows in the 2008 study (Ballenger and Acree). Although Tuolumne had proportionately more plots with high levels of mammal activity (except Lower Lyell, also a highly impacted meadow), the proportion of Tuolumne plots with any burrow activity falls within the normal range of variability of the other meadows.

Tree invasion into subalpine meadows has been observed and researched for nearly a century in the mountains of western North America. Several studies throughout the Sierra Nevada, including Tuolumne Meadows, indicate that conifer encroachment is likely a response to climate change (Cooper et al. 2006; Jakobus and Romme 1993), reduction in fire frequency (DeBenedetti and Parsons 1979) and high levels of bare ground and impacts from intensive grazing (Cooper et al. 2006; Millar et al. 2004; Miller and Halpern 1998; Ratliff 1985; Sharsmith 1959).

Conifer encroachment is widespread in Tuolumne Meadows. Lodgepole pines need bare mineral soil to establish so the high levels of bare ground found in Tuolumne Meadows provide ideal conditions for germination. Conifer encroachment takes place almost twice as often in drier meadow plant communities with higher cover of bare ground when compared with other communities in the meadow (Ballenger and Acree 2008). Cooper et al. (2006) found that lodgepole pine invasion in Tuolumne Meadows is linked to periods of low precipitation and low year-to-year variability in moisture conditions and follows recruitment patterns observed Sierra Nevada wide. Because tree removal activities have occurred in Tuolumne Meadows since around1933, it is unknown if earlier tree establishment episodes would have survived in the absence of managed tree removal.

Despite aggressive tree removal over the past 80 years, climate conditions as well as soil conditions likely contribute to the continued expansion of the conifer forest into the meadow. Studies of subalpine meadows in the Cascade Mountains indicate that soils in meadows and adjacent forests have different biochemical properties and that meadow soils rapidly assume forest soil characteristics as trees establish in the meadow (Griffith et al. 2005). Changes in the soil pH, extent of fungal mats, denitrification potential, and litter depth, favor continued establishment of conifers even after cutting (Griffith et al. 2005). In particular, higher pH and the presence of extensive fungal mats that depend on conifers as their hosts, discourage establishment of meadow species, further favoring conditions for conifer establishment. It is probable that conifer establishment will continue with the current soil, vegetation, and climate conditions and ecological restoration may not be appropriate or feasible. However, where conifer encroachment can be directly tied to bare ground from human trampling or development and/or research indicates that conifer encroachment is resulting from anthropogenic impacts, ecological restoration that includes conifer removal to restore those plant communities may be appropriate. Clearing of conifers may also continue to maintain scenic vistas and the cultural landscape.

Both natural and anthropogenic factors likely influenced the fire regime in Tuolumne Meadows. Lightning-ignited fires are documented in Yosemite National Park (van Wagtendonk 1993), but the spatial and temporal patterns in Tuolumne Meadows during the last 500 years are largely unknown. Prior to the 1850s, American Indians may have set fires in Tuolumne Meadows to modify vegetation (Gassaway 2005; Reynolds 1959). During the early years of sheep grazing, sheepherders may have set fires in forested areas around Tuolumne Meadows in order to expand grasslands (Babalis et al. 2006). Fire suppression efforts in Tuolumne Meadows began after 1891 and natural fires have not occurred since at least 1921 (Cooper et al. 2006; Cunha 1992). However, it is unknown if natural or anthropogenic fires burned across Tuolumne Meadows or stopped at the forest/meadow margin.

Based on a limited study (Cooper et al. 2006) of fire scarred trees in the Tuolumne Meadows area, fire has not occurred in Tuolumne Meadows since at least the early 1900s, but may have been relatively frequent prior to the mid 1800s. More frequent fires may have modified the meadow environment or led to the mortality of lodgepole seedlings, thus greatly changing the prevalence of conifer establishment. A fire history study of lodgepole pine forests in the Sierra Nevada is in progress and may shed some light on the spatial and temporal patterns of previous fires.

These findings support the importance of further investigation into the causes of differing vegetation and habitat features in Tuolumne Meadows. High levels of bare ground in areas that likely have rich organic soil suggest that the dense deep-rooted sedges and grasses that formed these soils over centuries of time may not be self-sustaining, and these areas may even be losing organic matter. When coupled with high forb:graminoid ratios, revegetation may not occur on its own. Research into the root causes of vegetation differences, the make-up of historic vegetation, and whether carbon is being lost in the soil, could confirm these hypotheses (Ballenger and Acree 2008). Meadow integrity is reflected in biotic elements and the processes that generate and maintain those elements such as groundwater levels (Angermeier and Karr 2005). Investigations into the presence of high groundwater levels during the growing season indicate the hydrologic regime of the meadow ecosystem is still in place, suggesting that other causal factors are occurring (Ballenger and Acree 2008).

Soils

Based on initial assessments of soils in Tuolumne Meadows completed by the National Resources Conservation Service (NRCS), meadow soils are comprised of sandy loams, loamy sands and silt loams, with some component of volcanic ash or glacial till (Jones and Stokes 2001). A hydric soils list has not been completed for the Tuolumne Meadows area, but redoximorphic features (those indicating prolonged inundation or saturation during the growing season) have been observed in many areas.

A 2006 study (Cooper et al.) of the organic matter in soils found that content ranged from 12-18% in wet meadow plant communities and approximately 7% in upland and border areas dominated by lodgepole pine and upland herbaceous plant species. Initial investigations indicate that the high organic content of these soils and the low below-ground plant production may suggest that the existing vegetation did not form the existing soils (Cooper et al. 2006). Further investigations are needed to determine if ecological restoration actions are feasible and warranted.

Hydrologic Processes

Fig. 1-5. Trails and channels can interrupt or channelize sheet water flows

Sheet flow is very important in maintaining meadow ecosystems by providing water via surface flow at low velocities and dropping out sediment that provides nutrients to meadow biota. Channel incision resulting from downcutting, vegetation loss and headcuts has altered sheet flow processes in the meadow, leading to concentrated flows and a lower groundwater level. Ponding associated with culverts further concentrates water and limits sheet flow.

The conditions of the riverbanks along the Tuolumne River, as well as the shallower and wider channel, also influence sheet flow processes and groundwater levels. According to recent assessments of the hydrologic regime in Tuolumne Meadows, most sediment transport occurs during spring or summer rainstorms (Roche, personal comm). During heavy downpours associated with thunderstorms, water flows off adjacent granite domes at high velocity in sheets that typically flow into lower lying areas such as meadows. Small streams quickly become bank full and redeposit sediment transported by the high velocity water sheeting off of landforms. However, when water reaches trail ruts, incised channels, bare or sparsely vegetated areas, flows are concentrated in these channels rather than sheeting across the meadow (Figure 1-5). Sediment accumulated during these storms is deposited in concentrated areas rather than dispersing throughout the meadow, limiting the distribution of nutrients. Flow concentration and channelization limit infiltration of storm water and snow melt, affecting soil moisture and groundwater.

Fig. 1-6. Headcut near Delaney Creek

Fig. 1-7. Headcut on Budd Creek

Fig. 1-8. Diffuse headcut

Fig. 1-9. Healthy transition between vegetation types

HEADCUTS

Numerous headcuts associated with trails, culvert ditches and natural water channels (such as incised sections of Budd Creek) occur throughout Tuolumne Meadows (Figure 1-6, 1-7). Headcuts occur when water flow is concentrated and channeled at high velocity, increasing scour and altering sedimentation dynamics. Headcuts lower the adjacent groundwater level, expose soils, and limit sheet flow across the meadow. With a lower groundwater level, the upper soil levels dry sooner in the year, potentially changing wetland plant communities to upland plant dominated communities with less anchoring roots. Headcuts are most commonly due to some perturbation such as vegetation loss, concentration of water flow, increase in flow or increase in slope. While these perturbations can occur naturally, most headcuts observed in Tuolumne Meadows result from artificial (human-caused) changes to hydrology.

