Meadow Restoration to Sustain Stream Flows and Native Trout

A novel approach to quantifying the effects of meadow restorations to native trout

Rene Henery, Sabra Purdy, Jack Williams, Jenny Hatch, Kurt Fesenmyer, Mark Drew, David Lass, and Curtis Knight

Aquatic Ecosystems Analysis Laboratory
University of Nevada, Reno
CALIFORNIA TROUT
KEEPER OF THE STREAMS
National Fish and Wildlife Foundation
50 YEARS
TROUT UNLIMITED
UCDAVIS
Center for Watershed Sciences
Beyond Conservation: New knowledge for a new era of river restoration and management.

Suggested Citation:

Rene Henery[1], Sabra Purdy[2], Jack Williams[3], Jenny Hatch[4], Kurt Fesenmyer[3], Mark Drew[4], David Lass[3], and Curtis Knight[4]. 2011. Meadow Restoration to Sustain Stream Flows and Native Trout: A novel approach to quantifying the effects of meadow restorations to native trout. A collaborative report to National Fish and Wildlife Foundation by Trout Unlimited, California Trout, University of Nevada, Reno, and University of California, Davis.

Acknowledgements:

We thank the National Fish and Wildlife Foundation for providing support to this project and express our appreciation of the Foundation's willingness to take on large scale meadow restoration in the Sierra Nevada with long term dedication and unparalleled support. Thank you to the Resource Legacy Fund for providing matching funds during Phase 1 of this project. We also thank the dedicated restoration practitioners that have taken on the hugely important and at times unwieldy task of restoring California's meadows and being willing to share that information with us and others. We thank the staff of the state, local, tribal, and federal agencies, non-profit organizations, and research institutions that have shown incredible willingness to participate in this task and improve all of our understanding of meadow restorations.

[1] University of Nevada, Reno

[2] University of California, Davis

[3] Trout Unlimited

[4] California Trout

Introduction

Meadow ecosystems are a key habitat type for the conservation of California's inland native trout. The vast majority of meadow systems in the Sierra Nevada and Southern Cascades ranges in California have experienced more than a century of degrading influences which have resulted in a marked loss of the critical functions montane meadows serve including water filtration, flood attenuation, support of biodiversity, and critically, water storage (Kattleman and Embury 1996). Over the past twenty years meadow restorations have become increasingly common, ranging from simple fencing against livestock grazing in the riparian corridor, planting riparian vegetation for bank stabilization, prescribed fire to reduce conifers, gravel augmentation in the stream, to full geomorphic projects involving plug and pond restorations and relocation of the stream channel (Hammersmark et al. 2008, Lindquist and Wilcox 2000, Swanson et al. 2007, Moyle et al. 2008). These restorations have typically been undertaken to address the hydrological problems associated with degraded meadows with a tacit assumption that habitat for fishes and other plants and animals would likely be improved at the same time. Based on the potential importance of restored meadows to fisheries conservation, this project examines the results of a number of restoration efforts that are diverse in methods, age, and intent and provides an analysis of each in order to maximize the benefit of restoration activities for native trout. In doing so, we believe we can increase the conservation benefits of restored meadows, collect much needed supporting data on the methods and outcomes of restoration efforts, and improve the overall ecosystem benefits of meadow restoration by targeting the selected needs of native fishes in all of their life history stages and guiding relevant monitoring work. This document represents the preliminary results of a collaborative effort between several universities, non-profit conservation groups, agencies, and stakeholders to determine the effects of meadow restoration projects on eight inland native trout taxa[5] in California and identify opportunities to maximize restoration benefits within planned or existing restorations.

In order to provide a robust and flexible analysis of meadow restoration across the highly diverse home-ranges of California's native trout we approached the problem in a series of steps. First, we built upon the considerable work that has come before us in the form of Trout Unlimited's Conservation Success Index (CSI) (Williams et al. 2007), and the UC Davis report commissioned by California Trout, "Salmon, Steelhead, and Trout in California: Status of and Emblematic Fauna" (Moyle et al. 2008). These documents helped us to identify the current status of the native trout taxa, their current and historic ranges, ecological needs, and past and ongoing conservation activities. We identified either past, current or future meadow restoration projects occurring in each taxon's range and established working relationships with the restoration practitioners, agencies, and local experts that participated in a given project. Once we chose test projects in a given trout taxon's range, we asked restoration practitioners to fill out a 16-question survey based on the River Restoration Analysis Tool (RiverRAT) developed by Skidmore and Associates to establish project context, design process, goals and objectives, alternative evaluation, and monitoring plans. This provided a helpful narrative about the project in question.

[5] The eight native trout taxa investigated by this project included McCloud River redband, Goose Lake redband, Eagle Lake rainbow, Paiute cutthroat, Lahontan cutthroat, California golden, Little Kern golden, and Kern River Rainbow trout.

We then developed a novel tool called the Meadow Restoration Fish Analysis Tool (MRFAT) to quantify the benefits of past, existing, or future restoration projects specifically for native trout. The tool and its use are more fully described in a separate document, but we provide a brief overview here.

The first step in using MRFAT is to identify the limiting factors (referred to as the Limiting Factors Analysis) facing each of the eight trout taxa within their range for a given project. This involved using Trout Unlimited's CSI to provide a base level of information (tier 1 and 2) and was confirmed and expanded by literature reviews and interviews with local experts, agency personnel, researchers, and restoration practitioners.

The second step in MRFAT is to analyze the efficacy of a restoration project toward mitigating the limiting factors affecting a given native trout taxon. The final scores were the results of the effect of a given restoration activity on a particular aspect of wild trout needs weighted (multiplied) by the pertinent limiting factors.

The final scores are calculated as a percentage that reflects how the project scored based on both how it addressed the overall limiting factors affecting fish, but also the degree to which the limiting factors are within the scope of the project, thus providing a look at the further restoration needs outside of the project scope and identifying opportunities that might be addressed within the project's scope.

Our team analyzed 12 existing meadow restoration priorities for eight native trout taxa that occur within the California Meadows project area. The suite of meadow related threats varied depending on taxa, local conditions, and history of land use. Among the primary threats we identified were 1) grazing effects including water quality decline, degradation to in-stream habitat, and loss of riparian vegetative shading and prey habitat (e.g. California golden trout, Goose Lake redband trout), 2) lack of in-stream flows, resulting from altered channel morphology as a function of surrounding historic and present land use (e.g. Lahontan cutthroat trout), 3) habitat fragmentation and diminished availability due to barriers, or degradation (e.g. McCloud redband trout, Eagle Lake rainbow trout), and 4) invasive species preying on native trout and in direct competition with native fishes for prey and habitat (e.g. Lahontan cutthroat trout, Paiute cutthroat trout, and California golden trout).

The following document contains the results of the twenty meadow restoration project reviews that we conducted during phase 1 of our project. We owe a huge debt of gratitude to the many people that took the time to participate in this project and freely share information about the successes and pitfalls encountered in the relatively new endeavor that is meadow restoration. This analysis is intended not to criticize or lay blame, but to provide a fish-eye view on how meadow restorations can impact fishes and help us to continue to improve and better understand our conservation efforts in the future. No restoration is perfect and we use this analysis strictly as a learning tool to improve our understanding and increase the success of meadow restoration into the future.

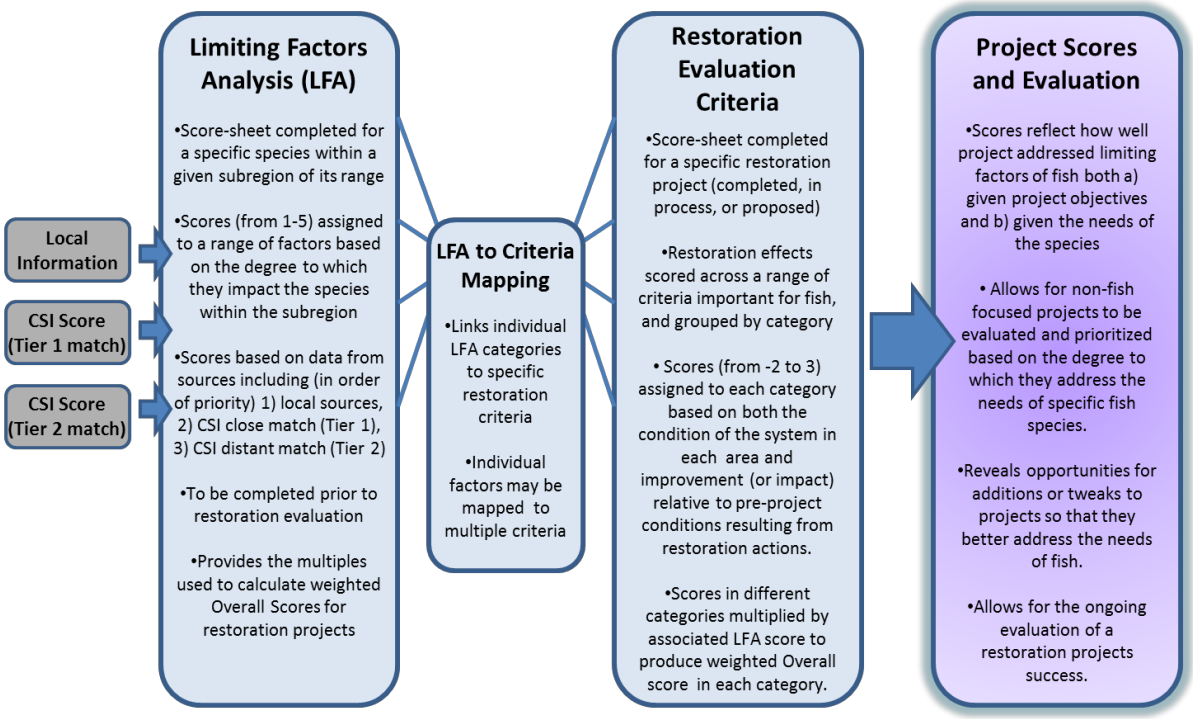
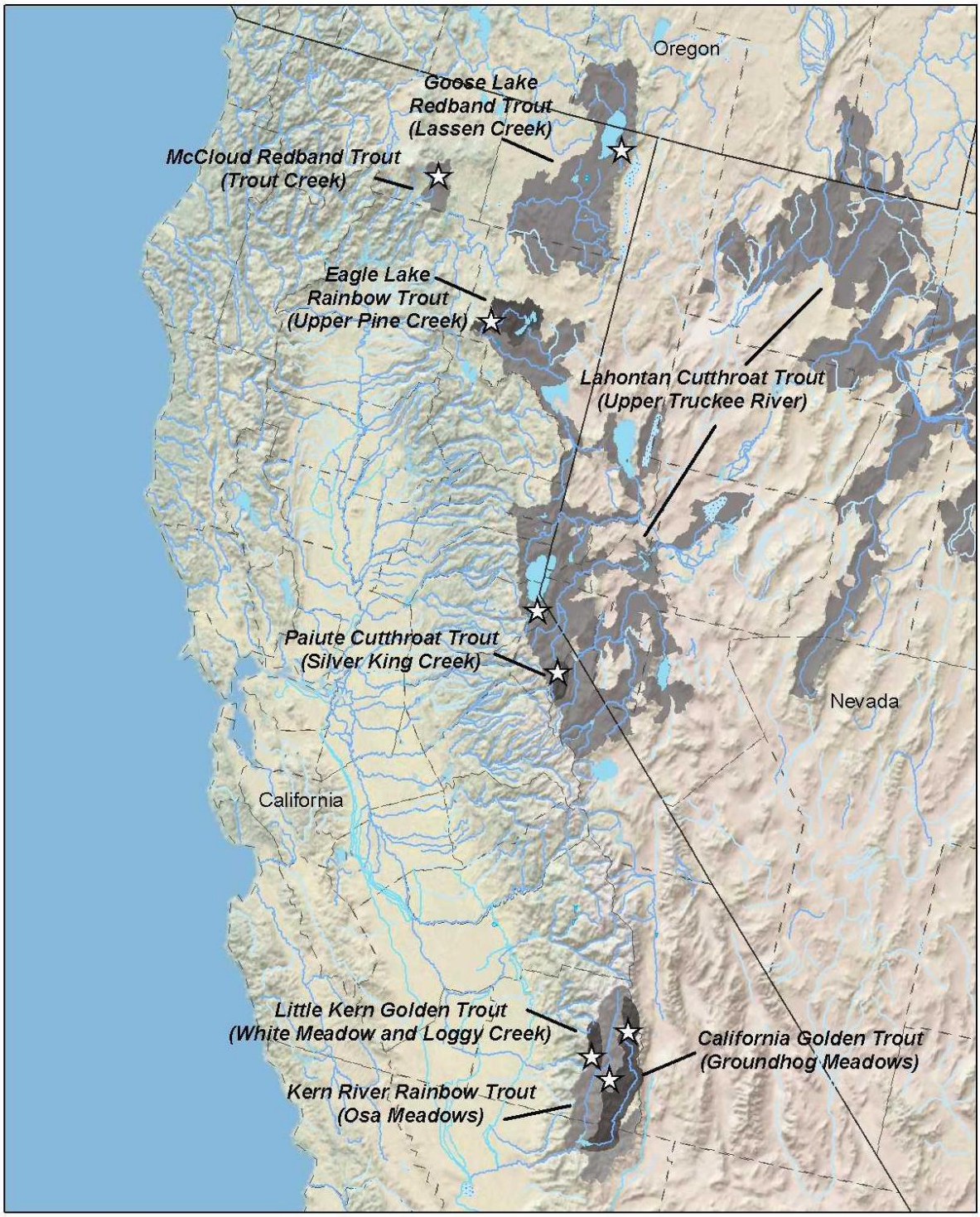
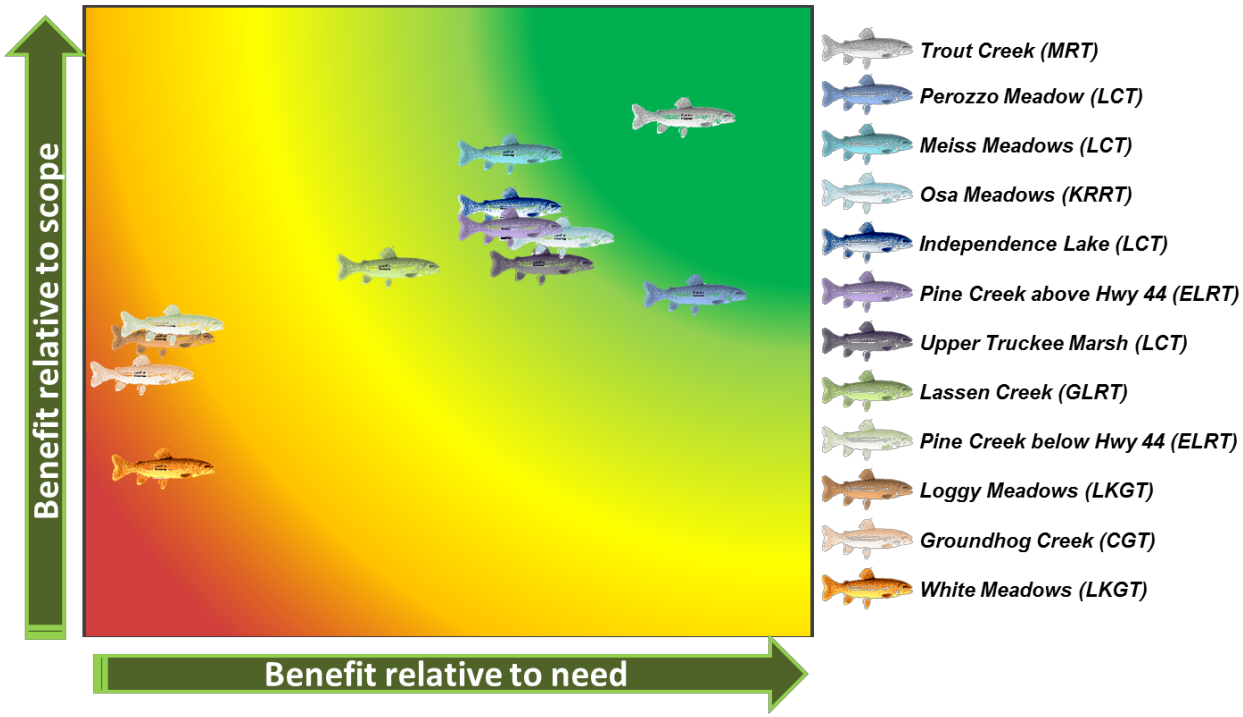


Figure 1. Overview of the Meadow Restoration Fish Analysis Tool (MRFAT) describing (left to right) a) prioritized information sources, b) Limiting Factors Analysis specific to species and project region, c) Restoration Evaluation Criteria, and d)Project Scores and Evaluation

California Native Trout: Historical Distribution and Meadow Restoration Opportunities



Interpreting the results



Comparison of project scores in terms of in-scope limiting factors addressed (**y axis**) vs. total limiting factors addressed (**x axis**), with total limiting factors scores weighted (multiplied) by the extent of limitation (*total possible points*). Weighting of x-axis scores provides a means of comparing project benefit for native trout populations, relative to their varying degrees of limitation.

We interpreted the results of the MRFAT analysis in two parts. The first component depicted how the restoration project performed within the context of all of the limiting factors affecting the fish in the project reach, whether those limiting factors were within the scope of the project or not. This is represented on the above graph as the y-axis (unitless). The second component depicts how a given restoration project performed relative to components that were within the scope of restoration goals. This is represented on the above graph as the x-axis (unitless). A project that scored relatively low (red and yellow) does not necessarily indicate that the restoration itself was a failure, but that a) there may be compounding factors outside the scope of the restoration project that outweigh the benefit derived by the restoration, b) the limiting factors affecting a taxon exceeded the capacity of a given restoration project to mitigate, c) that a given project did not correctly identify the factors limiting fish populations in the project reach, or d) that the project goals were not geared towards fish. However, in some instances, past restoration methods used did not meet the goals of the restoration project (for example the White Meadows and Osa Meadows restorations from the 1970s-80s using check dams) and actually caused further degradation to the meadow and stream resources. These provide an excellent learning opportunity for other restorations. Using the MRFAT analysis on past, current, and

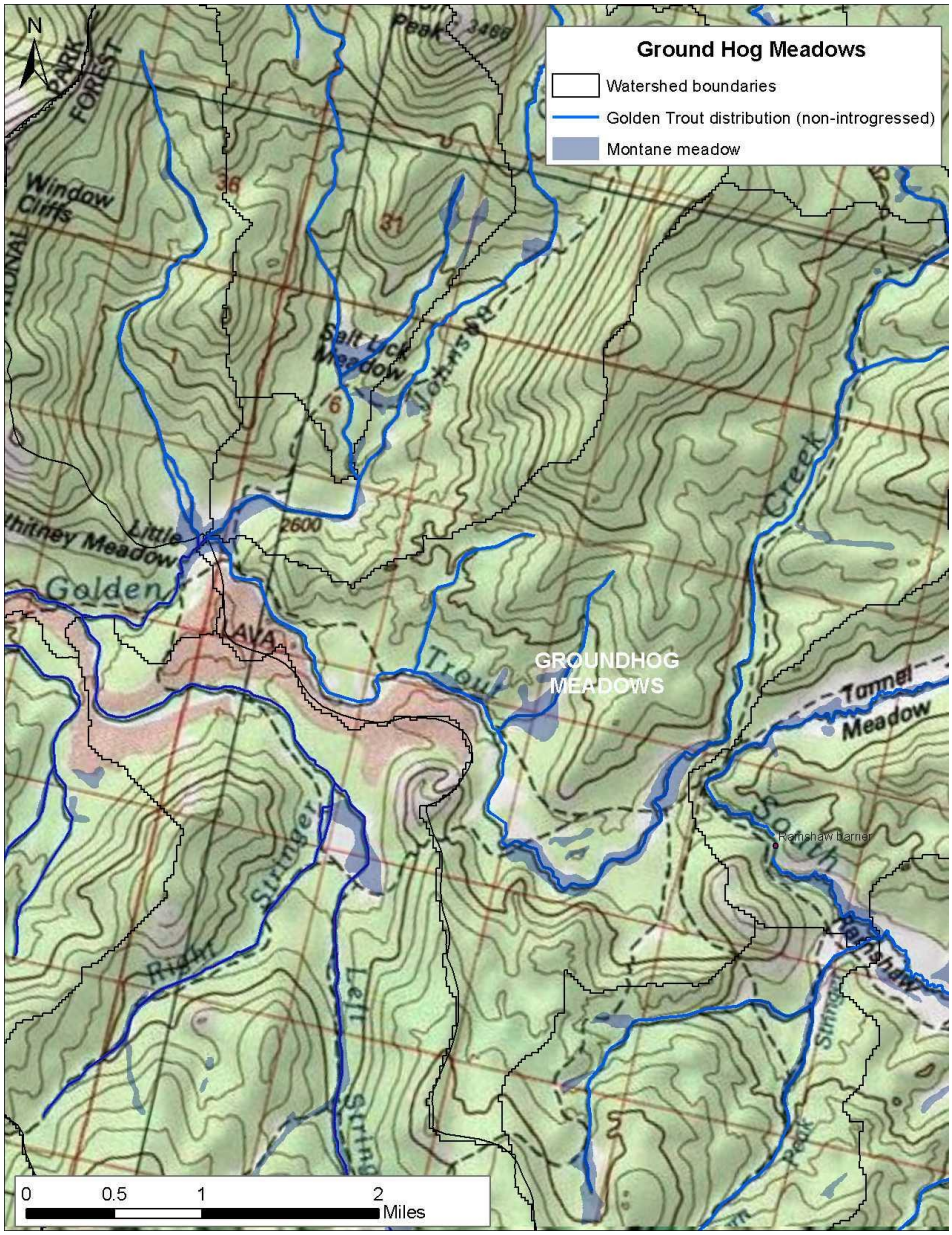
future restoration projects can help to identify gaps in a given restoration plan or recognize other opportunities that might dovetail with an existing restoration that would bring added benefit to both native fish populations and increase the overall value of restoration efforts.

Project Evaluation Summaries

Projects (by species) Page

Species: **California Golden Trout (*Oncorhynchus mykiss aguabonita*)**
Location: **Groundhog Meadow, Inyo National Forest**
Regional Contact(s): **Lisa Sims (USFS, Inyo NF)**
Project: **Groundhog Meadow restoration actions**
Timeframe: **~1999-present**

Project area map



Associated documentation, research, and data sources

- Study on climate change vulnerability in the region, Mallek and Safford (2011)
- SJ. Stephens, C. McGuire, and L. Sims. 2004. Conservation Assessment and Strategy and Strategy for the California Golden Trout (*Oncorhynchus mykiss aguabonita)* Tulare County, California. 91p.

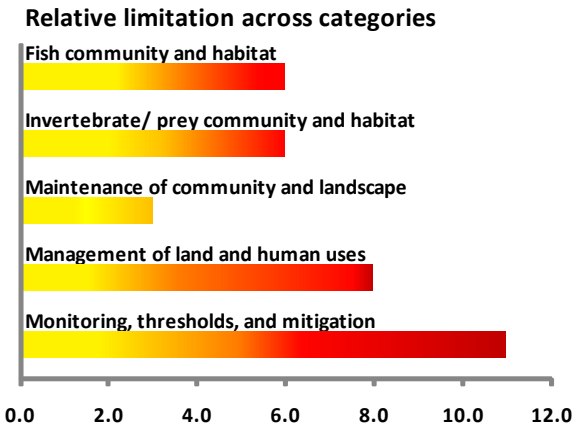
Restoration overview

- Habitat has undergone several restoration actions over the last ~10 years which are being assessed cumulatively.
- Main restoration actions include 1) addition of in stream structure at upper end of restored reach and 2) removal of cattle and grazing from meadow surrounding reach.
- Restoration targeted primarily at improving meadow function for the benefit of larger downstream habitats considered critical to the broader population.

Background on site, landscape, and species condition

Project site

- While it is difficult to know what ancestral conditions were like in the project areas, a range of information indicates that it has a long history of severe historic disturbance (planting, plowing, ditching, etc) between 1850 and early 1900s. The legacy of those impacts is however, unknown.
- Additionally the meadow was actively grazed for many years and for the later portion of those years may have even been the preferred grazing spot in the immediate area.
- Cattle have now been removed from site for ~10 years, and site is designated as wilderness, though wilderness designation allows for potential regrazing.



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

- Regrazing is currently under consideration though no formal review has occurred
- Currently there is no fencing present
- Golden Trout Creek as a whole supports ample habitat for fish (> 75 miles)

Climate considerations

- Based on modeling study and synopsis by Mallek and Safford (2011) the regions is:
  - high risk for increased winter flooding,
  - low risk for temperature change; only minor changes predicted for this area (Kern plateau).
  - Moderate risk for fire regime change due to decreased snow.

Species condition

- The affected reach contains a resident population of CGT only
- Population size and structure are considered to be in good condition and stable
- The fish in the reach are isolated by barriers. However, the stream is populated both above and below the affected reach.

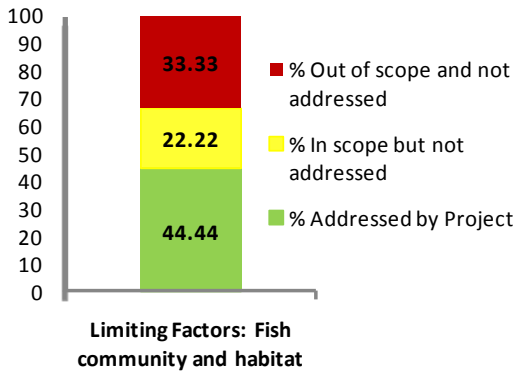
- Fish in reach are thought to be largely genetically pure, though whether genetic purity is a management objective in this reach and beyond is still to be determined pending the completion of a genetic management plan for the species.

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 44.4%
Limiting factors addressed relative to project scope: 66.7%



Project effects and site condition

- Restoration work has maintained habitat generally:
    - Existing connectivity is relatively equivalent to historical connectivity (at least during certain flows), though headcut in meadow restricts movements.
    - Habitat has varied over the years based on a variety of work but hard to determine whether patch size is changing on a relative scale
    - Habitat diversity has been fairly consistent
    - Banks present from past land use - Stream bank degradation and increased erosion were not severe even during grazing.
    - Little gravel presently and no evidence for there ever having been a great deal of gravel in the system
- Overhanging riparian vegetation and other cover increased since cow's removed (2001); need more understanding of site potential to fully evaluate change that has occurred
- Hydrograph more consistent now than historically, changes may have built on prior efforts/ previous work
- Improvements to water quality can be inferred (though not confirmed) from improved vegetation, physical characteristics, and meadow function.
- While pools are present, there is a lack of deep pools (though may have been no deep pools historically) and pool habitat availability is decreasing due to fill in.

Persisting concerns

- Lack of surrounding population to recolonize in the event of impact from some large event (e.g. fire)
- Existing head-cut in meadow that creates barrier and restricts passage
    - Head-cut has stabilized and provides habitat that wasn't there previously. Not necessarily desirable to modify to resolve passage issues.
- Structures in stream may be limiting pool habitat at certain times/ flows.
- Potential genetic risk from hybrid trout upstream were connectivity established

Data Gaps

- No information on tolerance of fish for turbidity, temp, DO, etc.
- No information on water quality (WQ) parameters in system including temp, DO, turbidity, or pH

- No data available for population density or age or size class distribution. General density range-wide of 128-836 fish is probably appropriate for this region as well (would need to confirm with Christy's data) Condition factor also unknown.

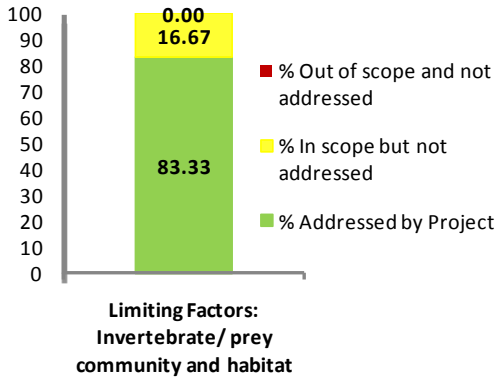
Opportunities

- Field research and/or lab experimentation to determine species tolerance for WQ parameters including turbidity, temp, DO, etc.
- Monitoring for WQ parameters in system including temperatures, DO, turbidity, pH, etc.
- Investigate potential to modify in stream structures to improve pool habitat.

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 83.3%

Limiting factors addressed relative to project scope: 83.3%



Project effects and site condition

- According to study diversity of invertebrates similar to historic community/ structure or that of reference reach
- Substrate improved through addition of head-cut structures and consequent removal of fines
    - Substrate could potentially be improved further but question about where improved substrate would come from.
- Water quality necessary to support ecosystem function, including temperature, turbidity, pH, etc. is assumed to be restored in the system
    - No baseline or monitoring data to test/ confirm this.

Persisting concerns

- Impacted water quality due to excess fines
- Potential impact to invertebrate density, distribution, community composition, and habitat.

Data Gaps

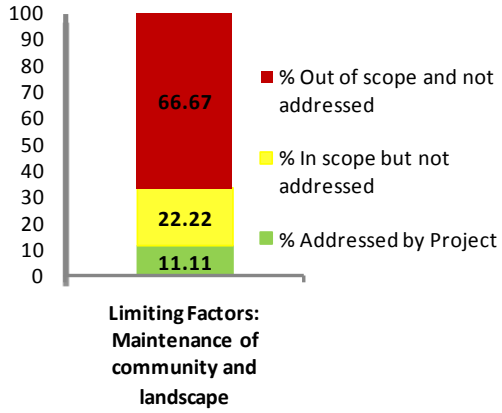
- Unknown condition of invertebrate community, including production, density, and distribution relative to previous or reference conditions due to discrepancy in the methodologies and objectives of historic versus more recent invertebrate surveys.
- Unknown whether adequate invertebrate production is occurring to support fish population
- Unknown invertebrate prey availability relative to historic or other systems. Some thought that post 1850 substrate change decreased diversity in invertebrates but unknown.

Opportunities

- Perform invertebrate study using methodology consistent with historic study in order to evaluate diversity, distribution, abundance, and production pre and post grazing removal. Compare to modern methods
- Develop bioenergetics model for species and evaluate current invertebrate food supply against needs based on physical habitat parameters and population size.

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape



Limiting factors addressed by project: 11.1%
Limiting factors addressed relative to project scope: 33.3%

Project effects and site condition

- Physical connectivity disrupted by restoration and inclusion of check-dam. Physical connectivity disruption impedes immigration or emigration relative to this population.
    - Goal of restoration, however, was/ is to improve meadow function for improvements downstream where more critical population/ habitat are.
    - Impediments to movement also only local with populated water above and below barrier
- Sediment sources not addressed as an issue

Persisting concerns

- Risk for increased winter flooding as a result of climate change.
- Risk of potential of fire regime change due to decreased snow.
- Risk of fire and associated impacts to water quality due to climate exacerbated lack of fire fuels management.

