Section 5: Project Description

1. <u>Project Objectives:</u>

Restoration is set to begin on Osa Meadow in Sequoia National Forest where – like in many Sierra meadows - loss of hydrologic function has led to significant loss of organic matter and native flora, threatening listed species and impairing the meadows' ability to store GHGs within soils and biomass.

Restoring Osa meadow affords an opportunity to develop methods for estimating net carbon (CO2-equivalent) sequestration under pre- and post-restoration conditions for mountain meadows. With an expert, ongoing, Technical Advisory Committee, California Trout will develop this protocol; apply it to Osa meadow; and, provide it to all partners in the Sierra Meadow Restoration Research Partnership (SMRRP) for application on 20 other proposed meadow restoration projects that represent a wide range of meadow conditions throughout the Sierra Nevada.

Overarching project objectives include:
1. Determining the potential contribution of GHG emissions to the overall carbon budget for "project meadows" and other meadows of same hydro-geomorphic type, geographic area (climate, growing season), and parent material by measuring changes in soil carbon and peak GHG emissions under un-restored and restored conditions.

2. Identifying the proximate, mechanistic controls on soil C sequestration and soil GHG fluxes that will be used to build a model to estimate meadow C sequestration and GHG emissions in meadows. Soil carbon and GHG emissions will be measured along gradients expected to control GHG flux such as: depth and duration of saturation, soil texture and carbon content, plant community type, and length of growing season. This model will be framed to meet regulatory requirements, vetted, and submitted to CAR, CAR and VCS to credit carbon sequestered through Sierra Meadow restoration efforts.

3. Plugging 13,000 cubic yards of existing meadow gullies, repairing 2,000 feet of degraded stream within the meadow, installing a valley grade, and reconnecting the stream to the floodplain of Osa Meadow. This will restore the water table, improve hydrologic function in groundwater and surface flows; reduce peak flows; increase/extend summer base-flows; and, improve topography and vegetative growth. Further, water quality and in-stream habitat will be markedly improved by reducing fine sediment loading; moderating temperatures; and increasing in-stream cover and shading to restore habitat for endangered mountain yellow legged frogs and native Kern River Rainbows, a form of golden trout.

Restoring the meadow and reducing stressors on the native species will build ecosystem resilience to climate change.

Ultimately, as a result of this project, we expect an advanced understanding of GHG dynamics in Sierra

Nevada meadows; a tool to measure and credit carbon gains from restoration; regional capacity to undertake this work; and, a demonstrated restoration strategy that increases ecological resilience, sequesters GHG, and recovers species and habitat associated with alpine meadow systems.

2. *Background and Conceptual Models*:

Linkages and Background

The Sierra Meadow Restoration Research Partnership (SMRRP, Partnership) will provide a robust and coordinated regional response to the historic opportunity that AB 32 presents. The partnership, comprising of eight NGO's, four Academic Institutions, a number of Forests and Resource Agencies, Consulting Scientists and Volunteers - represents a potential research sample of 22 meadows in 2015. SMRRP will work together to advance our understanding of GHG dynamics in Sierra Nevada and respond directly to the prioritization of meadow restoration needs identified in the CA State Water Action Plan.

Over the next four years, California Trout (CalTrout) will facilitate the quarterly meeting of a Technical Advisory Committee (TAC) comprised of Consulting Scientists and SMRRP partners to coordinate projects, develop methodologies, integrate and analyze data, train regional practitioners in sampling procedures, and develop a predictive model that will be submitted for approval by CAR, ACR and VCS.

This Partnership model will leverage proposed data from a wide range of SMRRP-member meadow types, locations, and conditions, for a comprehensive assessment of the range of potential GHG emissions and net carbon sequestration in Sierra Nevada meadows, and as a robust foundation for developing tools to predict changes in carbon sequestration in restored meadows across the region. The TAC will provide SMRRP-members with peer reviewed and standardized field sampling protocols, lab methodologies, and data analysis procedures for GHG measurements - allowing for a comparative analysis of meadows across the Sierra Nevada. SMRRP partners include: California Trout, Plumas Corporation, Sierra Foothill Conservancy, American Rivers, Sierra Streams Institute, Spatial Informatics Group – Natural Assets Laboratory (SIG-NAL), South Yuba River Citizens League, Stillwater Sciences, Truckee River Watershed Council., University of Nevada at Reno, University of California, Merced, University of California, Davis, California State University at Chico, Tahoe National Forest, and Sequoia National Forest.