There are also incipient headcuts that are more diffuse and characterized by an abrupt transition between different vegetation types (Figure 1-8, 1-9). These types of headcuts have been observed below Pothole Dome where surface water flows off the dome at high velocity and is channeled onto informal trails. The abrupt slope transition from sheet flow to the trail surface erodes the trail margin, progressively incising the meadow surface upslope from the trail. Once flow is concentrated by the trail, sediment is routed to discrete deposition points rather than diffuse deposition across broad areas of the meadow.

To mitigate downcutting, headcutting, and other disruptions to hydrologic flow, the source of the problem must be understood and addressed. Headcutting is a result of channeling (often in trail ruts or incised streambeds) and simply filling in the deep gouges does not address the cause of the headcut. The source or cause of the high velocity, concentrated flow, must be mitigated to limit the development and enlargement of headcuts. To restore the hydrologic conditions to limit further headcutting, the following actions are proposed:

- Determine source of problem (channeling of water from culvert ditches, trails, bare ground etc.) and mitigate to decrease velocity, slope and concentration of flow
- Fill in deep headcuts with local native soil to discourage continued channeling
- Apply bioengineering techniques (such as hydrodrilling of willows, brush layering, installing of woody debris, plant material, and erosion control structures such as wattles or blankets) to divert and disperse runoff, promote deposition and limit scour
- Re-contour surrounding area to natural landform
- Mulch, seed and plant to re-vegetate with native species and minimize bare ground, sediment loss and continued erosion
- Protect and document any cultural resources in the area

Fig. 1-10. Incised channel near Pothole Dome

Fig. 1-11. Ditch draining kettle pond

Fig. 1-12. Bare area adjacent to shuttle bus stop

Fig. 1-13. Bare area with lodgepole seedlings

Ditches and Incised Channels

There are several ditches and incised channels throughout Tuolumne Meadows associated with perennial and intermittent streams, trails, culverts and historic draining efforts (Figure 1-10). The most prevalent ditches are those adjacent to a section of the Great Sierra Wagon Road that serves as a trail between the Visitor Center and Soda Springs. Other, more subtle ditches are likely remnants of draining efforts of potholes (kettle tarns) and ponding associated with culverts for mosquito abatement (Figure 1-11). There is also extensive channel incision associated with perennial and intermittent streams throughout the meadows that may be attributed to poor or inadequate culverts and bare ground.

Ditches and incised channels alter the hydrologic regime by channeling and concentrating water flow, intercepting surface and groundwater, cutting off supplies to downstream areas and altering the timing, velocity, depth and direction of groundwater flow. The resulting concentrated flow and velocity leads to further downcutting. Upstream areas and the conditions that have led to channel incision also need to be addressed and mitigated. To restore the landform from past ditching and channel incision, the following actions are proposed:

- Determine source of problem and mitigate to decrease velocity, slope and concentration of flow
- Fill in ditches and incised channels with local native soil to discourage continued channeling
- Apply woody debris, native mulch, and plant material (willows using hydrodrilling techniques) to divert and disperse runoff, promote deposition and limit scour
- Re-contour surrounding area to natural landform
- Mulch, seed and plant to re- vegetate with native species and minimize bare ground, sediment loss and continued erosion
- Protect and document any cultural resources

Trampling

Several areas experience high levels of human trampling resulting in vegetation loss and degraded meadow habitat. Several of these areas are adjacent to trailhead parking, shuttle bus stops and visitor facilities such as the Visitor Center, Tuolumne Meadows Store and Grill and Gas Station. The meadow adjacent to these high use areas is characterized by a high proportion of bare ground, different vegetation communities than observed in undisturbed portions of the meadow (e.g. dominated by big sagebrush), dead or damaged vegetation, compacted soils, and disrupted hydrologic function such as headcutting (Figure 1-12). Because of the high level of visitor use in the Tuolumne Meadows area, allowing dispersed use only increases the area of vegetation damage. Human trampling may also, via soil compaction and bare soil exposure, contribute to the lodgepole pine encroachment apparent in Tuolumne Meadows (Vale and Vale 1994), (Figure 1-13). Based on a recent study of the effects of tramping on subalpine meadow habitat, Tuolumne Meadows is very sensitive to trampling impacts and is very slow to recover from damage and degradation

(Holmquist 2008). Several methods can be utilized to minimize these impacts and the following actions are proposed:

- Protect sensitive areas using closure signs, fencing, and/or other natural barriers such as rocks and logs as deterrents
- Focus use by delineating trails, signs and other means of concentrating visitor use to more sustainable areas
- Assess visitor flow associated with trailheads, shuttle bus stops and facilities and focus use to more appropriate areas
- Delineate parking areas adjacent to meadow
- Delineate trailhead areas and the beginnings of trails to reduce informal trail density and minimize area of impact
- Consider shuttle bus stop locations in respect to impacts on vegetation
- Protect and document any cultural resources

Parking and Trailheads

Limited parking for visitors to the Tuolumne Meadows area puts enormous pressure on the existing parking areas. These areas exhibit parking lot "creep" (Figure 1-14) and continue to expand as more and more visitors try to find parking. Areas around the parking areas exhibit damaged vegetation, bare ground and many informal trails. This also impacts cultural resources and archeological sites. The most impacted areas include the Cathedral Meadow Trailhead, the Soda Springs trailhead and the Lembert Dome/Glen Aulin Trailhead (Figure 1-15). Issues and design for the trailheads along the entire Tioga Road are being addressed in a separate environmental assessment. Depending on the preferred alternative for parking determined in the Tuolumne Meadows Plan, the following actions are proposed to maximize natural and cultural resource protection:

Fig. 1-14. Parking lot creep

- Delineate parking areas with rocks, logs, or other obstructions to discourage creep (expansion)
- Ensure that parking areas are flat to minimize erosion and runoff
- Organize parking areas and trail access to minimize the tendency for informal trails
- Focus parking areas away from meadow habitat or sensitive cultural areas
- Re-vegetate damaged areas by de-compacting soils, seeding, mulching and planting
- Protect newly restored areas from further impact with closure signs, fencing, and/or other natural barriers such as rocks and logs
- Protect and document any cultural resources in the area

Figure 1-15. Denuded area adjacent to trailhead parking

Cathedral Lakes Trailhead

The Cathedral Lakes and Cathedral Peak trailhead is one of the most popular in the Tuolumne Meadows area. Over decades, the roadside parking area has expanded further west and east along the road and further out into vegetated areas, particularly on the north side where parking is immediately adjacent to the meadow. The impacts extend beyond the parking as visitors walk further out into the meadow, trampling vegetation and promoting more bare ground. Because parking is limited, visitors annually increase the parking area by squeezing their cars between trees, boulders or directly onto meadow vegetation. Roadside parking in this fragile meadow ecosystem is neither sustainable nor appropriate. To restore this heavily impacted area after parking is removed, the following actions are recommended:

- Close area to parking with fencing, boulders or other obstructions
- In forested areas, de-compact, mulch and seed the area
- In meadow areas, de-compact, plant, seed and re-contour to restore natural meadow topography and vegetation
- Protect and document any cultural resources
- Collect seed and grow native vegetation in a nursery to plant the area
- Address any hydrologic diversions or channeling to limit erosion and facilitate sheet flow

Roads

Tioga Road

Highway 120 (Tioga Road), runs east to west along the southern edge of Tuolumne Meadows and surface water flowing from the southern slopes is channeled through 35 culverts. In 2006, culverts clogged with vegetation and sediment were observed in 12 locations and signs of ponding water south of the road were observed in 23

Fig. 1-16. Partially blocked culvert

Fig. 1-17. Culvert set too low in meadow

Fig. 1-18. Ponding below culvert at Budd Creek

Fig. 1-19. Budd Creek culvert

locations (Cooper et al. 2006), (Figure 1-16). In most places, water is diverted to run parallel to the road at a distance less than 10 meters before a culvert allows water conveyance under the road and into the meadow (Cooper et al. 2006). Ponding is much more frequent near the east end of the meadow, where culverts are spaced further apart. This is also where the campground, gas station, store, and other infrastructure, coupled with lower gradient surface slopes, further interrupt water flow. The Tuolumne River is spanned by a bridge on the east end of the meadows that impacts the free-flow of the river.