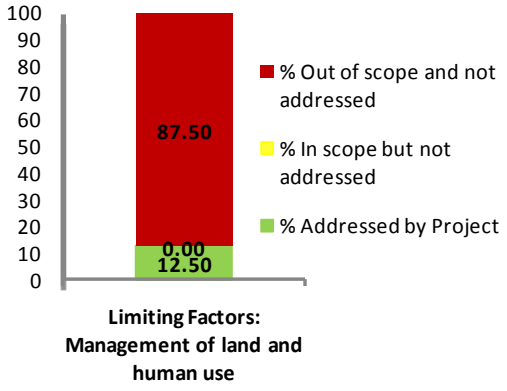
Data Gaps

- Aquatic community and species population structure not monitored
- Poor understanding of nutrient impact during grazing and change since.
- Poor understanding of sedimentation risk relative to current WQ and species tolerance

Opportunities

- Opportunity to monitor nutrient levels and coliform in stream and compare with similar currently grazed reach in order to assess a) effects of degrazing and b) potential impacts from regrazing.
- Potential opportunity for fuels management to reduce risk of impact from fire

Management of Land and Human Uses



Limiting factors addressed by project: 12.5%
Limiting factors addressed relative to project scope: 100%

Project effects and site condition

- Cows removed (~ 10 years)
- Area designated wilderness (though wilderness designation allow for potential regrazing)
- Increased runoff form impacted soils formerly an issue but 10 years of non-grazing has significantly improved.
- Recreational harvest of species is happening, is believed to have no impact on numbers, and is encouraged at present

Persisting concerns

- Legacy impacts to water quality, runoff, and habitat condition
- Risk of fire due to high fuel loads and no large fire for many years
- Risk of conifer encroachment
- Forage may be being used by pack stock
    - This, however, is non-regulated (and not easily able to be regulated)

Data Gaps

- No baseline data on grazing impacts to water quality including fecal coliform content of water. Important issue for future and potential to regraze

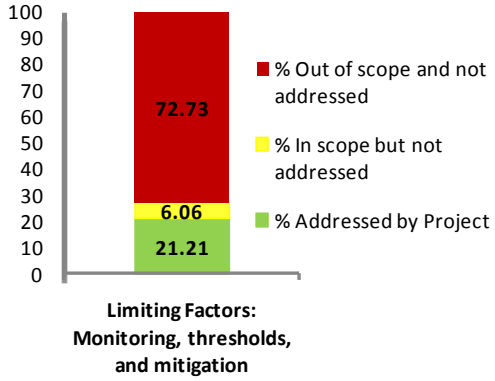
Opportunities

- Manage fuel loads to decrease risk of impact from fire
- Investigate/ monitor conifer encroachment and develop and implement treatment plan.
- Investigate aspen stand loss and develop restoration approach.
- Encourage riparian fencing if regrazing were to occur

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 21.2%

Limiting factors addressed relative to project scope: 77.8%



Project effects and site condition

- Headcuts and gullying is monitored annually and appears to have stabilized

Persisting concerns

- No existing thresholds established for species, ecosystem, or water quality
- No current monitoring program for water quality, habitat, ecosystem or species condition in place

Data Gaps

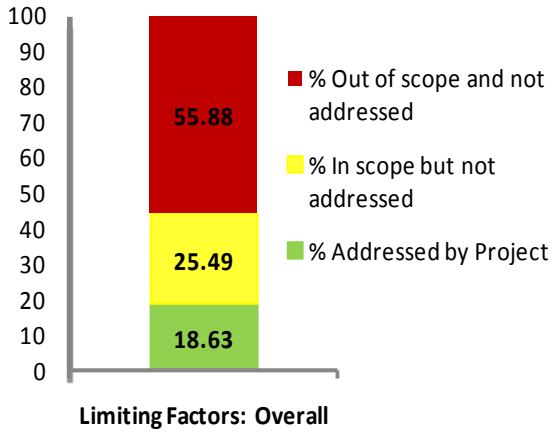
- Recovery of meadow, stream banks, and vegetation unmonitored
- Water quality unmonitored
- Fire and fuels and potential increased risk of fire not being addressed

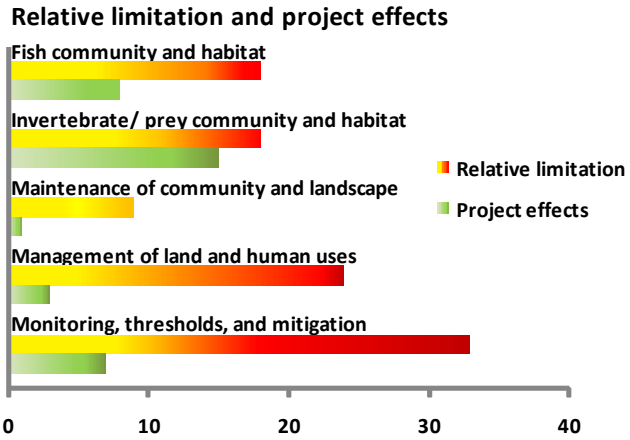
Opportunities

- Establish and monitor for population, water quality, and ecosystem condition thresholds
- Comprehensive meadow monitoring plan

Overall Findings and Key Points

Limiting factors addressed by project: 18.6%
Limiting factors addressed relative to project scope: 42.2%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

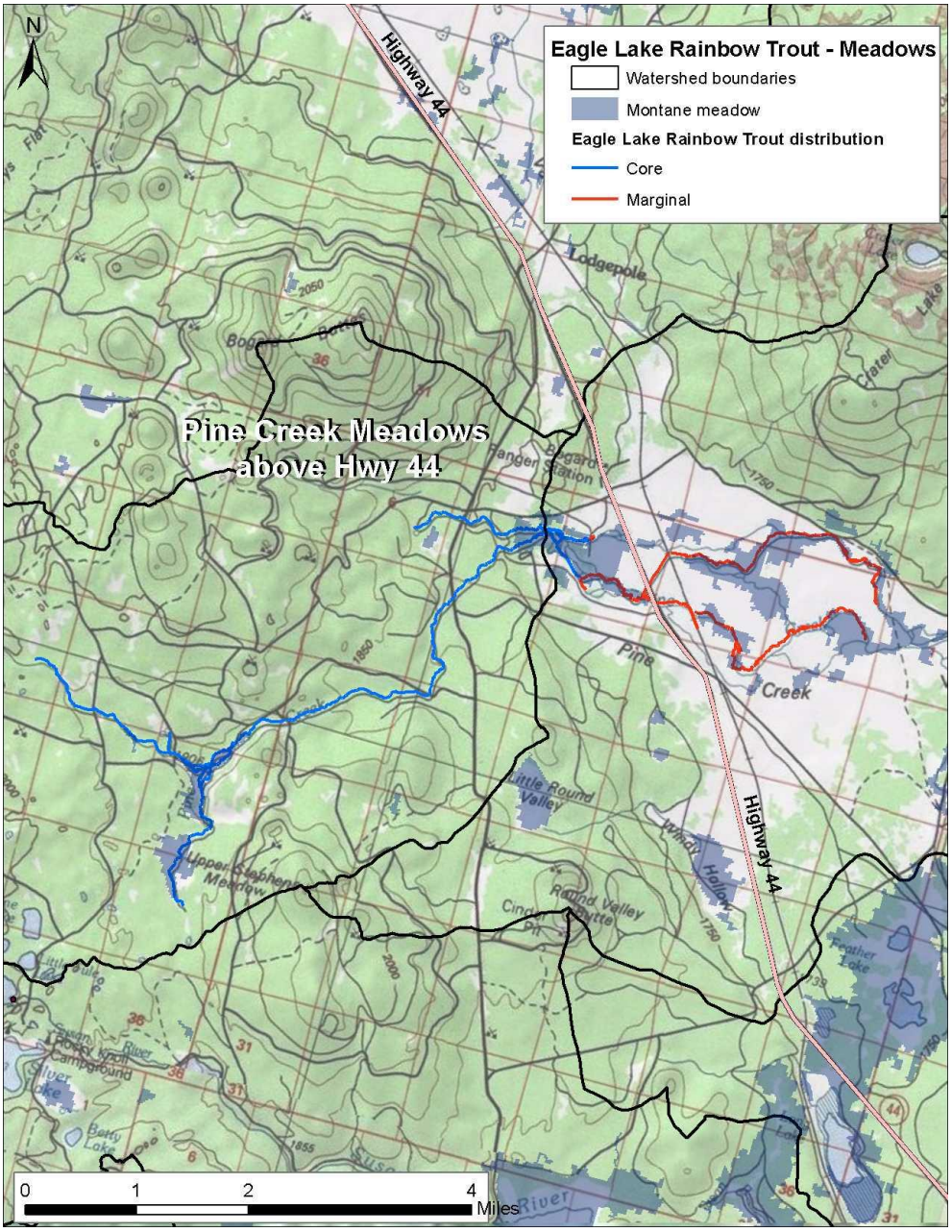
Species condition in project area:	Very Good
Area of greatest gains:	Invertebrate/ Prey Community and Habitat
Most significant actions:	Removal of cattle/ no grazing
Area of greatest need:	Management of land and human uses
Highest priority concerns:	Regrazing, Fire, Lack of connectivity, Potential Introgression

Highest priority opportunities:

- Investigate and monitor water quality (WQ) and establish current baseline
- Investigate invertebrate community relative to historic (grazing) era
- Investigate physiological tolerance of species to WQ parameters
- Establish thresholds for WQ and invertebrates
- Evaluate effects of de-grazing (based on above).
- Manage fuel loads and encroaching conifers to prevent potential damage from fire

Species: **Eagle Lake Rainbow Trout (*Oncorhynchus mykiss aquilarum)***
Location: **Pine Creek/Eagle Lake, California**
Regional Contact(s): **Teresa Pustejovsky (USFS, Tribes)**
Project: **Upper Pine Creek Restorations above Hwy 44**
Timeframe: **~1988-present**

Project area map



Associated documentation, research, and data sources

- A Conservation Plan for Pine Creek and Eagle Lake Rainbow Trout (Pustejovsky, 2007)
- Salmon, Steelhead and Trout in California: Status of an Emblematic Fauna (Moyle et al. 2008)
- Personal communication with Teresa Pustejovsky (2011 ELRT migration study)

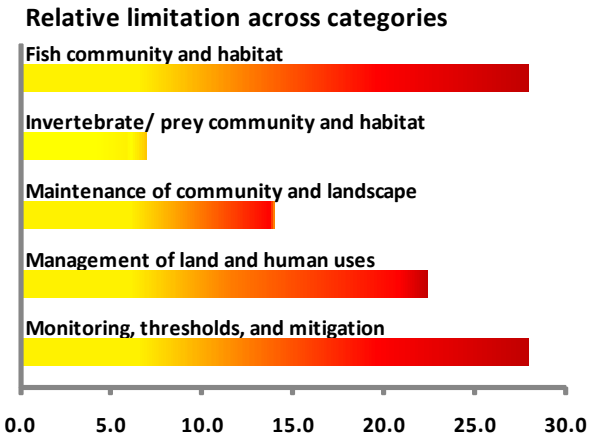
Restoration overview

- In 1987 the Pine Creek Coordinated Resources Management & Planning (CRMP) Group was established and projects were initiated to address historical impacts to riparian areas as related to decreased vegetation, particularly in the lower reaches
- Multiple projects have been undertaken throughout the watershed predominantly directed towards improving fish passage issues which are being assessed cumulatively
- Main restoration actions include 1) reducing or eliminating grazing in the upper reaches of Pine Creek at Stephen's Meadow and at Bogard Springs, 2) removal of fish passage barriers, and 3) non-native fish eradication in key areas

Background on site, landscape, and species condition

Project site

- The Pine Creek watershed consists mainly of low gradient stream passing through a series of meadows and sagebrush flats into Eagle Lake. Upper reaches have perennial, spring fed flows which become intermittent in the lower for most of the year except the spring run-off when Eagle Lake rainbow trout ascend the creek to spawn upstream in the perennial areas.
- We broke the watershed into two reaches 1) the upper reach which includes the headwaters to the highway 44 crossing, and 2) the middle reach which encompasses the section from highway 44 crossing Eagle Lake. This narrative relates specifically to restoration activities undertaken in the upper reach.



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

- The upper reach is generally forested with areas of higher gradient riffles and runs punctuated by montane meadows

Climate considerations

- Climate in the Eagle Lake/Pine Creek watershed has undergone dramatic fluctuations over the past 10,000 years and beyond. As part of the arid, intermountain west, climatic variability is the rule rather than the exception.
- During the Pleistocene, the area was much wetter and the basin was connected to surrounding watersheds. Alternating and sometimes prolonged wet and dry cycles characterize the watershed currently.
- As a terminal basin, the lake level is highly dependent on inflow from the few creeks that feed it, groundwater seepage, and evaporation. Recent drops in lake level have caused some concern.
- Climate change projections in the area indicate
    - a higher proportion of precipitation falling as rain

- high risk for increased winter flooding, especially rain on snow events
- a potential increase in drought conditions
- a shorter period of high spring runoff
- increased danger of catastrophic fire
- higher water temperatures

Species condition

- Eagle Lake rainbow trout (ELRT) nearly went extinct in the 1950s
- Hatchery spawned population size is large and stable but no natural spawning has occurred outside of the hatchery since 1952 except with tiny experimental populations in 2006-2007
- Historically, the vast majority of ELRT spawning took place in Pine Creek, but Merrill and Papoose Creeks may also have seen intermittent spawning activities, particularly in wet years
- Since 1952, there has been a weir that blocks the vast majority of fish from entering Pine Creek, though some probably ascended during high flow years. The weir at the mouth of Pine Creek was rebuilt in 1994 and prevents any migration into the creek. This is the sole remaining barrier to migration to historic spawning areas.
- Brook trout (*Salvelinus fontinalis*) were stocked in the upper reach west of Highway 44 from 1940-1949 where they remained in prolific numbers until recent eradication efforts began in the last decade. All indications show that Brook trout displace ELRT through higher population density (competition for habitat and resources) and through predation on eggs and juveniles.

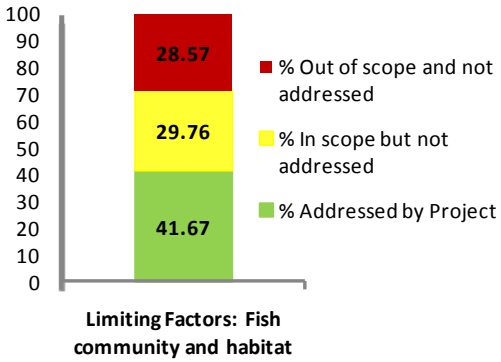
Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 41.7%

Limiting factors addressed relative to project scope: 58.3%



Project effects and site condition

- Restoration work has improved habitat and access generally,
  - Brook trout removal began in 2007 in Bogard Springs Creek (about 3 km). No brook trout removal in Pine Creek as of yet. Can be used as a comparison.
  - Keeping brook trout out of Bogard Springs a priority, though currently no physical structure and recent beaver activity makes access for brook trout easier.
  - Limited data collected to see how existing resident ELRT population has responded to brook trout removal.
  - Small ELRT population size missing reproductive adults due to downstream barriers with stocking of small numbers of breeding adults (20-30 individuals) the last few years with spawning observed upon release. No natural access to spawning adults due to weir at Eagle Lake.
  - Low overall density of ELRT and missing adult age class
- Numerous projects address barrier removal/access.
  - Hwy 44 bridge culvert resized for 100 year flood event, natural bottom
  - Fish ladder built at Leaky Louie's pond above Stephen's Meadow
  - Culvert removed downstream of L.L.'s at 31N08 road in 1998

  - Replaced culverts with natural bottom box culverts above Bogard Campground at Westwood logging road 32N22
- Within this reach, habitat is accessible to almost all life history stages during most flow levels
  - In extremely dry water years, stream becomes intermittent. It is not known if this is consistent with historical flows.
  - Livestock grazing is greatly reduced at Bogard Springs Campground and Stephen's Meadow. McKenzie Cow Camp rarely used. Habitat has seen large amount of recovery overall, but is still improving.
  - Historical diversions and ditching recovering, though still visible.
  - Water use at Bogard by Forest Service Work Station and Caltrans rest area may have a significant impact on flows in Bogard Springs Creek.
  - Old weir above Bogard Campground appears to be breaking down by itself and is probably only a barrier to juvenile fishes at low flow levels. Not a barrier to adults at during spring runoff flows
- Current (Spring 2011) migration study with an experimental release of 100 adult spawners indicates successful reproduction (many young of the year observed in the lower section) without adults migrating all the way to headwaters. This is counter to the previously held belief that ELRT historically spawned in the headwaters only. The good water year and prolonged winter/spring made conditions in the lower watershed favorable to spawning in what has generally been considered solely a migration corridor.

Persisting concerns

- Lack of natural reproduction and fish access through the weir at Eagle Lake is the primary concern.
- Meadow habitat in lower watershed is generally in poor condition due to legacy effects primarily from grazing and railroad grades from timber harvest as well as ditching and diversions. This may have significant effects on duration and magnitude of flows and negatively affect the ability of ELRT to migrate to headwater spawning areas at Stephen's Meadow and Bogard Springs Creek. This needs further study.

Data Gaps

- Data on the ability of ELRT to make it to upper watershed spawning areas is lacking.
  - Funding for studies has been inconsistent and there has been difficulty in the past coordinating adult fish release into the creek with appropriate timing of flows.
  - Numerous low water years have compounded the difficulties.
  - Current work by Teresa Pustejovsky for the Susanville Indian Rancheria attempting to track fish migration needs continued support and the cooperation of the agencies and other partners.
  - Better understanding of how fish communities use the lower watershed and how that varies with water year.
- Continued monitoring is needed in the upper watershed to determine the effect of brook trout removal on resident ELRT
- The effect of the Caltrans/Forest Service diversions on Bogard Springs Creek needs to be quantified.

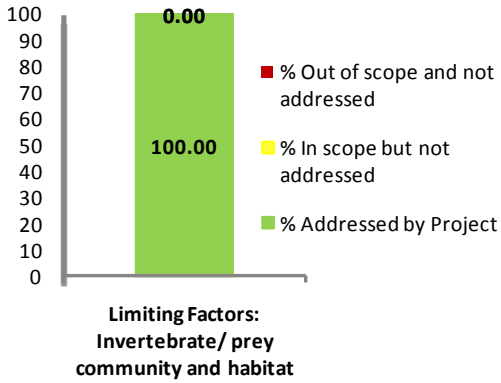
Opportunities

- Pine Creek/Eagle Lake and ELRT represent a unique opportunity to restore an entire sub-species to their full historic range as well as the opportunity to perform watershed-wide habitat restoration due to the small size of the watershed and the fact that Eagle Lake is a terminal lake.

- The new district ranger at the Forest Service has a fisheries background and may provide increased support for projects in the basin.
- The DFG is willing to cooperate with experimental releases of adult fish and is looking at restoration of naturally reproducing population in Pine Creek
- The local CRMP has finished most of its intended projects for fish passage issues. The capacity is there to do projects, but a new focus is needed. Flow issues and meadow restorations for hydrological improvement and fish passage might be a good area to refocus CRMP efforts.
- General sense of cooperation amongst agencies/stakeholders and willingness to continue projects

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 100%
Limiting factors addressed relative to project scope: 100%



Project effects and site condition

- Historic invertebrate diversity, community composition, and abundance is not known, but recent studies indicate that diversity and abundance of invertebrates is good and that EPT taxa are prevalent
    - There may be some effects on invertebrates due to the presence of dense populations of non-native brook trout.
- Substrate composition and water quality parameters are all within the tolerance levels for invertebrate communities.

Persisting concerns

- There is little data on historic invertebrate communities. Recent invertebrate sampling has occurred, but there is no ongoing monitoring of invertebrates.
- Baseline data would be very important to have in the event of brook trout removal using rotenone

Data Gaps

- Inconsistent monitoring and data collection methods
- No historic baseline data

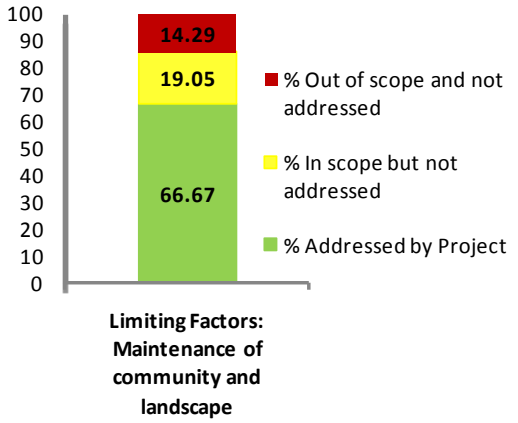
Opportunities

- Now is good time to institute regular invertebrate monitoring, particularly if large scale meadow restorations were planned in the watershed.

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape

Limiting factors addressed by project: 66.7%
Limiting factors addressed relative to project scope: 77.8%



Project effects and site condition

- Numerous restoration activities have taken place
    - Brook trout removal on Bogard Springs Creek began in 2007, smaller spot checks were used in 2009/2010
    - barriers were removed and passage improved at numerous locations
        - Fish ladder built at Leaky Louie's pond
        - removed culvert downstream of Leaky Louie's at forest road 31N08 in 1998
        - Replaced culverts with natural bottom box culverts above Bogard Campground at Westwood logging road 32N22
        - Hwy 44 culverts redesigned for 100 year flood event
    - Still a weir above Bogard campground below the road, but seems to be breaking down on its own. Still probably a barrier to certain life stages at low water. Not a barrier to adults.
    - Introduced around 20-30 spawning individuals to Bogard Springs over the last 3 seasons. Successful spawning occurred. Still a very small number though, just experimental. In 2011, 30 individuals were released in Bogard Springs and 20 were released at the highway 44 crossing.

Persisting concerns

- Weir at Eagle Lake prevents all migration of fishes into Pine Creek
- Adequate flows may no longer available due to anthropogenic alterations

Data Gaps

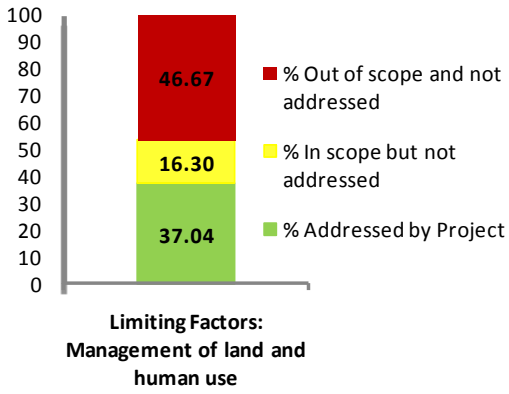
- Need to know if flows have been altered from historic flows by meadow incision in lower watershed to the point that adequate flow is no longer available for fish migration to upper watershed
- How did fish historically use Pine Creek? How did that change depending on water year? (see 2011 study by T. Pustejovsky finding successful spawning in lower watershed)
- Further studies are needed tagging fish both for in-migrating adults and out-migrating fry
    - What are the timing, duration and flow requirements for both in and out-migration?
- What are the effects of 60 years of exclusive hatchery propagation on ELRT genetics?
    - Do ELRT retain migrating instinct?
    - Do ELRT retain spawning instinct?
    - Has timing of spawning been altered by hatchery management practices?
    - Do hatchery reared ELRT have reduced fitness in the wild?

Opportunities

- Make use of the active and successful CRMP in the area to initiate next round of restoration activities
- Tribe (through collaborative CRMP efforts) currently sponsoring fish migration study, but more fish need to be released to provide definitive data
- New personnel at DFG and US Forest Service may provide opportunity for new studies and greater capacity for interdisciplinary approaches and coordinated adaptive management between agencies and stakeholders
- Improved cooperation between DFG, researchers, the US Forest Service and others to allow a certain percentage of each year's spawners to have access to Pine Creek above the weir

Management of Land and Human Uses

Limiting factors addressed by project: 37.0%
Limiting factors addressed relative to project scope: 69.4%



Project effects and site condition

- McKenzie cow camp has fenced riparian and shows a high level of recovery.
- Downstream of MCC is a fall gathering pasture that sees rare use these days so effectively fences the stream in most years.
- Grazing management has seen continued improvement and cooperation with permit holders and progressive grazing strategies are used in the upper watershed.
- Unlike most other meadow areas in the Sierra Nevada, there is no irrigated agriculture or ditches/diversions for irrigating pasture

Persisting concerns

- Lack of access to stream for fish caused by the weir at Eagle Lake
- The effect of the Caltrans/Forest Service diversions on Bogard Springs Creek needs to be quantified and potentially managed
- Grazing permittees are unlikely to want to make further reductions to grazing as many concessions have already been made, but may be willing to adjust timing and duration of use or other aspects of grazing management

Data Gaps

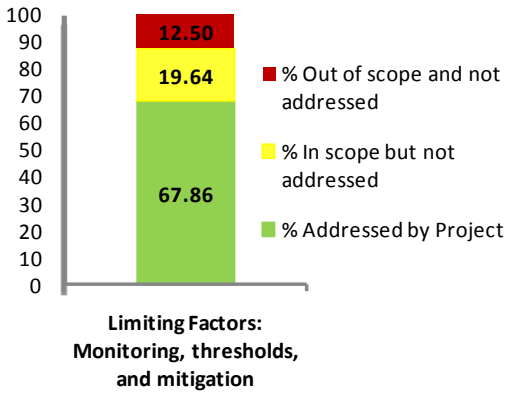
- The effects of grazing management changes should continue to be monitored and more in depth vegetation studies would be helpful

Opportunities

- Good data has been kept on grazing utilization studies, but needs further analysis
- The CRMP has the local capacity to gather further data on range use and recovery
- There is enormous potential to move forward with further studies and restoration efforts based on funding opportunities, staff changes at several agencies indicate willingness to participate, and continued presence and interest by people that have participated in past efforts (e.g. David Lile with CRMP, Melanie McFarland with USFS, Teresa Pustejovsky with Susanville Indian Rancheria, UC Davis researchers from the Moyle and Thompson labs, etc.)
- There is very little privately held land in the basin so ownership issues are negligible and Forest Service has the capability to institute large scale projects

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 67.9%
Limiting factors addressed relative to project scope: 77.6%



Project effects and site condition

- Monitoring and restoration efforts for Aspen stand regeneration has created a large amount of monitoring data

  - Most future projects have water quality component
- Forest Service Allotment management plans monitor grazing use, have a water quality component, and keep data on recovery and changes in riparian areas
- Good data has been collected on ELRT by UC Davis and the DFG. Paul Divine (DFG) wants to continue monitoring efforts and maintain gains made by brook trout removal.
- FWS/DFG in discussion on how to do further removal of brook trout. Some discussion about barrier at Bogard Springs/Pine Creek. Lots talk, no firm plan or solution as of yet. New beaver dams of immediate concern
- There is a heightened awareness of climate change threats in the basin, though there is no climate change specific plan. Many of the components of climate change effects are addressed in other studies/restoration/monitoring efforts
  - Tom Rickman's work on forest stand density and fuel reduction
  - Resizing of culverts to accommodate higher flows and 100 year storm events
  - Aspen stand restoration efforts address conifer encroachment

Persisting concerns

- New beaver dams at confluence of Pine and Bogard Springs Creeks allow brook trout easier access to Bogard Springs creek and may allow brook trout to repopulate the 3 km of Bogard Springs that had removal efforts since 2007

Data Gaps

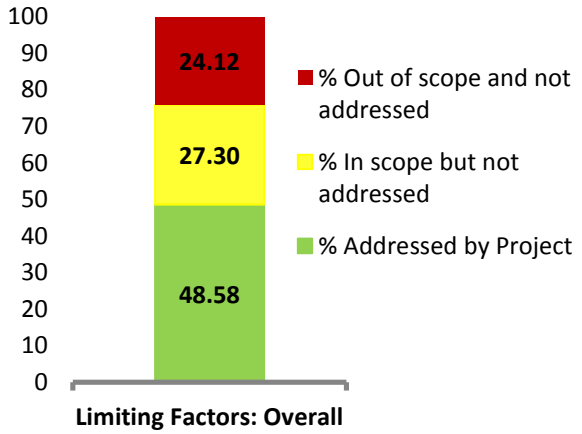
- Little is known about foodweb interactions and nutrient cycling in the upper watershed between invertebrates, invasive brook trout, the lack of spawning ELRT, etc
- Determine potential thermal and water quality tolerances of ELRT and compare to climate change projections for the area

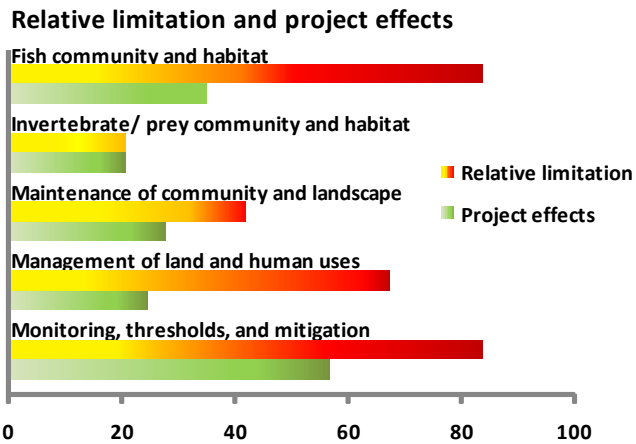
Opportunities

- New funding opportunities are available through NFWF and the USFWS and there is a general feeling that current and new agency personnel and others want to move forward with restoration of the watershed and a wild, self-sustaining population of ELRT

Overall Findings and Key Points

Limiting factors addressed by project: 48.6%
Limiting factors addressed relative to project scope: 64.0%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

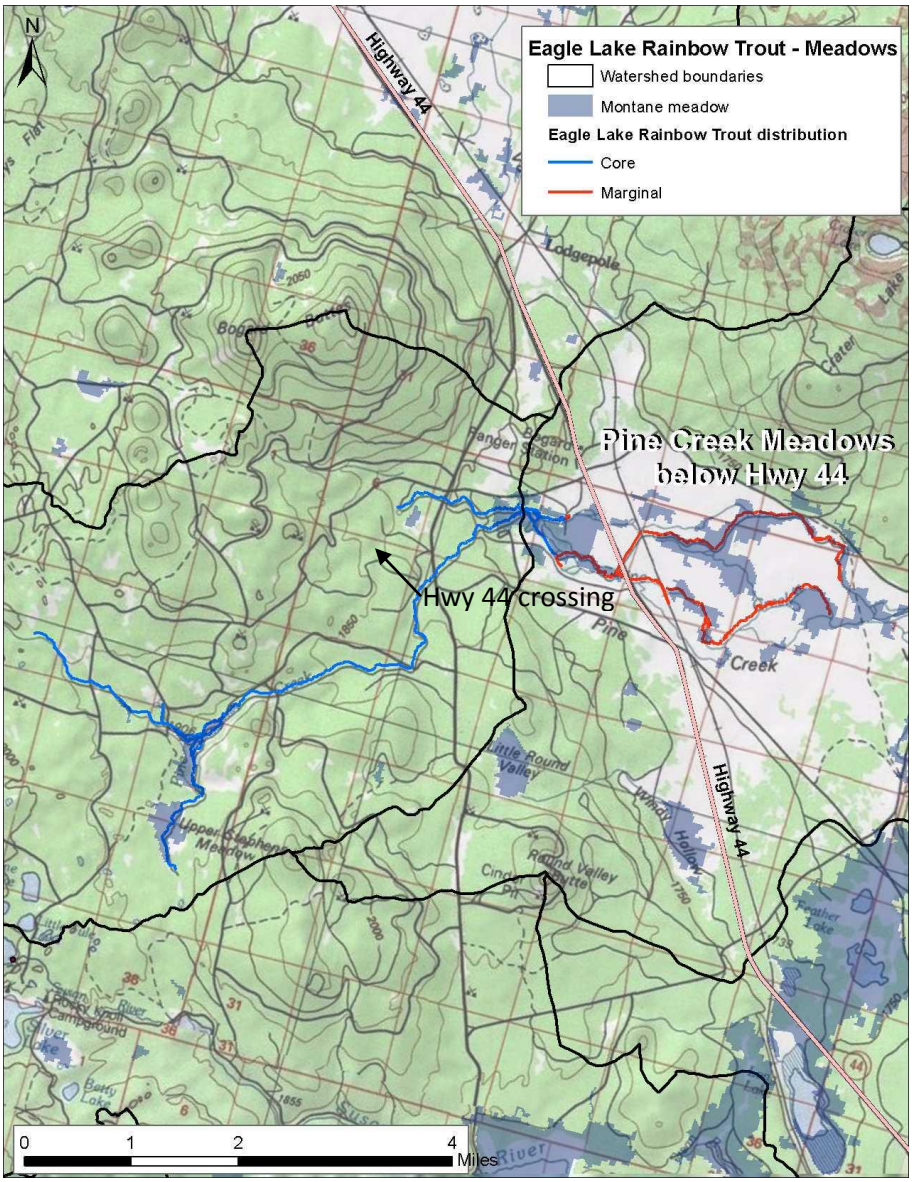
Species condition in project area:	Wild population seriously limited, but hatchery population is stable. Restoration of a self-sustaining wild population should be a focus.
Area of greatest gains:	Habitat improvement, barrier removal
Most significant actions:	Removing all significant fish passage barriers except the weir at Eagle Lake, improved grazing management
Area of greatest need:	Access to Pine Creek for spawning ELRT adults and other fishes
Highest priority concerns	Are flows in Pine Creek adequate for migrating fish (duration, temperature, etc)? Do ELRT still retain the instinct for migration? Brook trout presence in upper watershed

Highest priority opportunities:

- Continue brook trout removal and monitoring in Bogard Springs
- Begin brook trout removal in Pine Creek
- Allow a certain percentage of spawning adults to migrate past the weir at Eagle Lake (in daily or weekly increments to allow a broad variety of genetic and life history variations to attempt migration)
- Determine the effects of meadow incision and gullying in the lower watershed on flow duration and magnitude with the potential for restoration projects to improve hydrologic function
- Assess suitable spawning habitat and timing of spawn based on current weather year conditions in lower stretches of Pine Creek, based on success seen in 2011 migration study.

Species: **Eagle Lake Rainbow Trout (*Oncorhynchus mykiss aquilarum)***
Location: **Eagle Lake/Pine Creek**
Lead Organization and Sponsor: **US Forest Service, CRMP, CDFG, Susanville Indian Rancheria**
Regional Contact(s): **Teresa Pustejovsky**
Project: **Pine Creek Restorations below Highway 44 crossing**
Timeframe: **1987-Present**

Project area map



Associated documentation, research, and data sources

- A Conservation Plan for Pine Creek and Eagle Lake Rainbow Trout (Pustejovsky, 2007)
- Salmon, Steelhead, and Trout in California: Status of an emblematic fauna (Moyle et al. 2008)
- Personal communication with Teresa Pustejovsky regarding 2011 ELRT migration study

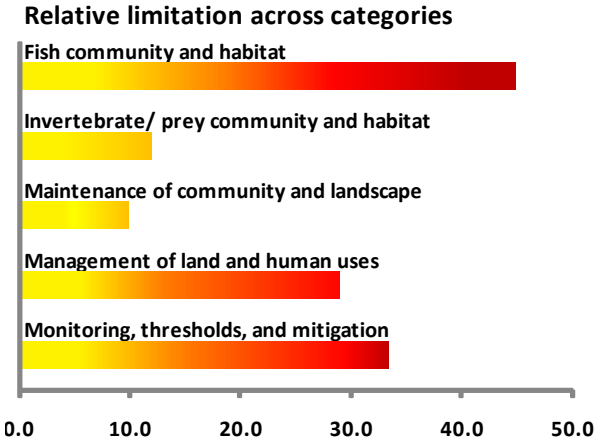
Restoration overview

- In 1987 the Pine Creek Coordinated Resources Management & Planning (CRMP) Group was established and projects were initiated to address historical impacts to riparian areas as related to decreased vegetation, particularly in the lower reaches
- Multiple projects have been undertaken throughout the watershed predominantly directed towards improving fish passage issues which are being assessed here cumulatively
- Restoration efforts in the lower watershed primarily consist of changes/restorations have consisted of changes in grazing timing, rotations, etc.
- Mid-1990s, 3 rock dams 3ft high 50 feet apart were installed at Bradford Crossing with the intention of raising the water table.
- Late 1930s Forest Service hydrologists wanted to put bigger dams in Pine Creek. Stopped by WWII. Again in the 1980s wanted to put dams in to keep water on site for longer. Put off for fish passage concerns
- Harvey Valley (tributary of Pine Creek) road removal in 1987.
- New culverts under rail line and stream channel exclosures against grazing at several locations

Background on site, landscape, and species condition

Project site

- Pine Creek is a 228 square mile watershed that drains into terminal Eagle Lake. It is the largest tributary to the lake. The surrounding land is predominantly forested rolling hills and open valleys and meadows that historically supported a robust timber and livestock industry.
- Railroad grades were installed throughout the watershed through the low gradient valleys (i.e. Pine Creek Valley and Champs Flat
- The majority of lands within the watershed belong to the Forest Service (86%), with the remaining lands in private or other hands.
- Since 1952, there has been a weir that blocks the vast majority of Eagle Lake Rainbow Trout (ELRT) and other fishes from entering Pine Creek, though some probably ascended during high flow years. The weir at the mouth of Pine Creek was rebuilt in 1994 and prevents any migration into the creek. This is the sole remaining barrier to migration to historic spawning areas.
- Brook trout (*Salvelinus fontinalis*) were stocked in the upper reach west of Highway 44 from 1940-1949 where they remained in prolific numbers until recent eradication efforts began in the last decade. All indications show that Brook trout displace ELRT through higher population density (competition for habitat and resources) and through predation on eggs and juveniles.
- The lower reaches of Pine Creek are ephemeral and are generally dry for ~6-9 months out of the year. Previously thought that lower Pine Creek probably never supported spawning or rearing of ELRT, but



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

served as a migratory corridor for spawning adults to reach the perennial upper watershed and for juveniles to outmigrate to Eagle Lake. However, migration study conducted by Teresa Pustejovsky in spring 2011 indicates that spawning does occur in the lower watershed, at least in higher water years. Much more research needed.
- Migration and river use very poorly understood
- The large alluvial valleys found in lower Pine Creek (Pine Creek Valley, Champs Flat, etc.) are highly disturbed by historic grazing, road building, and railroad grades resulting in incised stream beds, altered hydrology, and a drier system.

Climate considerations

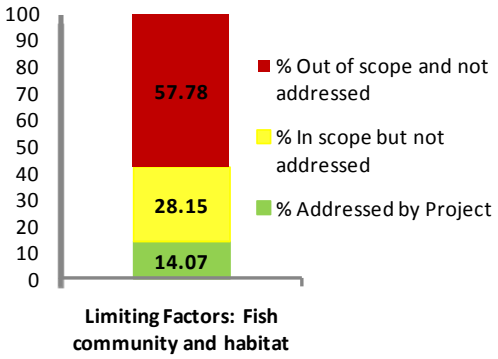
- Climate in the Eagle Lake/Pine Creek watershed has undergone dramatic fluctuations over the past 10,000 years and beyond. As part of the arid, intermountain west, climatic variability is the rule rather than the exception.
- During the Pleistocene, the area was much wetter and the basin was connected to surrounding watersheds. Alternating and sometimes prolonged wet and dry cycles characterize the watershed currently.
- As a terminal basin, the lake level is highly dependent on inflow from the few creeks that feed it, groundwater seepage, and evaporation.
- Climate change projections in the area indicate
    - a higher proportion of precipitation falling as rain
    - high risk for increased winter flooding, especially rain on snow events
    - a potential increase in drought conditions
    - a shorter period of high spring runoff
    - increased danger of catastrophic fire
    - higher water temperatures
    - lowered lake levels and increased low oxygen problems in both winter and summer

Species condition

- Eagle Lake rainbow trout nearly went extinct in the 1950s as a result of overfishing and habitat degradation
- This species is currently entirely dependent on hatchery production. The hatchery spawned population size is large and stable but no natural spawning has occurred outside of the hatchery since 1952
- Historically, the vast majority of ELRT spawning took place in Pine Creek, but Merrill and Papoose Creeks may also have seen intermittent spawning activities, particularly in wet years
- Since 1952, there has been a weir that blocks the vast majority of fish from entering Pine Creek, though some probably ascended during high flow years. The weir at the mouth of Pine Creek was rebuilt in 1994 and prevents any migration into the creek. This is the sole remaining barrier to migration into Pine Creek.
- Brook trout (*Salvelinus fontinalis*) were stocked in the upper reach west of Highway 44 from 1940-1949 where they remained in prolific numbers until recent eradication efforts began in the last decade. All indications show that Brook trout displace ELRT through higher population density (competition for habitat and resources) and through predation on eggs and juveniles.

