COVER PAGE

Project Title: Protecting the Headwaters in a Changing Climate: Managing Sierra Nevada Meadows for Water Supply & Habitat Benefits

Project Lead and Co-Lead Contact Information: Scientist - American Rivers, Luke Hunt, Ph.D. lhunt@americanrivers.org, (530) 478-0206. Manager - USFS (Eldorado NF), Chuck Loffland, cloffland@fs.fed.us, (209) 295-5954.

Project Duration: One year

Total Requested Funding: $30,000

Partners

Partner	Contact Information	Role
San Francisco State - Austen Lorenz	(530) 906-5910	GIS analysis and report author
UC Davis - Ryan Peek	(530) 383-3764	Meadow Restoration Database manager, publish and distribute datasets.
UC Merced - Josh Viers	(209) 591-8423)	Reviewer, share scorecard data, partner in outreach
Southwest Climate Science Center - Christine Albano	(775) 881-7560 ext. 7473	Share data, we will use NDVI from SW CSC. SW CSC will use our scorecard data.
Tuolumne River Trust - Patrick Koepele	(209) 815-2220	Share scorecard data from Tuolumne watershed collected by TRT. We will help them publish data on the UC Davis database.
CDFW–Dawne Emory	(760) 932-7174	Reviewer, partner in CDFW outreach.
USFS Region 5 –Jeff Tenpas	(707)562-8955	Reviewer, partner is USFS outreach and selection of trainees.
Trout Unlimited –Rene Henry	(510)528-4164	Reviewer, partner in outreach to angling community and CDFW.
Wildlife Conservation Society – Kathryn Dunning	(406) 370-8211	Co-funder and partner in climate adaptation outreach, including producing video.
NFWF –Carly Vynne	(206) 437-5247	Co-funder.
Sierra Nevada Alliance/Sierra Water Work Group –Gavin Feiger	(530) 542-4546	Partner in outreach to IRWMs and Alliance member organizations through annual conference.
California Water Foundation – Elizabeth Soderstrom	(916) 442-5057	Partner in experimental design and project outreach.

Geographic Scope: Sierra Nevada

Partner Contributions/Leveraging:

- Austen Lorenz: $1,000 in kind for Task 1 (complete data collection)
- Wildlife Conservation Society: $20,000 (cash) for Task 5 (Develop outreach materials, including video. Develop partnerships and agency relationships).
- National Fish & Wildlife Foundation: $40,000 (cash) for Tasks 1, 2, and 6. NFWF funded the original equipment purchase, data collection, and analysis on Indian Valley and will fund the training program ($181,000 total, we estimated $10,000 value added to this project, which is included in $40,000 contribution).
- Note: We calculated the major (≥$1000) estimated contributions. Other partners will contribute in-kind to this effort.

MAIN PROPOSAL

Project Summary/Management Relevance

Headwater Meadows & Climate Change

In California and western Nevada, the majority of fresh water comes from the Sierra Nevada, falling in winter as a blanket of snow that slowly melts in spring, delivering enormous quantities of clean water to the region. Climate models predict that in the Sierra Nevada a rise in temperature due to climate change will raise the snow-elevation, increase the proportion of precipitation falling as rain instead of snow, increase the incidence of rain-on-snow events, reduce overall accumulation of snow, and accelerate the spring snowmelt. Since the snowpack provides the single biggest portion of water storage in California and other arid regions of the West, these effects are already resulting in less reliable water supplies and a longer summer drought. Climate change will also significantly increase peak flows, leading to downstream flooding and erosion, which in turn causes water quality degradation. An innovative approach to address this problem is gaining traction with land managers: mountain meadow restoration.