Culverts

Because culverts force previously dispersed runoff into localized channels, downcutting has occurred downstream of many of the culverts, particularly in the west end of the meadow. This downcutting results in levee formation and accumulations of soils with greater permeability than surrounding meadow soils. These areas experience isolated prolonged inundation (in the channel) surrounded by higher elevation areas with little to no inundation. Surface water inflows, in particularly Unicorn and Budd Creek, provide groundwater recharge to the meadows, resulting in locally higher water levels near the streams. Downcutting may decrease recharge from surface water to meadow groundwater since it lowers the water table in the downcut streams and limits overbank flow (Cooper et al. 2006).

In addition, many of the culverts along Tioga Road were installed lower or higher than the surface level of the meadow (Figure 1-17). This increases downcutting, headcutting, and ponding, producing lower water availability and concomitant changes in species composition.

Currently, Budd Creek is conveyed through a single culvert that does not effectively accommodate high spring flows. As a result, on the south side of the road upstream incision has deepened the channel and reduced overbank flow. A secondary channel and associated culvert for Budd Creek only receives water at very high flows due to this channel incision and decreased overbank flow from the main stem (Figures 1-18, 1-19).

In order to improve the hydrologic connectivity between the surface flow from the south side of the road and Tuolumne Meadows, an assessment of the placement, number and size of existing culverts is recommended. In general, additional, larger and better-placed culverts could mitigate many of the observed impacts. Placement of culverts should depend on surface levels of the meadow to minimize downcutting, headcutting and ponding effects. In particular, culverts conveying water from Budd Creek and Unicorn Creek need to be much larger and numerous to accommodate peak spring runoff, some channel migration and flashy floods from summer thunderstorms. Several of the culverts are historic and reconstruction of these culverts would be guided by the recommendations in Chapter 2.

Once culverts are enhanced and replaced, work to restore the contours adjacent to existing culverts would help reduce the impacts and likelihood of further downcutting, channeling and ponding on the meadow vegetation and groundwater level. To mitigate impacts of the culverts on meadow hydrology, the following restoration actions are proposed:

- Fill in ditches associated with culverts with native soil
- Apply woody debris, native mulch, and plant material (willows using hydrodrilling techniques) to divert and disperse runoff, promote deposition and limit scour
- Place rocks to disperse outflow energy and prevent downcutting
- Re-contour slope and landform to natural conditions to encourage sheet flow
- Re-vegetate areas adjacent to and downslope of culverts with native species to slow velocity of water flowing into the meadow, encouraging sheet flow and sediment deposition

TIOGA ROAD BRIDGE

The Tioga Road Bridge, west of the Lembert Dome parking area, has a 400-foot length of fill on the northeast approach to the bridge that acts as a levee, bisecting the wetland floodplain into two separate areas. Transfer of water downstream across the right bank floodplain is impeded, forcing overbank flows back through the constricted bridge opening which increases hydraulic pressure on the bridge. This condition also erodes the riverbank, alters the composition of wetland soils in the area, and compromises the structural integrity of the bridge. To reestablish a hydrologic connection between the floodplain on either side of the fill and allow water to transfer under the approach road, one of the following actions is recommended: 1) Install a series of large culverts placed on grade under the road or 2) Increase span of bridge to a greater width, including more of the river and floodplain.

LITTLE BLUE SLIDE

Little Blue Slide is an unstable road cut east of Tuolumne Meadows along Tioga Road. With runoff and emerging groundwater, silt and boulder-sized material from the Slide erode and deposit in the Dana Fork of the Tuolumne River. This increases turbidity and poses risks to Tuolumne's public water supply. Re-vegetation of the roadcut is necessary to stabilize soils and the following actions are recommended:

- Engineer benches backfilled with soil with adequate rooting depth for plants to stabilize the surface layer, facilitating infiltration and providing cover
- Construct a small retaining wall at the base of the slope
- Re-vegetate the slope by planting, seeding and mulching

HISTORIC ROADS

There are remnants of old roadbeds along the northern and southern edges of Tuolumne Meadows (Figure 1-20, 1-21). Many sections of the roads are difficult to detect, while other sections are obvious and characterized by sparse vegetation, multiple ruts, and conifer encroachment. Old roadbeds impact meadow integrity in

a number of ways including channeling water, altering vegetation composition, compacting soils, and disrupting hydrologic connectivity (ponding upslope and drying downslope areas). Portions of old roadbed that impact meadow integrity and are not

Fig. 1-20. Old roadbed north of the Visitor Center

a contributing element to the cultural landscape may be candidates for ecological restoration. To mitigate these impacts, the following restoration actions are proposed:

- Ensure documentation of historic resources
- Re-contour, de-compact, seed and mulch to restore to natural conditions
- Remove any nonnative fill or infrastructure associated with these roads

Fig. 1-21. Old roadbed adjacent to Delaney Creek

In 1883, the Great Sierra Consolidated Silver Mining Company built the Great Sierra Wagon Road (GSWR) to access the company's mines east of Tuolumne Meadows. In 1915, the road became a public highway and was officially renamed the Tioga Road. Today, sections of the original Great Sierra Wagon Road are well defined and serve as a trail or access road while some portions lie under the footprint of Tioga Road, or are barely discernable. The Great Sierra Wagon Road is listed in the National Register of Historic Places and within Tuolumne Meadows, is a contributing feature to the Tuolumne Meadow Historic District. The objective for ecological restoration is to retain the road for foot and stock traffic, yet minimize impacts to the meadow. Chapter 2 in this report provides a cultural resource analysis with design recommendations and mitigations required to prevent impacts should restoration take place. Two sections of this original roadbed require special attention due to the impacts they have to ecological processes in the adjacent meadow and proposed restoration actions are listed below.

Fig. 1-22. Headcut and downcutting

SECTION 1: TUOLUMNE CAMPGROUND ENTRANCE TO THE TUOLUMNE LODGE

This section of the Great Sierra Wagon Road now serves as a trail but is up to 3 feet deep, up to 12 feet wide, and significantly impacts hydrology of the meadow. Its proximity to the Tioga Road and the Tuolumne River, combined with the sandy substrate, has lead to deep channeling, heavy erosion, headcuts and sediment transport into the river. Sheet flow coming off Lembert Dome is channeled through culverts, along the deeply rutted trail and toward the river. This diverts water from the meadow areas, lowers groundwater levels, and alters plant communities (Figure 1-22). Because this section of trail is so deep and sandy, it is difficult to walk on and visitors and pack stock walk on the edge of the trail, promoting more vegetation loss and further widening (Figure 1-23). This section of trail is heavily used by stock coming from the NPS stables towards the Glen Aulin trail. There are also several informal trails leading to the main trail that exacerbate channeling effects. In order to mitigate impacts to the meadow, prevent sediment from going into the Tuolumne River, retain the trail for foot and pack stock traffic, and retain the historic character of the Great Sierra Wagon Road, the following actions are proposed:

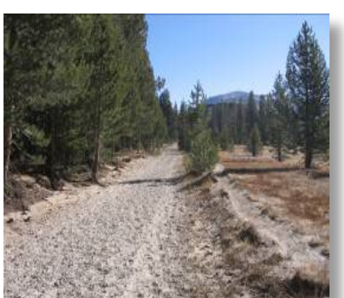


Fig. 1-23. Wide, deep rut with trail on the side

- Follow design considerations prescribed in Chapter 2
- Bring trail ruts up to the same elevation as the adjacent meadow (fill with native soil, rocks and/or gravel) – heavy equipment such as bobcat and excavator may be used
- Apply woody debris, plant material, and erosion control structures such as wattles or blankets to divert and disperse runoff, promote deposition and limit scour