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions



Fish Community and Habitat

Limiting factors addressed by project: 14.1%
Limiting factors addressed relative to project scope: 33.3%

Project effects and site condition

- Nearly all projects in the lower watershed related to fixing fish passage issues and improving grazing management particularly in the riparian corridor
- Despite having addressed nearly all fish passage issues in the entire watershed, ELRT and other fish do not have access to Pine Creek due to the weir at Eagle Lake. This weir prevents all migration in to Pine Creek.
- Habitat throughout the lower watershed is considered by local managers to be slightly improved as compared to the nadir 30 years ago. System is still highly disturbed but some vegetative improvement. Sediment starved and highly eroded system.
- Exclosure at area near culverts under train tracks below 44 looks a little better, but a very small section of the overall system.
- Slight improvement in riparian vegetation and bank stability but still overall a highly disturbed system
- The restoration efforts that have taken place thus far have yet to be tested by actual fish (other than small experimental releases), though the original intention of the CRMP was to eliminate fish passage barriers and allow a naturally spawning population of ELRT (and other native fishes) to access historic habitat and complete their life cycle
- Experimental releases and tracking studies from spring 2011 indicate that ELRT use the lower watershed for more than simply a migration corridor as previously thought. Teresa Pustejovsky's migration study found no migrants reaching the upper watershed, but instead found successful spawning and outmigration in the lower watershed with but upstream and downstream migration by adults. This study should be continued over numerous water years and flows. Study challenges previous hypothesis that all historic spawning occurred in the upper watershed and the lower watershed was simply a migration corridor.

Persisting concerns

- Lack of natural reproduction and fish access through the weir at Eagle Lake is the primary concern.
- Meadow habitat in lower watershed is generally in poor condition due to legacy effects primarily from grazing and railroad grades from timber harvest as well as ditching and diversions. This may have significant effects on duration and magnitude of flows and negatively affect the ability of ELRT to migrate to headwater spawning areas at Stephen's Meadow and Bogard Springs Creek. This needs further study.
- There is some indication that ELRT follow thermal migration cues. The timing of these cues may be different based on current flows and climate

Data Gaps

- Data on the ability of ELRT to make it to upper watershed spawning areas is lacking.
    - Funding for studies has been inconsistent and there has been difficulty in the past coordinating adult fish release into the creek with appropriate timing of flows.
    - Numerous low water years have compounded the difficulties.

  - Current work by Teresa Pustejovsky for the Susanville Indian Rancheria attempting to track fish migration needs continued financial support and the cooperation all interested agencies and stakeholders
- Data is needed to determine if current flows in the system are adequate to support fish migration, spawning and rearing, or if geomorphic restoration could provide a longer duration and higher base flow with cooler water.
- Results of 2011 fish migration study (100 adults released) indicate spawning, rearing, and juvenile outmigration in lower watershed, further study highly important.
- How fish use lower watershed is virtually unknown
- Availability and condition of juvenile rearing habitat in the lower watershed unknown

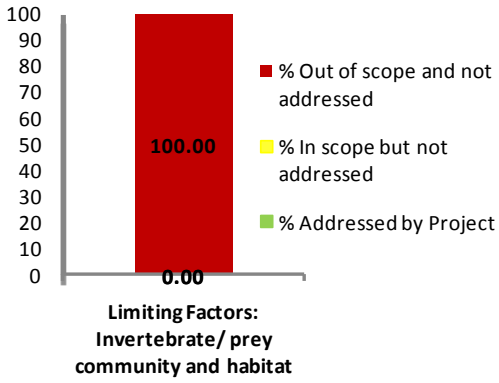
Opportunities

- There are many interested and motivated individuals currently working on ELRT and recent staff changes at key agencies (CDFG and USFS) may further foster new restoration activity in the basin
- There is a highly organized and active CRMP already in place at Eagle Lake that has already instituted successful restoration efforts in the basin. Coordination between the agencies and CRMP for a new round of restoration efforts targeting flow studies and allowing fish access to Pine Creek is the obvious next step.

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 0%

Limiting factors addressed relative to project scope: 0%



Project effects and site condition

- Next to nothing is known about invertebrate and prey conditions in the lower watershed either currently or historically. There have been no known invertebrate surveys, though as riparian vegetation improves it is possible that there is a concurrent response in the aquatic invertebrate community.
- It is likely that the creek has increased temperatures for a longer duration of the season due to gullying, incision, and erosion.
- Because this system has always been ephemeral, there may be an interesting and unique aquatic community structure and foodweb.

Persisting concerns

- Nearly no data exist on aquatic invertebrate and prey communities in this section of Pine Creek
- 2011 fish migration study indicates most released fish stayed below hwy 44 crossing, this indicates a need for much more focused study on lower watershed dynamics and habitat

Data Gaps

- Nearly no data exist on aquatic invertebrate and prey communities in this section of Pine Creek
- It is not known if either migrating adult fish or outmigrating juveniles used this section of the creek for forage. It is likely that adult fish might use it if their up-migration was blocked by ice and they had to wait for break up to continue migration. Many questions.
- Prey community availability and variance by water year is unknown. Particularly important in light of 2011 findings of successful spawning, rearing, and outmigration all in lower watershed.

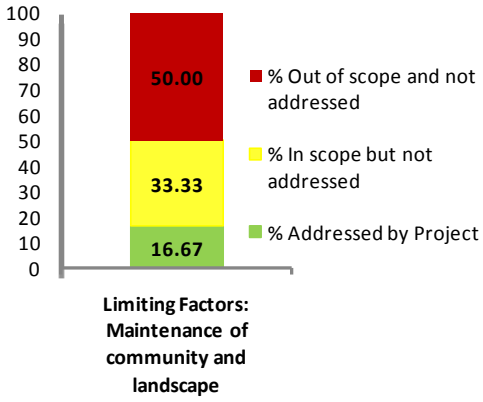
Opportunities

- New funding opportunities through NFWF, CDFG, the Susanville Indian Rancheria, and the USFS are available as well as an increased will amongst stakeholders to restore Pine Creek and ELRT.
- The presence of many willing participants and a general consensus that ELRT need access to Pine Creek provides an opportunity to move forward on restoration efforts in the basin and capitalize on the structures and relationships that already exist in the basin.

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape

Limiting factors addressed by project: 16.7%
Limiting factors addressed relative to project scope: 33.3%



Project effects and site condition

- All barriers have been removed except for the weir at Eagle Lake. Genetic Integrity/naturally reproducing population severely compromised.
- Non-native species are not thought to be a major concern in this reach due to its ephemeral nature. Occasional brook trout strays from the upper watershed above hwy 44, but timing does not seem to coincide with ELRT in a way that would negatively impact them. This should be further studied as a cause for concern given new findings of spawning in lower watershed in 2011.
- Grazing schedules and turn-on dates are primarily after the creek has already dried up, though there may still be issues with fecal coliform levels due to livestock.

Persisting concerns

- Much less restoration effort has taken place in the lower Pine Creek watershed than the upper watershed. It is possible that flow alterations stemming from incision/gullying in the lower watershed may have a significant impact on ELRT's ability to migrate to the upper watershed
- Much less monitoring information exists for lower watershed
- 2011 study finding successful spawning in lower watershed indicates need for understanding lower watershed better and focus on habitat improvement for spawning, rearing, and feeding

Data Gaps

- Body of knowledge and collected data is significantly less in the lower watershed than the upper
- Data needed in the following areas
    - Timing, duration, magnitude, and temperature of water flow in a variety of water years
    - Vegetation recovery
    - Hydrology
    - Invertebrate and prey community structure
    - Historic use of the lower reaches by ELRT (e.g., migrating adults/spawning/juvenile rearing)
    - Lower watershed use for spawning: Multi-dimensional study needed in light of new information.
        - What type of water year?
        - What cues?
        - How long do fish spend?

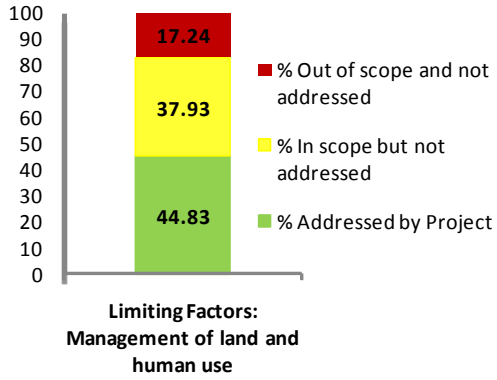
- Habitat availability?

Opportunities

- New availability of funding and renewed energy on the part of managers and researchers makes the present an important time to re-launch restoration efforts in Pine Creek/Eagle Lake
- 2011 study indicating much greater use of lower watershed by ELRT than previously thought highlights the need for focused study of all aspects of lower watershed ecosystem and further channel improvements/restoration efforts

Management of Land and Human Uses

Limiting factors addressed by project: 44.8%
Limiting factors addressed relative to project scope: 54.2%



Project effects and site condition

- Many historic alterations to the system involving roads, dams and diversions, railroad grades (and associated borrow pits) have been at least partially addressed where possible
- Grazing management, particularly timing of turn on date, adaptive management based on local conditions, fencing of riparian areas, off channel water, grazing rotation, and livestock numbers has been a particular focus of the CRMP restoration efforts and the Forest Service Allotment Management Plan
- General consensus is that conditions have improved considerably over the last 30 years but that the damage from legacy effects is considerable and resources are still recovering.
- Numerous alterations to the system such as railroad grades and roads have changed the hydrology to an unrecoverable extent
- Geomorphic restoration of stream beds may be the next step in restoring Pine Creek

Persisting concerns

- Adequacy of flows
- Several problem areas for holding cattle result in water quality issues
- Channel incision, continued erosion, and lack of riparian vegetation in lower watershed
- Lowered water table

Data Gaps

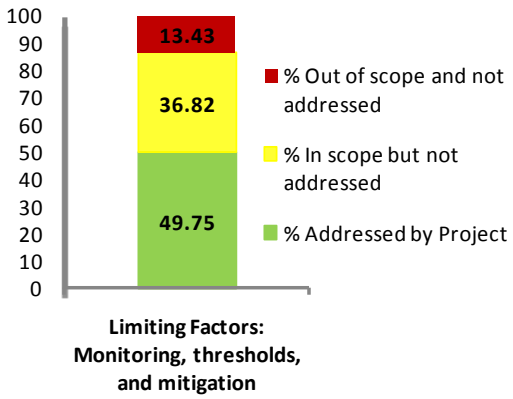
- Flow studies
- Water quality studies
- Vegetation surveys

Opportunities

- We currently have the capacity and funding to initiate needed studies and address the remaining issues for ELRT in Pine Creek

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 49.8%
Limiting factors addressed relative to project scope: 57.5%



Project effects and site condition

- Forest Service Allotment Management Plan addresses grazing concerns and has distinct thresholds and management trigger points and an overall conservation strategy for the basin
- Non-native species (fish) are not thought to be a major concern for this reach, however, this should be investigated further given new data finding spawning in lower watershed
- There is a heightened awareness of climate change threats in the basin, though there is no climate change-specific plan. Many of the components of climate change effects are addressed in other studies/restoration/monitoring efforts
    - Tom Rickman's work on forest stand density and fuel reduction
    - Resizing of culverts to accommodate higher flows and 100 year storm events
    - Aspen stand restoration efforts address conifer encroachment
- Unlike most montane meadow systems, there is little contemporary ditching and diversion in the basin, although historically it was extensive and resulting problems persist

Persisting concerns

- Lack of monitoring data and understanding of system dynamics in the lower watershed

Data Gaps

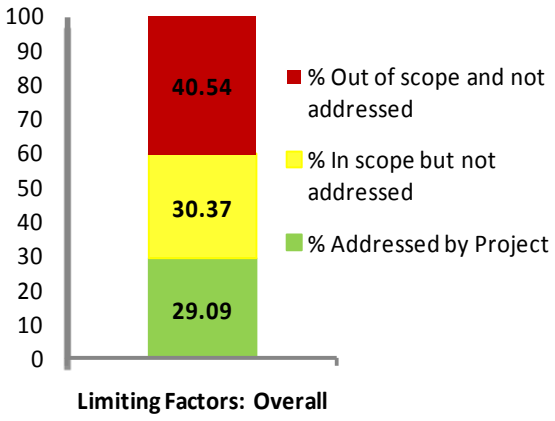
- Lack of monitoring data and understanding of system dynamics in the lower watershed
- Little is known about community structure, habitat use, foodweb interactions and nutrient cycling in the lower watershed between invertebrates, the lack of spawning/migrating ELRT, etc.
- Determine potential thermal and water quality tolerances of ELRT and compare to climate change projections for the area
- Modeling of projected climate change impacts to runoff and duration of flows

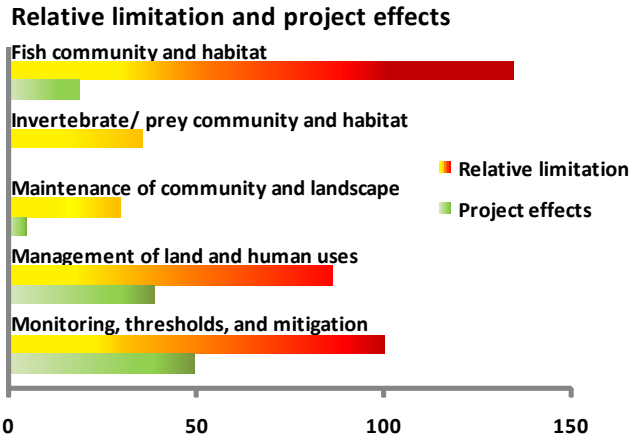
Opportunities

- New funding opportunities are available through NFWF, the USFWS and other entities and there is a general feeling that current and new agency personnel and others want to move forward with restoration of the watershed and a wild, self-sustaining population of ELRT

Overall Findings and Key Points

Limiting factors addressed by project: 29.1%
Limiting factors addressed relative to project scope: 48.9%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

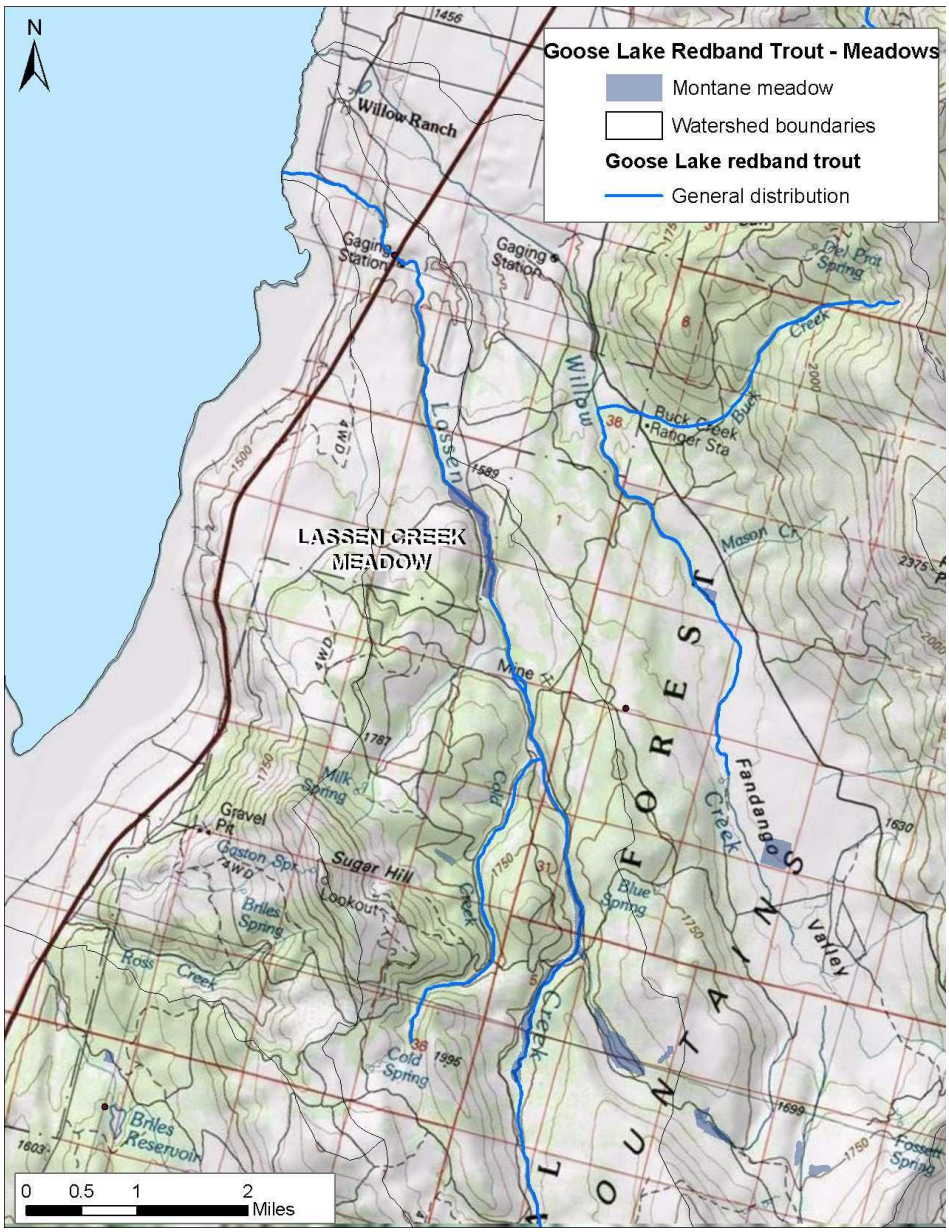
Species condition in project area:	Poor, essentially extirpated throughout entire watershed with tiny population in the headwaters augmented by experimentally released fish
Area of greatest gains:	Grazing management, permittee cooperation
Most significant actions:	Grazing management improvements, stream exclosures, off channel water, puncturing railroad grades, road closures and rehabilitation
Area of greatest need:	Fish Access to Pine Creek at the weir at Eagle Lake Flow studies, understanding of fish use of lower watershed
Highest priority concerns:	Loss of genetic integrity of ELRT based on 60 years of solely hatchery production Adequacy of flows currently and into the future based on climate change

Highest priority opportunities:

- Working with an energized, enthusiastic, organized, and previously successful CRMP as well as agency personnel and academic institutions. The current climate in the basin concerning agency staff, the CRMP, the tribes, research institutions, etc. presents a unique opportunity to move forward with restoration efforts in Pine Creek that has not been available in the recent past.
- Allow a certain percentage of spawning adults to migrate past the weir at Eagle Lake (in daily or weekly increments to allow a broad variety of genetic and life history variations to attempt migration and spawning)
- Determine the effects of meadow incision and gullying in the lower watershed on flow duration and magnitude with the potential for restoration projects to improve hydrologic function
- Further study and better understanding of fish use of ecosystem based on new findings of successful spawning in the lower watershed in 2011

Species: **Goose Lake Redband Trout (*Oncorhynchus mykiss newberrii*)**
Location: **Lassen Creek, Lassen Creek Meadows**
Regional Contact(s): **Rick Poore, StreamWise**
Project: **Lassen Creek Restoration**
Timeframe: **2002-present**

Project area map



Associated documentation, research, and data sources

- Goose Lake Fishes Working Group (GLFWG). 1995. Goose Lake Fishes Conservation Strategy, OR. 46p.

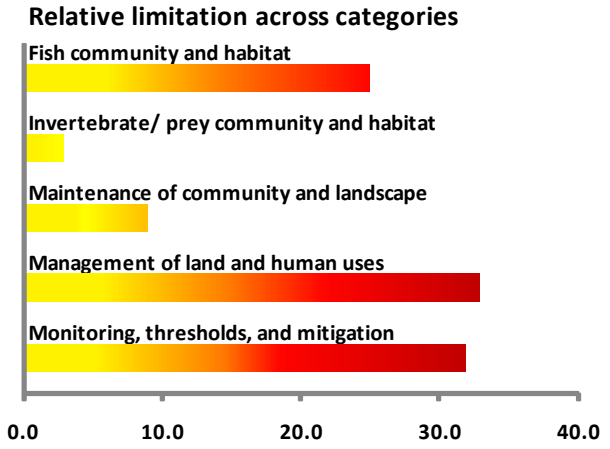
Restoration overview

- Habitat underwent two related restoration actions constituting the completed pond and plug restoration.
    - This project consisted of an initial plug and pond project that had a partial failure followed by a subsequent repair to the project site. The failure involved only constructed channel sections (~¼ of the project length) and sod-mats were used for stabilization. The other sections remained stable, guiding repairs to channel design.
    - This analysis examines the two actions as one complete project consisting of, 1) a pond and plug project to restore a severely incised channel, degraded meadow and floodplain, 2) meadow re-fencing, and 3) a channel bed re-grading, stabilization, and gravel augmentation, and 4) culvert removal and associated road crossing redesign.
- Restoration targeted primarily at improving stream and meadow function.
- Improved habitat for Goose Lake redband was a goal of this project, though secondary to restored meadow function.
- The restored reach is not, currently, being managed for fish specifically.

Background on site, landscape, and species condition

Project site

- The project site is on private land.
- Cattle grazing continues to be active on the private land where the project occurred in both the project area and the surrounding area. However, cattle have been excluded from the upper portion of the restored reach by fencing. Cattle maintain access to the downstream reach as well as portions of the meadow.
- Active timber harvest has and continues to occur in and around the project area.



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

Climate considerations

- Climate has been and continues to be a consideration for Goose Lake redband trout.
    - Goose Lake dried up in the 1420s, in the 1630s, 1926 (with low lake levels from 1925 to 1939), and 1992 (Moyle et al. 2008). Thus, the key to the survival of the Goose Lake trout (and other fishes) is presumably conditions in the lower reaches of the streams, as well as conditions in the headwaters.
    - While the region is not necessarily in high risk of drastic temperature regime change, existing variability or minor change could either or both result in Goose Lake Drying up intermittently and potentially with increased frequency over the next 50 years.
    - Additionally, the region is high risk for increased winter flooding as a result of precipitation change and for wildfire regime change either of which could impact critical tributary habitats.

Species condition

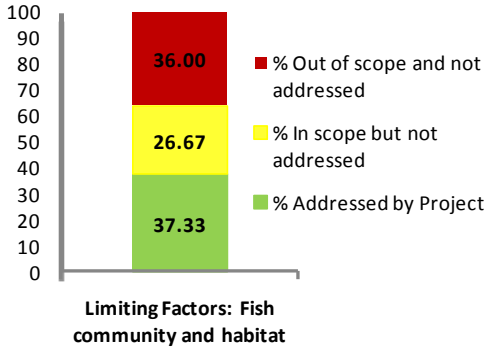
- Lassen Creek is the largest of the Goose Lake Tributary streams supporting redband trout and one of the principal spawning streams.
- Based on the limited available information, specific population size and structure in Lassen Creek are not known. Goose Lake redband are, however, known to be consistently present in numbers within the larger segment that encompasses the restored reach.
- Historically, the Goose Lake redband in the restored reach were intermittently isolated in certain segments by barriers to migration including culverts and diversions.
    - Though barrier (culvert) removal was a component of this restoration project, Lassen Creek is populated both above and below the affected reach.
- Current overall carrying capacity of Goose Lake tributary streams is presumably a fraction of their historic carrying capacity.
- Of the tributary streams, Lassen Creek is in perhaps the best condition
    - ODFW (2002), however, indicated that most of the redband trout streams are impaired to a greater or lesser degree, as the result of the accumulation of effects, from irrigation diversion dams, dewatering of streams, and generally poor habitat (from grazing, mining, and roads). Most of the streams also suffer from loss of connectivity to each other and to Goose Lake.
    - Lassen Creek likely represents critical habitat
- Fish in the affected reach are considered redband, though they show some evidence of introgression with introduced rainbow trout species.
    - Genetic introgression is not, however, considered an issue as rainbow trout have not been stocked in the region in over 30 years.
- Recreational harvest of redband is not a primary concern in the project area due to its being on private land with associated limited access.
    - On a broader scale, however, angling and poaching during spawning season are thought to have potentially contributed significantly to the decline in species numbers prior to 1992 when all headwater streams were closed to angling.
- Lassen creek is believed to support redband trout, native lampreys, tui chubs, sculpins, and suckers.
    - Predatory invasive species including brown trout and brook trout are present in the region but not in the restored reach of Lassen Creek.

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 37.3%
Limiting factors addressed relative to project scope: 58.3%



Project effects and site condition

- Restoration work has generally improved habitat condition:
    - Existing connectivity is greater than historical connectivity as a result of culvert removal and floodplain restoration.
    - Overall habitat availability and habitat diversity have expanded.
    - Habitat patch size may be largely unchanged

    - Juniper and boulders used to stabilize channel have created more instream habitat types than were present before
    - Significantly more pool habitat is available as a function of bank revetment
- Substrate significantly improved from previously down-cut channel through stabilization and gravel additions.
- Project included intentional creation of pools within the stream that seem to be self-maintaining at meander bends.
    - Ponds intentionally unavailable to fish
- Riparian vegetation and other cover increased since exclusion of cattle from the upper portion of the restored reach but still in the early stages.
- Floodplain habitat and vegetation returning.
    - Reference condition is strong sedge community which is in the process of reforming
- Undercut banks increased initially from log and rock revetment
    - Undercut bank habitat has/ will likely continue to increase as vegetation continues to develop and add stability.
- Water quality improvements have not been monitored and were not a primary focus of the project.
    - Water quality enhancements, however, can be inferred (though not confirmed) from partial cattle removal, as well as improved vegetation, improved channel physical characteristics, and restored floodplain and meadow function.

Persisting concerns

- Restoration site has not been revisited to assess the progress of the habitat and effects of the restoration
- The site is not currently being managed or regularly monitored for fish
- Limited patch size, and potentially fragmented habitat (due to persistent presence of Cattle in the downstream portion of the restored reach).
- Habitat still re-establishing after restoration and in need of additional structure
- Water quality in the lower portion of the restored reach where cattle continue to be present.

Data Gaps

- No recent data on population size, characteristics (age, or size class distribution), or habitat use for redband and other fish species in the restored reach.
- No population data or specific habitat use data for redband or other fish species (lamprey) in the restored reach
- No information (pre- or post-project) on water quality (WQ) parameters in system including temp, DO, turbidity, or pH.
- Unknown current condition of habitat and associated risks to species

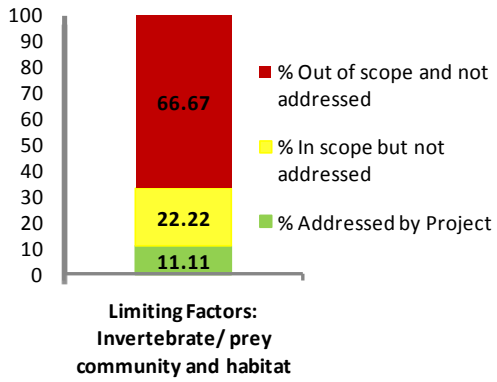
Opportunities

- Perform assessment of redband population characteristics and habitat use to compare with existing data and assess potential effects of restoration.
- Perform site visit to assess the state of the system post restoration, with an emphasis on habitat characteristics and status of fish population.
- Perform water quality assessment to determine overall condition and potential persisting impacts from grazing or surrounding land use.

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 11.1%

Limiting factors addressed relative to project scope: 33.3%



Project effects and site condition

- No pre or project assessment of ecosystem condition, or invertebrate community characteristics was performed, and no baseline data was available.
- Significant improvements to habitat from project are presumed to be beneficial for invertebrates but this assumption has not been confirmed and is not contextualized in the disturbance or impacts associated with the project itself.
    - Substrate improved through bed stabilization and gravel augmentation
    - Interstitial habitat likely expanded
    - Amount of wetted channel area significantly increased
    - Riparian and meadow vegetation improved
- Water quality necessary to support ecosystem function, including temperature, turbidity, and pH, likely improved but no data to confirm this or to relate it to specific needs of invertebrate species.

Persisting concerns

- Severely degraded habitat prior to project though to have been improved by restoration but not confirmed.
- Restoration actions (initial and subsequent fix) involved a high degree of disturbance with unknown impacts to the invertebrate community or associated recovery.
    - Existing invertebrate community may have been severely impacted by restoration and still be in recovery resulting in diminished diversity, and density or altered distribution.
    - Presumed recolonization from adjacent reaches, but extent of this unknown
- Altered temperature in the restored channel at certain times of year may be impacting invertebrate production

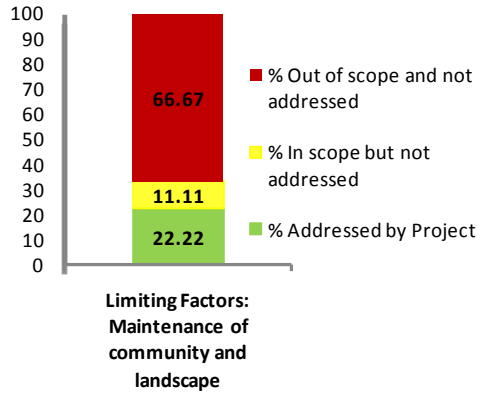
Data Gaps

- Unknown condition of aquatic or terrestrial invertebrate community, including production, density, diversity and distribution relative to previous or reference conditions.
- No information on impact to invertebrate community diversity, abundance, species richness, or habitat use from pre-project conditions or project actions.
- Unknown whether adequate invertebrate production is occurring to support fish population
- Unknown water quality conditions relative to tolerances of invertebrates present both pre and post restoration.

Opportunities

- Perform an assessment of stream invertebrate diversity, density, and distribution across the restored reach and by habitat type as an indicator for ecosystem condition post project and to assess the impacts of the project on the restored reach, as well as the speed of recovery.
    - Include assessment of reference reaches (both degraded (pre-project) and healthy (post project) as components.

Maintenance, management, monitoring, and mitigation



Maintenance of community and landscape

Limiting factors addressed by project: 22.2%
Limiting factors addressed relative to project scope: 66.7%

Project effects and site condition

- Non-native species were not present in the reach prior to the project and so were and are not a management concern.
- Though unmonitored, the fish community was presumed healthy (in terms of adequate numbers and population size) prior to the project, and appears qualitatively to have been maintained if not improved by the project and habitat improvements, despite the significant disturbance caused by the project.
- Connectivity was significantly improved with removal of the culvert, the only fish passage issue prior to the project and had remained improved at the time of the last site visit.
    - The restoration was designed specifically not to concentrate flood flows and create new or additional passage issues.
- Stream channel-floodplain connectivity was restored and is being maintained by project.
- Restoration of channel-floodplain connectivity paired with bed stabilization significantly reduced sediment load from restored reach and upstream
    - The restored meadow acts as an ongoing sediment trap, though the reduction in sediment has not been monitored or quantified by pre and post project monitoring.
- Cattle were present in entire reach prior to project before and now confined to the lower portion of the reach.
    - Reach is completely fenced, but cattle are moved inside the fenced area on the lower portion to graze periodically.
    - Stream channel itself cannot be fenced permanently due to restored flooding.
    - Ponds from project create off channel water for Cattle but are located within existing fencing.
- Water quality improvements from reduced grazing are presumed but have not been assessed or quantified.
- Project may have improved impacts to water quality from upstream grazing, however there is no pre or post project data to confirm this or assess project benefits to water quality.
- Agreement with regional RCD to graze cattle in a manner that won't destroy the improvements made by the project, but no associated reporting.
    - Livestock turn on-take off dates, grazing rotation, and active herding away from riparian zones and re-vegetating floodplain, as well as and site and water year sensitive adjustments should fall within RCD management agreement, but currently there is no enforcement of the agreement.
- Active logging on land surrounding project.
    - Logging interactions with or impacts on channel appear to be have been minimal historically and are thought to continue to be minimal though this has not been assessed or quantified.

Persisting concerns

- Lack of project review or site evaluation to measure ongoing effects of project and adaptively manage the system.
    - Unknown fish population and ecosystem condition in restored reach
    - Unknown water quality in restored reach

- Continued presence of cattle in the lower portion of the reach with unknown impacts on water quality and habitat condition
- Logging and surrounding land use with potential impacts to stream water quality
- Risk of potential of fire regime change due to climate change.
- Risk of potential for increased flooding due to climate change.

Data Gaps

- Aquatic community and species population structure and effects of project unknown
- Development and morphology of restored channel not known, evaluated or managed to ensure proper meadow function.
- Water quality in the restored reach is unknown as are specifics effects of project and ongoing surrounding land use.

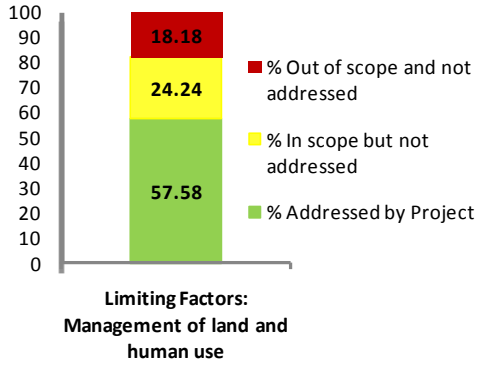
Opportunities

- Perform an onsite assessment and develop a new baseline for ongoing monitoring as well as a basis for evaluating potential adaptive management needs and opportunities.
- Work with landowner to develop a resolution to the continued presence of cattle in the lower portion of the restored reach (e.g. mobile fencing to keep cattle out of channel but allow access to the meadow and ponds, paired with a carefully managed and time schedule of grazing)
- Work with landowner and RCD to revise their management plan for the site to include monitoring impacts from grazing and adaptive management of the project area to minimize any impacts.

Management of Land and Human Uses

Limiting factors addressed by project: 57.6%

Limiting factors addressed relative to project scope: 70.4%



Project effects and site condition

- Cows were removed from upstream portion of the stream and the surrounding meadow, and exclusion fencing was erected.
    - Off channel/ alternate water for cattle was provided (ponds)
    - Cattle maintain access to stream in lower portion of restored reach
- Increased runoff and increased sedimentation from upstream grazing and degraded habitat formerly an issue (though unquantified), but presumed improved through sediment trapped in pond and on floodplain.
- Riparian zones in the process of re-establishing, though status or rate of recolonization unknown
- Encroachment of conifers and other non-desirable species unmanaged, but presumed improved by restoration of channel-floodplain connectivity.
    - Floodplain restoration resulted in replacement of annual grasses and retreat of sage from meadow in favor of wetland vegetation
- In conjunction with culvert removal, the road crossing was reworked so that is was functional and no longer a sediment source for the stream channel
    - Culvert replaced with a three sided box to spread out flood flow and prevent failures.
    - Additional culverts installed at floodplain elevation to allow for dissipation of flood energy and floodplain function without concentration of flood flows at a single point.

Persisting concerns

- Continued impacts from livestock grazing on-site, in the lower portion of the restored reach, as well as upstream grazing without management that is sensitive to stream condition, seasonal flow variation, or fish population
- Continued potential impacts from surrounding land use to reaches adjoining the restored reach

Data Gaps

- No baseline data on adjacent land use (grazing, recreation, or timber harvest) impacts to species, water quality, or ecosystem condition.

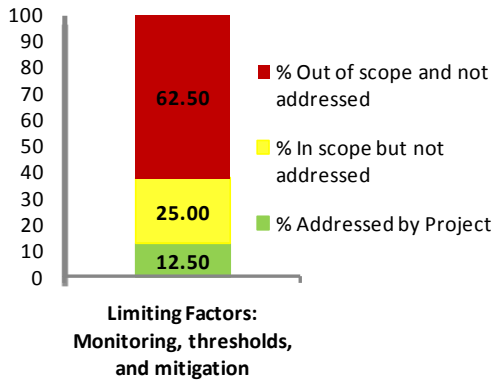
Opportunities

- Work with upstream landowner to manage livestock grazing in surrounding area more effectively (e.g. turn on/ take off dates that are sensitive to water year and site condition)
    - Re-approach and engage the upstream landowner about the potential to perform a complimentary restoration of the upstream reach.