Mountain meadows are hotspots of biodiversity and an iconic part of the Sierra landscape. From a hydrologic perspective, mountain meadows are high-elevation floodplains, and like other floodplains, healthy meadows soak up peak runoff in spring and provide cool groundwater-derived flows during late summer. Two modelling studies of meadows and empirical data from analogous floodplain systems suggest that healthy, functioning meadows are capable of addressing the very impacts that climate modelers predict for California's Sierra Nevada by increasing groundwater storage capacity, attenuating peak flows, prolonging summer base flows, and reducing in-stream water temperatures (Lindquist and Wilcox 2000, Loheide and Gorelick 2006, Tague et al. 2008, Cornwell and Brown 2008, Hammersmark et al. 2008, Jones and Stokes 2008, Hammersmark et al. 2010, Hill 2012 and references therein, Hill 2014).

Unfortunately, these critical ecosystems and the benefits they provide are threatened by the impacts of historic and ongoing degradation. According to the US Forest Service (USFS), thousands of acres of meadows in the Sierra Nevada are in need of restoration. Between 75,000 and 115 acres (40-60%) of meadows are degraded as a result of over-grazing from the late 1800s through 1930s, as well as the building of roads, mining, logging, and urbanization (NFWF 2010, Viers et al. 2013). Degraded meadows cause a wealth of problems that affect the larger watershed. In degraded meadows, the stream channel is disconnected from the meadow floodplain and the channel itself is deeply eroded, which drains flow quickly downstream, drawing down the natural water table. This in turn encourages non-meadow species to take over and reduces species diversity and productivity (NFWF 2010). Incised stream channels also lead to increased bank erosion in the meadow and sediment transport from areas downstream, where erosion is caused by increased peak flows. Meadows are predicted to experience intense changes in hydrology as a result of climate change, including earlier peak snowmelt, reduced groundwater storage, lowered annual runoff, and increases in stream temperatures (Dettinger et al. 2004, Knowles et al. 2006, Null et al. 2010, Ficklin et al. 2012).

Although meadows are vulnerable to these climate change impacts, this does not mean that meadows and the critical benefits they provide are lost. Meadow restoration (defined here as restoring a naturally shallow water

table and meadow floodplain) can reverse historic damage, reestablish natural hydrology and critical habitat for sensitive species and build resiliency in the face of climate change by increasing ground water storage that will help mitigate for loss of snow pack, and improve the function of headwater regions.

Specific Management Need

Growing recognition of the critical benefits that healthy meadows provide has led to an interest in restoration across the Sierra Nevada. Public agencies have recently set ambitious targets for restoration. For example, the USFS seeks to restore half of all accessible meadows on USFS land—some 40,000 acres—in California over the next 15 years (USFS Region 5 Leadership Intent). Additionally, the California Water Action Plan has committed the Department of Fish & Wildlife (CDFW) to restore 10,000 acres of meadow within the next five years for water supply and other benefits. However, a current data gap threatens funding and broad support for these efforts. There are no published empirical data to support the claims that meadow restoration produces the hydrologic benefits that are anticipated. The habitat benefits of meadow restoration are well-supported. The water supply and groundwater storage benefits are not as well-established, although these benefits are critically important to the largest potential funders of restoration, including agencies distributing millions of Proposition 1 dollars. The only estimate we know of regarding the potential increase in groundwater storage from meadow restoration across the Sierra is between 5,000 and 50,000 acre feet (California Water Plan 2013).

The threat of poorly established claims to agency targets is real. In February, CDFW solicited proposals for meadow restoration to sequester carbon. The reasoning that links meadow restoration and carbon is sound. Wet meadows are peatlands that contain large quantities of soil carbon, and the common understanding is that meadow degradation and drying leads to the oxidation and loss of soil carbon. However, in recent discussions with CDFW, we learned that this funding (to reduce greenhouse gas through meadow restoration) is at risk because of the uncertainty of the benefits. Few or no awards may be made to mountain meadow projects from the recent $25 million solicitation, despite the clear direction in the both the grant guidelines and the California Water Plan that meadows are a priority. In this case, CDFW may not be able to convince the Air Resources Board (another department within the Resources Agency that is involved in awarding the GHG reduction proposals) that meadow restoration is a sound investment.