Working with the shared premise that re-establishing hydrological connectivity between the stream and surrounding meadow will improve soil capacity to sequester GHG from the atmosphere, CalTrout will measure the effect of restoration on GHG emissions in Osa meadow, in Sequoia National Forest.

As part of a multi stake-holder effort for Kern River Rainbow recovery, Osa meadow has been prioritized for restoration by the Sequoia National Forest, Fish and Wildlife Service, CA Department of Fish and Wildlife, Kern River Foundation, Kern Fly Fishers and the Southern Sierra Integrated Regional Water Management Plan. This project will further the aims of the CA Global Warming Solutions Act (AB 32) by researching, demonstrating and monitoring GHG sequestration. Sampling methodologies developed on Osa meadow will be fine-tuned by our TAC, contributed and applied to partner meadows across the Sierra – providing the region with a protocol for measuring GHG emissions and carbon sequestration and a framework to credit GHG restoration gains. At the federal level, the US Forest Service has identified aquatic and meadow system restoration as a critical need in their revision of National Forest Management Plans in the Sierra Nevada and OSA meadow has a clear path through the bottleneck of permitting and planning (completed by July 2015). Because Osa will be shovel ready by summer 2015, it is well positioned as a demonstration project by a number of State Agencies awarding Cap and Trade grants according to that criteria. Lastly, restoring meadow systems has been identified as a critical water management strategy within the State Water Action Plan. Building resilient forest meadow systems and understanding GHG dynamics has been called out as essential to developing the California Climate Change Strategy to which Osa Meadow can contribute an integrated and holistic understanding of ecosystem resilience through a suite of monitored benefits planned for frogs, fish, groundwater levels, water quality and GHG storage.

Baseline conditions at Osa Meadows

The 2002 McNally Fire burned over 150,000 acres of the forest including the headwaters surrounding Osa Meadow. The fire was followed by a rainstorm event in November of 2002 which dropped twenty inches of rain in a twenty-four hour period. The combination of the past gullying, 2002 McNally Fire, and the November storm significantly increased down-cutting in Osa Meadow, resulting in erosion and warming of water temperatures - impacting Kern River Rainbow habitat within Osa Creek as well as downstream. This project would plug 13,000 cubic yards of existing meadow gullies, repair 2,000 feet of degraded stream within the meadow, and install a valley grade to restore the water table. The outcomes of these restoration actions will be measured to quantify improvements in hydrologic function in groundwater and surface flows; topography and vegetative growth; and, nutrient cycling and carbon dynamics. Further, water quality and instream habitat will be markedly improved by reducing fine sediment loading and moderating temperatures - restoring habitat for endangered mountain yellow legged frogs and native Kern River Rainbows, a form of golden trout. Restoring the meadow and reducing stressors on the native species will build ecosystem resilience to climate change.

Impact of Climate Change

Climate predictions point to changing precipitation patterns throughout the Sierra Nevada. It is expected that in higher elevation areas precipitation will transition from a primarily snow-based to more rain-based form which will impact the region's hydrology. This presents significant challenges for habitat and species management. Meadows are a critical component of watershed hydrology because they act as natural reservoirs, regulating stream flow through storage and release of snowmelt and rainfall runoff that passes over and through fine-grained, sod-covered meadows. It is our premise that the most effective way to enhance resiliency of meadow systems and thereby ensure their continued provision of ecological goods and services e.g. long-term benefits, is to restore the ecological functionality of the meadows themselves. This project aims to restore ecological functionality primarily by restoring the hydrologic connectivity of the stream and floodplains within Osa Meadow. Through monitoring and evaluation of the changes within and downstream of Osa Meadow, we will be able to document the long-term benefits are realized.