- Establish vegetation (seeding, planting, mulching) to slow water velocity
- Narrow roadbed to recommended width to retain historic character (determined by cultural resource specialists), while minimizing impacts to natural resources
- Improve culverts conveying water flowing off of Lembert Dome (north of the road) to reduce channeling, downcutting, headcutting, and velocity, and encourage sheet flow
- Stabilize existing headcut – completely fill and plant or install a series of properly designed checkdam structures to encourage sediment accumulation
- Where the trail diverges from the historic GSWR (through the meadow in front of the Ranger Station), relocate the trail to the edge of the road and restore the meadow to natural conditions
- Improve signage to encourage visitors to stay on the trail

SECTION 2: VISITOR CENTER TO SODA SPRINGS

There are two sections of the Great Sierra Wagon Road leading to Soda Springs and Parsons Lodge, one from the east and the other from the south. The east section of road, currently used by maintenance vehicles to access wastewater treatment facilities, originates in the Lembert Dome parking area and follows the northeast edge of the meadow. While the wastewater treatment facilities remain in the current location, this section of road is not a candidate for ecological restoration.

Fig. 1-24. Headcut and ditch adjacent to trail

The section from the south begins at the Visitor Center and serves as a foot trail to access Parson's Lodge, the old Sierra Club Campground and the Soda Springs area. The Great Sierra Wagon Road was improved in the early 1900s so that vehicles could access the Sierra Club Campground and averages 12 feet in width. During road construction, soil dug from the sides of the road was used to raise the roadbed above the level of the meadow (Figure 1-24). Water is channeled laterally in these ditches alongside the roadbed into one of three culverts, one of which conveys Unicorn Creek. The damming action of the roadbed, headcuts, vegetation loss and incised channels associated with the ditches and culverts impact the surface flow of water throughout the meadow. The surface of the roadbed is characterized by multiple trail ruts, vegetation loss and soil compaction (Figure 1-25). It is also detracts from scenic views. A bridge spans the Tuolumne River just south of Parson's Lodge. Abutments constructed in the middle of the river support this bridge but alter natural river processes and sediment deposition and scour. This bridge also does not accommodate the overflow channel to the south and a large headcut is forming.

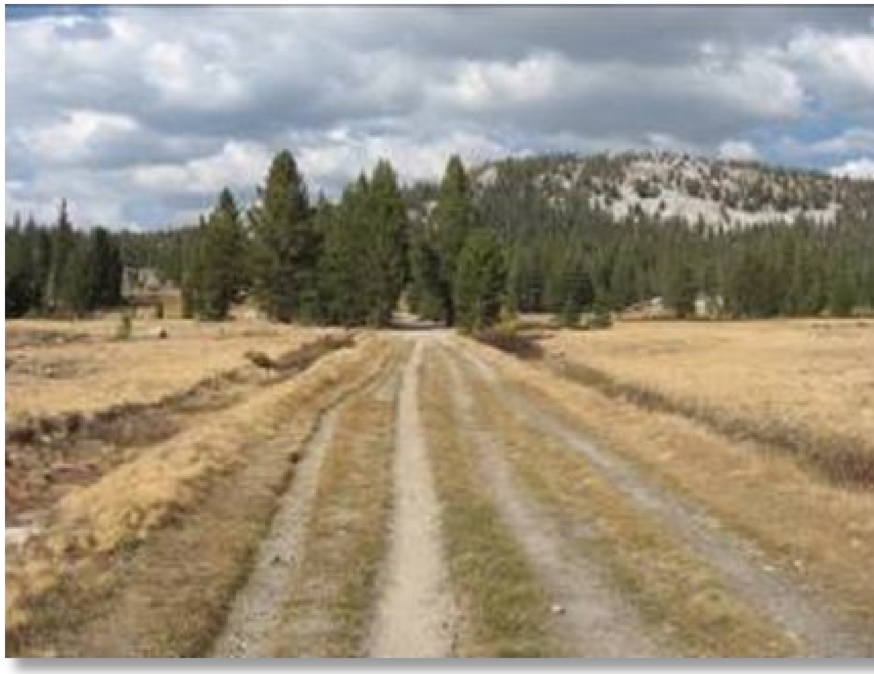


Figure 1-25. Trail to Soda Springs

In order to mitigate impacts on hydrology and meadow vegetation, retain the trail for foot and pack stock traffic, and retain the historic character of the Great Sierra Wagon Road, the following actions are proposed:

- Remove or lower causeways that act as dams
- Apply woody debris, plant material, and erosion control structures such as wattles or blankets to divert and disperse runoff, promote deposition and limit scour
- Narrow roadbed to recommended width to retain historic character (determined by cultural resource specialists), while minimizing impacts to natural resources
- Remove non-native fill and/or use to fill in ditches (specifically those parallel to the Soda Springs trail) or incised channels - heavy equipment such as a bobcat and/or excavator may be used
- Salvage native fill and plants
- Restore multiple ruts to natural conditions by re-contouring, de-compacting, seeding and re-vegetating
- Improve signage to encourage visitors to stay on the designated trail
- Install additional and larger culverts to accommodate flow from Unicorn Creek and improve hydrologic connectivity across the trail
- Re-design Soda Springs Trail bridge (considering historic values) over the Tuolumne River to accommodate overflow channel to the south of the bridge (currently only a small culvert) and to limit impact on the free flow of the river
- Install sections of boardwalk or other surface types through wet and saturated areas to maintain sheet flow and protect vegetation from trampling
- Obstruct restored areas with natural materials and improve signage to encourage visitors to stay on the designated trail

Fig. 1-26. Wilderness sign at informal trail

TRAILS

There are miles of both formal and informal trails throughout the Tuolumne Meadows area. Trails through meadows can affect hydrology, compact soils, reduce vegetation cover and degrade scenic views. In general, multiple rutted trails are common in meadows because as the ruts deepen they are subject to more saturation and inundation, causing visitors to move to drier areas adjacent to the trail, thus creating a new trail that also will become rutted (Figure 1-25). In some areas of frequent saturation, the trail may be built up to keep the tread dry but this impacts hydrology by obstructing sheet flow by acting as a dam. Most of the formal trails in the Tuolumne Meadows area lie within the footprint of the Great Sierra Wagon Road and are described in that section. There are also heavily used trails along the Dana and Lyell Forks of the Tuolumne River. Sections of these trails also exhibit braiding, rutting and widening. To mitigate impacts of both formal and informal trails, particularly multiple, rutted trails, the following restoration actions are proposed:

- Reroute trails out of meadows to drier, more resilient areas in collaboration with Trails, Wilderness, and RMS staff
- Remove any non-native fill, salvage native fill and vegetation
- Restore multiple ruts to natural conditions by re-contouring, de-compacting, seeding and re-vegetating
- Improve sheet flow disrupted by existing trails by improving or adding causeways
- Lower trail sections that act as dams
- Fill ditches that channel water with native soil
- Apply woody debris, plant material, and erosion control structures such as wattles or blankets to divert and disperse runoff, promote deposition and limit scour
- Install boardwalks or other trail types in very wet sections to promote sheet flow, protect vegetation and discourage multiple trail ruts
- Assess site appropriateness for formal trails considering wetland status, duration and depth of flooding/saturation, impacts of installing boardwalks or elevated trails and recovery of subalpine vegetation
- Delineate trails with natural materials and improve signage to encourage visitors to stay on the designated trail
- Narrow trails where appropriate (considering historic character)
- Protect and document any cultural resources