The justification of hydrologic benefits of meadows is similar to the reasoning behind carbon benefits in that both rely on a logic chain that links modelling studies and data from analogous hydrologic systems to strongly indicate benefits. Unfortunately, to date there is no empirical data to directly justify investment.

A March 2015 report by The Nature Conservancy (*Estimating the Water Supply Benefits from Forest Restoration in the Northern Sierra Nevada*) also highlighted a lack of critical data. The report stated that although meadow restoration has the potential to modify downstream water supply, particularly the timing of flows, there is only one study that has quantified the shift in water timing resulting from restoration. Given the lack of research, TNC did not extrapolate these findings to meadows across the Sierra Nevada. In addition, we do not yet have concurrence on which meadows are most likely to provide the most benefits in the most efficient manner.

Our 10-year experience with meadow restoration has shown us that in order to make significant headway in landscape-scale efforts it is necessary to have strong and diverse partnerships, shared strategy in which

everyone is pulling in the same direction, and funding to implement all stages of projects (from planning to implementation and monitoring)—data is a critical foundation for all of this. Our proposed project is aimed at filling an important data gap. The project would leverage data we have collected in partnership with the National Fish and Wildlife Foundation (NFWF) and the Eldorado National Forest in Indian Valley Meadow (http://www.americanrivers.org/blog/pond-plug-timelapse-indian-valley). We have collected continuous stream flow data from above and below the meadow as well as groundwater data from within the meadow before and after restoration. Currently there is one year of pre-project and three years of post-project data. The timing of this data collection is particularly useful because of the drought. If we demonstrate a base flow and groundwater increase in response to restoration, as preliminary analyses suggest, we will be able to show that water supply benefits can be realized even in very dry water years.

CA LCC funding would enable us to consolidate, analyze, publish, and broadly disseminate our data to inform USFS and other management and investment decisions. Not only is the timing and the amount of data sufficient for robust analysis, Indian Valley is also high-profile and will have an impact across the Sierra Nevada. Construction of this project was partially funded by the Coca-Cola Replenish Program and highlighted by the East Bay Municipal Utility District during the construction phase. Both the company and the district expressed interest in supporting similar projects, if the water supply benefits become clearly established. This is particularly promising because many meadows are located in the headwaters of rivers that supply large population centers, and thus improved management and investment to restore these meadows could have broad and lasting effects.

Project Goal

The goal of our project is two-fold: 1) to increase the understanding of how meadow restoration impacts hydrology and 2) to inform management and investment decisions around using restoration as a tool to build resilience under climate change.

Our objectives in support of this goal include:

- Complete data collection and analysis and publish peer-reviewed research article on the results of groundwater and surface water measurements before and after restoration in Indian Valley Meadow (Eldorado National Forest)
- Double the published scientific literature on the water supply benefits of meadow restoration and produce the first empirical study
- Estimate groundwater and base flow (late season groundwater derived flow) benefits as a result of restoration for 350 meadows (every meadow larger than 15 acres) in 8 watersheds: Mokelumne, Kern, Walker, Yuba, American, Truckee, Bear, and Carson watersheds
- Estimate the flow benefits and change in hydrograph (change in amount and timing of surface flows) that could occur in small headwaters streams as a result of restoration
- Identify the highest priority meadows for restoring natural, resilient hydrology and estimate the water supply benefits expected from each meadow
- Use results from and provide data to the US Department of the Interior Southwest Climate Science Center's classification of long-term vegetation changes in Sierra meadows to identify climate-impacted meadows with restorable hydrology
- Increase support and investment for meadow restoration and preservation across the region

- Provide a published scientific foundation for the California Water Action Plan's focus on meadows and climate resilience
- Attract water-focused investment from corporations and water and state agencies to enable the USFS meadow restoration targets to be met

Ecological Outcomes

The importance of meadows as a water-cycle buffer is likely to increase as climate change results in a shift from snowmelt to rainfall-dominated runoff at mid-elevations in the Sierra Nevada, where many critical meadows are located (Knowles et al 2006, American Rivers 2012, Viers et al 2013). At these elevations, snowmelt currently dominates and provides available surface water into mid-summer. As the proportion of precipitation shifts toward more rain, the local hydrology will become more variable ("flashier") and the summer dry period will increase (Young et al 2009). Land managers including the USFS and CDFW believe meadow restoration is one tool to combat these effects and improve riparian summer habitat.