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 12.5%

Limiting factors addressed relative to project scope: 33.3%



Project effects and site condition

- Currently there are no established thresholds or funded monitoring for conditions in the restored reach including species condition, water quality, or ecosystem condition.
- There is an agreement in place for RCD to track ongoing impacts of grazing including condition of habitat and water quality, but there are no established thresholds against which this can be evaluated, plan for monitoring, adaptive management plan, or associated funding.
- Headcuts and gullying monitored through annual site visits
    - Annual site visits have not occurred for multiple years
    - No headcuts or gullying were identified during initial three years of annual visits

Persisting concerns

- No existing thresholds established for species populations, ecosystem condition, or water quality
- No current monitoring program to track condition of species, ecosystem, or water quality
- Existing management not being informed by and adapted in response to monitoring data concerning redband, or invertebrate/ ecosystem responses to restoration.
- Limited monitoring program set in place at the time of the project (RCD Cattle monitoring and owner/ restoration practitioner monitoring of geomorphology) unfunded and not readily practiced/ up to date.

Data Gaps

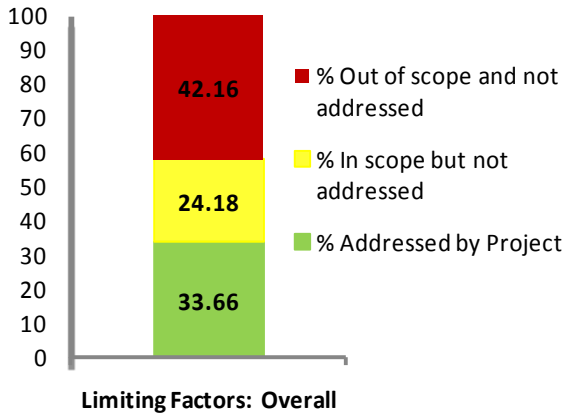
- Redband response to restoration monitored qualitatively and sporadically with no analysis
- Water quality in response to restoration unmonitored (though not believed to be impacted)
- Ecosystem response (e.g. invertebrate community) to restoration unmonitored
- Impacts from grazing unmonitored

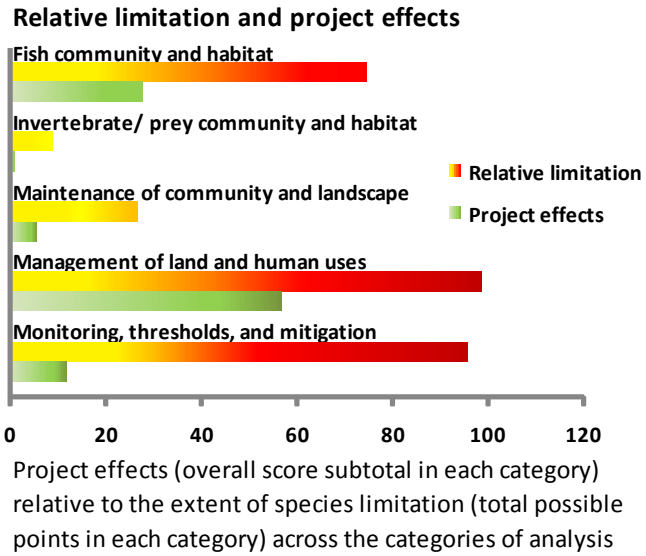
Opportunities

- Establish thresholds for redband population condition, water quality, and ecosystem conditions as a component of adaptive management of the project site going forward.
- Include water quality, species condition, ecosystem condition and stream geomorphology in a comprehensive ongoing monitoring program for the site.
- Work with RCD to develop and fund larger cooperative regional monitoring and adaptive management program, in partnership with landowners, based on thresholds, and with reporting requirements that can be applied constructively to ongoing management planning.
- Mitigate potential climate change driven risk of increased fire by assessing fuel loads and encroachment in meadow and managing appropriately.
- Mitigate potential climate change driven risks to water quality, habitat, and ecosystem condition by working with upstream landowners on potential complimentary restoration efforts, and land use practices that buffer against threats to water quality from increased flooding and runoff.

Overall Findings and Key Points

Limiting factors addressed by project: 33.7%
Limiting factors addressed relative to project scope: 58.2%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

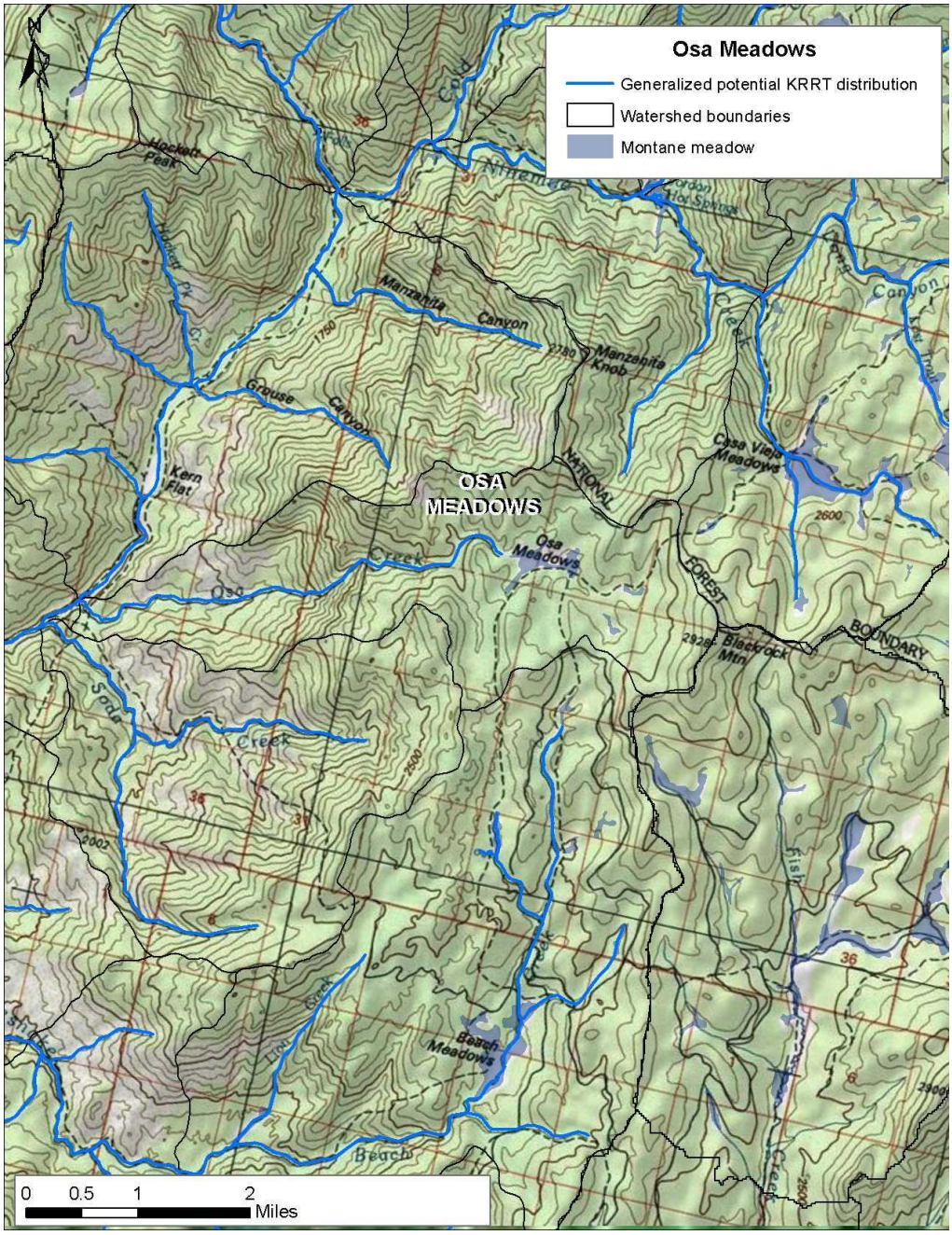
Species condition in project area:	Unknown
Area(s) of greatest gains:	Management of land and human uses
Most significant actions:	Degrazing, meadow, floodplain and channel restoration, buffering of impacts from grazing
Area(s) of greatest need:	Management of land and human uses, Monitoring, thresholds and mitigation
Highest priority concerns:	Species, habitat and ecosystem condition in grazed reach, condition of site and need for monitoring and adaptive management plan, impacts from adjacent land use, climate change impacts.

Highest priority opportunities:

- Perform an on-site assessment of site condition (habitat, ecosystem, species, geomorphology and land use) and develop a new baseline for ongoing monitoring as well as a basis for evaluating potential adaptive management needs and opportunities.
- Work with landowner to develop a resolution to the continued presence of cattle in the lower portion of the restored reach (e.g. mobile fencing to keep cattle out of channel but allow access to the meadow and ponds, paired with a carefully managed and time schedule of grazing)
- Work with regional RCD 1) to develop and fund larger cooperative regional monitoring and adaptive management program, in partnership with landowners, based on thresholds, and with reporting requirements that can be applied constructively to ongoing management planning and 2) to revise their management plan for the site to include monitoring impacts from grazing and adaptive management of the project area.
- Mitigate potential climate change driven risks to water quality, habitat, and ecosystem condition by working with landowners on potential complimentary restoration efforts, and land use practices that buffer against threats to water quality from fire as well as from increased flooding and runoff.

Species: **Kern River Rainbow Trout (*Oncorhynchus mykiss gilberti*)**
Location: **Osa Meadows/Osa Creek, Sequoia National Forest**
Regional Contact(s): **Terry Kaplan-Henry (USFS, Sequoia NF)**
Project: **Osa Meadow Restoration Project (Planning Phase)**
Timeframe: **August 2010-present**

Project area map



Associated documentation, research, and data sources

- Study on climate change vulnerability in the region, Mallek and Safford (2011)
- Osa Meadow Restoration Project NEPA scoping document, Larson and Stewart (2010)
- Personal communication with Terry Kaplan-Henry, Joshua Courter, and Kyle Wright

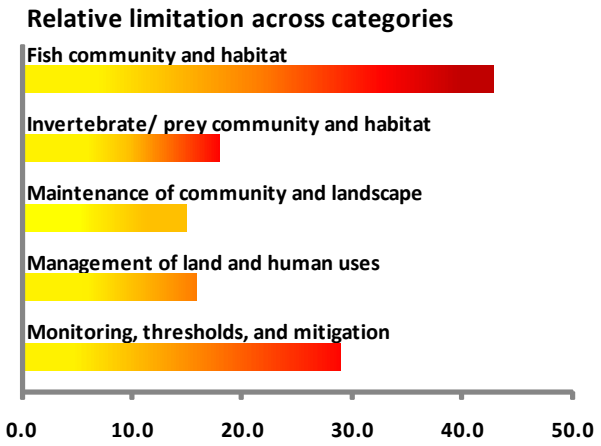
Restoration overview

- Main restoration actions include 1) gully elimination using the pond and plug technique 2) incorporating whole trees into the meadow channel and ponds 3) and the staging and installation of a rock/vegetation valley grade feature at the lower end of the meadow to address the need to restore the natural meadow and stream water table, stream characteristics, and vegetation components.
- Restoration targeted to provide the following ecosystem benefits: 1) establish a single-thread, low flow channel, 2) reduce peak flows and increase/extend summer baseflows, 3) increase in-stream cover and shading, 4) enhance aquatic and terrestrial habitat, 5) improve water quality, 6) raise the local groundwater level within the meadow, and 7) improve viability of Kern River rainbow trout, mountain yellow legged frog, and Sacramento sucker.

Background on site, landscape, and species condition

Project site

- Project is located just inside the Golden Trout Wilderness.
- Osa Creek is almost entirely fed by springs for most of the year, Spring excluded where flow is dominated by snow runoff.
- Habitat has undergone several restoration actions over the last ~30 years – mainly in the form of check dams and rock structures - which are showing to have a negative impact on stream and meadow function along with stream characteristics.
- In the late 1970's rock check dams were installed along a gully in Osa Creek (Anderson, personal comm. 2010). This work provided grade control to help prevent continued erosion in the meadow.



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

- Additionally since the late 1800's and until 2003, Osa Meadow was used for seasonal grazing of sheep and cattle.
- Sheep and cattle have now been removed from site for 8 years, and the allotment will remain vacant until NEPA is completed to reissue a permit.
- In the 1990's the rock work was removed and retrofitted to help reduce bank erosion and reduce channel widening associated with check dam instillation.
- The meadow has stabilized however the channel has access to only about 10% of the meadow approximately 5 to 10 feet on either side of the creek.
- Most of the meadow is comprised of dryer species and lacks species diversity and vigor expected in a functioning meadow ecosystem.

- Two ORV trails are located in the meadow and recent decisions on Travel Management have prohibited use on these trails. Restoring one of these ORV trails is considered a component of this project.
- Upper and Lower Osa Creek fish are a Golden/Kern River Rainbow Trout hybrid.

Climate considerations

- Based on modeling study and synopsis by Mallek and Safford (2011) the regions is:
    - moderate risk for increased winter flooding,
    - low risk for temperature change,
    - High risk for fire regime change due to decreased snow.

Species condition

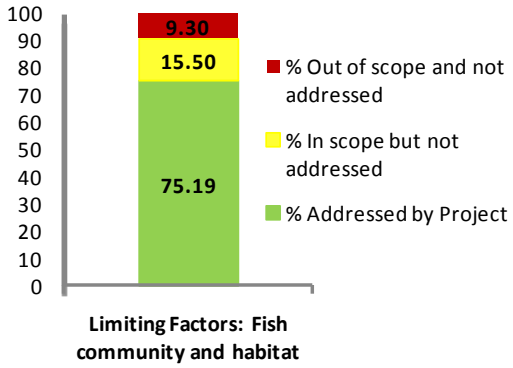
- The affected reach contains a resident population of hybridized Kern River Rainbow/Golden Trout.
- Population size and structure are considered to be in poor condition because of degraded habitat that contributes to stream dewatering in sections.
- In good water years, fish can access upstream and downstream habitats of Osa Creek and move throughout the system, but this is very rare.

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 75.2% Impinge
Limiting factors addressed relative to project scope: 82.9%



Project effects and site condition

- Habitat in Osa Meadow is affected by myriad historic uses and events:
    - Existing connectivity is significantly degraded because of channel downcutting, leading to limited to no access to floodplain and disappearing flow during certain seasons.
    - Habitat patch size is variable on channel function due to transport of sediment and loss of connectivity (pool, dry, pool).
    - Habitat diversity has been consistent but there is a lack of deep pools through the meadow.
    - Banks are collapsed from historic grazing practices on the Beach Allotment.
    - In 2002, the McNally Fire burned over 150,000 acres at the headwaters of Osa Creek, followed by 20" of rain in 24 hours, lead to significant downcutting in the already degraded meadow.
    - Little gravel presently system, mostly sand bottom.
- Implementing the Osa Meadows Pond and Plug project should improve the following:
    - Reduce conifer encroachment, and improve aspen and willow growth in meadow creating overhanging riparian vegetation, rocks, downed wood and other cover.
    - Allow steam to consistently access the floodplain and re-water the meadow.
    - Improve pool depth and diverse habitats capable of supporting all of the life history stages and native fish species, though reduce the amount of undercut bank because of the Pond and Plug technique.
    - Connectivity to downstream and upstream habitats at various flow levels because hydrograph is more consistent now than historically.

  - Water temperature and turbidity were already within historic thresholds and should all remain unchanged.
- Significant monitoring of temperature, turbidity, pH, etc. is already completed by Sequoia NF at Osa Meadows and is ongoing and scheduled for throughout the duration of the project and post-completion.

Persisting concerns

- Trout cannot access upstream and downstream habitats and cannot escape stochastic events such as fire, flood, etc.
- Lack of riparian cover habitat and shade for trout, though this is somewhat typical for the Kern River watershed.
- Present stream structure limits pool habitat at certain times/ flows and water goes subsurface creating a stagnant pool, dry streambed, then another stagnant pool.
- Water in stagnant pools gets warmer then it historically did.
- Trout throughout this section of Osa Creek are already introgressed so potential genetic risk from hybrid trout upstream and downstream with re-established connectivity is not an issue.

Data Gaps

- No information on exact genetics in upper Osa Creek and level of hybridization of fish that currently occupy this reach.
- No data available for exact population density and/or age or size class distribution.

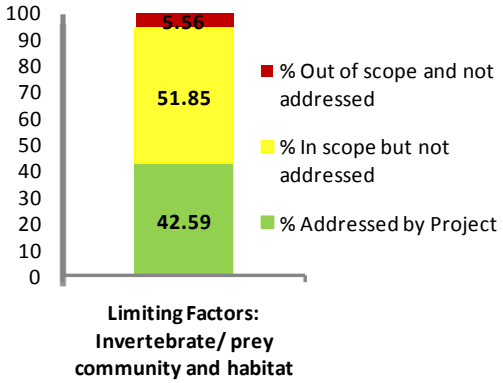
Opportunities

- Osa is dominated by spring flows so a functional meadow and stream channel should support viable flows and add complexity to the existing habitat supporting trout annually.
- Monitoring the creek pre and post project for exact population density and/or age or size class distribution of the resident trout in Osa.
- Remove existing OHV trails that are adjacent to stream channel.
- Continue to rest the Beach Allotment or install grazing fences along remnant channel to prohibit impacts of cows/sheep and new resource concerns.

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 42.6%

Limiting factors addressed relative to project scope: 45.1%



Project effects and site condition

- Historically Osa Creek through Osa Meadow did not support dense numbers of invertebrate populations because of its sandy bottom, however the channel has continued to silt in over the past decades and the gravel that did exist is almost absent from the system.
  - Substrate is likely to improve once the stream is redirected into the remnant channel
- Contaminants/pollutants are below the threshold tolerance levels of the most sensitive species.
- Temperature and water chemistry components are within the range of tolerance and there is little to no turbidity currently in the system.

- The project should show no change to these components.

Persisting concerns

- Lack of good gravel to support clingers and crawlers and other invertebrate species, though historic community structure is not known.
- Pre-project, the site has lack of good invertebrate populations to support dense numbers of trout.
- There is almost no riparian vegetation thus no decaying leaf matter that enters Osa Creek to feed invertebrates.

Data Gaps

- Unknown condition of invertebrate community, including production, density, and distribution relative to previous or reference conditions due to discrepancy in the methodologies and objectives of historic versus more recent invertebrate surveys.
- Unknown whether adequate invertebrate production is occurring to support fish population
- Unknown invertebrate prey availability relative to historic or other systems.

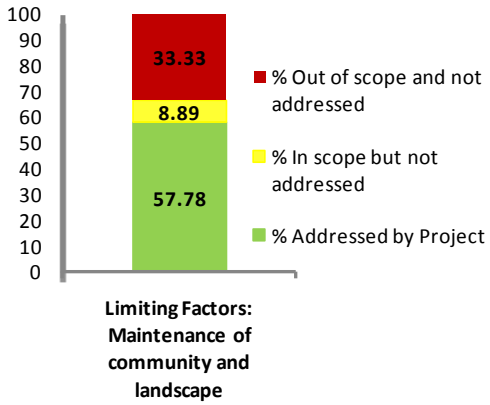
Opportunities

- Perform invertebrate study using methodology consistent with historic study in order to evaluate diversity, distribution, abundance, and production pre and post grazing removal. Compare with modern methods
- Develop bioenergetics model for species and evaluate current invertebrate food supply against needs based on physical habitat parameters and population size.

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape

Limiting factors addressed by project: 57.8%
Limiting factors addressed relative to project scope: 86.7%



Project effects and site condition

- Physical connectivity disrupted by restoration and inclusion of a check-dam, additional scouring from the McNally fire and substantial grazing for decades that lead to collapsing stream banks. Physical connectivity disruption impedes immigration or emigration relative to this population and creates an isolated population.
    - Goal of restoration, however, is to improve meadow function for improvements downstream, where more critical population/ habitats are, and create tolerable habitat throughout the meadow.
    - A restored remnant channel will provide movement for trout throughout Osa Meadow in the short term and reconnect this population to downstream populations/habitats, which are currently healthier than upstream.
- There are presently no water quality impacts in Osa Creek, this is a first order headwater stream, and the primary problem is dewatering and loss of connectivity from August through November each year.
- No new nutrients entering the stream since the 2003 resting of the Beach Allotment.

Persisting concerns

- Risk for increased winter flooding as a result of climate change.
- Risk of potential of fire regime change due to decreased snow, though headwaters were recently burned and fuel loads are currently low.
- Risk of fire and associated impacts to water quality due to climate exacerbated lack of fire fuels management.
- Risk of grazing impacts if management direction changes to allow cows and sheep to once again graze in Osa Meadows.
- Recreation risks from motorized use in the meadow, one OHV trail is still considered a legal route.

Data Gaps

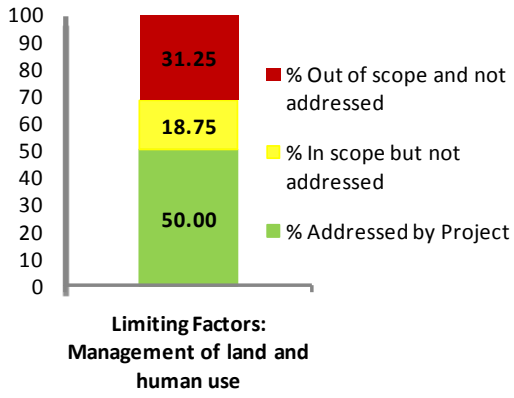
- Aquatic community and species population structure not monitored
- Poor understanding of nutrient impact during grazing and change since.
- Poor understanding of sedimentation risk relative to current WQ and species tolerance

Opportunities

- Encourage management to decommission the OHV route that parallels the current channel.
- Potential opportunity for fuels management to reduce risk of impact from fire.
- Opportunities to encourage management to continue to rest allotment, or install fencing along remnant channel once restoration is completed.

Management of Land and Human Uses

Limiting factors addressed by project: 50.0%
Limiting factors addressed relative to project scope: 72.7%



Project effects and site condition

- Cattle removed (~ 8 years)
- No historic or current fencing along creek.
- Retired Allotment, Sequoia National Forest is currently going through NEPA to consider reopening the Beach Allotment.
- Area designated federal Wilderness, though Wilderness designation allows for potential grazing.
- Increased runoff from impacted soils formerly an issue but 10 years of non-grazing has significantly improved conditions in Osa Meadow, though stream banks are still is poor condition.
    - Goal of restoration, however, will restore meadow function and eliminate historic impacts from decades of grazing.
- Conifer encroachment and lack of willow and aspen are a primary concern in Osa Meadows.
    - Making Osa a wet meadow will solve this issue and provide forage for invertebrates and cover for trout.
- Two OHV trails, one that is currently active and one that is decommissioned but not yet restored, are potentially contributing to further degradation of the meadow system.
    - Project manager Terry Kaplan-Henry, who worked on Travel Management, is working on adding the removal of this active trail to the current restoration plan.

Persisting concerns

- Continued risk of further conifer encroachment if no project is implemented.
- Risk of impacts from unmanaged motorized recreation in the meadow.

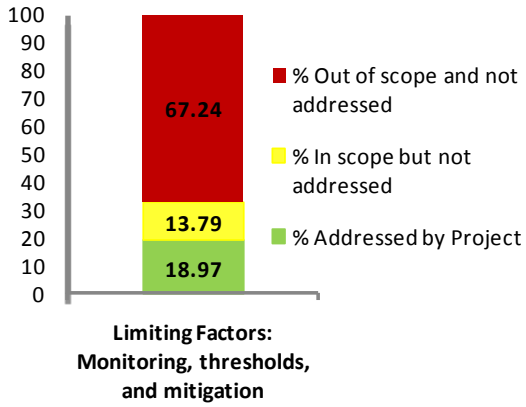
- NEPA decision to reopen the Beach Allotment.

Data Gaps
- Monitoring of motorized use in Osa Meadows and a study of impacts and use trends in the area assessing potential for increased risk and impact to the meadow.

Opportunities
- Advocate closure of Beach Allotment or propose fencing along meadow once allotment is reopened.
- Minimize road densities in Osa Meadow.
- Opportunities for aspen regeneration project once Pond and Plug project is implemented.

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 19.0%
Limiting factors addressed relative to project scope: 57.9%



Project effects and site condition
- This project site is extensively monitored for temperature, DO, nutrients, and other pollutants.
- Headcuts and gullying are monitored annually and are showing to be increasing.
- Monitoring has shown the undercut banks are decreasing and caving in along the current channel, which is also widening and deepening.
- Currently no cows and no urban runoff concerns, but the stream cannot naturally repair itself because it cannot access its floodplain.

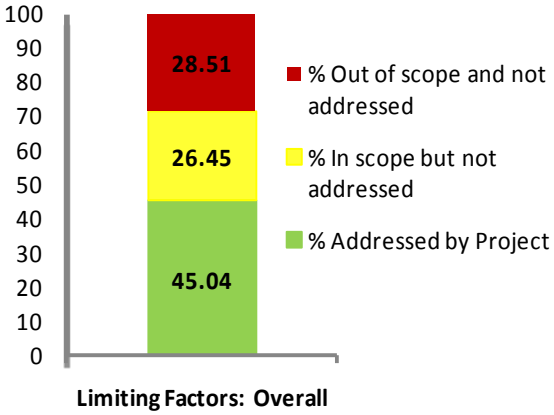
Persisting concerns
- Forest Plan Revision process for the Sequoia National Forest and unknown management direction.

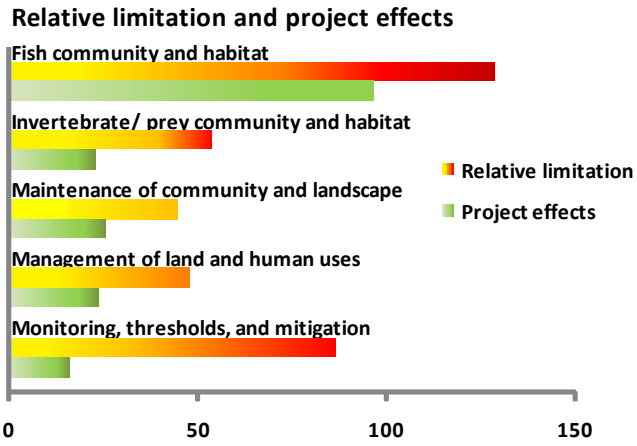
Data Gaps
- Recovery of meadow, stream banks, and vegetation will be extensively monitored over the life of the project but are currently unknown.

Opportunities
- Continue current land use management in Osa Meadows.
- Continue to monitor water quality pre and post project implementation.
- Continue to monitor undercut banks and gullying and headcuts pre and post project implementation.

Overall Findings and Key Points

Limiting factors addressed by project: 45.0%
Limiting factors addressed relative to project scope: 63.0%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

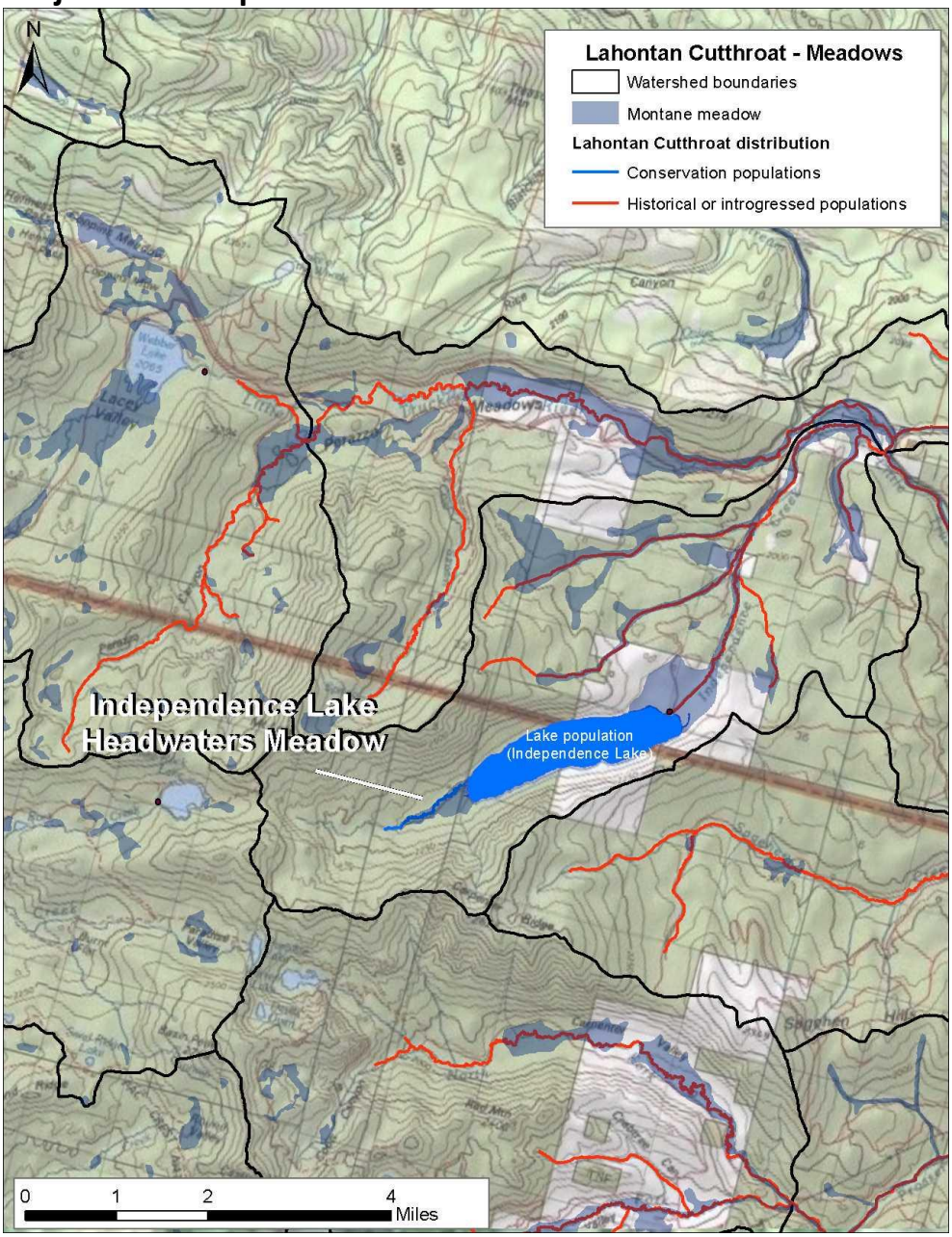
Species condition in project area:	Moderate
Area of greatest gains:	Fish Community and Habitat/ Maintenance of community and landscape
Most significant actions:	Pond and Plug/Re-establishing remnant channel/Reconnect stream to upstream and downstream habitats
Area of greatest need:	Management of land and human uses/Invertebrate/ Prey Community and Habitat
Highest priority concerns:	Headcuts and Gullying/NEPA decision to reopen the Beach Allotment/Fire/Lack of connectivity/OHV/ Introgressed species/Conifer Encroachment

Highest priority opportunities:

- Implement Plug and Pond Restoration Project at Osa Meadows and re-establish the creek in the remnant channel with adequate monitoring and adaptive management plans
- Decommission and restore current OHV trails in meadow and manage area to exclude existing and new motorized use.
- Continue extensive monitoring.
- Establish thresholds for WQ and invertebrates
- Evaluate effects of de-grazing (based on above).
- Manage encroaching conifers and reestablish aspen and willow along riparian corridor.

Species: **Lahontan Cutthroat Trout (*Oncorhynchus clarki henshawi*)**
Location: **Independence Lake and Inflow**
Regional Contact(s): **Chris Fichtel, The Nature Conservancy; Beth Christman, Truckee River Watershed Council; Deborah Urich, USDA Forest Service**
Project: **Restoration of a failed weir to improve LCT spawning habitat**
Timeframe: **2008 to present**

Project area map



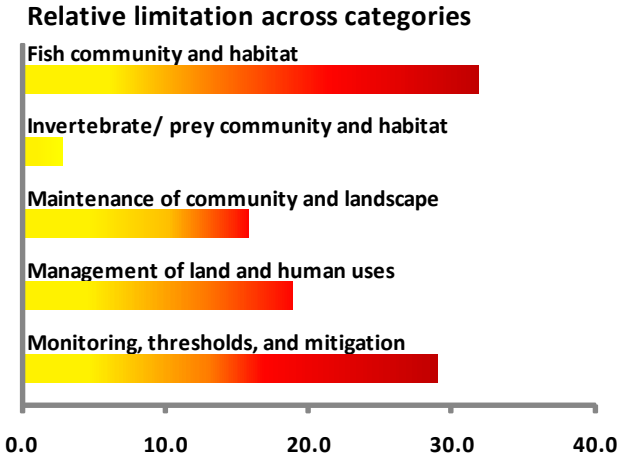
Associated documentation, research, and data sources

- U.S. Fish and Wildlife Service. 1994. Lahontan cutthroat trout, *Oncorhynchus clarki henshawi*, Recovery Plan. Portland, OR. 147 pp.
- Personal Communication with Beth Cristman (Truckee River Watershed Council) and Deborah Urich (USFS)

Restoration overview

- This project seeks to improve LCT spawning habitat in the small section of Independence Creek that feeds Independence Lake. Specifically, the project intent is to restore a highly eroded cut bank caused by a failed weir that was originally put in place for LCT management. The weir failed in a flood event and the remnants have directly led to increased downstream erosion and siltation. Project is in planning stages and scheduled to be implemented in 2012.

Background on site, landscape, and species condition



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

Project site

- Independence Lake is one of only 2 self-sustaining lake populations of LCT
- LCT were never extirpated from Independence Lake, unlike all other Sierra Nevada lake populations
- The area surrounding Independence Lake has been both extensively logged and grazed for 150+ years
- Non-native fishes including brook trout, brown trout, kokanee, and rainbow trout exist in Independence Lake and Creek.
    - Brook trout compete with adult LCT and prey upon juvenile LCT within their spawning stream
    - Kokanee compete with adults for food and habitat within the lake
- Independence Creek above the lake supports less than 1mile of LCT spawning habitat, therefore the managing and collaborating agencies and groups consider any loss of spawning habitat or redd sites unacceptable
- There is a comprehensive plan in place to protect and restore LCT and the aquatic ecosystem of Independence Lake including such wide reaching activities as:
    - recreation management to reduce risk of aquatic invasive species introductions
    - forest management to reduce the risk of catastrophic fire & impacts to water quality
    - non-native species removal
    - prevention of upstream migration of other non-native salmonids
    - habitat restoration

Climate considerations

- The Truckee River Watershed/Northern Sierra region is considered to be an area of high risk for climate change associated problems including
    - Stand density and high fuel loads lead to increased risk of catastrophic fire
    - Likelihood of a higher proportion of precipitation falling as rain rather than snow
    - Potential for changed hydrograph (change in timing, duration, magnitude, and frequency)

- Potential for decreased surface water in the summer season

Species condition

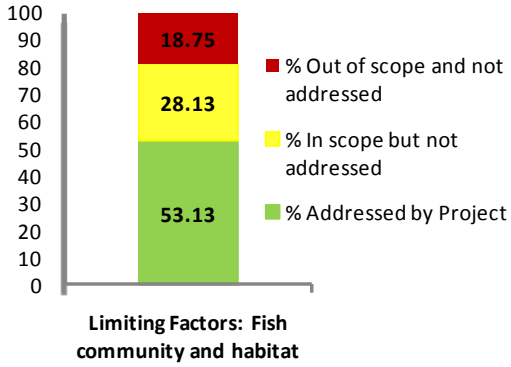
- LCT are listed as federally threatened
- Subspecies almost entirely hatchery propagated, with few exceptions
- Self-sustaining populations of the species occur in 10.7 percent of the historic stream habitats and 0.4 percent of the historic lake habitats.