INFORMAL TRAILS

Informal hiking trails are common throughout Tuolumne Meadows. Some of these trails exhibit heavier use just in the past decade, as they become more defined from constant traffic. Informal trail conditions vary depending on the level of use. Some are deeply rutted and are characterized by multiple ruts while others only exhibit trampled vegetation. A restoration project at Pothole Dome in the 1990's addressed multiple informal trails and proved effective in protecting the central part of the meadow. Fencing was installed, guiding visitors to walk along the edge of the meadow. In recent years, an informal trail originating from parking just east of Pothole Dome and extending to the Tuolumne River has become much more prominent, particularly after an “Entering Yosemite Wilderness” sign was placed at the edge of the road (Figure 1-26). The sign is an indication to visitors that it is a formal trail and subsequently, use has increased. High concentrations of informal trails exist adjacent to the Tuolumne Store and Grill, at the Soda Springs trailhead, around the Soda Springs area, along the Cathedral Peak parking area and along the banks of the Tuolumne River. Many of these informal trails also affect cultural resources and merit removal. To minimize the extent and impact of informal trails, the following actions are proposed:

- Restore informal trails to natural conditions through de-compacting, re-contouring, seeding and re-vegetating
- Close the meadow to off-trail hiking
- Direct visitors to established trails
- Formalize sections of the existing informal trails based on visitor use patterns
- Install temporary deterrents to protect sensitive areas from further impact
- Allow dispersed use in more resilient and less popular areas
- Protect and document any cultural resources

Tuolumne Meadows Campground

The Tuolumne Meadows Campground has seven loops and 304 campsites. While most of the campground is within lodgepole pine forest, the A loop is very close to the riparian corridor of the Lyell Fork of the Tuolumne River. This loop road experiences ponding and flooding in the early part of the season. At the end of the A loop, flooding in 1997 washed out some of the road, prompting park mangers to lay riprap to harden the riverbank (Figure 1-27). Riprap can be effective in protecting infrastructure from further flood exposure, but it decreases the free flow of the river, compromising channel morphology and altering scour and deposition dynamics. There are many informal trails along this section of riverbank as well. The access road, campsites and other hardened areas concentrate water flow and sediment movement. To restore the free flowing character of the Tuolumne River and to protect and restore riverbanks and the riparian corridor, the following actions are proposed:

Fig. 1-27. Riprap along river in Tuolumne Campground

- Remove the A loop access road, informal trails and infrastructure to better protect the riverbanks from further impact and to allow free flow of the Tuolumne River
- Remove riprap and any other erosion control structures
- Remove asphalt, re-contour, de-compact, re-vegetate and mulch impacted areas
- Reroute the road entering the campground further away from the river out of the floodplain
- Re-vegetate and re-contour disturbed areas adjacent to the reroute
- Salvage any soil or vegetation that is removed for any new road development
- Apply bioengineering techniques (e.g. brush layering, anchor logs, intensive planting of vegetation) to stabilize riverbanks, promote sediment accretion, and minimize further riverbank loss
- Minimize the extent and concentration of informal trails by focusing access to more resilient areas and restore impacted areas to natural conditions
- Protect and document any cultural resources

Tuolumne Meadows Lodge

Fig. 1-28. Employee housing next to river

The Tuolumne Meadows Lodge is a historic resource and provides overnight accommodation for visitors and housing for employees. Several structures, particularly the lodge and employee housing, are located within 10 meters of the Dana Fork of the Tuolumne River (Figure 1-28). These areas exhibit compacted soils, vegetation loss, exposed roots and riverbank erosion. Having structures so close to the river can also affect water quality. If any structures are removed, the following are proposed:

- Remove all above and below ground infrastructure (including pipes or any utilities)
- Re-contour the area to natural landform
- De-compact, mulch, seed and plant to promote vegetation establishment
- Protect newly restored areas from further impact with closure signs, fencing, and/or other natural barriers such as rocks and logs
- Protect and document cultural resources

Glen Aulin High Sierra Camp

The Glen Aulin High Sierra Camp is a historic resource and provides overnight lodging six miles into the wilderness. A wetland delineation of the area completed in 2006 documents areas of fragmented wetlands, a heavily used trail through a wetland and areas in need of ecological restoration. Denuded riverbanks also occur in the area. Whether the camp remains, is reduced in size, or is completely removed, ecological restoration is needed to mitigate current impacts to wetlands and riverbanks. Because Glen Aulin is located in a Potential Wilderness Addition, extra sensitivity to natural and cultural resources and wilderness character is necessary. For any structures or utilities that are removed or altered, the actions outlined in this plan under "Removal or Relocation of Facilities" apply. In addition, the following restoration actions are recommended:

- Remove any impacts to wetlands and restore currently impacted areas to natural conditions
- Reroute the heavily used trail out of the fragmented wetland to a less sensitive upland area
- Salvage plants in reroute area and transplant to obstruct old trail
- Remove trail in wetland by de-compacting soils, filling in ruts, re-contouring natural meadow topography, seeding and mulching to promote plant establishment
- Obstruct old trail with natural materials to encourage visitors to use the new route
- Restore the natural drainage that was filled in and flattened to natural conditions, thereby improving access to toilets
- Re-vegetate (de-compact, mulch and seed) the historic corral on the granite bench that once was an extension of a delineated wetland
- Re-vegetate, stabilize and protect denuded riverbanks on the Tuolumne River
- Protect and document cultural resources in the area

SODA SPRINGS AND PARSON'S LODGE

Soda Springs is a natural alkaline spring, unusual in the high Sierra Nevada, which provides habitat for many special status plant species. Soda Springs is not only ecologically valuable but is also an important American Indian historic resource. Parsons Lodge is listed on the National Register of Historic Places and is designated a National Historic Landmark. It is currently used for workshops and as a starting point for interpretive walks and talks. This area experiences high levels of use, with most people accessing the site via the trail from the Visitor Center. Additionally, the road to the sewage treatment ponds, the Glen Aulin trail, and many informal trails provide access to this very popular area. The Glen Aulin trail, heavily used by stock, passes very closely to the springs and the associated manure and dust has potential to contaminate the springs. To improve the ecological integrity of the site, the following actions are proposed:

- Consult with park-associated American Indian tribes and groups to develop restoration strategies, ensuring that treatments incorporate native concerns, issues, and perspectives
- Improve delineation of trails
- Improve signage
- Remove informal trails and restore to natural conditions
- Direct visitors to use established trails
- Reroute the Glen Aulin trail further away from the springs
- Protect and document and cultural resources
- Establish monitoring of vegetation and hydrology

STABLES

To provide supplies to the High Sierra Camps, day rides for visitors, and park management operations in wilderness, stock is housed in one of two corrals in the Tuolumne area. Issues associated with the corrals include soil loss from erosion and dust, potential water quality issues, water diversions for water supply, and vegetation loss. For alternatives of the Tuolumne Meadows Plan that propose to relocate, remove or consolidate stock staging areas, the following ecological restoration actions are recommended to minimize continued impacts:

- Re-contour impacted area to natural landform (i.e. if stables are consolidated or removed)
- De-compact, mulch, seed and plant to re-vegetate with native species
- Restore hydrologic processes to minimize erosion, eliminate water diversions and address water quality issues
- Remove and restore associated trails that would no longer be needed to natural conditions
- Where stables are retained, ensure that water quality issues are addressed
- Where stables are retained, minimize footprint

- Protect newly restored areas from further impact with closure signs, fencing, and/or other natural barriers such as rocks and logs
- Protect and document any cultural resources