Healthy meadows are key habitats for many animal species because they provide water and forage during the three- to six-month dry season. Meadows with shallow water tables also promote lower summer stream temperatures, increased insect prey availability, and special vegetation structures such as willow thickets and overhanging vegetated stream banks. During summer months, montane meadows are considered the single most important habitat in the Sierra Nevada for birds (Graber 1996). Meadows provide breeding habitat for endangered amphibians including the Yosemite toad and for native fish including Lahontan Cutthroat and California Golden Trout. Moreover, these ecologically rich oases often occur along riparian corridors, linking meadow-to-meadow and creating movement pathways across the broader landscape. In the face of climate change and growing development pressures, these corridors are lifelines for wildlife.

Looking deeper, it is the unique hydrology of meadows that support herbaceous plants and enable a cascade of ecological benefits. Eroded meadows, in which the groundwater drains by early summer, are undergoing a vegetation transition toward more upland vegetation. Absent restoration, the processes that sustain a diverse community are sometimes lost (for example we have calculated that 40% of the meadow area in the Kern Plateau, an area , once famous for lush forage, has been replaced with sage brush).

This project will provide a published basis for the assumption that meadow restoration increases summer base flows, reduces temperatures, and increases groundwater storage. American Rivers and our partners will use this information to accelerate the pace of restoration in the Sierra to benefit rivers, and nature, and people.

Capacity

American Rivers is a leader in meadow restoration in the Sierra Nevada with a decade of technical, on-the ground experience, and the organizational capacity to maintain successful and efficient partnerships with individuals, organizations, and agencies. Our California staff has been at the forefront of major river restoration and protection efforts including the Sacramento-San Joaquin Bay-Delta Conservation Plan, the San Joaquin River restoration program, the historic Klamath River agreement to remove four large dams on one of the most important salmon rivers on the Pacific coast, the acquisition and dedication of water rights to instream flows in the Sierra and on the coast, the integration of river ecology in the redesign of California's flood control system, and restoration of headwater meadows in the Sierra Nevada.

In the Sierra Nevada, we developed a rapid assessment tool that has been used on 400 meadows by academic institutions, conservation organizations, and land management agencies to prioritize meadows for restoration. We have led the way in large-scale, multi-stakeholder restoration efforts. We have also attracted the first two private investors to meadow restoration for hydrologic benefit: Coca-Cola and Keurig Green Mountain. A national agreement with the USFS facilitates our collaboration, and we have partnered with seven out of the nine National Forests in the Sierra Nevada. We have also partnered with CDFW on three meadow restoration and climate resilience projects. We have partnered with researchers to revise the accepted range of beavers (allies in meadow restoration). With UC Davis and others, we partnered to create a meadow database that includes data, reports, assessments using the scorecard we developed and restoration projects. We partnered with the USFS to install stream and groundwater monitoring equipment in Indian Valley, and we are requesting funding from the CA LCC to publish these data with our partners and bring conclusions to land managers.