In addition to the work proposed, there are several other related planning and implementation projects that have or are currently taking place in the region that compliment this proposed project. They include the following:

- Southern Sierra Integrated Regional Water Management Plan (SSIRWM Plan). This plan, developed under the guidance of the Southern Sierra Regional Water Management Group has identified restoration of Osa Meadow as a priority project within the SSIRWM Plan.
- Sequoia National Forest Scoping Letter. This letter initiated scoping for the proposed restoration of Osa Meadow that is the basis for the restoration work proposed within this proposal. Results from the scoping process will be included in the final NEPA that will be completed as a result of the California Trout/Sequoia National Forest project noted below.

- Although still in progress, the Sequoia National Forest is in the process of revising their Forest Management Plan along with the Southern Sierra and Inyo National Forests. For all three, restoration of aquatic habitat, including meadow systems, has been identified as an area that will be prioritized in the revised Plans.
- California Trout/Sequoia National Forest Project to restore Osa Meadow: This is a project funding through the National Fish and Wildlife Foundation (NFWF) that directly supports the work identified within this proposal. The project will result in the completion of a NEPA process and for on-the-ground restoration of Osa Meadow to be completed.
- Meadow Restoration to Sustain Stream Flows and Native Trout. This was a study completed in 2011 centered on assessing limiting factors within Sierra Nevada and Southern Cascade meadows impacting native trout. One of the assessments conducted as part of this project (and addressed in the report) analyzed limiting factors for Kern River Rainbow in Osa Meadow. Findings identified hydrologic disconnect between the main stream in Osa Meadow and the associated floodplain as being a primarily limiting factor inhibiting the health of Kern River Rainbow populations. Recommendations directly support restoration actions included in this proposal.

Conceptual Model

The distribution of vegetation types in mountain meadows reflects seasonal differences in ground water levels and litter decomposition (Allen-Diaz 1991, Merrill et al. 2006, Loheide and Gorelick 2007). Thus, hydrologically degraded Sierra meadows experience a radical change in plant community type distribution and overall plant biomass after restoration. In many cases, sparse cover of sagebrush, annual grasses, and forbs is replaced with dense thatch of sedge and willow species with similarly dense rooting structures (Chambers and Miller 2004, Lindquist and Wilcox 2000). In restored wet or very moist meadows, this change in meadow plant community structure co-occurs with an increase in net primary productivity and a decrease in aerobic decomposition rates of fine roots and above ground litter. These two changes (high NPP rates and slow decomposition) result in increased soil organic matter content represents carbon sequestration (Figure 1). Preliminary measurements of soil carbon in restored versus unrestored meadows in the Feather River watershed show that restoring meadows could provide a one-time increase in below ground C stores by 110 to 220 CO2e tons per acre over a 2 to 10 year post-restoration period (Wilcox et al. unpublished project results 2009). During the initial post-restoration years, these C sequestration numbers are very large and comparable to estimated rates of CO2e sequestration reported for Delta fresh water wetlands and redwood forests (Miller et al. 2008, Miller et al. 2011, Knox et al. 2014).

Despite a paucity of existing data, the limited knowledge we have in these restored ecosystems is highly encouraging from a C-sequestration perspective. However, the net change in greenhouse gas (GHG) emissions from mountain meadows that occurs with restoration needs to be expanded to include fluxes of the greenhouse gases methane and nitrous oxide as well as soil carbon and carbon dioxide. The common unit, CO2-equivalents, is used to combine the radiative forcing effects of all greenhouse gases into a single value for any source, such as a wetland, forest, or manufacturing plant (Forster and others 2007). Thus, net CO2-equivalents sequestered from a meadow take into account carbon dioxide uptake through photosynthesis and release to the atmosphere through respiration, as well as methane and nitrous oxide uptake and release to atmosphere. Net methane and nitrous oxide emissions from soils and sediment are critical because these gases, known to be important parts of the GHG budgets in other wetland types, have 25 and 298 times the radiative forcing of carbon dioxide, respectively, per mole of gas (over a 100-yr time horizon; Forster and others 2007). Unfortunately, the few studies that measured methane and nitrous oxide emissions from meadows covered only a narrow range of meadow types (Mosier et al. 1993, Blankinship and Hart 2014). In addition to being a potent greenhouse gas, nitrous oxide has other impacts on the biosphere: it is known to degrade ozone (Crutzen 1970), but it also removes nitrogen from streams and standing water where this limiting nutrient can reach such high levels it becomes a pollutant (Lowrance et al. 1984).