REMOVAL OR RELOCATION OF FACILITIES

There are several facilities providing visitor and park management services in the Tuolumne Meadows area including roads, trails, employee housing, maintenance facilities (including stock operations, water collection and wastewater treatment facilities, and storage and staging areas), the Tuolumne Meadows Visitor Center, Tuolumne Meadows Campground, Tuolumne Meadows Lodge, Store, Grill, Mountaineering Shop and Gas Station, and Glen Aulin High Sierra Camp. Day use, overnight parking areas, and utilities are also associated with these facilities. Depending on the preferred alternative, any plans to remove or relocate facilities would require consideration for natural and cultural resources to ensure that impacts are minimized. If facilities, utilities, and/or associated infrastructure are removed, the following actions are proposed to restore areas to natural conditions:

- Survey for rare or sensitive plant and animal species
- Restore historic wetlands that were previously impacted
- Remove all above and below ground infrastructure impacting hydrologic conditions (pipes, asphalt, water diversion etc.)
- Crush, fill (slurry), or remove all abandoned underground utilities
- Re-contour area to natural landform
- Restore primary ecosystem processes, primarily hydrology and wetland function
- Salvage any soil or vegetation impacted by removal
- De-compact, mulch, seed and re-vegetate impacted area
- Minimize impacts to surrounding vegetation by limiting size and development of staging and construction areas
- Minimize impacts to hydrology
- Minimize impacts to wildlife
- Ensure that all equipment and materials are weed seed free
- Ensure that impact does not degrade the surrounding area, specifically wetland, riparian or riverine ecosystems or any primary ecological processes
- Protect rare or sensitive plant and animal species from impact
- Protect and document cultural resources
- Protect restoration areas from further impacts with fencing or appropriate deterrents

WASTEWATER TREATMENT

Wastewater from Tuolumne Meadows facilities is currently conveyed through pipes to two sewage ponds and spray fields north of Parsons Lodge (Figure 1-29). If the preferred alternative is to move wastewater treatment facilities to another location, significant restoration of the existing site is needed. Any site chosen for new

Fig. 1-29. Sewage Treatment Pond

Fig. 1-30. Pump station associated with treatment pond

wastewater treatment facilities or associated infrastructure would require an impact analysis for natural and cultural resources. The following actions are proposed to ecologically restore the existing site as well as associated access routes (including roads) to the site:

- Restore natural contours which match the surrounding landscape using heavy equipment (excavator, bulldozer, loader, dump trucks)
- Fill in pond sites (potentially using fill material left from the construction of the ponds)
- Remove asphalt, de-compact, re-contour, re-vegetate and restore to natural conditions
- Remove pump station and restore area to natural conditions (Figure 1-30)
- Remove and properly dispose of any toxic substances associated with the wastewater treatment
- Remove or crush all pipes and underground infrastructure associated with wastewater treatment
- Remove riprap and re-contour mounds associated with construction of the ponds
- Re-contour ditched areas associated with the spray field and restore area to natural conditions
- Remove sections of non-historic road and restore to natural conditions; narrow sections of historic roads to retain historic character

Research

Additional research is needed to quantify the degree of degradation of meadow plant communities and the Tuolumne River, and the relationships to past and current land management practices. In particular, more research is necessary to examine evidence of the historic vegetation communities in these areas of concern, the most efficient and effective techniques for restoration, and the feasibility or appropriateness of ecological restoration. Research into the composition of historic vegetation is likely to entail analysis of soil seed banks, plant macrofossils and phytoliths (microscopic pieces of plants that are resistant to decay and can identify historic plant species). Analyses of organic matter content, soil carbon, carbon cycling, and plant productivity may also be included. Ecological restoration techniques to actively restore meadow plant communities, if feasible or appropriate, are likely to involve planting, seeding and mulching with temporary closure to foot traffic as vegetation re-establishes. These data may also provide information on the conditions that increase the rate and extent of conifer seedling establishment as related to past land use (i.e. intensive grazing). All of these studies would address the potential influence of climatic conditions and consider those interactions.

Cooper et al. (2006) recommended a detailed study of willows in order to understand the factors that limit willow establishment and persistence in the area and the relationship between willow growth and bank stability. Research may also focus on mammalian herbivory (pocket gophers, voles and deer) and the effects on establishment and growth of perennial plants typical of wet meadows. This research may require installation of temporary experimental plots that eliminate entry of small mammals. The effects of deer browsing would be assessed by protecting individual willows from grazing by small exclosures and assessing any changes in willow height, productivity, and catkin/seed production. These research plots would be located outside of designated Wilderness. If research indicates that vegetation communities are in an altered state due to anthropogenic influence, restoration actions to restore these plant communities may be desired and appropriate.

Fire also played a role in shaping the vegetation communities and landscape of Tuolumne Meadows but knowledge of the frequency and ignition source of fire is largely unknown. Ongoing studies of fire history in subalpine forests may shed some light on the role that fire may have played in shaping Tuolumne Meadows and point to using fire as an additional restoration tool.

Monitoring and Long-Term Maintenance

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. However, successful ecological restoration should include continued protection and management of the project site into the indefinite future (Clewell et al. 2005). Frequently, ecological restoration projects are not funded for subsequent management that may be required to prevent recurrent degradation of restored ecosystems. To ensure success and to facilitate learning (sometimes from mistakes), it is critical to include monitoring and utilize adaptive management in ecological restoration planning.

Monitoring can help to determine the efficacy of the restoration efforts and provide guidance for future restoration projects in similar environments. Monitoring methods may include vegetation transects, quadrats or ocular estimations, temporary exclosures, groundwater monitoring wells, and photo point establishment.

Tuolumne Meadows and the Tuolumne River corridor comprise diverse and dynamic ecosystems. Any alterations can effect cascading changes to the complex physical, chemical and biological interactions and conditions. Monitoring the efficacy of restoration efforts and the conditions stemming from those actions can feed into adaptive management and help avoid unwanted results. Ecological restoration is a long-term process of initiating autogenic repair but when the degree of degradation is high, further intervention may be necessary. Future ecological restoration actions and monitoring will also be guided by ongoing and future research as understanding of the causal factors for ecosystem damage increases.

Future monitoring of restoration actions will be dependent on Park staff to secure funding through proposal processes.

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CHAPTER 2. MITIGATION MEASURES TO PROTECT THE GREAT SIERRA WAGON ROAD

By Daniel Schaible, Historical Landscape Architect

HISTORIC OVERVIEW OF THE GREAT SIERRA WAGON ROAD

The Great Sierra Wagon Road was built in 1883 by the Great Sierra Consolidated Silver Mining Company to access the company's mines on Tioga Hill east of Tuolumne Meadows. This road was unpaved, built to a maximum grade of 10% and was 10-20 feet wide. In 1915 it was acquired by Stephen Mather and donated to the Department of the Interior as a public highway serving motor tourism in the area. At that time the road was officially renamed the Tioga Road, although it had been referred to by that name for some time earlier.

In the early 1930s, the National Park Service decided to reconstruct the Tioga Road in three phases. The first involved rebuilding the road from the east, from Tioga Pass to Cathedral Creek, the second from the west, from Crane Flat to White Wolf, and the third involved connecting these two road segments. Although the first two segments were constructed on schedule, the third section of roadway, having been stalled following the U.S. entering into World War II, was not completed until 1958. The "new" Tioga Road was built to contemporary Forest Highway Standards, as defined by the Bureau of Public Roads, and was 26-28 feet wide with a maximum grade of 6%. Although following a similar route in some locations, the new Tioga Road deviated from the alignment of the original road in many stretches. Today, many remnants of the original alignment of the Great Sierra Wagon Road are still present, some of which are currently used as foot and stock trails.

The western portion of the Great Sierra Wagon Road, from the area near Aspen Valley to White Wolf, (which is far outside of the proposed ecological restoration project area) was listed in the National Register of Historic Places in 1978 with local significance within the fields of transportation, industry and engineering. Furthermore, the remnant section of the Great Sierra Wagon Road that passes through the project study area is a contributing feature within the Tuolumne Meadow Historic District, as defined in the Tuolumne Meadows Cultural Landscape Inventory of 2007.