Approach and Scope of Work

Meeting Objective 2 of the Science-Management Framework

As described above, meadow restoration is a climate adaptation tool that, with sufficient support, federal and state land managers can use to maintain a resilient hydrology in the Sierra headwaters. Through the proposed tasks below, we will leverage existing efforts and data to publish the first empirically based hydrologic analysis of a meadow rewatering project. The Indian Valley site is high-profile with corporate, water agency, federal, state, and conservation partners at the headwaters of the Mokelumne River, which is becoming a model watershed for assessing the effects of headwater management on water supply. Additionally, we will combine these results with soils data and our field measurements of incision in more than 350 meadows across the Sierra to estimate changes in groundwater storage and stream-flow timing that would result if meadows were restored. Combining these hydrologic estimates with published predictions of snowpack change, we will identify meadows that are expected to most effectively add hydrologic resilience in climate-affected landscapes. American Rivers and our partners have found that a transparent, science-based, and participatory process to assess prioritize meadows in a watershed is an absolutely critical step to identifying and forging important relationships and determining shared restoration goals. Climate resilient hydrology is at the forefront of land managers' priorities, and with CA LCC support we would be able to add significantly to the understanding of the relationship between meadow restoration and water supply. In this way, the proposed project will help to generate climate-smart conservation strategies and assist the USFS, CDFW, and others in addressing critical stressors such as increasingly extreme weather patterns within the Sierra Nevada ecoregion.

Tasks

Task 1: Compile and Distribute Site-Specific Data

This task is 80% complete. It will involve completing streamflow and groundwater measurements at Indian Valley Meadow after restoration. (We have already collected the pre-restoration data and 2 years post-restoration.) We will compile streamflow (above and below the meadow) and groundwater time series, as well as long-term, remotely sensed vegetation data (NDVI) from Southwest Climate Science Center. Timelapse photographs showing sediment accumulation will be combined with flow data to estimate sediment capture rates. As part of this task, we will also develop a data management plan that includes providing data to the LCC Climate Commons, UC Davis meadows database, and the Natural Resource Project Inventory.

Task 2: Analyze data

The goal of this task is to calculate changes in groundwater elevation and stream flow across seasons before and after restoration. Preliminary analysis suggests the meadow soaks up and stores water in spring and releases water it autumn. We will quantify changes in the volume of spring capture, autumn release, and total annual discharge as a result of restoring the meadow's hydrology. For two summer thunderstorm events, we will estimate sediment captured by the project from timelapse photography, as the upper ponds in the project were rapidly filled. Thirty years of NDVI data will be used to determine the meadow's long-term vegetation trend pre-restoration and to provide context for the short-term (three-year) effects of restoration on vegetation.

Task 3: Publish

Under this task, we will prepare findings for publication with collaborators at San Francisco State University, USFS, and UC Davis. These will be the first empirical data published on the hydrologic impact of reconnecting an incised channel to the meadow floodplain. The target journal is *Restoration Ecology*.

Task 4: GIS Prioritization

Using hydrologic data from two studies, incision data from 350 meadows, and soil data, we will estimate the potential changes to groundwater storage and stream-flow timing as a result of meadow restoration in eight major watersheds (Mokelumne, Yuba, Tuolumne, Walker, Carson, Truckee, American, and Kern). Coupled with published data (cal-adapt.org/data/) on expected changes in snowpack across the Sierra, we will identify the meadow sites that, if restored, would most effectively ameliorate climate-change-driven effects on hydrology. These analyses would be part of an SF State masters' thesis in collaboration with researchers at UC Davis.

Task 5: Outreach and Application

The process of raising the groundwater table and affecting stream flow and meadow habitat is of interest to state and federal land managers, including the USFS, Bureau of Land Management, Natural Resource Conservation Service, CDFW and CA Department of Water Resources. American Rivers has strong relationships and data-sharing practices with all of these agencies (for example, our meadow condition scorecard data has been used by all of these natural resource managers), and we will reach out to these partners to apply data in setting priorities, including current National Forest planning. For example, the restoration technique called "pond and plug" is widely applied but seldom monitored and has recently been banned on the Plumas National Forest until hydrologic effects are better understood. This study will provide data to address these concerns. In addition, it will provide data on pond filling rates in one volcanic watershed (Mokelumne). This will enable the focus to shift from what is currently unknown (hydrology) to what is currently known but also controversial (new pond habitat created on the landscape) and help shift the conversation toward finding solutions that increase resiliency without unacceptable landscape changes. We will also present findings to Integrated Regional Water Management Groups in the Sierra as part of the Sierra Water Work Group. Additionally, we will share our data on the CA LCC Climate Commons site. We will also develop a one-page fact sheet describing the accomplishments of the project and its contribution to supporting Climate-Smart Conservation.