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 53.1%
Limiting factors addressed relative to project scope: 65.4%



Project effects and site condition

- The project's preliminary results indicate that it is working towards its stated goals of
  - Reducing siltation of spawning gravel and redd sites downstream of the defunct weir
  - Removal of the non-functioning weir and associated structures
  - Rehabilitation of the eroded cutbank through
    - laying the bank back to a sustainable angle
    - reinforcing the toe with engineered rock and log jams
    - revegetation with native vegetation
    - constructing a lowered inset floodplain to reduce stress on the constriction point where the old weir was located

Persisting concerns

- Headcut erosion moving upstream into the meadow rendering downstream restoration efforts non-functional
- Skewed sex ratio
- Skewed age class ratio towards younger population
- Bottlenecked population
- Presence of non-native fishes and other aquatic invasive species

Data Gaps

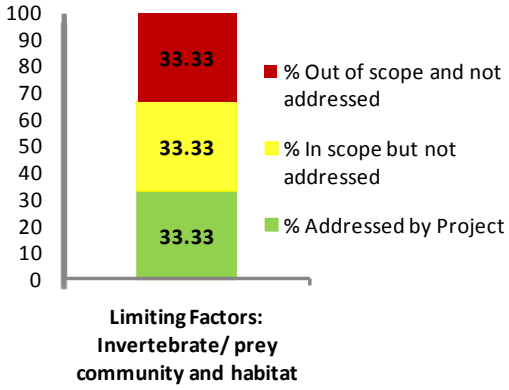
- Foodweb analysis
- Native and non-native fish community interactions

Opportunities

- Further enhancement of spawning habitat
- Continued improvement of stream channel stability and heterogeneity
- Improved hydrologic function associated with stream bank stabilization and stopping headcut
- Opening downstream habitat through non-native fish removals

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 33.3%
Limiting factors addressed relative to project scope: 50.0%



Project effects and site condition

- Bank Stabilization project may improve invertebrate diversity and abundance by reducing siltation

Persisting concerns

- Presence of non-native crayfish

Data Gaps

- Little historical data has been collected on invertebrate community structure and abundance
- Little foodweb information exists

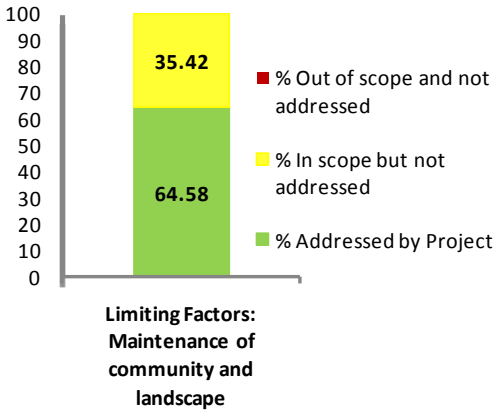
Opportunities

- Pre and post-project monitoring may provide useful data on invertebrate community

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape

Limiting factors addressed by project: 64.6%
Limiting factors addressed relative to project scope: 64.6%



Project effects and site condition

- Project seeks to improve
  - hydrologic function
  - LCT spawning habitat
  - Sediment and erosion problems
  - Access to upstream areas
  - Headcutting
- Pre and post-project monitoring include monumented photopoints and cross sections to maintain a visual assessment of project evolution

Persisting concerns

- Recreational use impacts
- Non-native fishes
- Non-native aquatic plants
- Other invasive aquatic species (e.g., crayfish)
- Maintenance of LCT genetic diversity without hatchery influences

Data Gaps

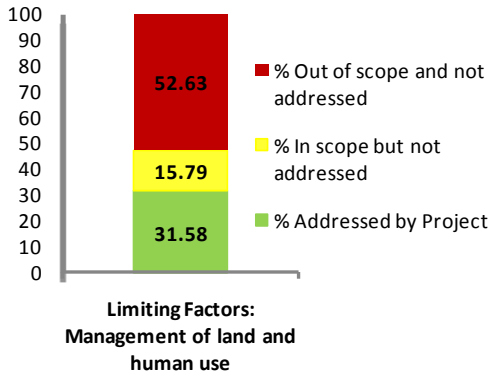
- Potential positive effects of restoration efforts to undesirable non-native species

Opportunities

- To continue to improve habitat for LCT in Independence Creek
- To continue to support and improve opportunities for self-sustaining wild populations of lake-type LCT without hatchery influence
- Improve the downstream barrier of Lower Independence Creek which contains several species of non-native trout
- Remove non-native trout from Lower Independence Creek to extend LCT range

Management of Land and Human Uses

Limiting factors addressed by project: 31.6%
Limiting factors addressed relative to project scope: 66.7%



Project effects and site condition

- Grazing protection of the site is in place and habitat is recovering
- Area timber harvest operations have a buffer

Persisting concerns

- Skewed sex and age ratios in LCT population
- Post-project monitoring methods may be too subjective to capture changes/problems

Data Gaps

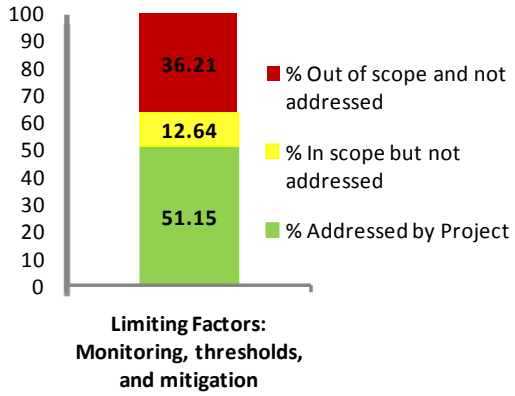
- Well studied and monitored as a result of the USFWS Recovery Plan

Opportunities

- Continued Interagency/NGO partnership and efforts to restore a healthy, sustainable LCT population without hatchery dependency

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 51.1%
Limiting factors addressed relative to project scope: 80.2%



Project effects and site condition

- General land use, water quality issues, and monitoring have all been addressed in the monitoring plan

Persisting concerns

- As mentioned above, genetic concerns for LCT populations involving
    - Genetic bottleneck/small population size
    - Skewed sex ratios
    - Skewed age class ratios
    - Limited spawning habitat availability
    - Hatchery influences
    - Non-native fishes
    - Other aquatic invasive species (i.e., non-native mollusks)

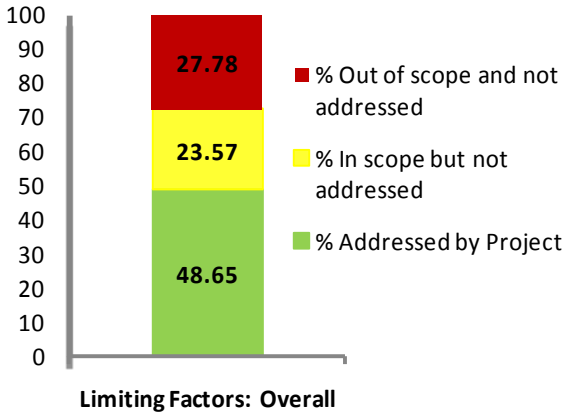
- Current monitoring plan addresses invasive plant species actions but no formal monitoring plan for animals such as brook and brown trout
- Impacts from angling activities and mistaken identification (mistaken for rainbow trout)

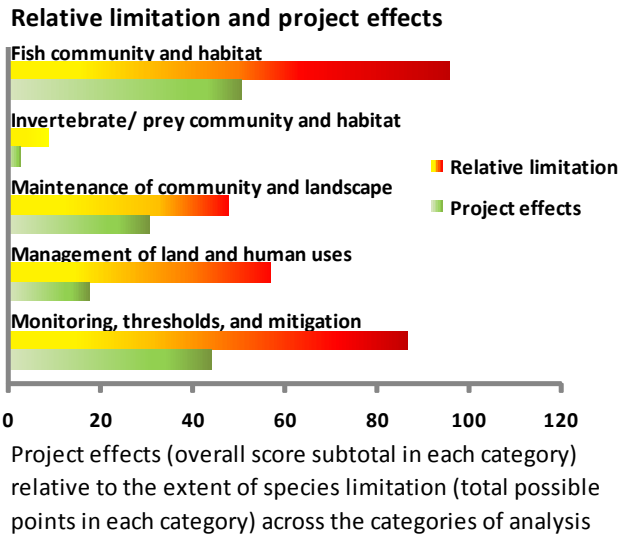
Data Gaps
- The effect of angling activities on the population

Opportunities
- Continued non-native species removal
- Further education and outreach with anglers/recreational users about LCT needs, particularly lake forms
- Opening downstream habitat to LCT through non-native species removal

Overall Findings and Key Points

Limiting factors addressed by project: *48.7%*
Limiting factors addressed relative to project scope: 67.4%





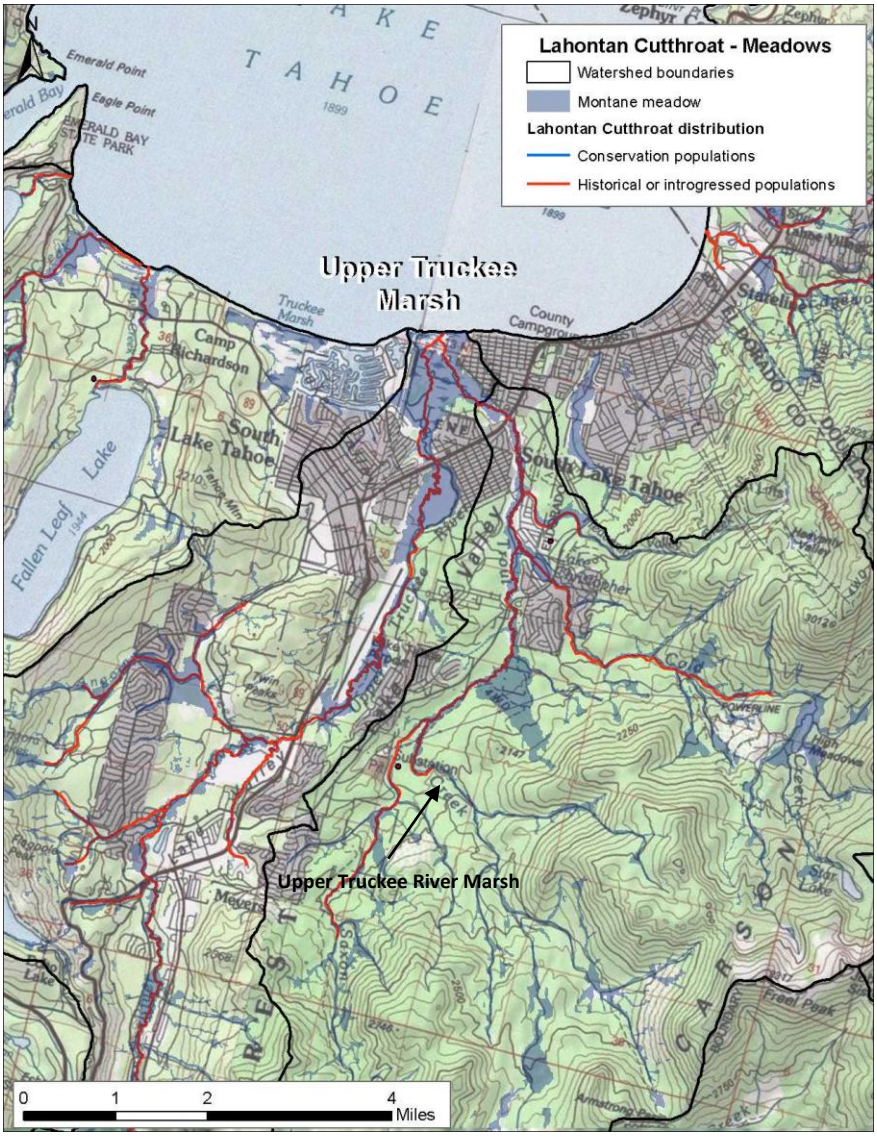
Species condition in project area:	Species condition is trending upwards though there are still major concerns about genetics, spawning access, and non-native species interactions
Area of greatest gains:	Project addressed a significant source of erosion and sediment that negatively affected Independence Lake LCT spawning habitats, improved water quality, Stopped a potential head cut from moving into the meadow above
Most significant actions:	Removal of defunct weir and rehabilitation of the stream banks and channel, brook trout removal
Area of greatest need:	Non-native species control (continue brook trout, focus on Kokanee), Spawning habitat access
Highest priority concerns:	Genetic/small population issues

Highest priority opportunities:

- Continued protection and improvement of LCT habitat
- Access to downstream habitat with non-native species control
- Continued protection and enhancement of self-sustaining non-hatchery derived LCT

Species: **Lahontan Cutthroat Trout (*Oncorhynchus clarki henshawi*)**
Location: **Upper Truckee River above the Keys**
Lead Organization and Sponsor: **California Tahoe Conservancy, Bureau of Reclamation, Tahoe Regional Planning Agency, Lake Tahoe Basin Management Unit of the Forest Service**
Regional Contact(s): **Adam Lewandowski**
Project: **Upper Truckee River and Marsh Restoration Project**
Timeframe: **2007 to future (project in planning stages)**

Project area map



Associated documentation, research, and data sources

- Upper Truckee River Watershed Advisory Group's (UTRWAG) guidance on monitoring plans for Upper Truckee River (UTRWAG 2007)
- A detailed monitoring plan has been developed for the project and is available upon request (Conservancy 2008)
- Schematic plans for the alternatives are available at: http://www.tahoecons.ca.gov/project_info/index.html#utm
- ArcGIS shapefiles and coverages showing various project elements and monitoring locations are available

Restoration overview

- The comprehensive project plan, the Upper Truckee River Watershed Restoration, and the regional Environmental Improvement Plan all consider the project and/or evaluate alternatives within multiple ecological, physical, and social contexts.
- The Plans address issues including
    - Geomorphology
    - hydrology and flooding
    - fisheries
    - wildlife and vegetation (including invasive species)
    - recreation
    - scenic values
    - soils
    - water quality
    - transportation
    - land uses
    - cultural resources
    - environmental justice
    - human health
    - utilities
    - public services
- The project is the result of a comprehensive planning effort. It consists of many individual elements that will address specific problems
    - removing fill from a lagoon
    - installing bank stabilization structures
    - creating a geomorphically sized river channel
    - re-routing/ restoring trails
    - hydrologically reconnecting historic lagoons
- The project is also a critical piece of the Upper Truckee River Watershed Restoration, which involves several large projects that will restore approximately 7 miles of the Upper Truckee River.
- The project is also part of the regional Environmental Improvement Program and was identified as necessary to achieve targeted thresholds for fisheries, wildlife, vegetation, and water quality.
- Extensive Goals and Objectives have been identified in the plan
    - **Goal 1: Restore natural and self-sustaining river and floodplain processes and functions.**
        - Restore natural channel planform and dynamics to the extent that adjacent urban constraints allow.
        - Increase frequency of overbank flow and floodplain deposition of suspended sediment during small magnitude events.
        - Increase floodplain flows and retention time during moderate events.

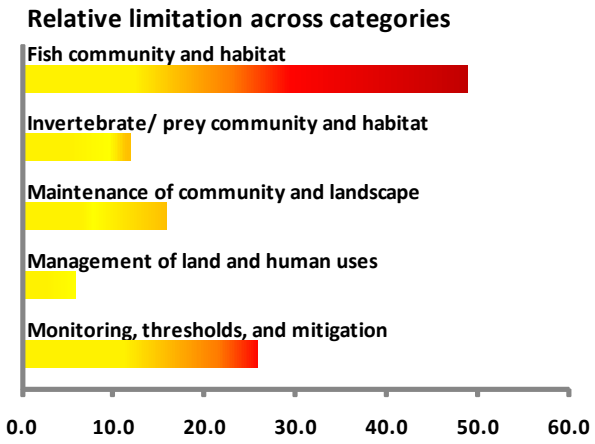
        - Reestablish site-appropriate barrier beach-river mouth dynamics.
        - Minimize the need for regular channel/bank maintenance.
    - **Goal 2: Protect, enhance, and restore naturally functioning habitats.**
        - Increase, where appropriate, hydration of wetland habitats on the site.
        - Increase, where appropriate, the quantity of riparian vegetation on the site.
        - Protect and restore upland habitats to serve as wetland buffers and provide natural habitat diversity.
        - Avoid establishment of invasive plant species, and institute control actions if they become established.
    - **Goal 3: Restore and enhance fish and wildlife habitat quality.**
        - Protect sensitive wildlife habitats from excessive public use by managing public access.
        - Enhance wildlife habitat values for native raptors, waterfowl and shorebirds, and songbirds.
        - Maintain, and if feasible enhance, the aquatic habitat values of the river and site for supporting native invertebrates, amphibians, and fish passage to upstream spawning areas.
    - **Goal 4: Improve water quality through enhancement of natural physical and biological processes.**
        - Reduce phosphorus, nitrogen, and fine/suspended sediment inputs from the Upper Truckee River to Lake Tahoe.
        - Reduce phosphorus, nitrogen, and fine/suspended sediment inputs from adjacent urban upland areas to Lake Tahoe.
        - Minimize site-generated fine sediment, nutrient and other pollutant inputs to Lake Tahoe.
    - **Goal 5: Protect and, where feasible, expand Tahoe yellow cress populations.**
    - **Goal 6: Provide public access, access to vistas, and environmental education at the Lower West Side and Cove East Beach.**
    - **Goal 7: Avoid increasing flood hazard on adjacent private property.**
    - **Goal 8: Design with sensitivity to the site's history and cultural heritage.**
    - **Goal 9: Design the wetland/urban interface to help provide habitat value and water quality benefits.**
    - **Goal 10: Implement a public health and safety program, including mosquito monitoring and control**
- **Specific measurable objectives will include:**
    - restoring up to 12,000 linear feet of river channel
    - stabilizing up to 1,500 additional linear feet of eroding bank
    - increasing frequency and extent of sediment deposition and nutrient uptake on 300 – 550 acres of floodplain
    - restoring up to 550 acres of SEZ
    - removing fill from 5 – 15 acres of SEZ
    - enhancing and increase protection of habitat for 4 threshold species (Waterfowl, Bald Eagle winter, Osprey, and Deer)
    - enhancing up to 592 acres of habitats of special significance (riparian, wet meadow, emergent vegetation lagoons and forest/meadow edge habitat)
    - reducing direct human impacts to up to 592 acres of special significance habitats by creating up to 18,000 linear feet of formalized trail to manage recreational use
    - enhancing physical and biological process necessary to sustain an identified uncommon plant community
    - expanding suitable habitat for at least one sensitive plant (Tahoe Yellow Cress) at 2 population sites

- improving the abundance, species richness, and spatial pattern of underrepresented common vegetation types across approximately 592 acres
- restoring up to 12,000 linear feet of stream habitat
- reducing populations of invasive warm-water fish species and Eurasian milfoil

Background on site, landscape, and species condition

Project site

- Site was historically a 1300 acre wetland (the largest in the Sierra Nevada). Over 700 acres of the wetland was dredged and filled to create a residential development. The multiple channels of the Upper Truckee River were combined into one straightened and oversized canal with little complexity of floodplain connectivity.
- The project is addressing the following issues:
  - Water Quality:
    - Lack of floodplain connectivity resulting in reduced sediment deposition and nutrient uptake.
    - Direct channel erosion and sediment delivery into Lake Tahoe. Stormwater from surrounding neighborhoods being conveyed directly into the river.
  - Fisheries and Wildlife:
    - Lack of aquatic habitat diversity (pools and riffles, undercut banks, backwaters)
    - Reduced lagoonal and backwater rearing habitat
    - Oversized channel with reduced riparian vegetation
    - Reduced extent and quality of wet meadow habitat.
- Four restoration alternatives are currently being evaluated. The alternatives use different approaches to river restoration (channel aggradation and narrowing, constructing a new geomorphically sized channel, reconnecting remnant channel segments, and creating inset floodplains). Schematic plans for the alternatives are available at: http://www.tahoecons.ca.gov/project_info/index.html#utm



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

Climate considerations

- Lake Tahoe area climate predictions include
  - More precipitation falling as rain rather than snow
  - Potential flooding from rain on snow events
  - Less surface water available in the summer season
  - Increased fuel loading, forest stand density
  - Higher risk of high intensity crown fires

Species condition

- Lahontan cutthroat trout (LCT) were historically present throughout Lake Tahoe with adjacent rivers and streams supporting spawning activities as well as resident stream-type fish
- LCT are currently extirpated from Lake Tahoe and most of the Upper Truckee river though there is a small population of stream-type LCT at the Upper Truckee headwaters in Meiss Meadows

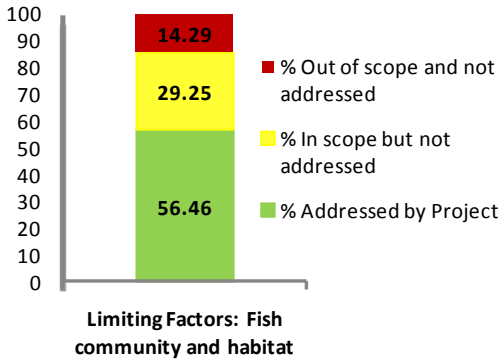
- Current LCT populations in the basin are genetically bottlenecked and may be introgressed with rainbow trout genes
- LCT are listed as federally threatened under the Endangered Species Act

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 56.5%
Limiting factors addressed relative to project scope: 65.9%



Project effects and site condition

- If stated project goals and objectives are met, habitat conditions for LCT in the lower portions of the Upper Truckee River will be dramatically improved, see listed goals and objective above
- Stream channel incision may have altered flows somewhat, but there are no major diversions or dams on the Upper Truckee

Persisting concerns

- Persistence of non-native fishes including brook, rainbow, and brown trout, potentially bass and bluegill migrating upstream from the Tahoe Keys area
- Restoration of Upper Truckee River and Marsh may result in increased populations of non-native fishes to the detriment of LCT recovery
- Lack of genetic diversity and small population size in LCT populations
- Population introgressed with rainbow trout

Data Gaps

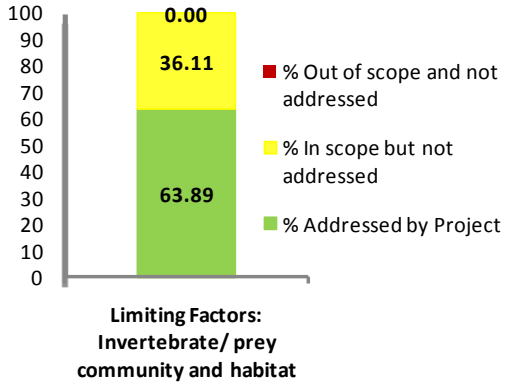
- Will LCT populate the lower river on their own if competition/predation from non-native fishes is addressed?
- Watershed-wide data is needed to quantify fish community structure
- Identify and evaluate potential migration barriers between headwaters and Lake Tahoe

Opportunities

- Considerable resources and effort are being devoted to restore the Upper Truckee River. Stated goals and objectives should dramatically improve habitat in the lower watershed potentially allowing recolonization by LCT throughout the watershed after later phases
- Bass and bluegill may take advantage of restored habitats in the lower watershed and should be addressed in all of the alternative restoration plans.
- Management and control of non-native fishes will complement habitat restoration efforts associated with this project

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 63.9%
Limiting factors addressed relative to project scope: 63.9%



Project effects and site condition

- Planned project activities will temporarily disturb invertebrate production, abundance, diversity, and community structure, however it is anticipated (and supported by the scientific literature) that rapid post project recolonization will occur and ultimately the project will improve invertebrate habitat and community structure to be more similar to the historical condition
- The intended restoration activities may disrupt habitat and reproduction of native minnows and other fishes that currently inhabit the lower reaches of the Upper Truckee River

Persisting concerns

- The disturbance created by restoration activities will negatively affect invertebrate populations and community structure in the short term
- Has of will enough baseline data be collected before the project initiation to address concerns about the effects on invertebrate communities
- Will non-salmonid native fishes be negatively impacted by planned restoration activities? How can this be minimized?

Data Gaps

- Comprehensive data on non-salmonid native fish communities in the watershed is lacking
- Comprehensive data on invertebrate communities in the watershed is lacking

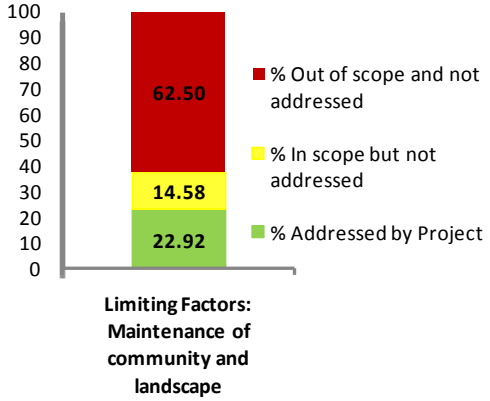
Opportunities

- Planned pre and post monitoring should address the majority of questions and data gaps regarding fish and invertebrate community structure in the watershed
- Anticipating and minimizing disturbance to existing fish and invertebrate communities during restoration activities

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape

Limiting factors addressed by project: 22.9%
Limiting factors addressed relative to project scope: 61.1%



Project effects and site condition

- Planned project activities primarily target stream habitat restoration including
  - Geomorphic restructuring of damaged channels
  - Reconnecting floodplains

  - Raising water tables
  - Increasing lost sinuosity
  - Increasing wet meadow and riparian vegetation
  - Stabilizing banks and creating self-sustaining heterogeneous habitats
  - Improving water quality
- LCT and native fish are a concern and motivation for this restoration, but the plan takes a broader view including a wide variety of fish, wildlife and habitat values (see goals and objectives above)

Persisting concerns
- Non-native vegetation such as Eurasian Milfoil may take advantage of habitat restoration and provide habitat for undesirable fish species like bass and bluegill
- Control of non-native salmonids is not addressed in this restoration and will be a key factor in whether LCT colonize the restored reaches.

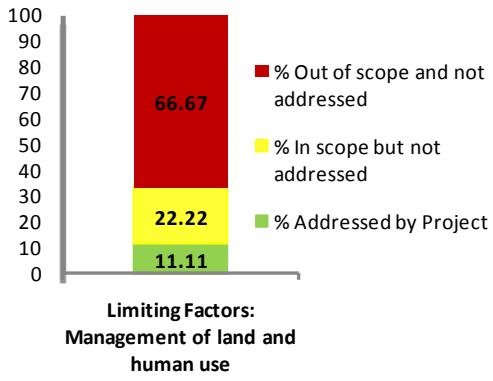
Data Gaps
- Risk analysis of the potential positive effects of the planned restoration on undesirable non-native species

Opportunities
- Scoping and assessing options for non-native species control and management
- Initiate dialogue with DFG and FWS regarding the potential of non-native species enhancement and the need for barriers or weirs, etc. to prevent colonization

Management of Land and Human Uses

Limiting factors addressed by project: 11.1%

Limiting factors addressed relative to project scope: 33.3%



Project effects and site condition
- Most timber harvest and grazing has already been eliminated in the basin
- Human use in the area is entrenched (i.e., housing developments, boat marinas, paved roads, airport, etc.) and will not be affected by the restoration, though the majority is downstream of the restoration site

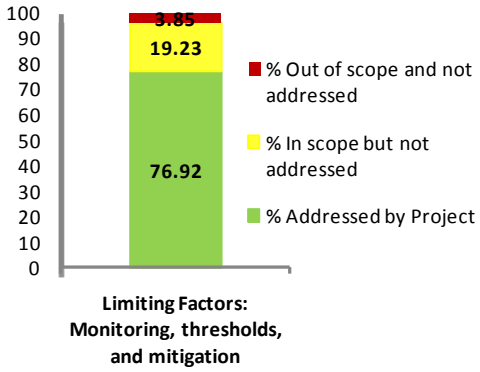
Persisting concerns
- Water quality from urban runoff, roads
- High E. coli readings potentially linked to pet feces (popular dog walking area)
- Recreational use damaging restored stream banks

Data Gaps
- Well studied, but creel and recreational use surveys might be beneficial

Opportunities
- Plan addresses these concerns

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 76.9%
Limiting factors addressed relative to project scope: 80.0%



Project effects and site condition

- The objectives will be measured through project effectiveness monitoring. The project monitoring plan describes specific monitoring variables that will provide measurable information on each project goal and objective
- The design is based on an extensive amount of surveys, data analysis, and modeling. Input on alternative development and evaluation was provided by a variety of technical experts in the public, private, and academic sectors.
- A detailed monitoring plan has been developed for the project and is available upon request (Conservancy 2008). This comprehensive monitoring plan describes a 10-year period of monitoring for the overall project to:
    - characterize baseline conditions
    - track project performance related to objectives
    - establish tentative approaches to monitor for regulatory requirements and construction impacts
    - provide information to direct adaptive management
- The monitoring plan has been: coordinated with prior, existing, and anticipated monitoring to the extent practicable; prepared to be consistent with the Upper Truckee River Watershed Advisory Group's (UTRWAG) guidance on monitoring plans for Upper Truckee River (UTRWAG 2007); and designed to document the Project's contributions to attainment of TRPAs relevant biological and physical threshold carrying capacities.
- Some pre-project (baseline) monitoring has occurred and will continue until project construction. Post project monitoring will occur for several years after construction.
- Project monitoring reports will be available, and raw data can be made available upon request.

Persisting concerns

- Monitoring plan specifically addresses invasive plant species, but not animals. This is out of the scope of the restoration plan, though the restoration could have far-reaching implications for aquatic invasive species

Data Gaps

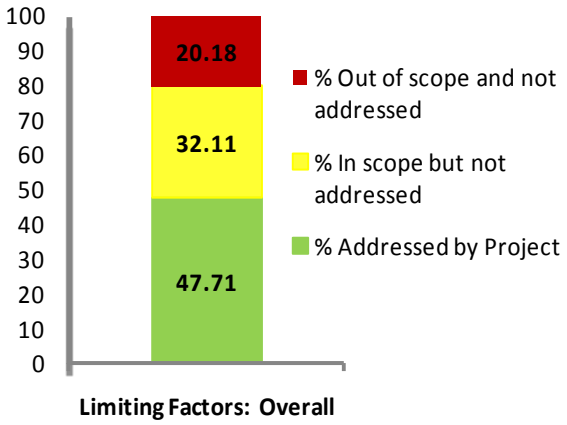
- The potential positive effects of the restoration on undesirable non-native species (animals)
- Baseline pre-project fish monitoring

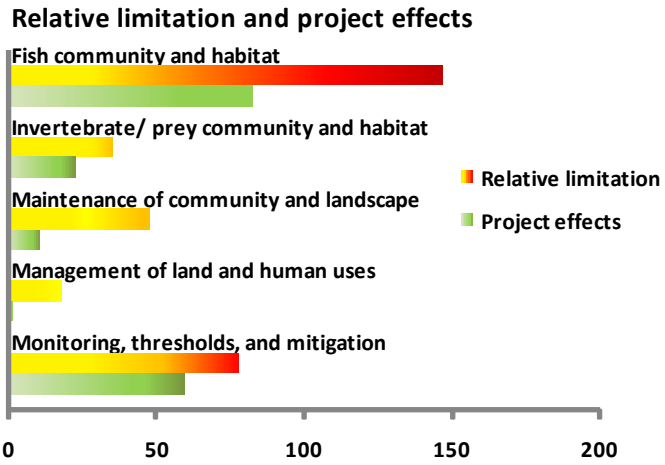
Opportunities

- Pre-project baseline data can be used to assess the effect of the restoration on non-native species
- Further investigation into the logistics of reintroducing LCT into the lower reaches of the Upper Truckee and extending the Meiss Meadows Population further downstream

Overall Findings and Key Points

Limiting factors addressed by project: *47.7%*
Limiting factors addressed relative to project scope: 59.8%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

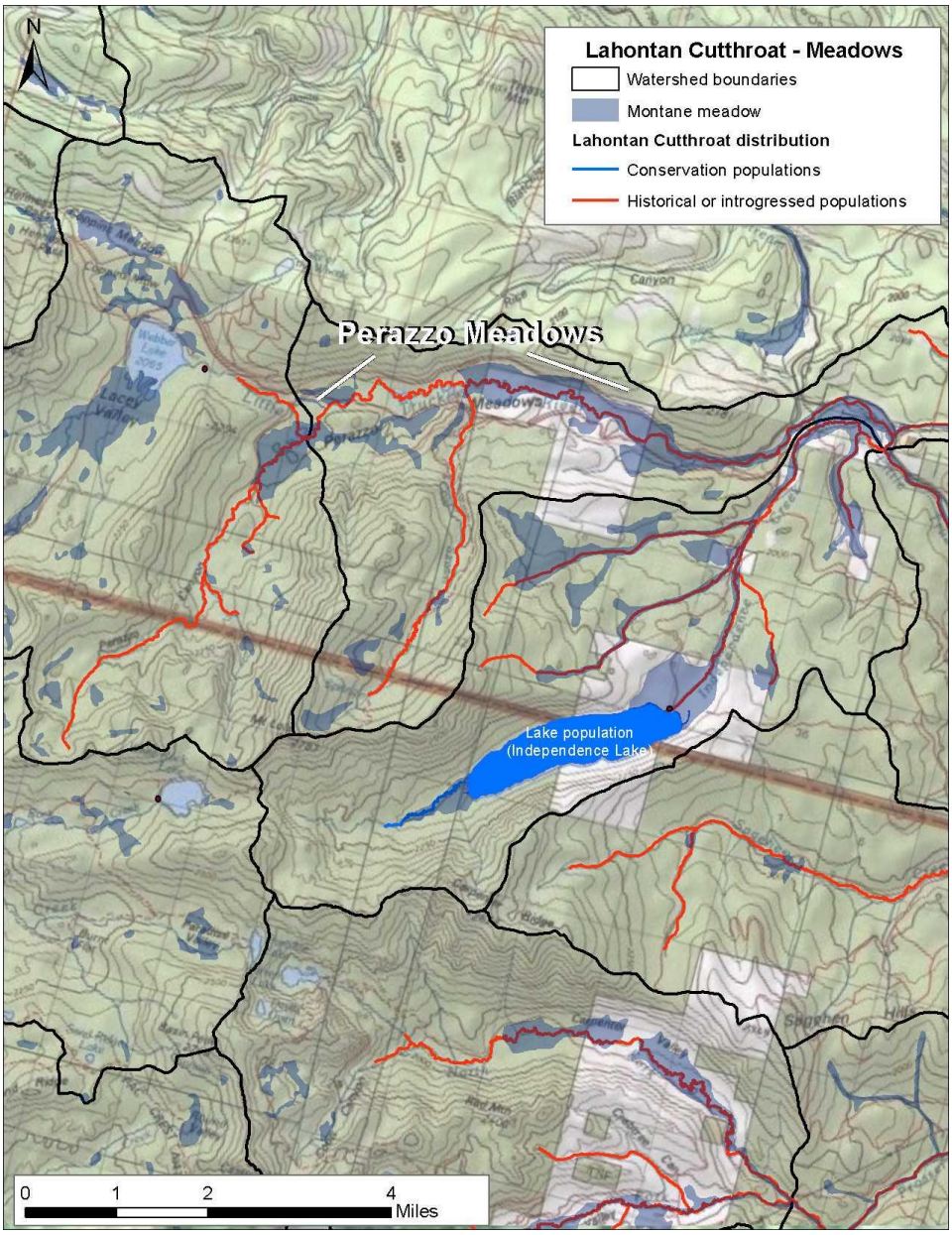
Species condition in project area:	Poor, LCT are extirpated from project reach
Area of greatest gains:	Water quality, hydrologic function, protection and enhancement of biodiversity
Most significant actions:	Geomorphic channel restructuring and vegetation restoration
Area of greatest need:	Habitat rehabilitation, channel reconstruction, hydrologic function
Highest priority concerns:	The effect of the restoration on undesirable non-native species

Highest priority opportunities:

- Monitoring to assess the potential for invasive species colonization of new habitat
- Preventing colonization into the restored areas by bass and bluegill from the Tahoe Keys area
- Pre-project monitoring of all resources

Species: **Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*)**
Location: **Little Truckee River, Tahoe National Forest**
Regional Contact(s): **Deborah Urich and Randy Westmoreland (USFS, Tahoe NF), Beth Christman (Truckee River Watershed Council)**
Project: **Perazzo Meadows restoration project**
Timeframe: **~2009-present**

Project area map



Associated documentation, research, and data sources

- Study of fish present (USFS, Deborah Urich)
- Study on stream invertebrate diversity (USFS, Deborah Urich)
- Personal communication with Deborah Urich (USFS) and Beth Christman (Truckee River Watershed Council)
- USFWS Lahontan cutthroat trout webpage: http://www.fws.gov/nevada/protected_species/fish/species/lct.html
- Short-term Recovery Action Plan for Lahontan cutthroat trout within the Truckee River Watershed. Accessible at http://www.fws.gov/nevada/protected_species/fish/documents/lct/final_trit.pdf

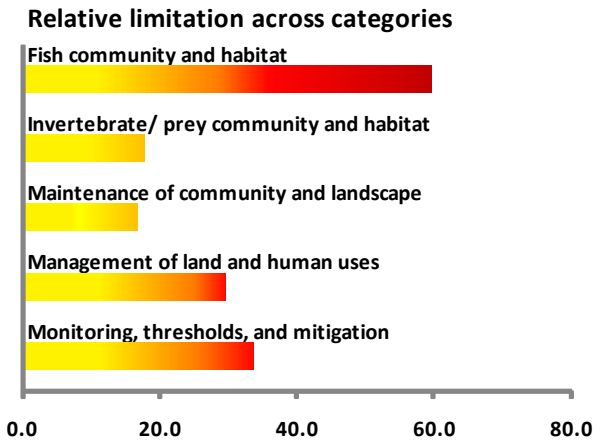
Restoration overview

- Main restoration actions include 1) Plug and Pond project in 2 reaches, in planning stages in 3rd reach
- Restoration targeted primarily at improving meadow function
- Project proposes to construct a more natural channel that will improve fisheries conditions however, this is not the current project priority
- Addressing road decommissioning in project

Background on site, landscape, and species condition

Project site

- 100 years of deterioration caused by dairy operations at the turn of the century. There are indications that the dairy operators diverted the stream from its original channel initiating a chain of events leading to the meadow deterioration (erosion/incision, dropped water table)
- Grazing continues, but is tightly controlled



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

Climate considerations

- Lake Tahoe area climate predictions include
  - More precipitation falling as rain rather than snow
  - Potential flooding from rain on snow events
  - Less surface water available in the summer season
  - Increased fuel loading, forest stand density
  - Higher risk of high intensity crown fires

Species condition

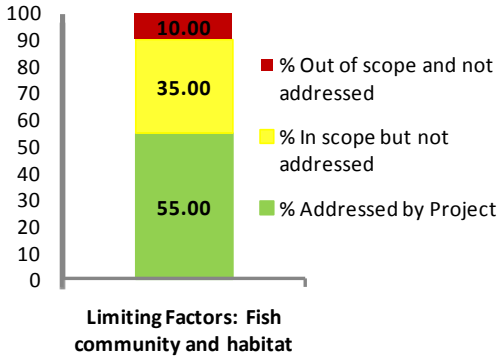
- The affected reach contained LCT historically however, current populations have been extirpated.
- A population of native non-game fish exist along with brook trout in diminishing numbers due to limited habitat

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 55.0%
Limiting factors addressed relative to project scope: 61.1%



Project effects and site condition

- Restoration work is in progress:
  - Challenged by whether gravel is natural in a meadow system
  - Change in stream type and function associated with plug and pond construction
- Overhanging riparian vegetation and other cover increased
- Improvements to water quality can be inferred (though not confirmed) from improved vegetation, physical characteristics, and meadow function.
- Major increase in stream access to floodplain and inundated areas during runoff.