PROJECT OVERVIEW

The goal of this project is to restore natural hydrological functions and reduce erosion and trampling of native vegetation within Tuolumne Meadow.

A component of this project will involve regrading and narrowing remnants of the Great Sierra Wagon Road (1883) that are now used as foot and equestrian trails in the Tuolumne Meadows area. These modifications are necessary because (in many locations) the remnant road corridor has resulted in deep incisions and erosion within the meadow. The section of the road that crosses the meadow to Soda Springs was built on fill primarily acquired from the side of the roadway (creating a roadside swale that has, in many locations, become deeply incised). The roadbed disrupts natural hydrologic flow. There are currently an inadequate number of culverts resulting in disrupted surface water flow and increased erosion. Furthermore, the trail itself is deeply rutted and braided in some locations, resulting in unsecure walking surfaces and leading people to walk off the intended surface, further widening the trail and negatively impacting meadow vegetation.

The following actions can assist in the restoration of natural processes within Tuolumne Meadows:

- Narrow stretches and eliminate braiding of the Great Sierra Wagon Road roadbed.
- Remove fill and reduce the profile from the Great Sierra Wagon Road roadbed.
- Add fill and raise the profile of eroded sections of the Great Sierra Wagon Road.
- Add culverts underneath portions of the Great Sierra Wagon Road roadbed.
- Fill in and/or re-contour the swales that run parallel to the Great Sierra Wagon Road.
- Remove vegetation that has grown on the elevated Great Sierra Wagon Road roadbed, particularly lodgepole pine.
- Obliterate social trails that now run parallel to the Great Sierra Wagon Road.
- Fill in ditches of unknown origin that were constructed at an unknown time within Tuolumne Meadows to drain kettle ponds. These ponds were likely drained as part of a mosquito abatement project.

Mitigation Measures to protect Euro-American Historic Landscape Resources within Tuolumne Meadows

In order to minimize impacts to cultural resources, the following guidelines should be followed during the ecological restoration project at Tuolumne Meadows:

- When narrowing the roadbed (which is wider than historically and excessively braided in some locations) maintain a minimum width of 10 feet in order to convey the corridors historic use as a wagon road.
- Maintain the current alignment of historic remnants of the Great Sierra Wagon Road.
- If modifications are necessary to historic culverts and their associated headwalls, efforts should be undertaken to ensure that the modifications match their historic character. These efforts may include photo-documentation, contracting with a qualified stone mason, numbering headwall stones for reconstruction and locating granite that matches the color and texture of the existing stone masonry granite.
- New culverts (if added) should be built in a manner of similar culverts along the roadway, with simple, understated stone masonry headwalls with discrete, low profiles. The stone used in the headwalls should match, as closely as possible, the color, texture and dimensions of the stone found in other historic culvert headwalls found at Tuolumne Meadows.
- Reducing or adding to the vertical profile of the roadway is acceptable. However, it should be maintained at least slightly above the grade of the meadow.
- It is acceptable to remove woody vegetation from the roadside shoulders, as these features were not present during the historical period.
- Filling and re-contouring the swales on either side of the Great Sierra Wagon Road is acceptable as these features have been scoured out and are now deeper than they were during the historic period. We would recommend against eliminating the ditches entirely, as this would likely lead to the road/trail washing out.
- The ditches that lead from and drain many of the area’s kettle ponds are not documented as historic features. As such, filling and regrading them is acceptable within the Historic District.
- Major reroutes of historic trails in the area, particularly iconic trails such as the John Muir Trail and the Pacific Crest Trail, might constitute an adverse effect on the resource, and should go through additional impact analysis and environmental compliance.
- Do not pave any sections of the Great Sierra Wagon Road. Appropriate surface materials are dirt or dirt with a thin application of locally sourced decomposed granite.

- Removal and naturalization of the A-Loop Access Road in the Tuolumne Meadows Campground could result in an adverse effect to the Historic District. If pursued, this work should be preceded by requisite environmental compliance processes and the establishment of additional mitigation measures for the loss of the historic features.

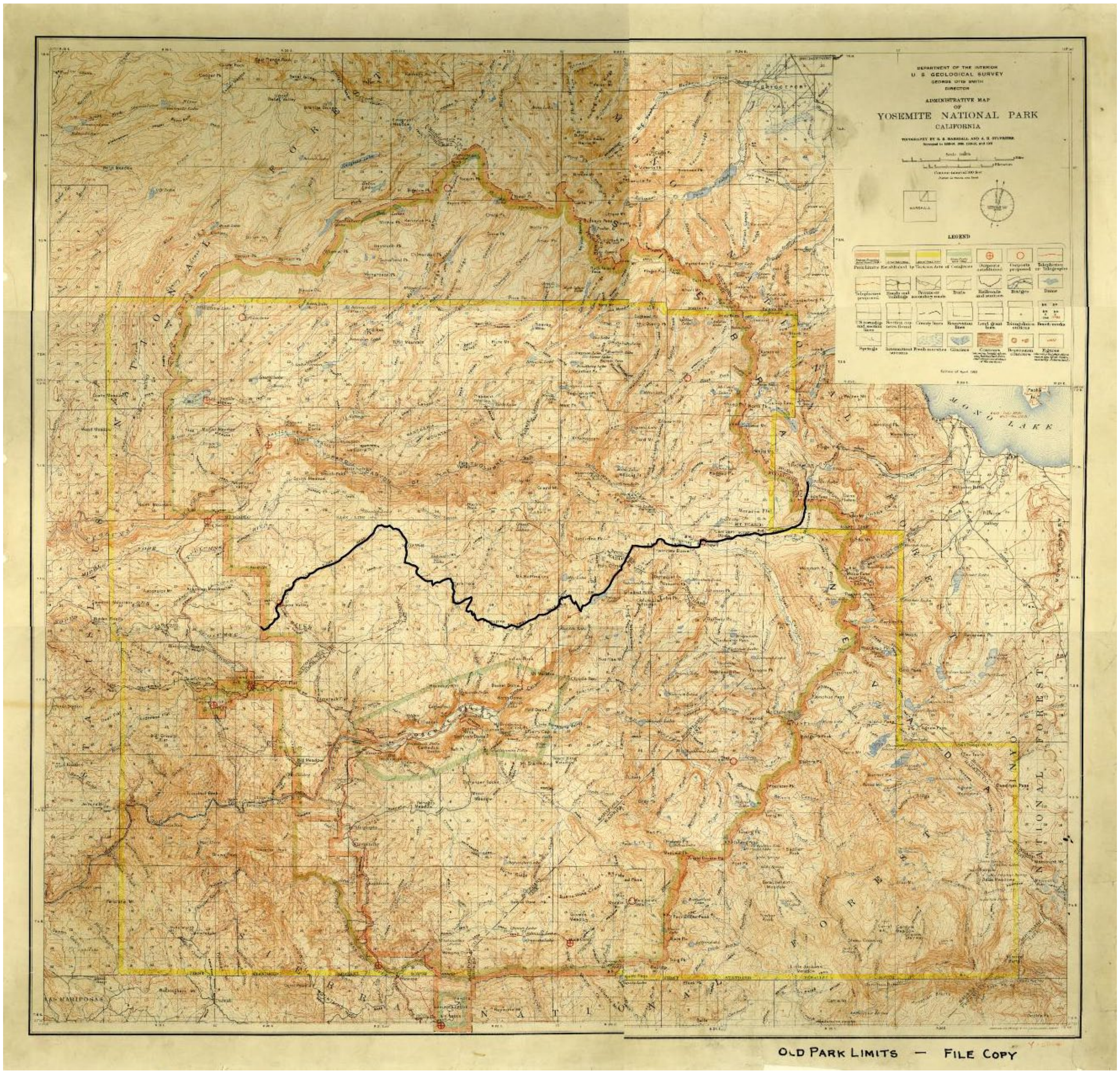

Figure 2-1. U.S. Geological Survey map of Yosemite National Park from 1910, 1:125,000. The alignment of the Tioga Road is traced in black.