Task 6: Training

Under this task, we will incorporate project results into a meadow restoration training program that American Rivers and the USFS are co-developing with funding from the National Fish & Wildlife Foundation. This training program will reach approximately 40 land managers that are directly involved in meadow restoration.

Promoting Cross-Sectoral Understanding

Meadow restoration is a priority of CDFW as part of their greenhouse gas reduction program and Proposition 1-funded grants program because re-watering meadows is expected to reduce the rate of peat oxidation and soil carbon loss. This project's focus on hydrologic effects of restoration will dovetail with efforts by American Rivers and our partners to quantify greenhouse gas fluxes from meadows before and after restoration.

In addition, our work with indigenous communities (North Fork Mono Tribe, CSU Chico and the Indian Water Commission) is proceeding with the twin goals of 1) increasing the abundance of traditionally used plants and restoring traditional practices (including managing with fire), and 2) enhancing water supply and wet-meadow habitat. Currently the least well-supported goal is water supply/ raising groundwater elevation. Our hope is that this project will help us move forward with reintroducing traditional meadow stewardship practices by attracting water-related support.

Lastly, incision leads to erosion and increased sedimentation. We have seen in timelapse monitoring the capacity for meadow restoration projects to capture sediment, and will quantify these observations as part of the proposed studies.

Measuring Results

As described above, when a stream channel is connected to its meadow floodplain, it creates a unique hydrology that supports numerous ecological benefits. Functioning floodplain processes are the key to the ecological outcomes of meadow restoration. The ecological benefits of this research, publication, and outreach project will result from an increased pace of meadow restoration throughout the Sierra.

We anticipate that publication of the first empirical hydrologic data on meadow restoration will fundamentally change the conversation about meadow restoration and climate adaptation by providing evidence of hydrologic benefits and a quantification of their magnitude. We anticipate that the magnitude of the benefits will be smaller than what many proponents hope for. However, the measurements will enable planning to start from a scientific basis. To measure the visibility of our publication, we will track the number of land managers reached through presentations, the number of people reached through web downloads. To measure the efficacy, we will track when our results are included in planning and strategy documents (we anticipate inclusion in the NFWF Sierra Nevada Meadow Restoration Business Plan Update, the California Water Plan Update, and National Forest planning documents for early-adopter forests as well as CDFW, Sierra Nevada Conservancy, and Nature Conservancy publications). We will also provide an online prioritization of meadows for restoration based on estimates of potential hydrologic benefit and the change in predicted snowpack. We will track the number of these priority meadows that are restored and the time it takes for a meadow to move from identification to the implementation of restoration.

Metric	Target	Date
# land managers reached	150	9/2016
# meadows identified as water supply priorities	Unknown (to be determined)	9/2016
# web downloads	300	9/2016
# priority meadows restored	5	2020
# priority meadows in planning	15	2018
% increase in meadows restored/year	300	2018
# water supply funders of restoration	5	2018

Value-added and Transferability

Support from the CA LCC would enable us to complete analysis and publication of the first empirical data on the effects of meadow restoration on hydrology. It would also enable us to use existing data to develop water supply and snowpack buffering priorities for meadow restoration. Research funding for restoration projects is very limited, and although we have successfully supported collecting the data and a preliminary analysis with other funds, LCC support would fill a critical missing piece to enable results to be made usable and widely available. This information is timely and land managers have asked us for it. So far, we have provided preliminary results, but have not been able to allocate time to bring the results up to the standards required for peer review and publication. Agencies have cited our data; however, using unpublished data (even if they are the only data available) opens up initiatives for attack and doubt and can backfire and dramatically slow the pace of progress (as described above in the Plumas National Forest, once a leader in meadow restoration). This project leverages funds provided to purchase and install monitoring equipment and collect four years of data. The larger funding pool it leverages is the water-related funding that is poised to be invested in meadow restoration for climate resiliency, if a water supply benefit can be shown.