In soils and sediments, nitrous oxide emissions typically occur as a result of two processes: nitrification and denitrificiation (Davidson et al. 1986). Nitrification is an aerobic, oxidative process that converts ammonium to nitrate. Nitrous oxide is produced by nitrification during the incomplete oxidation of ammonium to nitrate. On the other hand, denitrication is a reductive process, meaning it occurs in anaerobic environments by which nitrate is reduced to nitrous oxide and eventually to dinitrogen gas. In well drained soils, nitrification is an important source of nitrous oxide, but in wet, anaerobic sites, denitrification is the primary source of nitrous oxide (Davidson et al. 1986). However, even under optimal conditions for both processes, denitrification usually produces more nitrous oxide than nitrification, all else being equal (Wrage et al. 2001). Thus, restoration from a dry and well drained meadow to a moist and more productive meadow could cause a shift in nitrous oxide sources from nitrification to denitrification, and increase nitrous oxide emissions (Figure 1). Areas of a hydrologically restored meadow where soil saturation remains high and organic matter is biologically available could support denitrification and associated nitrous oxide emissions. Similarly, in anaerobic conditions, decomposition of organic matter by soil microbes produces methane (methanogenesis; Figure 1). Therefore, any increase in soil C accumulation due to restoration must also carefully consider the production of methane and nitrous oxide to the environment. We do not mean to suggest that methane or nitrous oxide production are likely to cause restored meadows to be a net source of GHGs (measured in carbon dioxide equivalents to the atmosphere); however nitrous oxide and/or methane emissions (or uptake aka Blankinship and Harart 2014) could be a significant part of the overall meadow GHG budget, and therefore the importance of their contribution needs to be determined and if needed, included in any predictive models used to assess carbon credits gained through mountain meadow restoration.