Figure 2-2. U. S. Geological Survey map of Yosemite National Park from 1958, 1:125,000. The alignment of the Tioga Road is traced in red.

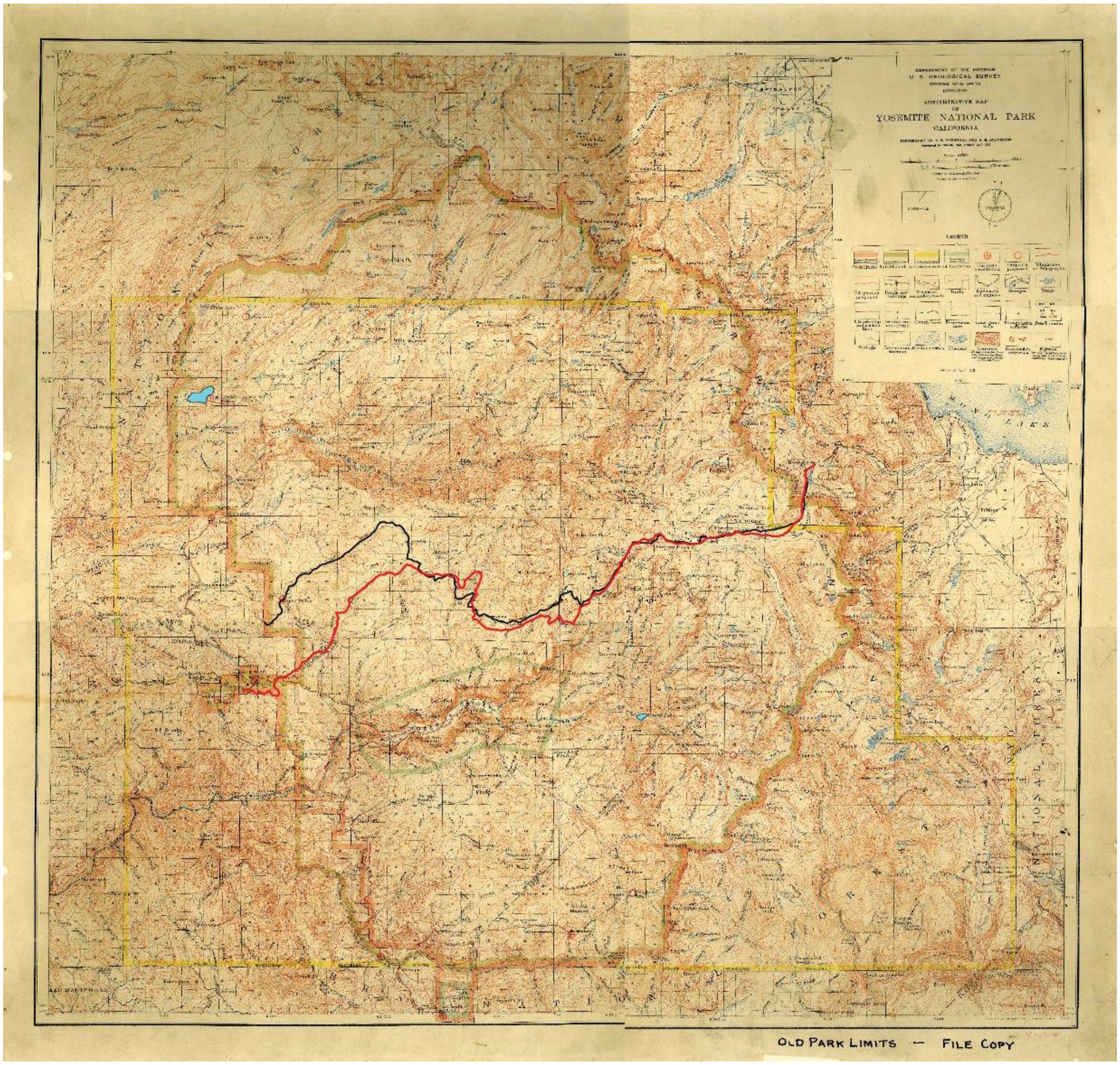

Figure 2-3. Map showing the 1910 alignment of the Tioga Road (black) overlaid with the 1958 alignment of the Tioga Road (red). Notice that the alignment is profoundly different, particularly along the western stretches of the road.

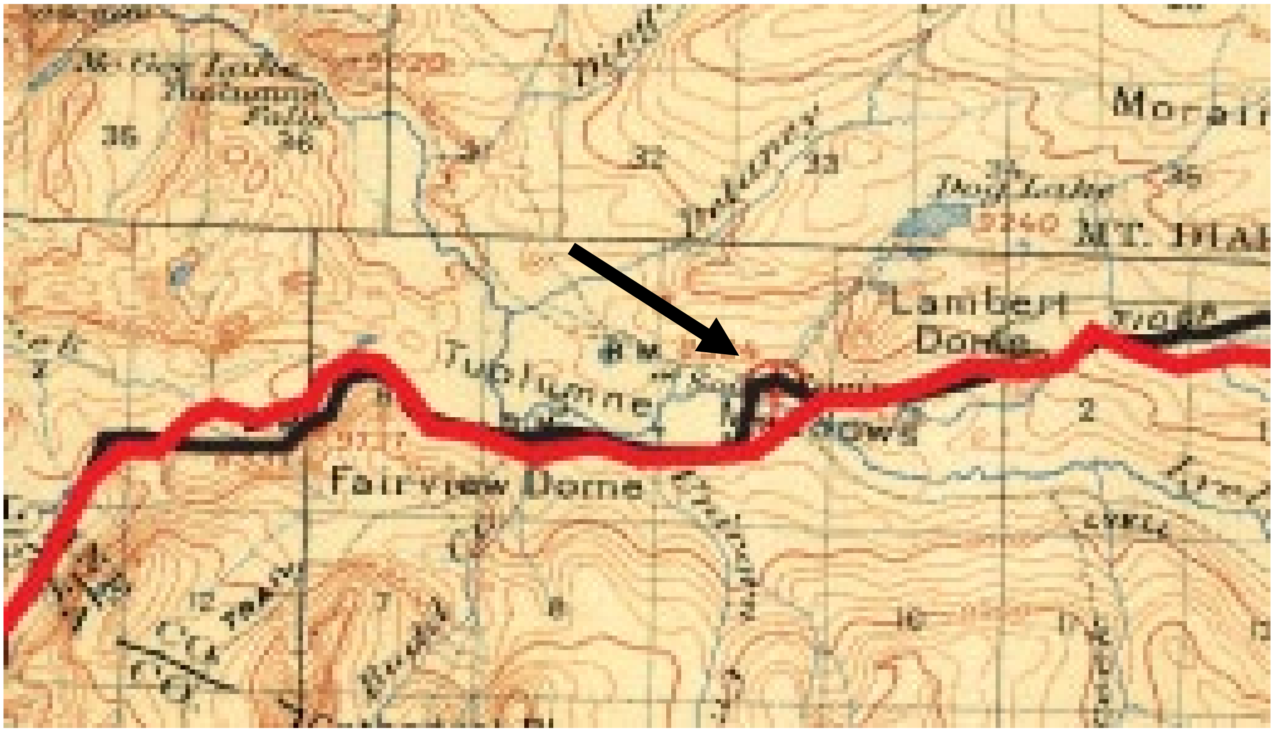

Figure 2-4. Map showing a detail of the 1910 (black) and 1958 (red) alignments of the Tioga Road as it passes through Tuolumne Meadows. Although the alignments are quite close for this stretch of the road, the arrow points to the section of the 1910 road that used to cross Tuolumne Meadows out towards Soda Springs, but, since the 1930s, now runs along the meadows perimeter. Most of the ecological restoration work will take place on this stretch of the historic roadway.