Persisting concerns

- Lack of connection to larger watershed due to upstream and downstream dams (Stampede, Boca, and Webber).
- Non-native competitors
- Very short-term pre-project data collection and not collected on all aspects

Data Gaps

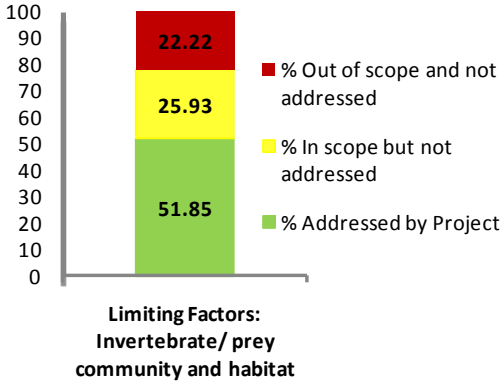
- Historical LCT community structure used for reintroduction study

Opportunities

- Prioritize fishery more in restoration plans, especially LCT reintroduction opportunities
- Initiate a dialog for LCT reintroduction
- Collect adequate post-project data

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 51.9%
Limiting factors addressed relative to project scope: 66.7%



Project effects and site condition

- *Truckee River Watershed Council sampled for BMI with only 500 bugs collected*
- *With improved habitat conditions abundance and diversity could be enhanced*

Persisting concerns

- Impacted water quality due to excess fines

- Potential impact to invertebrate density, distribution, community composition, and habitat.

Data Gaps

- Unknown condition of invertebrate community, including production, density, and distribution relative to previous or reference conditions due to discrepancy in the methodologies and objectives of historic versus more recent invertebrate surveys.
- Unknown whether adequate invertebrate production is occurring to support fish population
- Unknown invertebrate prey availability relative to historic. However, data has been collected for most other streams in the Truckee River watershed (within Ca.).

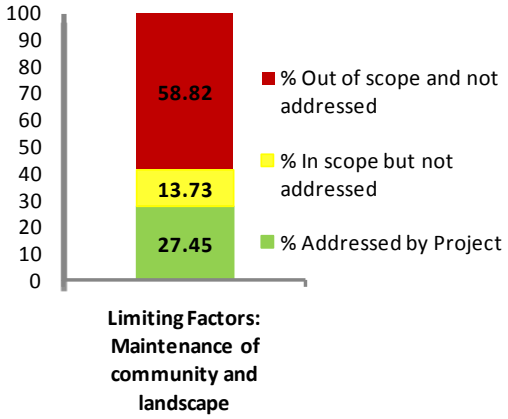
Opportunities

- Develop bioenergetics model for species and evaluate current invertebrate food supply against needs based on physical habitat parameters and population size.

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape

Limiting factors addressed by project: 27.5%
Limiting factors addressed relative to project scope: 66.7%



Project effects and site condition

- Primary goal of restoration is to improve meadow function and water quality
- Basic fish and benthic macro-invertebrate monitoring has occurred as a baseline pre-restoration

Persisting concerns

- Risk of minimized ground water storage as a result of climate change.
- Risk of fire and associated impacts to water quality due to fire fuels

Data Gaps

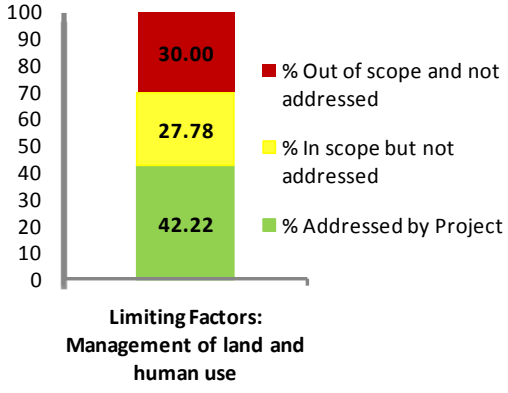
- Aquatic community and species population structure not monitored. Why declines?
- Poor understanding of nutrient impact during grazing and change since current grazing management enacted.
- Poor understanding of sedimentation risk relative to current WQ and species tolerance

Opportunities

- Potential opportunity for continued fuels management to reduce risk of impact from fire
- Potential to enhance back water pools and habitat for fishery
- Potential opportunity to do more to reduce OHV use

Management of Land and Human Uses

Limiting factors addressed by project: 42.2%
Limiting factors addressed relative to project scope: 60.3%



Project effects and site condition

- There is still grazing throughout Perazzo, limited timing and numbers. Recently restored areas are retired from the

grazing rotation for minimum of 3 years, grazing not resumed until meadow fully recovered. Decreased runoff from OHV impacted roads near site.

Persisting concerns

- Risk of fire due to high fuel loads and no large fire for many years
- Risk of conifer encroachment in unrestored, lower reaches, though too wet in restored reaches
- OHV use

Data Gaps

- Impacts of OHV use

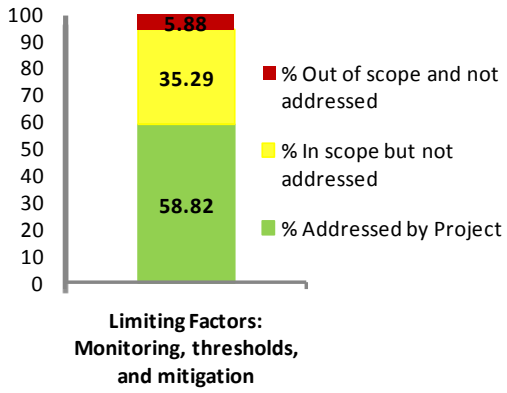
Opportunities

- Manage fuel loads to decrease risk of impact from fire
- Investigate/ monitor conifer encroachment and develop and implement treatment plan.
- Investigate aspen stand loss and develop restoration approach.

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 58.8%

Limiting factors addressed relative to project scope: 62.5%



Project effects and site condition

- Water quality and BMI from Truckee River Watershed Council

Persisting concerns

- No existing thresholds established for species or ecosystem,
- No on-going fisheries monitoring

Data Gaps

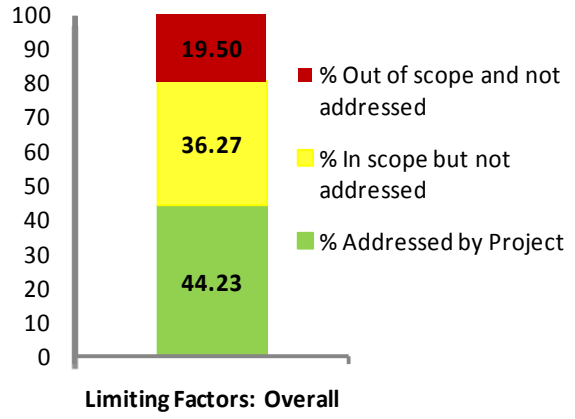
- More on aquatic community and in relation specifically to LCT

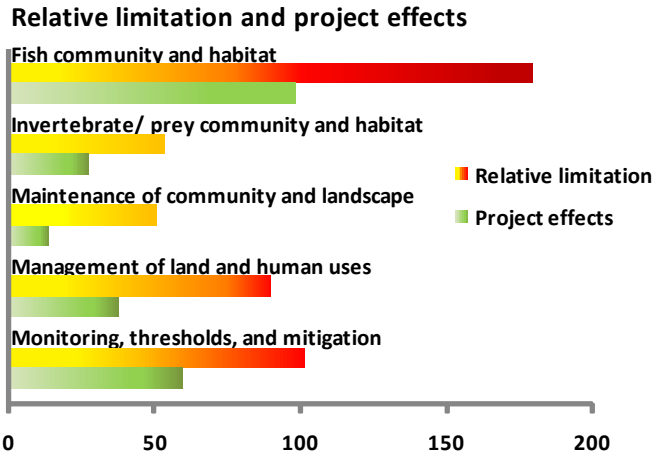
Opportunities

- Establish and monitor for population, water quality, and ecosystem condition thresholds

Overall Findings and Key Points

Limiting factors addressed by project: 44.2%
Limiting factors addressed relative to project scope: 54.9%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

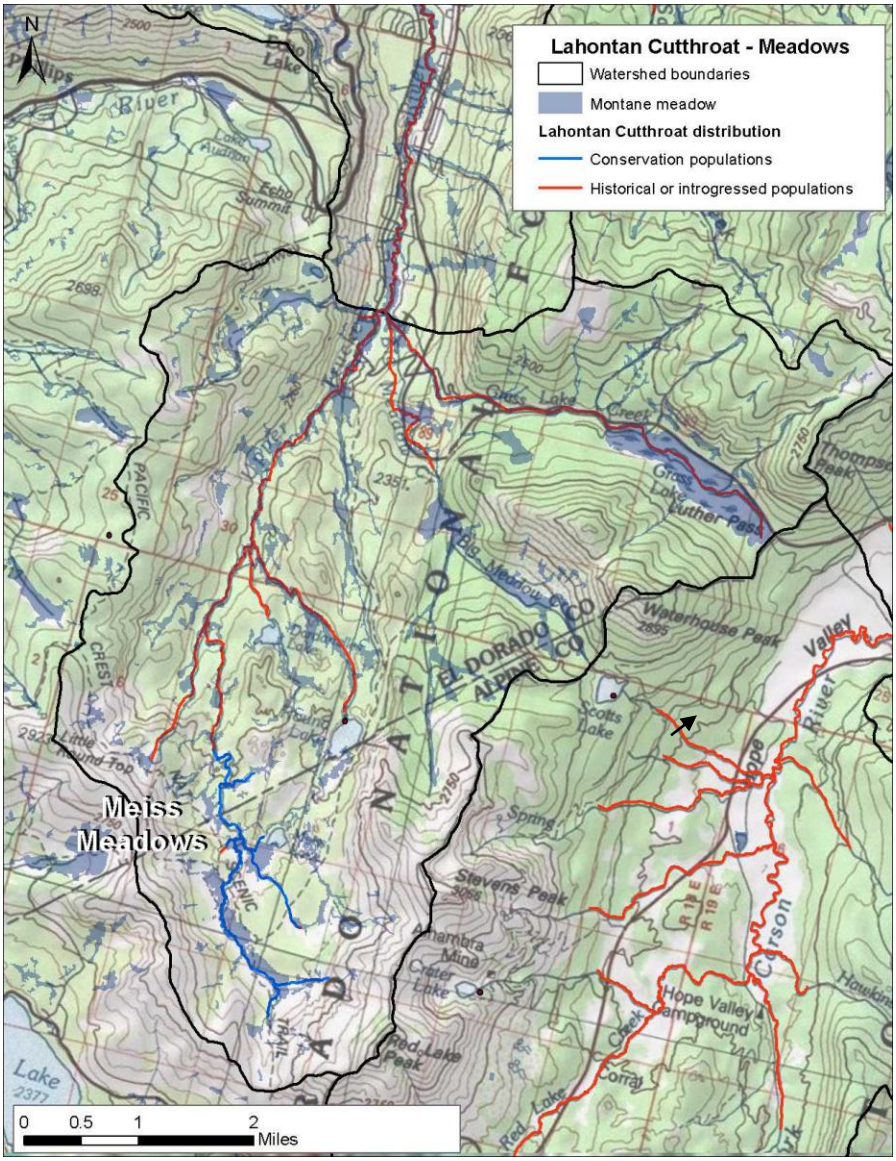
Species condition in project area: LCT not present and existing fish declining
Area of greatest gains: Invertebrate/ Prey Community and Habitat
Most significant actions: Removal of OHV roads and regaining meadow function
Area of greatest need: Coordination with LCT recovery team
Highest priority concerns: Regrazing, Fire, Lack of connectivity

Highest priority opportunities:

- Manage fuel loads and encroaching conifers to prevent potential damage from fire
- Investigate invertebrate community relative to historic (grazing) era
- Examine fish community declines in more detail
- Explore opportunity for LCT reintroduction

Species: **Lahontan Cutthroat Trout (*Oncorhynchus clarki henshawi*)**
Location: **Meiss Meadows**
Lead Organization and Sponsor: **California Department of Fish and Game; USFS Lake Tahoe Basin Management Unit; US Fish and Wildlife Service**
Regional Contact(s): **Richard Vacirca, Sarah Muskopf, US Forest Service**
Project: **Meiss Meadows**
Timeframe: **Late 1980s to 2012**

Project area map



Associated documentation, research, and data sources

Forest Service and EPA documents

- http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm9_046019.pdf
- http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm9_045961.pdf
- http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm9_045999.pdf
- http://water.epa.gov/polwaste/nps/success319/ca_bigmeadow.cfm

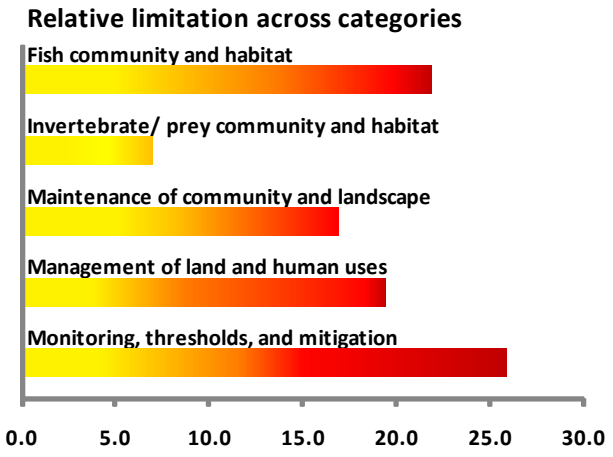
Restoration overview

- Primary restoration strategy for LCT is to expand local range through the removal of introduced salmonids (brook trout)
- Chemical treatment (rotenone) to remove non-native brook trout 1989, illegally reintroduced in early 1990s by anglers
- Reintroduction of Lahontan cutthroat trout (LCT) in the late 1980s and early 1990s
- Start of manual fish removal in 1996 due to illegal introduction of brook trout 7 years post-original rotenone treatment
- In 1999 Forest Service revoked all grazing permits in the Meiss Meadows area based on continued water quality violations (fecal coliform) since at least the 1990s after numerous attempts to bring allotments into compliance with iterative implementations of best management practices. No grazing since.
- Manual (electrofishing) removal of brook trout completed in 2009
- Non-native fish removal efforts cover four miles of the Upper Truckee River (headwaters) and approximately eight acres of Meiss Lake and Four Lakes down to a natural barrier (falls)
- The project objectives are to provide potential for the expansion of the Meiss Meadow population, remove the non-native brook trout, and monitor the progress and restoration of self-sustaining LCT populations in the Upper Truckee River.

Background on site, landscape, and species condition

Project site

- Meiss Meadows and the associated lakes are located on US Forest Service land and form a complex of wet meadow habitat that is saturated with standing surface water in the spring and early summer that allows fish passage between lakes and streams. Riparian vegetation and channel condition factors continue to recover in post-grazing era
- Brook trout removal was completed in 2009 in the Meiss Meadows area. The downstream expansion area was initiated in 2008 and spot checking (electrofishing) is projected to continue until 2020



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

Climate considerations

- Lake Tahoe area climate predictions include
  - More precipitation falling as rain rather than snow
  - Potential flooding from rain on snow events
  - Less surface water available in the summer season

- Increased fuel loading, forest stand density
- Higher risk of high intensity crown fires

Species condition

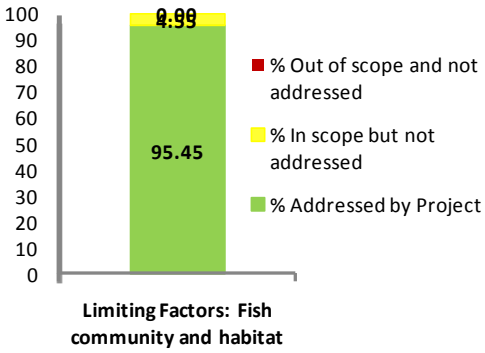
- Meiss Meadows is the only known reproducing population of LCT in the Lake Tahoe basin, although restoration efforts at Fallen Leaf Lake may result in an additional spawning population
- The population ranges from 1500-3000 individuals occupying approximately 6 miles of stream habitat and 90 acres of lake habitats
- More recent population estimates are approximately 151-400 LCT per mile
- The population is genetically bottlenecked

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 95.5%
Limiting factors addressed relative to project scope: 95.5%



Project effects and site condition

- Continuous brook trout eradication program since 1996 following successful 1989 rotenone treatment, but set back by illegal reintroduction of brook trout
- Completion of electrofishing efforts to remove brook trout in Meiss Meadows area in 2009
- Brook trout removal in downstream expansion area below Meiss Meadows (see map) will hopefully allow further downstream colonization by LCT
- Some brook trout still present in expansion area, but electrofishing in Meiss Meadows area indicates near total eradication
- Removal of all livestock grazing in 1999 has improved water quality, bank stability, channel geomorphology, stream shade, and sedimentation
- Natural barriers preclude upstream migration by all fish size classes. Downstream movement to Lake Tahoe is feasible and has been observed; natural barrier precludes return to Meiss meadows. Fish movement data within the meadow itself is limited

Persisting concerns

- Illegal reintroduction of brook trout by anglers remains a threat
- LCT genetic diversity is limited in this population
- No longer expressing adfluvial life history. Potential connectivity to local lakes, but historic use unknown.
- A natural barrier is currently used to protect existing LCT populations from non-native trout. There is currently no goal identified to reconnect LCT in the Upper Truckee River as the existing network of non-native salmonids would preclude reproduction and rearing.
- Ability to naturally persist through potential natural stochastic events such as wildfire or post-fire erosion

Data Gaps

- Genetic level data on the population

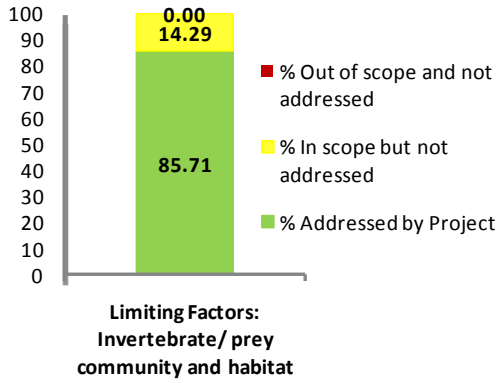
  - Amount of genetic diversity—Originally stocked with Macklin Creek strain LCT, then later supplemented with Independence Lake strain
- Moderately networked. Viable population in relationship to occupied streams has not been determined
- Population structure across a variety of habitat types (i.e., low gradient streams in meadows vs. high gradient streams in narrower valley types.

Opportunities

- With continued brook trout eradication, the opportunity exists to connect lower river segments to Meiss Meadows and further expand occupied LCT habitat
- Restoration work and non-native fish control lower in the Upper Truckee basin may eventually result in a full reconnection to Lake Tahoe and the expression of all life history forms, although this has not yet been identified as feasible

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 85.7%
Limiting factors addressed relative to project scope: 85.7%



Project effects and site condition

- Invertebrate and prey community not well studied in Meiss Meadows area, but the assumption is that there has been a positive response with removal of grazing
  - Brook trout removal releases invertebrate and prey community from predation pressure
  - Elimination of cattle grazing and the subsequent improvement to water quality, bank stability, riparian and meadow vegetation, and reduced siltation all have positive effects on invertebrate and prey communities

Persisting concerns

- NA

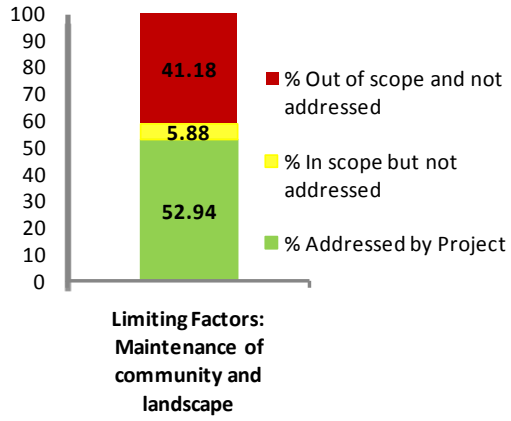
Data Gaps

- Little comprehensive data on foodweb structure, invertebrate communities, and the response to the restoration exists
- No known data regarding invertebrate community structure prior to rotenone treatments in 1989 and how invertebrate communities have recovered

Opportunities

- Foodweb information could be useful for the continued expansion of LCT occupied areas.
- Invertebrate sampling could inform water quality concerns
- Comparison of foodweb structure in brook trout occupied vs. LCT occupied areas would provide useful information for other restorations

Maintenance, management, monitoring, and mitigation



Maintenance of community and landscape

Limiting factors addressed by project: 52.9%
Limiting factors addressed relative to project scope: 90%

Project effects and site condition

- Elimination of cattle grazing has resulted in a significant improvement of water quality
    - Fecal coliform counts are within EPA standards
    - Reduced siltation
    - Stabilized banks
    - Improved riparian and meadow vegetation
- A natural barrier prevents upstream fish movement into Meiss Meadows
- Assessments, inventories, and monitoring of the aquatic habitat were completed in the 1990s. Stream monitoring has continued, with the establishment of a stream condition inventory (SCI) monitoring and meadow trend transects.
- NEPA EIS/EIR completed for expansion areas in 2008

Persisting concerns

- The occupied area is small and the population is vulnerable to stochastic events such as flood or fire

Data Gaps

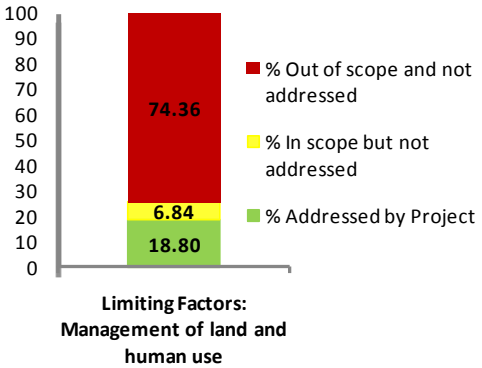
- NA

Opportunities

- Continue to monitor all aspects of the ecosystem as the recovery continues
- Address downstream barrier issues as brook trout removal continues and look for opportunities to connect Meiss Meadows with downstream LCT expansion area
- Study local LCT genetics and selectively enhance the population with individuals of an appropriate strain
- Proposed conifer removal in Meiss Meadows in the next phase of the project
- Study and plan for anticipated climate change impacts

Management of Land and Human Uses

Limiting factors addressed by project: 18.8%
Limiting factors addressed relative to project scope: 73.3%



Project effects and site condition

- Grazing has been eliminated after management tried and failed to reduce fecal coliform counts
- Meiss Meadows is in a roadless Forest Service area where ATV use, timber harvest, dams and diversions, and private lands are not a factor

Persisting concerns

- Impacts from recreational use

- Erosion
- Inappropriate trails
- Water quality degradation from improper camping
- Illegal angling
- Reintroduction of brook trout or other non-natives by anglers
- Conifer encroachment into meadow system

Data Gaps

- NA

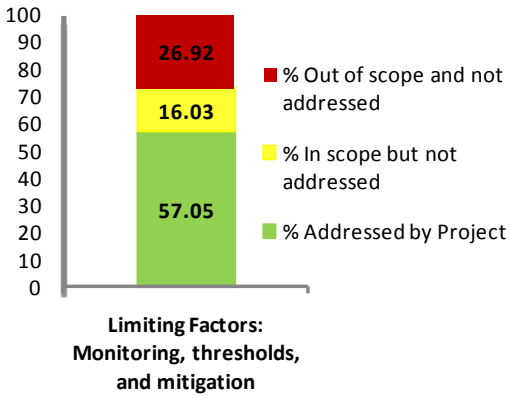
Opportunities

- Continue outreach and education with public and recreational users
- Wild and Scenic eligibility
- Re-establish historical meadow boundary by managing conifers and reintroducing fire

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 57.1%

Limiting factors addressed relative to project scope: 78.1%



Project effects and site condition

- Non-native salmonids have been eradicated from Meiss Meadows area, though continued monitoring is needed. Eradication program is ongoing in the expansion area. Other issues such as whirling disease are addressed in other indirect public education forums
- Riparian and herbaceous vegetation and channel condition has recovered with removal of grazing. Follow up treatments are anticipated to maintain meadow function
- Potential for further genetic studies
- Invertebrate monitoring will take place but is linked to another, basin-wide, monitoring project

Persisting concerns

- Small population size and genetic bottlenecking may have adverse effects to the Meiss Meadows population of LCT
- Stochastic events such as fire or flood could impact LCT in Meiss Meadows
- Climate change impacts are hypothesized but remain unknown factor

Data Gaps

- Specific factors of climate change are still uncertain

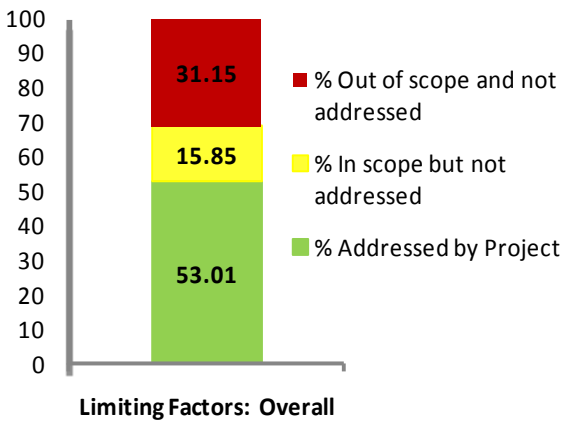
Opportunities

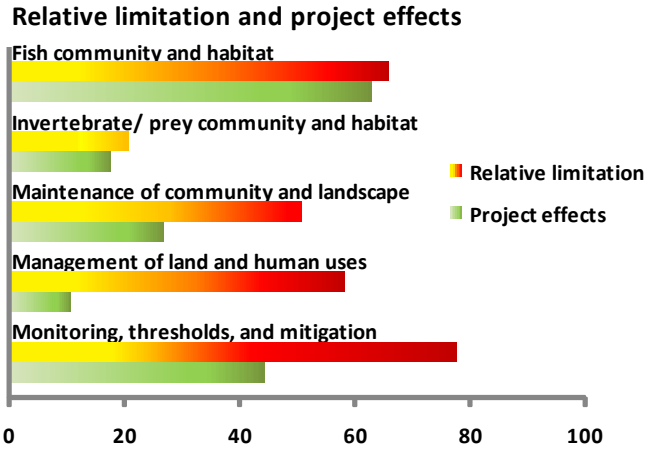
- Continued research on reproduction and habitat use by LCT in Meiss Meadows and the expansion area downstream
- Continued removal of brook trout and other competitive non-native fishes throughout the Upper Truckee River
- Continued public outreach and education to maintain support for the project
- Little data or reporting on the results of Meiss Meadows monitoring and studies is easily available to the public. This should be remedied.

Overall Findings and Key Points

Limiting factors addressed by project: *53.0%*

Limiting factors addressed relative to project scope: 77.0%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

Species condition in project area: Good; Population growing and naturally reproducing; Increased habitat will become available as brook trout eradication continues in the expansion area

Area of greatest gains: Well established population of wild LCT that is reproducing naturally

Most significant actions: Brook trout eradication in Meiss Meadows and further expansion of eradication project downstream
Elimination of livestock grazing in the Meiss Meadows area

Area of greatest need: Continued brook trout eradication and monitoring and further expansion of eradication project downstream
Population genetics studies of the Meiss Meadows LCT population and appropriate stocking to improve fitness and genetic diversity

Highest priority concerns:

- Lack of genetic diversity, small isolated population
- Ability to persist as a result of potential stochastic events

Highest priority opportunities:

- Population structure studies of the LCT in Meiss Meadows and appropriate management practices to improve fitness and genetic diversity (i.e., stocking, habitat, etc.)
- Continued brook trout eradication and monitoring and continuance of eradication project downstream

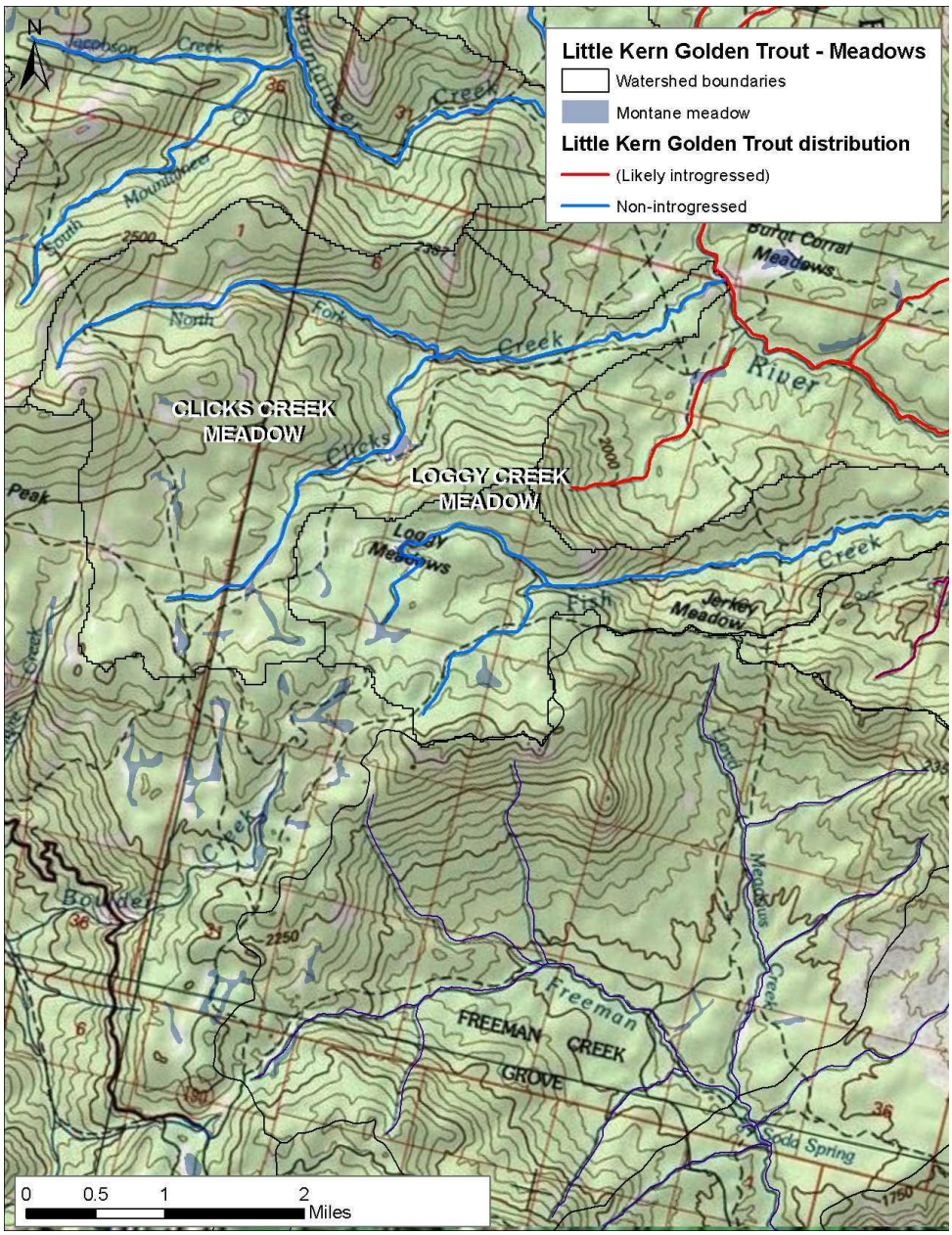
Appendix

YEAR	NUMBER OF BROOK TROUT CAUGHT	LCT POPULATION ESTIMATES	COMMENT
1996	20	3251	7 years post-original rotenone treatment – Start of manual fish removal
1997	464	2189	Initiate target removals during fall spawning (Sept – Oct)
1998	256	4068	
1999	121	3207	
2000	156	2062	
2001	656	4393	
2002	52	3656	
2003	5	3965	
2004	16	3544	
2005	7	3719	
2006	2	Not yet known	SNPLMA Round 6 funding
2007	0	Not yet known	SNPLMA Round 7 funding

Table A1. Data on brook trout removal and estimated LCT populations from US Forest Service Report on SNPLMA funded brook trout removal

Species: **Little Kern River Golden Trout (*Oncorhynchus mykiss whitei*)**
Location: **Loggy Meadow/Fish Creek, tributary to Little Kern River, Sequoia National Forest**
Regional Contact(s): **Terry Kaplan-Henry (USFS, Sequoia NF)**
Project: **Loggy Meadow Restoration Project**
Timeframe: **2006-2008**

Project area map



Associated documentation, research, and data sources

- Study on climate change vulnerability in the region, Mallek and Safford (2011)
- Personal Communication with Sequoia National Forest Hydrologist staff – Joshua Courter, Terry Kaplan-Henry, and Kyle Wright.