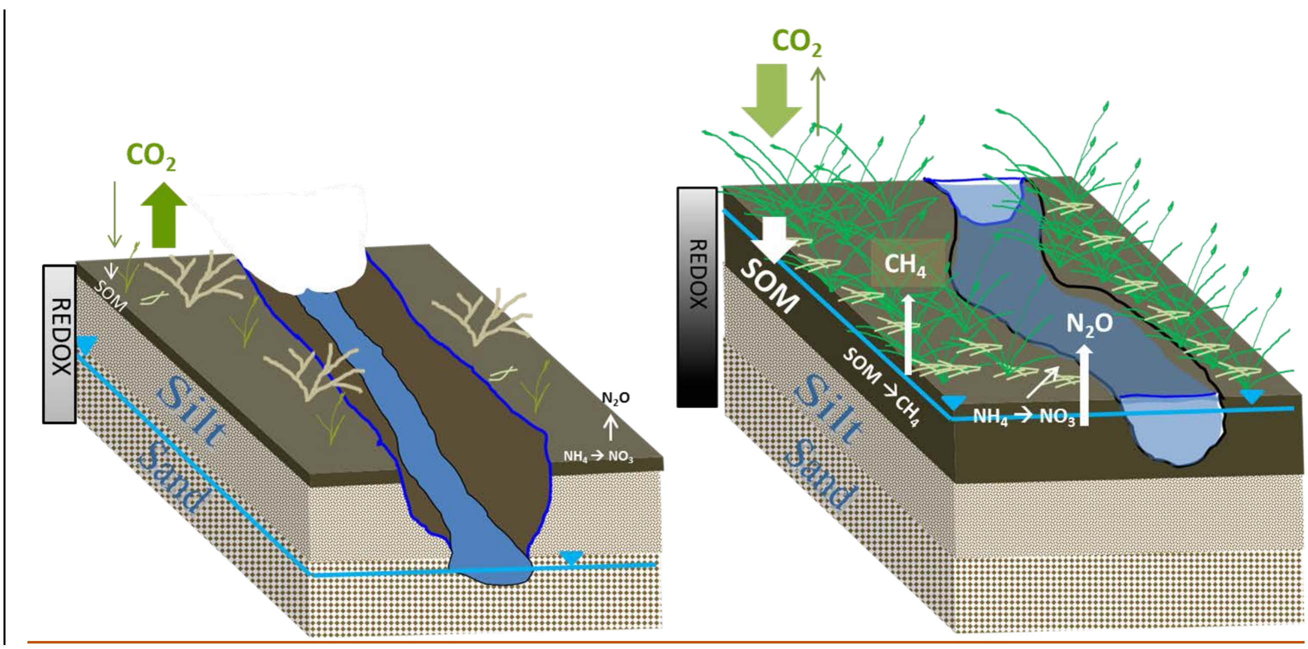


Figure 1. Conceptual model of meadow restoration effects on C sequestration and GHG dynamics (a)

Hydrologically degraded meadow to the left with a groundwater table below the rooting zone during the growing season, supporting plant community with overall low productivity. Most of litter is rapidly decomposed, leaving little soil organic material (SOM). Small amounts of litter is mineralized, supporting low rates of nitrification and no or small N2O emissions as an intermediate by product of nitrification. (b) Restoration raises growing season water table to support much more productive plant community; saturated soils support very slow anaerobic decomposition, leading to rapid buildup of soil organic material (SOM), and potentially supporting reductive processes of denitrificiation and methanogensis.

Through this research, we will test the hypothesis that: re-establishing the hydrological connectivity between the stream and the surrounding meadow will increase net carbon sequestration, taking into account net GHG emissions, compared to non-restored conditions. To test this over-arching hypothesis, we will measure net carbon sequestration in Osa meadow under pre and post-restoration conditions and at the same time measure net carbon sequestration in a similar degraded and unrestored meadow, completing a before-after-control-impact experimental design. We will assume that the change in net carbon sequestration in Osa meadow, compared to changes in the unrestored meadow, are due to restoration.

We will develop and apply the science to measure GHG (carbon, methane, and nitrous oxide) gains from restoration on PROJECT NAME Meadow. The same protocol will be applied to partner meadow-restoration projects in 2015 across the Sierras, and to 3 type-matched degraded control meadows to clearly demonstrate effects of restoration on net sequestration. Other meadows will be added in subsequent years to include a full range of meadow types. Peer reviewed findings will be shared at an annual conference, developing a protocol to measure GHG dynamics and quantify the impact of restoration strategies on GHG capture in Sierra meadows.

3. ***Detailed project description, including all tasks to be performed:***

California Trout will bring together a multidisciplinary team of Scientists, Biologists, Academics and Practitioners and steward their engagement in developing a meadows protocol for GHG sequestration. This will involve quarterly meetings of an expert TAC, standardizing sampling procedures, analyzing pre and post restoration data and reference data to quantify GHG gains across meadow types and over time. CalTrout will support this process with regular communications, an annual conference, public presentations, published articles and a web site with data archive, a library of relevant studies and a consistently updated “living document” reflecting the decision points and development of the TAC. In addition, California Trout will coordinate, contract, and implement restoration activities on Osa Meadow, beginning in July 2015; conduct water, vegetation, fish and frog monitoring to integrate co-benefits; and, reporting on scheduled progress. CalTrout’s finance team will implement appropriate administrative and accounting procedures, receive and pay monthly invoices, prepare account for annual audit and close books at project end.