Protecting the Headwaters in a Changing Climate:
Managing Sierra Nevada Meadows for Water Supply & Habitat Benefits

California Landscape Conservation Cooperative 2015 Proposal Budget

Budget Categories	CA LCC Request	Partner(s) Contribution(s) (monetary)	Partner(s) Contribution(s) (non-monetary value/in-kind)	**Total**
Salaries	$ 10,087	$ 40,000		$ 50,087
Supplies		$ 175		$ 175
Overhead	$ 3,913	$ 7,825		$ 11,738
Equipment	$ -	$ 3,000		$ 3,000
Other: Contractual	$ 16,000	$ 9,000	$ 1,000	$ 26,000
Total	$ 30,000	$ 60,000	$ 1,000	$ 91,000

Other:

Contractual: These funds will be used for analysis, modelling and manuscript preparation by academic partners. The line item includes model license fees and publication page charges.

Match information (source, status, and how funds will be used)

$61,000 total match

-- Austen Lorenz: $1,000 (in kind) for Task 1 (complete data collection)

-- Wildlife Conservation Society: $20,000 (cash) for Task 5 (Develop outreach materials, including video. Develop partnerships and agency relationships).

-- National Fish & Wildlife Foundation: $40,000 (cash) for Tasks 1, 2, and 6. NFWF funded the original equipment purchase, data collection, and analysis on Indian Valley and will fund the training program ($181,000 total, we estimated $10,000 value added to this project, which is included in $40,000 contribution).

Note: We calculated the major (≥$1000) estimated contributions. Other partners will contribute in-kind to this effort.

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Deliverables, Timeline, Accessibility

Deliverable Name	Deliverable Type (select from pull-down)	Expected Delivery Date	Description	How will access to this product be provided? (See examples)	Target Audience (be as specific as possible)
Quarterly Financial and Progress Reports	Administrative	Quarterly	American Rivers will provide all required quarterly financial and progress reports.	Quarterly Financial and Progress Reports will be emailed to CA LCC	Financial: CA LCC Progress: CA LCC and Partners
Draft analysis and Powerpoint presentation	Presentation or Poster	Jan-16	Analysis and presentation of results for partners.	Email, in person, webcast	Partners, including, USFS, CDFW, SF State, UC Davis, UC Merced, copy to LCC.
Draft manuscript	Publication	Mar-16	Manuscript includes comments from presentation	Email	Partners, co authors. Copy to LCC.
Final manuscript	Publication	Jun-16	Flow and groundwater timeseries, vegetation and sediment effects of restoration for publication.	Email, web page	Restoration Ecology, partners. Copy to LCC.
Prioritized list of meadows	Datasets: Tabular data	Jan-16	GIS analysis of meadows will indentify priorities for restoration based on water supply (from incision and yield estimates) and capacity to buffer changes in snowpack (from predicted snowpack changes).	Email, UCDavis meadow database, Climate Commons. Natural Resource Project Inventory	Land managers, especially USFS, CDFW, Park Service. Also, water agencies, conservation organizations, and funders (including NFWF, Coke and other private funders, such as the Bonneville Foundation).
Prioritization report	Report	Apr-16	Report describing prioritization methods, data used, and conclusions about range of water supply benefits.	Email, UCDavis meadow database, Climate Commons, Natural Resource Project Inventory, web page, blog	Land managers, especially USFS, CDFW, Park Service. Also, water agencies, conservation organizations, and funders (including NFWF, Coke and other private funders, such as the Bonneville Foundation).
Meadow Restoration Training	Training, Outreach, or Workshop	Aug-16	Restoration training (funded by NFWF) developed in partnership with USFS. Training for land managers on all aspects of meadow restoration, including: design, permitting, partnerships, fundraising, implementation, monitoring. Water supply monitoring methods and results developed with LCC funding will be of interest to many. Training will include on-the-ground pairing with mentors in the field and will establish relationships between land managers with limited experience and experts in meadow restoration.	In person	Land managers, especially USFS, CDFW, Park Service

ATTACHMENTS

1) Citations
2) One-page CV for scientist, Luke Hunt
3) One-page CV for manager, Chuck Loffland

CITATIONS

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EDUCATION

Ph.D. in Biology 2006
Stanford University, Hopkins Marine Station, Pacific Grove, California.