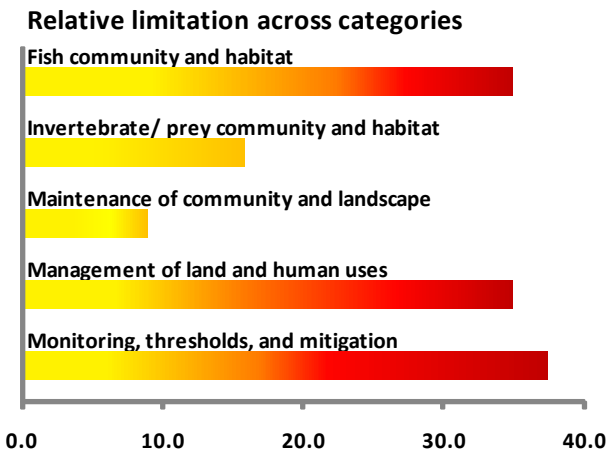
Restoration overview

- The Loggy Meadow restoration project is a joint effort between WildPlaces and the U.S. Forest Service to restore the meadow's hydrology and ecology to a healthy state.
- Main restoration actions include 1) Fencing off the meadow and stream to cattle, 2) Securing hay bales to the stream banks to slow erosion, create undercut banks, and restore a narrower and deeper channel, and 3) Planting willows to add riparian vegetation and cover for aquatic species.
- Secondary goal of restoration targeted to improve habitat conditions and viability of Little Kern River Golden trout in meadow.

Background on site, landscape, and species condition

Project site

- Loggy Meadow is on Fish Creek in the Giant Sequoia National Monument and drains into the Little Kern River in the Golden Trout Wilderness. It is located at around 7500′ elevation.
- This meadow has been actively grazed for almost a century and the absence of any permanent or temporary fencing has led to significant erosion of the stream banks and widening of the stream channel.
- Cattle trampled the riparian vegetation along the stream, allowing the soil to erode quickly.
- This meadow is still actively grazed; the project positively mitigated all negative impacts.



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

- The Loggy Timber sale that occurred in the early 80's was a significant harvest that added to the degradation of the meadow and down cutting of the stream channel.
- The meadow's water table dropped causing it to dry out.
- The meadow grows less grass, shrubs and forbs then historically present.
- Lodgepole pines have encroached in on the meadow.
- Loggy Meadow goes dry during most years and carries a large sediment load adding to the gullying and channel widening.
- Loggy Meadow is the headwaters of Fish Creek, a perennial tributary to the Little Kern River.
- There is no introgression of native Little Kern Golden Trout in Fish Creek, though trout do not occupy the Loggy Meadow section year-round, and are presumed to migrate to downstream habitats as the flow in this area decreases during the year.

Climate considerations

- Based on modeling study and synopsis by Terry Mallek and Safford (2011) the regions is:

- Moderate risk for increased winter flooding,
- High risk for fire regime change,
- Low risk for temperature change

Species condition

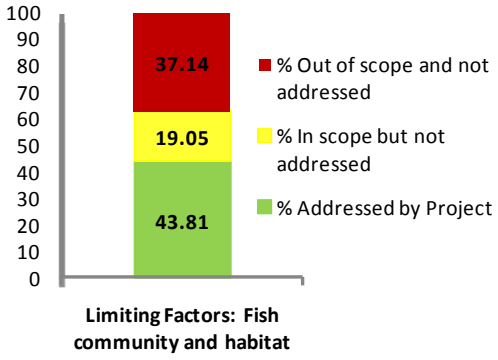
- The affected reach contains a resident population Little Kern River Golden Trout, with hybrid trout present downstream in Kern River mainstem.
- Population size and structure in Loggy Meadow are considered to be in poor condition because of degraded habitat that contributes to stream dewatering throughout meadow. Only 9.02 miles of habitat within Fish Cr. (assumes introgressed fish in mainstem Little Kern) supports fish.
- Data unavailable for exact densities in upper Fish Creek, but general density range-wide is 500 fish/mile, however densities in upper Fish Creek are considered much lower than range-wide numbers.
- In good water years this section stays wet and fish can access downstream habitats of lower Fish Creek and move throughout the system.

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 69.7%
Limiting factors addressed relative to project scope: 43.8%



Project effects and site condition

- Fish community structure is similar to historic community structure or that of reference streams/reaches.
  - CSI indicates that upper reaches of Fish Creek supported resident populations only (98% pure: length-weighted average for watershed)
- Restoration work has shown considerable ecological gains in Loggy Meadow, though without current fish monitoring, no empirical data exists that demonstrates direct benefits to Little Kern Golden Trout.
  - Flows in through Loggy Meadow are very low to dry still during some years (historically consistent).
  - Trout are observed occupying stream in wet months and travel downstream during periods of low flow.
- General habitat benefits include:
  - Habitat is now accessible at a variety of different flow levels.
  - Existing connectivity is relatively equivalent to historical connectivity (at least during certain flows).
  - Banks stability was greatly improved from degradation of past grazing/land uses.
  - Little gravel presently and no evidence for there ever having been a great deal of gravel in the system.
  - Channel is much less exposed than before with more overhanging willow vegetation surrounding the riparian corridor with additional undercut banks now present.
  - Shallow backwater habitats for juvenile rearing are considerably improved as stream reaches floodplain and top of meadow.

  - Hydrograph more consistent now and mimics what was historically present in Loggy Meadow.
- General water benefits include:
  - Dissolved Oxygen, conductivity, and other water chemistry components within the tolerances of all life history stages were improved from existing conditions. Monitoring validates this.
  - Mean turbidity within the tolerance of all life history stages for most of the year, with the exception of short periods during high flow events, improved drastically.
  - Deep pools now exist and the average depth greater and channel width much narrower (~50%).

Persisting concerns

- Lack of surrounding population to recolonize in the event of impact from some large event (e.g. fire)
- Existing check dam upstream not changed, creating barrier and restricts passage in upper watershed.
  - Passage issues might not be important because flows at this upper reach go dry for most of the year.
- Very high genetic risk from hybrid trout downstream with restored connectivity.
- Adequate flow - Throughout the year, to meet varying needs of all life cycle stages.

Data Gaps

- No information on tolerance of fish for turbidity, temp, DO, etc.
- No data available for population density or age or size class distribution. Data unavailable, general density range-wide of 500 fish/mile might not be appropriate for this region as well.

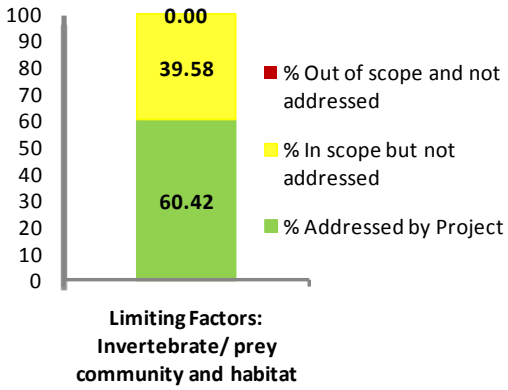
Opportunities

- Potential opportunity to use CDFG Wild Trout Crew to monitor Little Kern Golden Trout populations through Loggy Meadow to achieve a baseline.
- Monitoring for WQ parameters in system including temperatures, DO, turbidity, pH, etc.
- Investigate potential to modify in stream structures - rocks and large woody debris - to improve pool habitat.
- Investigate removing or altering structure of check dam upstream.
- Plant more riparian vegetation along stream to armor banks and provide shelter.

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 60.4%

Limiting factors addressed relative to project scope: 60.4%



Project effects and site condition

- Diversity of invertebrates similar to historic community/ structure of that of reference reach (Personal Comm. Kaplan-Henry).
- Diverse habitats available including emergent aquatic vegetation, decaying leaf matter, exposed substrates was improved from project and continues to improve with recent wet winters in the Southern Sierra.
- Water quality necessary to support ecosystem function, including temperature, turbidity, pH, etc. has been monitored by FS staff and considered restored in the system. The greatest gain was in turbidity and reduction in contaminants.

- Sequoia NF has pre and post-project monitoring to prove this.
- Removal of cows from the riparian corridor by fencing was paramount to achieving these improved results.

Persisting concerns

- Grazing in the upland habitats in the headwaters may continue to impact water quality. Cows still get their water from intermittent sections of the stream above the project area and out of the meadow.

Data Gaps

- Unknown condition of invertebrate community, including production, density, and distribution relative to previous or reference conditions due to discrepancy in the methodologies and objectives of historic versus more recent invertebrate surveys.
- Unknown whether adequate invertebrate production is occurring to support fish population.
- Unknown invertebrate prey availability relative to historic or other systems.

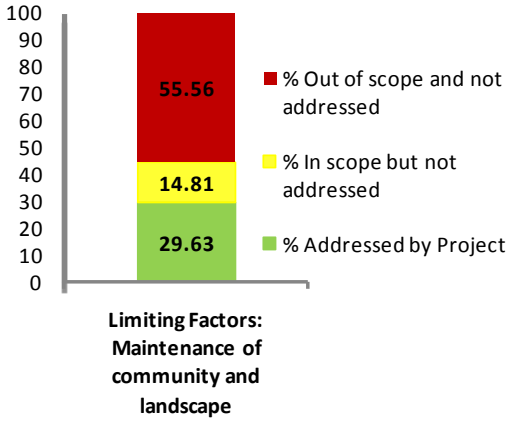
Opportunities

- Perform invertebrate study using methodology consistent with historic study in order to evaluate diversity, distribution, abundance, and production pre and post grazing removal.
- Develop bioenergetics model for species and evaluate current invertebrate food supply against needs based on physical habitat parameters and population size.

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape

Limiting factors addressed by project: 29.6%
Limiting factors addressed relative to project scope: 66.7%



Project effects and site condition

- Point and non-point sources of pollutants or TMDL substances, both major limiting factors, identified and mitigated by restoration and removal of grazing near riparian area.
- Physical connectivity disrupted by upstream check-dam and intensive grazing throughout White meadow. Physical connectivity disruption impedes immigration or emigration relative to this population, most of which will come from downstream population sources.
  - Restoration improved meadow function for improvements downstream where more critical population/ habitat are and eliminated any increased gullying in downstream habitats.
  - Impediments to movement also only local with populated water above and below barrier
- Sediment sources and fecal nutrients, both major limiting factors, eliminated from success of in-stream restoration and removal of cows/sheep.

Persisting concerns

- Wildfire risk due to earlier spring drying, especially high in places with fine fuels.
- Winter Flooding risk related to rain on snow events.

- Increased temperature risk related to summer warming.

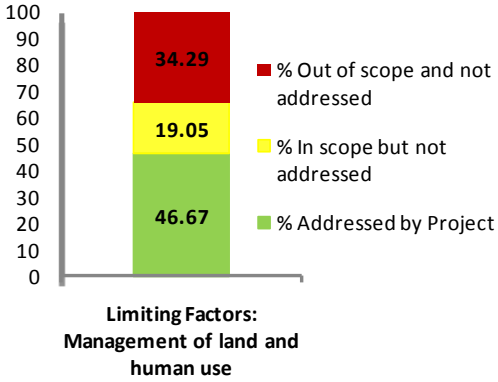
Data Gaps
- Aquatic community and species population structure not monitored
- Understanding of how downstream introgressed fish move throughout the Fish Creek system and what effect this restoration – restored connectivity - will have on this movement.
- Monitoring of upstream grazing affects.

Opportunities
- Potential opportunity for future fuels management to reduce risk of impact from fire.
- Planting more riparian vegetation to armor stream banks.
- Instream structure to add habitat for fish at various flow levels, especially low flow.

Management of Land and Human Uses

Limiting factors addressed by project: 46.7%

Limiting factors addressed relative to project scope: 71.0%



Project effects and site condition
- This area is still actively grazed, July 15th-Septmeber every year, however protection for stream channel, banks and water was managed by moving the cows/sheep out of riparian area by installing exclusionary fencing along the extent of the stream.
- Area designated federal Wilderness (though Wilderness designation allows for potential grazing)
- Meadow has restored its function and continues to improve every year reducing conifer encroachment.
- No plans for a significant timber sale in the upland/headwater habitat and fuel loads are low to moderate from a past sale in the 1980s.
- No current recreational angling occurs in Loggy Meadow at present.
- Check dam upstream is not maintained, but is thought to have lowest impact on fishes and hydrological function of downstream meadow.

Persisting concerns
- Stability of hay bales restoration technique during an extreme flow/rain on snow event.

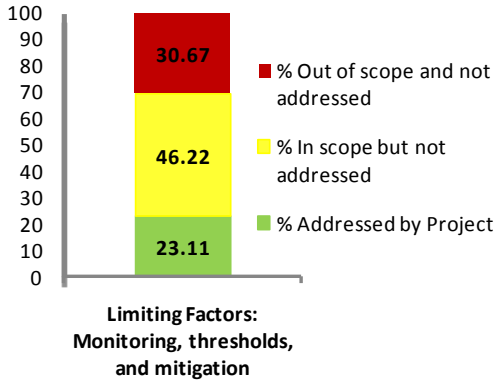
Data Gaps
- No baseline data on grazing impacts to water quality including fecal content of water. Important issue for future and potential to regraze

Opportunities
- Manage fuel loads to decrease risk of impact from fire.
- Robust aspen regeneration restoration project.
- Consider off water storage opportunities.

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 23.1%

Limiting factors addressed relative to project scope: 33.3%



Project effects and site condition

- Addressing and mitigating excessive trampling of stream banks, exposed soil, increased erosion, siltation of water, utilization of forage, headcuts/gullying, high fecal coliform counts and collapsing undercut banks was the primary purpose of this restoration project.
    - Restoration improved all of these limiting factors to tolerance or historic levels by removing grazing from the meadow and stabilizing/armoring the collapsing banks.
- One headcut from an upstream check dam exists but is monitored annually and appears to have stabilized and not having a negative impact on meadow. This check dam is outside of the meadow and is on an intermittent stream.

Persisting concerns

- Monitoring and enforcing permit requirement of active grazing allotment.
- Funding to maintain exclusionary fence.

Data Gaps

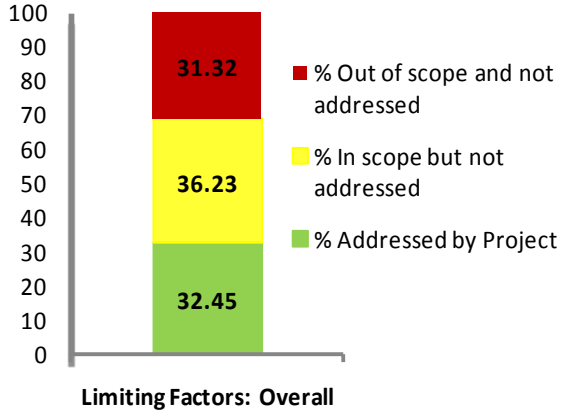
- Extensive pre and post project monitoring is done in Loggy Meadow. No know Data gaps for this section.

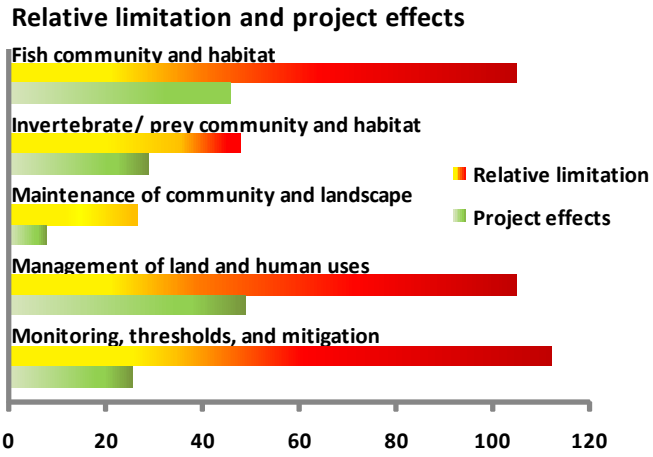
Opportunities

- Continue similar restoration techniques to downstream habitats.
- Continue all monitoring that has been completed to date.

Overall Findings and Key Points

Limiting factors addressed by project: 32.4%
Limiting factors addressed relative to project scope: 46.9%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

Species condition in project area: Low (historically low)

Area of greatest gains: Maintenance of community and landscape/ Management of Land and Human Uses

Most significant actions: Removal of cows from riparian area/Exclusionary fencing/In-stream bank stabilization/Planting willows/Monitoring

Area of greatest need: Fish Community and Habitat (though percentage somewhat skewed, CSI uses regional scores, and fish were never historic in Loggy Meadow in large numbers)

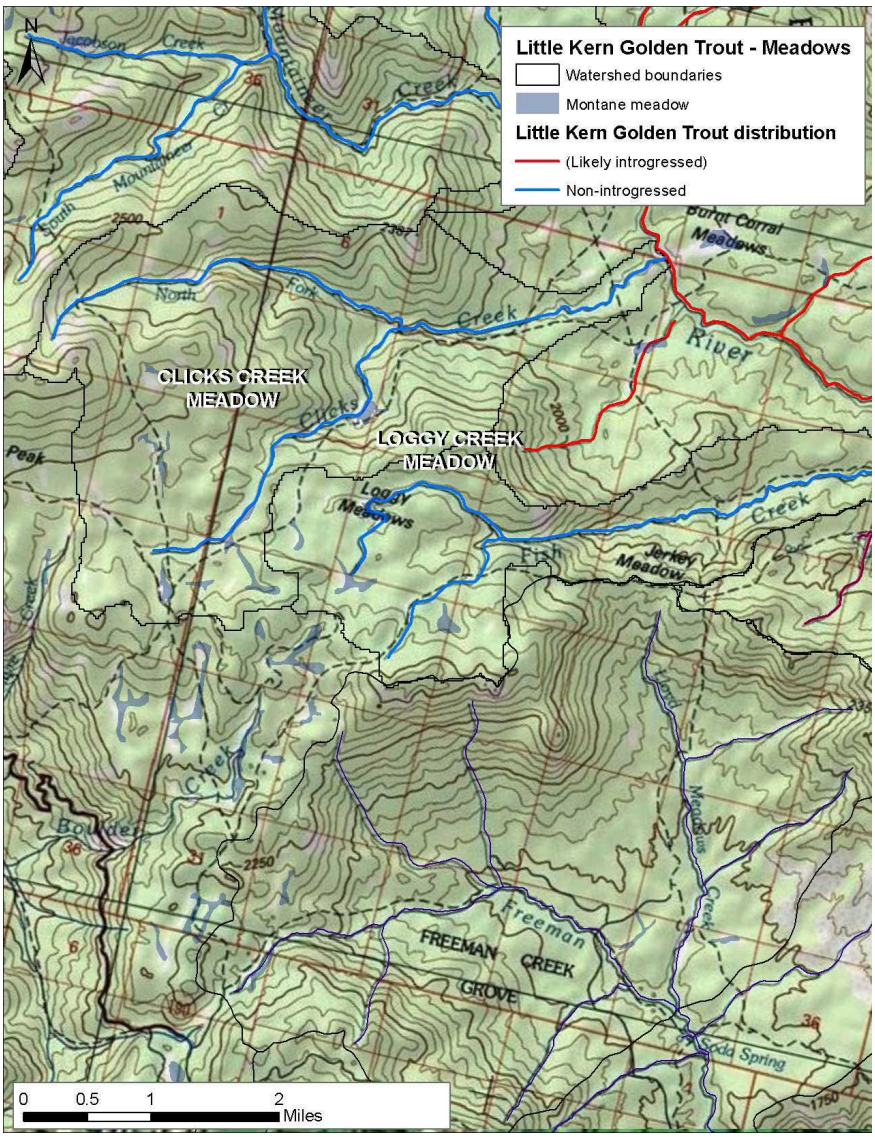
Highest priority concerns: Grazing, Fire/flood, Restored connectivity (hybridization from downstream populations)

Highest priority opportunities:

- Consider planting more willows and pursue an Aspen regeneration project for the meadow.
- Perform invertebrate study using methodology consistent with historic study in order to evaluate diversity, distribution, abundance, and production pre and post grazing removal. Compare to modern methodology.
- Develop bioenergetics model for species and evaluate current invertebrate food supply against needs based on physical habitat parameters and population size. Investigate physiological tolerance of species to WQ parameters
- Remove upstream check dam and restore area around the existing headcut.

Species: **Little Kern River Golden Trout (*Oncorhynchus mykiss whitei*)**
Location: **Clicks Creek/White Meadow, tributary to Little Kern River, Sequoia National Forest**
Regional Contact(s): **Terry Kaplan-Henry (USFS, Sequoia NF)**
Project: **Clicks Creek Check Dams Meadow Restoration Project**
Timeframe: **Check Dams Installed in 1990, raised in 1993**

Project area map



Associated documentation, research, and data sources

- Study on climate change vulnerability in the region, Mallek and Safford (2011)
- Personal Communication with Sequoia National Forest Hydrologist staff – Joshua Courter, Terry Kaplan-Henry and Kyle Wright.
- Personal Communication with Stan Stephens, California Department of Fish and Game Biologist.

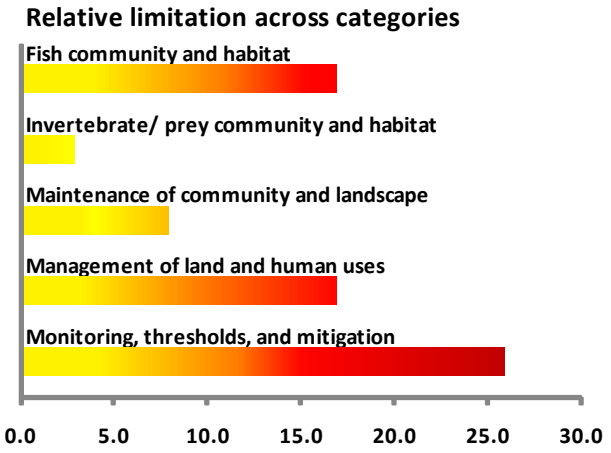
Restoration overview

- The Clicks Creek Check Dams Meadow restoration project is a U.S. Forest Service project to restore the meadow's hydrology and ecology to a healthy state by raising the water table and correcting past grazing land uses.
- Main restoration actions include 1) Installing a series of large check dams to create backwater habitats, slow water velocity and raise water table, and 2) Place large snags along stream to deter cows from accessing riparian zone.
- A secondary goal of restoration was targeted to meet management objectives for the recovery of the Little Kern Golden Trout in the upper Clicks Creek drainage by improving habitat conditions and viability of Little Kern River Golden trout in meadow.
- Resource damage from the dams was noticed around 1996 and notches in the dams were cut in the dams to act as spillways and edges were reinforced with rock to try and reduce the erosion concentrated at the edges of the dams where the near bank stress was the highest.
- In the late 1990's these structures were cut down even more to their current size.

Background on site, landscape, and species condition

Project site

- White Meadow is on the headwaters of Clicks Creek in the Giant Sequoia National Monument and drains into the Little Kern River in the Golden Trout Wilderness. It is located at around 8,000 ft. elevation, is spring fed, and stays cold year-round.
- Past land uses were very severe to fish (pre-1940s), and this meadow was actively grazed for almost a century, where the absence of any permanent or temporary fencing led to significant erosion of the stream banks and widening of the stream channel. By the 1970s, Clicks Creek no longer accessed its floodplain in White Meadow.
- Cattle trampled the riparian vegetation along the stream, allowing the soil to erode quickly.



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

- In August 1987, Stan Stephens CDFG Biologist wrote about the damage below to the meadow below road 22S50, where sediment run off and cattle damage had broken down stream banks.
- This meadow is still actively grazed, and minimal fencing was established as part of any meadow restoration to protect the stream along with snags that were placed to deter cows from the riparian area.
- The Mountaineer and Jerky Timber sales that occurred in the early 1980s were a significant harvest that minimized negative effects to Clicks Creek.

- In July 1989, Stan Stephens CDFG Biologist wrote about negative impacts of sediment flows from Clicks Creek trail, Summit trail, road 21S50, timber harvest, and Forest Service pack station facility.
- This road was eventually paved, however the impacts that it caused are still yet to be mitigated.
- Stephens also witnessed "extensive and unacceptable" grazing bank damage and removal of vegetation by grazing cattle causing sediment flow and water quality problems, as well as higher high-water and lower low-water flows. Stephens recommended exclusion fences to prevent future grazing damage.
- Clicks Creek flow through White Meadow gets very dry during most years and carries a large sediment load adding to the gullying and channel widening, which is especially evident below the many check dams.
- Little Kern Golden Trout are genetically pure in Clicks Creek.

Climate considerations

- Based on modeling study and synopsis by Mallek and Safford (2011) the regions has:
  - Moderate risk for increased winter flooding,
  - High risk for fire regime change,
  - Low risk for temperature change

Species condition

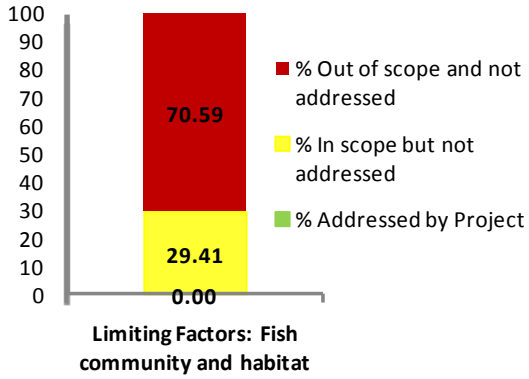
- The affected reach contains a resident population Little Kern River Golden Trout, with hybrid trout present downstream in Kern River mainstem.
- Population size and structure in White Meadow are currently considered to be in poor condition because of degraded habitat from a check dam that contributes to a large headcut and loss of in-stream connectivity throughout meadow.
- 10.94 miles of habitat within Clicks Cr. (assumes introgressed fish in mainstem Little Kern)
- Data unavailable for exact densities in upper Fish Creek, but general density range-wide is 500 fish/mile, however densities in Clicks Creek are considered much lower than range-wide numbers due to negative impacts of check dam restoration.

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 0%
Limiting factors addressed relative to project scope: 0%



Project effects and site condition

- Fish population and community structure in Clicks Creek is similar to historic community structure or that of reference streams/reaches prior to restoration.
  - Post-restoration, fish population and structure was impacted but are still considered close to historic numbers.
- Restoration impacts to habitat post-restoration include:
  - Undercut banks were reduced by the backwater habitats created from the multiple check dams.

  - Habitat offering connectivity throughout the meadow significantly reduced once the check dams were built, and connectivity is much lower than historical available. Fish cannot breach check dam and there is an active headcut created by the check dam.
  - A great deal of good spawning gravel in the system was lost because of the pool and sediment trap created behind the check dams.
  - Overhanging riparian vegetation (willows, alder), rocks, and downed wood or other cover is reduced, impacted by backwater pool behind the check dams.
  - Channel is much less exposed than before with more overhanging willow vegetation surrounding the riparian corridor with additional undercut banks now present.
  - Shallow backwater habitats for juvenile rearing were considerably improved in the large pools created above check dams.
- Restoration impacts to water include:
  - Dissolved Oxygen, conductivity, and other water chemistry components within the tolerances of all life history stages were degraded from existing conditions. Sequoia NF monitoring confirms this.
  - Mean turbidity within the tolerance of all life history stages for most of the year were also degraded. There is currently a serious sediment problem in Clicks Creeks which is identified as a major problem contributing to covering spawning beds used by Little Kern Golden trout.
  - One deep pool in the meadow now exists and water temperatures in this stagnant pool have been recorded at the top end of tolerance levels for Little Kern Golden trout during summer months.

Persisting concerns

- There is a need to replace or remove several check dams (stream improvement structures) along approximately 100 meters of Clicks Creek.
- In addition, there is a need to repair an active headcut that has recently developed within the project area.
- Both the headcut and the failed check dams have led to an increase in available sediment that can be transported to nearby Little Kern Golden Trout spawning beds
- Headcut is leading to changes in geomorphology of Clicks Creek and creating gullying through White Meadow.

Data Gaps

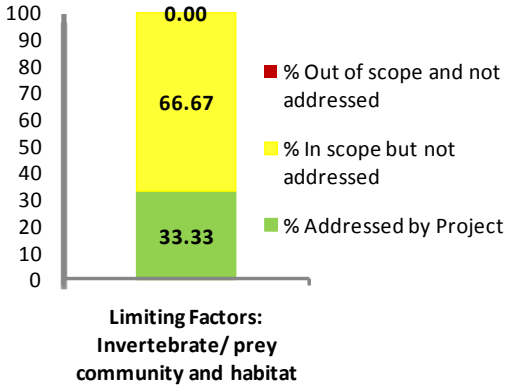
- No primary monitoring focus on fish age class, population size, density, etc.
- No information on tolerance of resident fish for turbidity, temp, DO, etc.
- No data available for population density or age or size class distribution. Data unavailable, general density range-wide of 500 fish/mile might not be appropriate for this region as well.

Opportunities

- Potential opportunity to use CDFG Wild Trout Crew to monitor Little Kern Golden trout populations through Clicks Creek to achieve a baseline data.
- Monitor sediment impact on downstream Little Kern Golden trout spawning gravels.
- Investigate removing or altering structure of check dams throughout White Meadow.
- Mitigate headcut and erosion problems through well-designed restoration project

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 33.3%
Limiting factors addressed relative to project scope: 33.3%



Project effects and site condition

- Diversity of invertebrates thought to have diminished in reference reach from that of historic community/structure. (Personal Comm. Kaplan-Henry).
- Diverse habitats available including emergent aquatic vegetation, decaying leaf matter, exposed substrates was degraded from project and continues to degrade as stream channel continues to downcut.

Persisting concerns

- Grazing in the upland habitats in the headwaters may continue to impact water quality. Cows still get their water from intermittent sections of the stream above the project area and out of the meadow.

Data Gaps

- Unknown condition of invertebrate community, including production, density, and distribution relative to previous or reference conditions due to discrepancy in the methodologies and objectives of historic versus more recent invertebrate surveys.
- Unknown whether adequate invertebrate production is occurring to support fish population.
- Unknown invertebrate prey availability relative to historic or other systems.

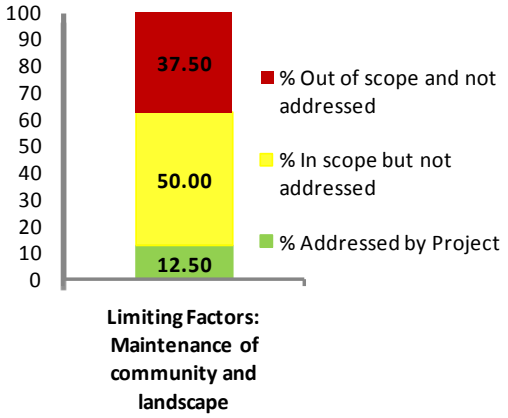
Opportunities

- Perform invertebrate study using methodology consistent with historic study in order to evaluate diversity, distribution, abundance, and production pre and post grazing removal.
- Develop bioenergetics model for species and evaluate current invertebrate food supply against needs based on physical habitat parameters and population size.

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape

Limiting factors addressed by project: 12.5%
Limiting factors addressed relative to project scope: 20.0%



Project effects and site condition

- Control of non-native species that will either compete with, interbreed with, predate upon, spread disease, or otherwise cause adverse lethal or sub-lethal effects to the fish community is greatly improved because of barrier to migration from downstream habitats. Check dams act like fish barriers in most flow levels.

- Point and non-point sources of pollutants or TMDL substances, which were not major limiting factors prior to restoration, were identified as major limiting factors post-restoration.
- Physical connectivity, not a major limiting factor prior to restoration, was significantly disrupted by the large check-dam built in White meadow. Physical connectivity disruption impedes immigration or emigration relative to this population, and almost all recruitment comes from downstream population sources in Clicks Creek.
    - Restoration degraded meadow function likely causing indirect downstream impacts where more critical population/ habitat for Little Kern Golden trout are found.
- A Forest Service road was paved and culvert removed downstream of the project site, part of a separate restoration for Clicks Creek which helped reduce headcutting, gullying and sediment transport.

Persisting concerns

- Check dams causes erosion, channel goes under the check dams and along the sides, eroding the meadow surface further.
- Restoring connectivity to downstream habitats in Clicks Creek and the Little Kern is a major concern for White Meadow.
- Increasing turbidity and TMDL being monitored in Clicks Creek.
- Moderate risk for increased winter flooding.
- High risk for fire regime change.

Data Gaps

- Comprehensive monitoring information exists on all water quality info such as turbidity, temp, DO, etc.
- Aquatic community and species population structure not monitored.
- Understanding of how downstream introgressed fish move throughout the Clicks Creek system and to what effect this restoration is reducing overall connectivity and movement.

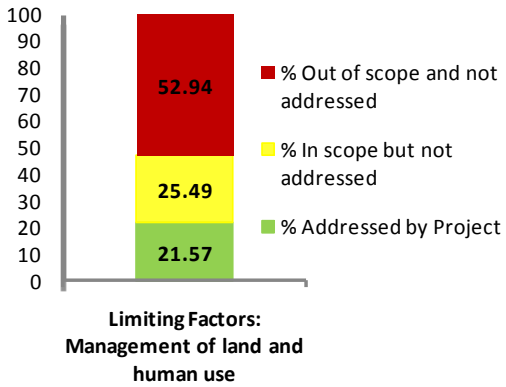
Opportunities

- Remove the series of check dams in White Meadow and restore headcuts.

Management of Land and Human Uses

Limiting factors addressed by project: 21.6%

Limiting factors addressed relative to project scope: 45.8%



Project effects and site condition

- This area is still actively grazed, July 15th-Septmeber every year, however protection for stream channel, banks and water was afforded at an improved level placing large dead wood snags along the extent of the stream.
- Area is just outside of designated federal Wilderness (though Wilderness designation allows for potential grazing)
- Active herding away from riparian zones is still not achieved because there is no off stream water available, and cows still get their water from upstream tributaries, though these are out of project area.
- No plans for a significant timber sale in the upland/headwater habitat and fuel loads are low to moderate from a past sale in the 1980s.
- Recreational angling in White Meadow not considered a major limiting factor at present.

- Additional check dam upstream of the project area is not maintained, but is thought to have lowest impact on fishes and hydrological function of downstream meadow habitats.

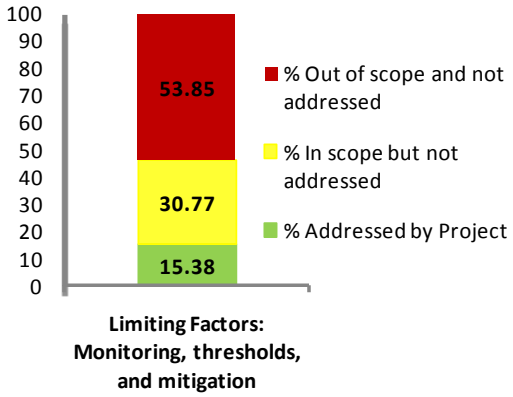
Persisting concerns
- Management of future grazing impacts.
- Land management decisions to allow for future timber sales.