M.S. & B.S. in Earth Systems Science 1995
Stanford University, Stanford, California.

EXPERIENCE

Director of Conservation American Rivers, Nevada City, CA 2009-Present

- Develop headwaters program ($1.3 million over past 3 years, > 15 projects) in collaboration with the USFS and numerous partners.
- Represent American Rivers in regional watershed management working groups and panels, and nationally at scientific conferences.
- Prepare comments on diverse policies and permits in collaboration with agencies and academic and non-profit partner organizations.
- Write and have received numerous grants (>$2 million) with multiple partners.

Principal & Chief Scientist Design Catalytix LLC, Portland, OR. 2007-2009

- Built a multidisciplinary team supported by a nonprofit and foundation to design, market and support an affordable machine for treating cataract blindness in the developing world.
- Fluid modeling, technical design, project analysis and management, developing strategies, product prototyping and innovation.

Dissertation Research Hopkins Marine Station, Stanford University. 2001-2006

- Conducted a multidisciplinary study of ecosystem range shifts in response to sea level rise.
- Integrated methods include: Fluid modeling, Historical genetics, Field experiments, Statistics, Image analysis, Spatially-explicit modeling, and GIS analysis.
- Published papers, presented at scientific conferences, wrote and received grants.

Antarctic Research McMurdo Station, Antarctica. August - December 1998, 1999, 2002

- Designed and carried out experiments on biological antifreeze in Antarctic fish.
- Initiated project's SCUBA program and conducted more than 100 under-ice dives (in 2002).

SELECTED PUBLICATIONS

Denny, M.W., **L J.H. Hunt**, L.P. Miller, and C D.G. Harley. 2010 On the Prediction of Extreme Ecological Events *Ecological Monographs* 79:397–421

Hunt, L.J.H. and M.W. Denny 2008 Desiccation Protection vs. Disruption: a Tradeoff for Intertidal Marine Algae. *Journal of Phycology* Vol 44, No. 5 pp. 1164-1170.

Hunt, L.J.H. 2007 Surveying and Climate Change. in: *The Encyclopedia of Tidepools and Rocky Shores*. eds. M. W. Denny and S. D. Gaines. University of California Press.

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Education

UC Davis: **BS in Wildlife Biology**
Year: **1989**

College of the Sequoias, Visalia, CA: **AS in Biology**
Year: **1986**

Monache High School, Porterville CA: **Graduate**
Year: **1984**

Experience

USDA Forest Service, Amador Ranger District, District Biologist
2002-present

Management of the wildlife program for the Amador Range District, including: habitat restoration projects, hiring, supervision survey and data collection and interpretation, budget, staff and acting District Ranger tasks. Responsible for NEPA document preparation, team leadership, meeting participation, forest level analysis, and database management.

USDA Forest Service, Amador Ranger District, Assistant District Biologist
1993-2002

Assist in the management of the wildlife program for the Amador Range District, including: habitat restoration projects, hiring, field supervision survey and data collection and interpretation, budget, staff and acting District Ranger tasks. Responsible for supporting NEPA document preparation, meeting participation, forest level analysis, and database management.

USDA Forest Service, Amador Ranger District, Wildlife Biologist
1989-2002 Various Term and Temporary Appointments

Primarily responsible for survey work, crew supervision, NEPA document preparation, and habitat restoration work.

Various consulting and other jobs *1989-2006* **when not employed by the Forest Service**

Conducted bird surveys for San Francisco State University, forestry related work including: tree marking, boundary marking, document preparation, data collection, and contract inspection.

Current Supervisor

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USDA Forest Service, Amador Ranger District, District Ranger