Data Gaps
- Cumulative road density impacts to all water quality info such as turbidity, temp, DO, etc.

Opportunities
- Install a permanent exclusionary fence in White Meadow to eliminate all impacts from grazing, or consider resting the allotment.
- Implement a robust aspen regeneration restoration project.
- Build off-stream water access opportunities for cows.
- Manage White Meadow to maintain low road densities and reduce the amount of user created OHV trails.

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 15.4%
Limiting factors addressed relative to project scope: 33.3%



Project effects and site condition
- Water in White Meadow partially improved for PH and nutrients after the project as cows were deterred from accessing stream channel.
- The project failed to mitigate excessive trampling of stream banks, exposed soil, increased erosion, siltation of water, utilization of forage, headcuts/gullying, high fecal coliform counts and collapsing undercut banks.
    - Restoration did not mitigate any of these limiting factors and they continued unabated, and in some cases like availability of undercut banks, the project reduced the availability of important habitats.

Persisting concerns
- This restoration project did not meet any of its original intentions and instead created the following limiting factors that presently exist:
    - Downcutting
    - Numerous headcuts
    - Barriers to migration
    - Increased stream temperature
    - Turbidity/Sediment load
    - Eroding stream banks, changes in stream geomorphology.

Data Gaps
- Comprehensive monitoring plan

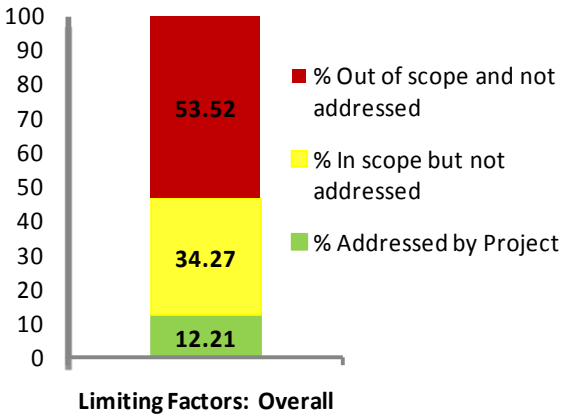
.

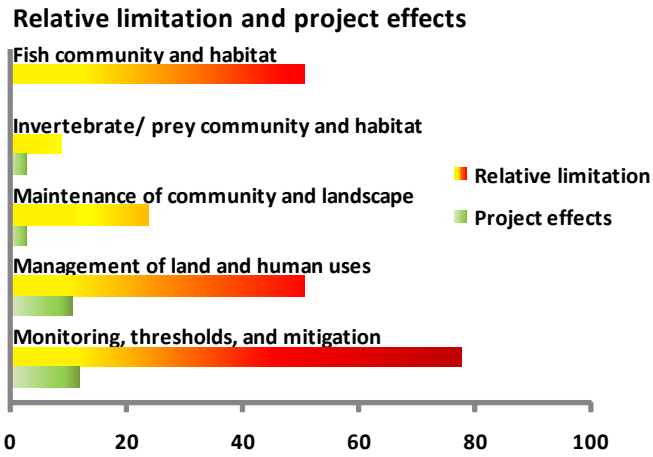
Opportunities

- Mitigate impacts from historic restoration in White Meadow.
- Continue all monitoring that has been completed to date.
- Create a comprehensive monitoring plan
- Design and implement a restoration project to mitigate past cattle grazing damage and failed restoration attempts

Overall Findings and Key Points

Limiting factors addressed by project: 12.2%
Limiting factors addressed relative to project scope: 26.3%





Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

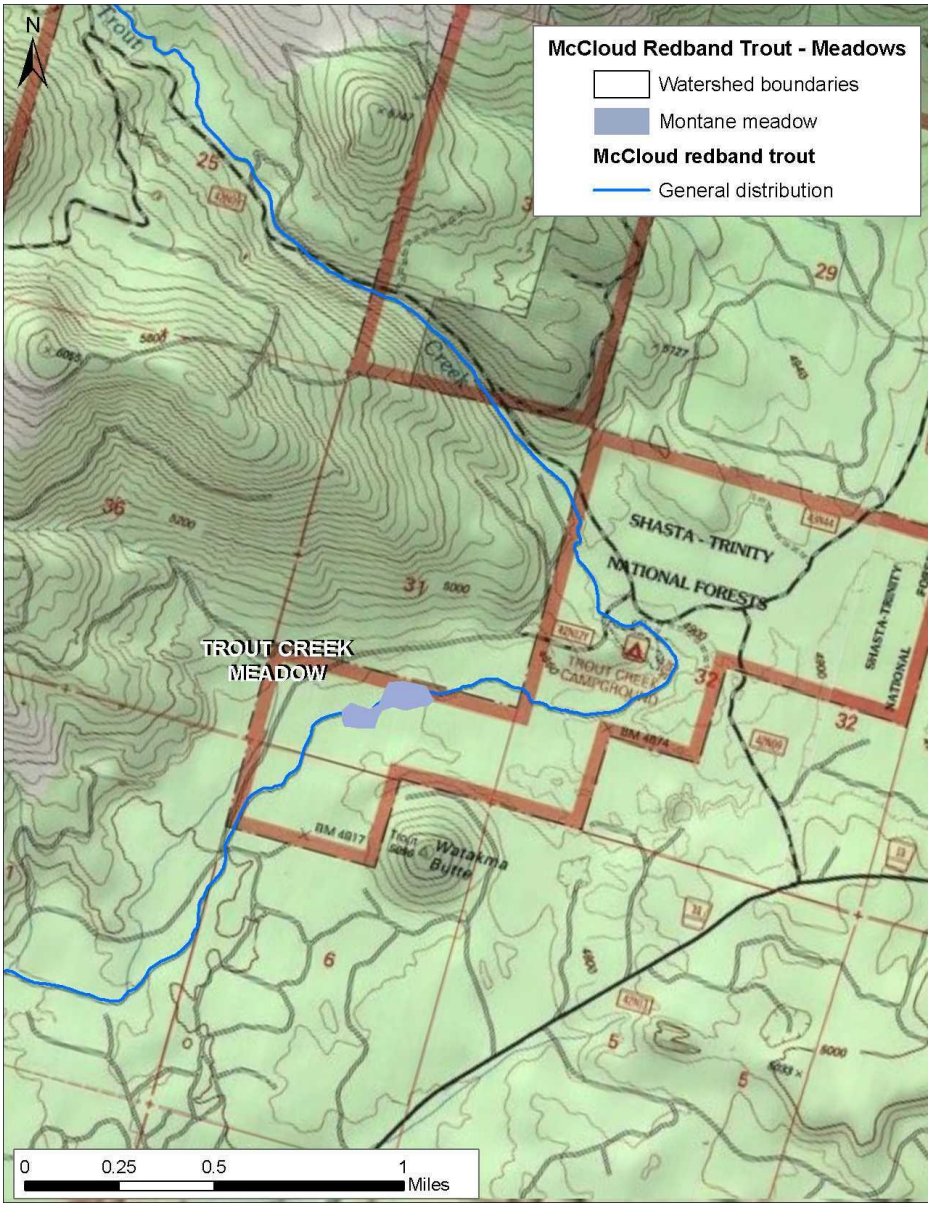
Species condition in project area:	Moderate/Good
Area of greatest gains:	Slight improvement in WQ
Most significant actions:	Improved herding practices
Area of greatest need:	Mitigate impacts from historic restoration in White Meadow; Prevent ongoing grazing impacts
Highest priority concerns:	Grazing, Fire/flood, Current state of meadow (continuing to degrade)

Highest priority opportunities:

- Consider planting willows and pursue an Aspen regeneration project for the meadow.
- Develop bioenergetics model for species and evaluate current invertebrate food supply against needs based on physical habitat parameters and population size. Investigate physiological tolerance of species to WQ parameters.
- Install exclusionary fencing to reduce future grazing impacts.
- Completely remove check dams in White Meadow and restore area around the existing headcuts.
- Develop and implement a comprehensive restoration to mitigate past damage and prevent future damage

Species: **McCloud Redband Trout**
Location: **Trout Creek, Shasta-Trinity National Forest**
Regional Contact(s): **Steve Bachmann (USFS, Shasta-Trinity NF)**
Project: **Trout Creek Restoration and Mitigation Project**
Timeframe: **2006-present**

Project area map[6]



[6] See appendix for as built map of project site

Associated documentation, research, and data sources

- Streamwise, USFS 2001. Trout Creek - McCloud District, Siskiyou County, California. Stream Assessment. 20p.
- Streamwise, USFS 2005. Trout Creek - Siskiyou County, California: Stream Restoration Design 15p.
- Streamwise, USFS, CalTrout 2007. Trout Creek Backwater Pools project. 11p.
- USFS 2007. Trout Creek Meadow Restoration Project Environmental Assessment - Draft.19p.
- USFS 2007. Trout Creek Restoration Project Fact Sheet. 3p.
- USFS 1990 Habitat typing report - Trout Creek. 78p.
- USFS (*Unknown Date*). Trout Creek Mitigation Project As-Built (Map). 1p.
- Redband Core Group, USFS 2005. Redband Trout Conservation Agreement Shasta Trinity National Forest - Renewal Draft 4(2) 69p.

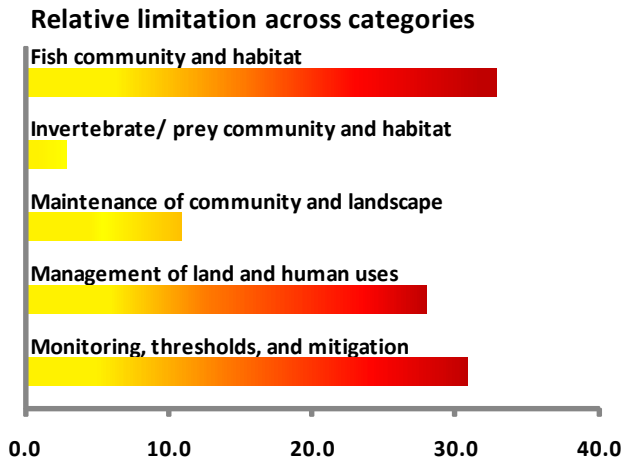
Restoration overview

- Habitat has undergone several restoration actions over the last ~10 years.
- This analysis is focused the two (coupled) most significant projects, 1) a pond and plug project to restore a severely incised channel and degraded meadow, and 2) meadow re-fencing, conifer removal, and riparian replanting to restore meadow from effects of grazing and conifer encroachment.
- Restoration targeted primarily at improving stream, floodplain / meadow function.
- Improved habitat for redband one of several goals for this project.

Background on site, landscape, and species condition

Project site

- The project site includes lands within the Shasta-Trinity National Forest, managed by the USFS and private lands owned by Sierra Pacific Industries and Hancock Forest Management.
- Cattle grazing continues to be active on the private lands in the project vicinity. However, cattle have been excluded from the project stream reach and adjacent meadow by fencing.
- Active timber harvest has and continues to occur on both the public and private lands in and around the project area.
- Active recreation, including camping, and OHV use continues to occur in the project vicinity outside of the fenced area. OHVs are excluded from the stream with the exception of one crossing upstream of the restored reach. Recreational harvest of redband occurs upstream of the affected reach. The extent of the harvest and its impact on population size and stability is unknown. However, due to their small size, redband are not believed to be heavily targeted by fisherman.



Comparison of limitation to species (Limiting Factors Score totals) across the five categories of restoration analysis

Climate considerations

- As a function of Trout Creek's position in the upper McCloud Watershed, and the history of surrounding land use, potential climate change impacts include:

- Increased wildfire risk due to earlier spring drying, in some cases exacerbated by historic fire suppression, and increased fuel loads;
- Increased winter flooding risk, related to a potential increase in rain on snow events;
- Temperature risk to aquatic species and habitats related to increased summer warming

Species condition

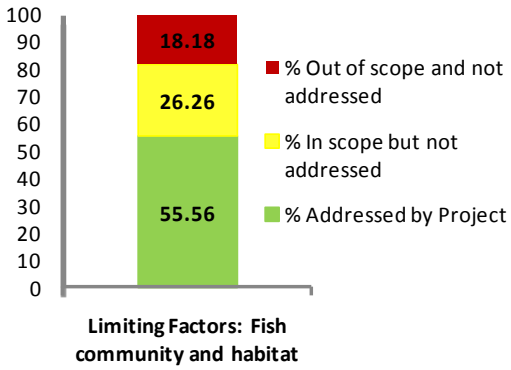
- Trout Creek supports one of the largest redband trout populations of any of the tributaries to the upper McCloud River. Populations of trout in the stream have undergone several episodic periods of research and monitoring.
- Based on the limited available information, specific population size and structure are not known. Redband are, however, known to be consistently present in numbers within the larger segment that encompasses the restored reach.
- Historically, the redband in the restored reach segment have been periodically isolated by seasonal disappearance of surface flow downstream of the restored reach as well as in the area where restoration occurred. Redband trout have always been present above the restoration site in the perennial reach of Trout Creek and have been observed far downstream of the restoration in the intermittent reach during years of high spring runoff.
- Fish in the affected reach are considered redband, though they show some evidence of introgression with introduced rainbow trout species, relative to other more isolated populations in the watershed.
- Predatory invasive species including brown trout continue to persist in the segment where the restoration occurred.

Summary of findings from collaborative analysis

Habitat and Ecosystem Conditions

Fish Community and Habitat

Limiting factors addressed by project: 55.6%
Limiting factors addressed relative to project scope: 67.9%



Project effects and site condition

- Restoration work has generally improved habitat condition in the restored channel reach:
  - Existing connectivity may be greater to historical connectivity as a result of restoration, but interannual variability in flow has made this difficult to determine. The channel dried out in the initial years following implementation of the project.
    - In 2006 (the year of implementation, the channel lost all flow in the project.
    - 2007 and 2008 were unusually dry winters during which the channel dried out completely below the backwater pool in both years. Additional work was done on the backwater pool which helped reduced the surface flow loss and improve flow conditions in the restored reach.
    - In 2009 better spring flow conditions maintained consistent flow to the restored reach out of the backwater pool although the lower end dried out in August.
    - In 2010 even better spring maintained flow to the entire restored reach, which never dried out.
  - Similarly, the length of time during which the channel has retained surface flow has also varied.

    - As a function of less seasonally dewatered channel, as well as the creation of ponds, habitat patch size may also have increased, but observation under more interannually variable conditions is necessary to determine this conclusively.
    - Habitat quality and diversity has improved as well, as a function or channel and meadow restoration. New bank, and riffle habitat has been created in restored reach, and new pool habitat, if intermittent has been created in the ponds.
    - Substrate quality has also been significantly enhanced with more gravel present in the restored channel reach, though continued augmentation is necessary.
- Overhanging riparian vegetation and other cover increased since exclusion of cattle from the meadow and riparian replanting.
- Turbidity was not a major issue prior to the project, and monitoring subsequent to the project has not revealed any new turbidity concerns.
- Water quality concerns were not a primary focus of the project. Water quality enhancements, however, can be inferred (though not confirmed) from cattle removal, as well as improved vegetation, channel physical characteristics, and meadow function.

Persisting concerns

- Restoration site not currently being managed or monitored for fish
    - No fish monitoring was planned for the first four years after implementation, but beginning the fifth year fish presence and absence in the restored reach will be monitored as detailed in the HMMP (Habitat Mitigation Monitoring Plan).
- Small portion of the channel continues to be dewatered for much of the year, continuing to limit patch size, expansion and create fragmented habitat.
- Risk of increased competition and predation from invasive species already present and perhaps better equipped to take advantage of restored habitat.
- Substrate requires additional gravel augmentation
- Habitat still re-establishing after restoration and need for additional structure to form

Data Gaps

- Although presence/absence surveys for habitat use have occurred, data has yet to be analyzed to evaluate effects of restoration on redband.
- No population monitoring (density, age, or size class distribution) or specific habitat use monitoring for redband or other competing fish species.
- No information (pre- or post-project) on water quality (WQ) parameters in system including DO, turbidity, or pH.
    - Temperature monitored and data collected pre and post project

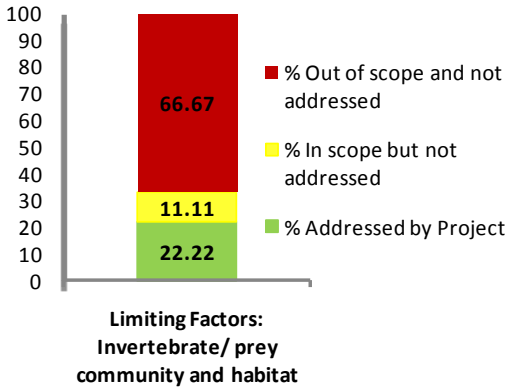
Opportunities

- Assemble and analyze existing presence absence/ data, to establish a pre-project baseline (if partially qualitative) on fish distribution, density in the restored reach vs. the surrounding area, and habitat preference.
- Perform monitoring for population characteristics and habitat use to compare with existing data and assess potential effects of restoration.
- Continue gravel augmentation.

Invertebrate/ Prey Community and Habitat

Limiting factors addressed by project: 22.2%

Limiting factors addressed relative to project scope: 66.7%



Project effects and site condition

- Substrate improved through gravel augmentation
- Amount of wetted channel area significantly increased
    - Wetted channel area has been increasing since project inception but started below that of the original gully channel due to the meadow recharge being so high following initial implementation.
- Riparian and meadow vegetation has improved significantly
- Water quality necessary to support ecosystem function, including temperature, turbidity, pH, etc. not significantly impacted prior to project and assumed to be improved (though no data to confirm).
    - Sediment generated during peak flows has definitely been reduced due to the sediment trapping effects of the backwater pool.

Persisting concerns

- Severely degraded habitat prior to project thought to have been improved by restoration but not confirmed.
    - While habitat is improving, low flows in late summer fall are still believed to be the primary limiting factor for fish (at least during the late summer and fall).
- Existing invertebrate community may have been severely impacted by restoration and still be in recovery resulting in diminished diversity and density or altered distribution.
- Altered temperature in the restored channel at certain times of year may be impacting invertebrate production

Data Gaps

- Unknown condition of aquatic or terrestrial invertebrate community, including production, density, diversity, and distribution relative to previous or reference conditions.
    - Stream invertebrate sampling has occurred as a component of post project monitoring, but data has not yet been analyzed relative to pre-project conditions.
    - Terrestrial invertebrate prey densities from restored meadow unmonitored (though bat densities monitored as a potential indicator for terrestrial invertebrate recovery).
- Unknown whether adequate invertebrate production is occurring to support fish population.
- Unknown water quality conditions relative to tolerances of invertebrates present both pre and post restoration.

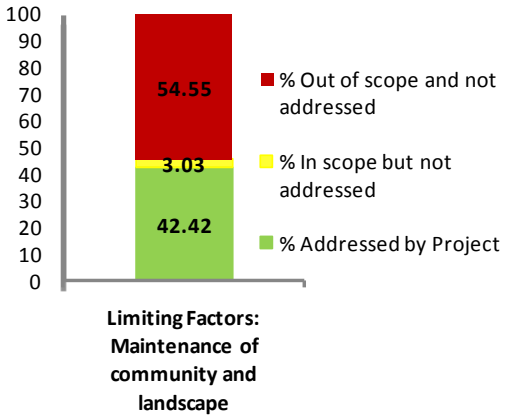
Opportunities

- Analyze existing invertebrate data to determine 1) current status of community, 2) effects of restoration (including habitat use and availability, and water quality relative to species tolerances), and 3) estimate production.
- Continue invertebrate monitoring with enhancements, as needed, to inform the three key issues (above).
- Develop bioenergetics model for fish species and evaluate current invertebrate food supply against needs based on physical habitat parameters and population size.

Maintenance, management, monitoring, and mitigation

Maintenance of community and landscape

Limiting factors addressed by project: 42.4%
Limiting factors addressed relative to project scope: 93.3%



Project effects and site condition

- Extensive sedimentation from the formation and continued widening/deepening of the gully within the meadow as well as, to a lesser extent campgrounds and past land use, negatively impacting the site prior to restoration have been largely resolved by sediment capture in backwater pool.
    - Unknown and under debate how rapidly pond will aggrade.
    - Sediment sources, supply, and capture being closely monitored and will be adaptively managed as needed.
- Encroaching conifers and accumulated fuels removed from meadow and project area.
- Stream channel-floodplain connectivity restored.
- Development and morphology of restored channel being actively monitored, evaluated and managed as needed to ensure proper meadow function.
- Riparian vegetation being actively monitored and managed as needed to promote effective re-colonization.

Persisting concerns

- Increased predation and competition from introduced species.
- Potentially small population size relative to that needed to maintain genetic diversity as well as resilience to natural disturbances such as disease, or potential climate change exacerbated landscape events such as fire, flooding, or drought.
- Risk for increased winter flooding as a result of climate change.
- Risk of potential of fire regime change due to decreased snow.

Data Gaps

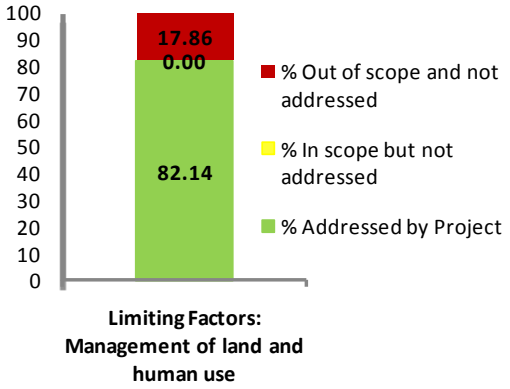
- Aquatic community and species population structure not monitored and effects of project unknown
- Introduced species population size, habitat use, and response to restoration unknown and unmonitored.

Opportunities

- Opportunity to monitor introduced species, particularly predatory brown trout, presence and habitat use in restored reach
- In the case where redband become a management priority for the restored reach going forward, consider introduced species management or removal, as a component of redband habitat and population management.
- Incorporate climate change impacts into ongoing adaptive management of restoration site, including decision over how habitat should be managed for fish and how to accomplish this more effectively.

Management of Land and Human Uses

Limiting factors addressed by project: 82.1%
Limiting factors addressed relative to project scope: 100%



Project effects and site condition

- Cattle were removed from stream and the surrounding meadow, and exclusion fencing was erected
- Off channel/ alternate water for cattle was provided
- Though previously unmonitored, any nutrient or coli-form impacts from cattle presumed resolved by their exclusion from the reach
- Increased runoff and increased sedimentation from grazing formerly an issue, but runoff resolved through removal and replanting, and sediment trapped in pond.
- Riparian zones are now reestablished and restored meadow acts as buffer from timber harvest.
- Conifer encroachment was and is being managed without impact to habitat
- OHV use has been eliminated from meadow reach, and road crossings impacts minimized
- Hancock Forest Management and Sierra Pacific Industries both participating in a cooperative MOU with USFS to ensure that land use standards, and associated habitat condition and site function are maintained going forward.

Persisting concerns

- Legacy impacts to habitat condition that remain unresolved.
- Recreational harvest of redband continues, despite lack of information on the condition of their population or the supporting habitat and ecosystem post restoration.
- Continued impacts from surrounding land use and OHV use to reaches adjoining the restored reach
- Livestock grazing continues around adjacent reaches without management that is sensitive to stream condition, seasonal flow variation, or fish population.

Data Gaps

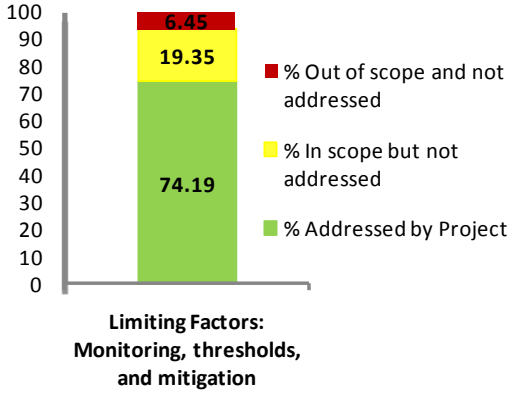
- Minimal baseline data on adjacent land use (grazing, recreation, or timber harvest) impacts to water quality, or protocol for managing these to protect conditions in restored reach.

Opportunities

- Manage livestock grazing in surrounding area more effectively (e.g. turn on/ take off dates that are sensitive to water year and site condition).
- Manage OHV use in adjacent stream segments to exclude them from stream channel and riparian area
- Manage recreational fish take, as needed, based on results from population assessment
    - If restored habitat is deemed appropriate and desirable for redband management, manage or limits recreational fishing in the restored reach and adjacent area to promote expansion of existing populations into the new habitat.

Monitoring, Thresholds, and Mitigation

Limiting factors addressed by project: 74.2%
Limiting factors addressed relative to project scope: 79.3%



Project effects and site condition

- Streamflow and groundwater being monitored in restored reach.
- Availability and utilization of forage being monitored in areas in exclusion areas.
- Erosion, soil condition, and siltation, being monitored on a five year basis.
- Stream bank condition being monitored qualitatively on a regular basis.
- Headcuts and gullying being monitored and aggressively corrected in cases where they occur.
- Climate change threat are being considered and weighted in ongoing management decision.
- Susceptibility to climate change impacts was decreased significantly by restoration.
- In addition to likely benefits to flow in the stream channel, vegetation work (conifer removal) and follow-up treatments have and will be increasing the resiliency of the ecosystem by promoting more species diversity (e.g. aspen restoration, riparian vegetation restoration).

Persisting concerns

- No existing thresholds established for species populations, ecosystem condition, or water quality
- Existing management not being informed by and adapted in response to monitoring data concerning redband, or invertebrate/ ecosystem responses to restoration.

Data Gaps

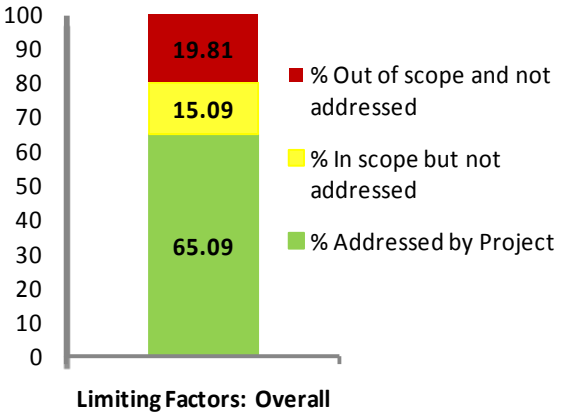
- Redband response to restoration unmonitored for first four years (scheduled to begin 2011).
- Water quality in response to restoration unmonitored (though not believed to be impacted)
- Ecosystem response (e.g. invertebrate community) to restoration monitored intermittently, but data has not been analyzed, thresholds have not been established, and management protocols have not been defined

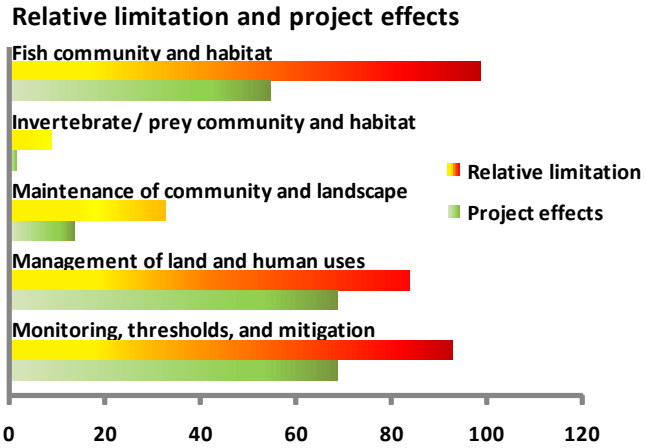
Opportunities

- Establish thresholds and monitor for redband population condition, water quality, and ecosystem conditions as a component of adaptive management of the project site going forward.

Overall Findings and Key Points

Limiting factors addressed by project: 65.1%
Limiting factors addressed relative to project scope: 81.2%





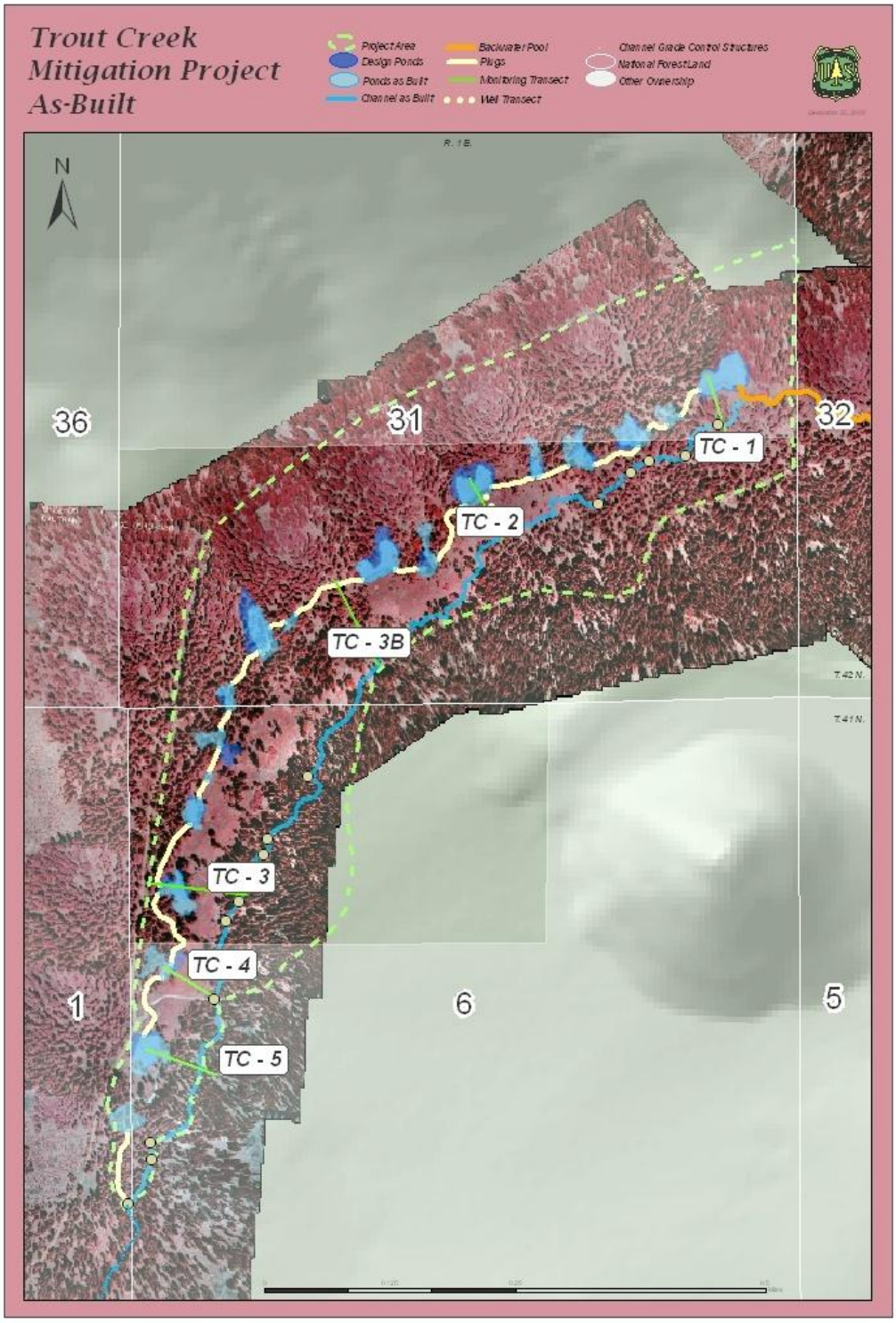
Project effects (overall score subtotal in each category) relative to the extent of species limitation (total possible points in each category) across the categories of analysis

Species condition in project area:	Unknown, but present
Area(s) of greatest gains:	Management of land and human uses
Most significant actions:	Degrazing, meadow restoration, buffering of impacts from timber harvest and roads
Area(s) of greatest need:	Fish Community and Habitat; Invertebrate/ Prey Community and Habitat
Highest priority concerns:	Redband population condition, ecosystem condition, invasive species

Highest priority opportunities:

- Assemble and analyze existing data, to establish a pre-project baseline for redband abundance and habitat use.
- Investigate and monitor population characteristics and habitat use to compare with existing data, assess project effects, and determine appropriate management.
- Analyze existing invertebrate data to 1) determine current status, 2) assess effects of restoration, and 3) estimate production.
- Investigate and monitor introduced species abundance and distribution in restored habitat and adjacent reaches.
- Establish thresholds for redband, invasive species, invertebrates, and physical habitat conditions/ WQ

Appendix



As-built map of Trout Creek restoration and mitigation project

References

Goose Lake Fishes Working Group (GLFWG). 1995. Goose Lake Fishes Conservation Strategy, OR. 46p.

Hammersmark, C.T., Rains, M.C., and Mount, J.F. 2008. Quantifying the hydrological effects of stream restoration in a montane meadow, Northern California, USA. *River. Res. Applic.*, 24, 735–753.

Kattelmann, R. and Embury, M. 1996. Riparian Areas and Wetlands. Sierra Nevada Ecosystem Project: Final Report to Congress, vol. III, Assessments and scientific basis for management options. University of California, Davis, Centers for Water and Wildland Resources.

Larson, R., Stewart, C. (2010). Osa Meadow Restoration Project NEPA Scoping Document. United States Department of Agriculture, Sequoia National Forest. (1-7)

Lindquist, D. S., & Wilcox, J. 2000. New concepts for meadow restoration in the northern Sierra Nevada. Feather River Coordinated Resource Management Group.

Mallek, C.R., and Safford, H. 2011. A summary of current trends and probable future trends in climate and climate driven processes in the Inyo National Forest and adjacent lands. Inyo NF climate change trend assessment, Jan. 2011. Report to USDA Forest Service.

Moyle, P.B., Israel, J., and Purdy, S.E. 2008. Salmon, Steelhead and Trout in California: Status of an emblematic fauna. A report commissioned by California Trout.

Pustejovsky, T. 2007. A Conservation plan for Pine Creek and Eagle Lake Rainbow Trout. Under Contract with Honey Lake Valley Resource Conservation District. Funded by Lassen County Resource Advisory Council. At Recommendation of Pine Creek Coordinated Resources Management Planning Group

Redband Core Group, USFS 2005. Redband Trout Conservation Agreement Shasta Trinity National Forest - Renewal Draft 4(2) 69p.

Streamwise, USFS 2001. Trout Creek - McCloud District, Siskiyou County, California. Stream Assessment. 20p.

Streamwise, USFS 2005. Trout Creek - Siskiyou County, California: Stream Restoration Design 15p.

Streamwise, USFS, CalTrout 2007. Trout Creek Backwater Pools project. 11p.

Stephens, S.J., McGuire, C. and Sims, L. 2004. Conservation Assessment and Strategy and Strategy for the California Golden Trout (*Oncorhynchus mykiss aguabonita)* Tulare County, California. 91p.

Swanson, F.J., Halpern, C.B., and Cissel, J.H. 2007. Restoration of dry, montane meadows through prescribed fire, vegetation and fuels management: A program of research and adaptive management in western Oregon. Project 01C-3-3-10 Final Report to the Joint Fire Science Program. 63 p.

USFS 2007. Trout Creek Meadow Restoration Project Environmental Assessment - Draft.19p.

USFS 2007. Trout Creek Restoration Project Fact Sheet. 3p.

USFS 1990 Habitat typing report - Trout Creek. 78p.

USFS (*Unknown Date*). Trout Creek Mitigation Project As-Built (Map). 1p.

U.S. Fish and Wildlife Service. 1994. Lahontan cutthroat trout, *Oncorhynchus clarki henshawi,* Recovery Plan. Portland, OR. 147 pp

Williams, J.E., A.L. Haak, N.G. Gillespie, and W.T. Colyer. 2007. The Conservation Success Index: synthesizing and communicating salmonid condition and management needs. *Fisheries* 32:477-492.