Research Approach

The Sierra Meadow Restoration Research Partnership works from the premise that re-establishing hydrological connectivity between the stream and surrounding meadow will increase plant biomass above and below ground, increase soil organic matter, and thereby improve soil capacity to sequester GHGs from the atmosphere. The partnership leverages the considerable experience and expertise of Academic and Consulting Scientists, Practitioners and Resource Agencies to (1) establish the scientific foundation for what drives variation in GHG emissions and net carbon sequestration across a range of Sierra meadow types, (2) standardize field sampling, lab methodologies, and data analysis procedures for GHG measurements, (3) develop a predictive model for net carbon sequestration in Sierra meadows and an associated quantification protocol. The partnership also leverages a wide range of meadow types, locations, and conditions that will provide a 'gold mine' of information on the range of variability and associated controls on GHG emissions in the Sierras. Information on GHG emissions and their proximate controls will be collected at these sites and used to develop a predictive model for meadow carbon sequestration that is robust for the entire Sierra region. Finally and very importantly, through the process of implementing this project, the partnership will build regional and local capacity to monitor (and predict, using quantitative models) carbon sequestration and GHG emissions in meadows across the Sierras.

The proposed research will address the basic question: How does restoration of mountain meadows alter carbon sequestration in these ecosystems? We will address this broad question by collecting two sets of data at complimentary temporal and spatial scales. The first data set will be applied to what we refer to as the 'state factor meadows', and will address the question of how state factors (Jenny 1994), including climate (elevation and latitude), parent material, topography (slope and aspect), vegetation zone, and time since disturbance, affect carbon sequestration and GHG emissions. Effects of these state factors will be addressed by measuring GHG emissions and associated field characteristics at coarse temporal yet fine spatial scales. Sierra Meadow Restoration Research Partnership meadows represent a wide range meadows and state factors across the Sierra Nevada (Table 1; Figure 2). The second data set will be collected in focus meadows in order to (a) build robust annual GHG emission budgets that will inform annual estimates for other sites, and (b) to characterize key fine-scale hydrologic, geomorphic, vegetative, and biogeochemical parameters that relate to soil GHG fluxes. Information gained from this two-pronged approach will be used in order to create an empirically based model that can accurately predict the effect of restoration on soil GHG fluxes and carbon sequestration in meadows throughout the Sierra Nevada. Data from the proposed project will be made available to the entire SMRRP team to support development of the predictive model for meadow carbon sequestration.

Data from the state factor and focus meadows will be combined to establish quantitative relationships between readily measured proxy variables and carbon sequestration and between proxy variables and GHG emissions in Sierra meadows. These relationships will be used to build a model that estimates carbon sequestration and GHG emissions from un-restored and restored meadows in different parts of the Sierra Nevada. This draft model will be validated using emissions and sequestration data collected at a subset (at least one meadow complex) of the state factor meadows that will not be used develop model parameters, but rather set aside for this purpose. The quantitative model will be part of the carbon credit protocol for developed for meadow restoration through the SMRRP and under the leadership of CalTrout.

Table 1. Location and state factors associated with meadows to be sampled through the SRRMP.

Meadow Name	**Elevation (ft)**	**Mean Annual Precip (cm/yr)**	**Mean Annual Temp (oC)**	**Parent Material**	**Vegetation Zone**	**Hydrogeomorphic type**
Bean Creek	3100	84	15.6	Meta-sedimentary	Sierra Mixed Conifer	RLG
Clarks Meadow	5400	63.5	10	Mixed volcanics-granitics	Eastside Pine	RLG
Deer Meadow	6345	178	4.4	Mixed volcanics-granitics	Sierra Mixed Conifer	RHG
Foster Mdw Lower	6850	152	4.4	Mixed volcanics-granitics	Red fir	RLG
Foster Mdw Upper	7100	152	4.4	Mixed volcanics-granitics	Red fir	RMG
Greenville	5050	76	10	Meta-volcanics	Eastside Pine	RLG
Loney	5968	178	4.4	Mixed volcanics-granitics	Sierra Mixed Conifer	RMG
Mattley Meadow lower	7050	152	4.4	Mixed volcanics-granitics	Red fir	RHG
Mattley Meadow upper	7100	152	4.4	Mixed volcanics-granitics	Red fir	RMG
Middle Martis Valley	5850	80.3	6.22	Andesite, alluvium	White fir zone	RMG
Osa Meadow	8500	58.0	7.2	Granite	Eastside Pine	RMG
Red Clover-McReynolds	5600	63.5	10	Meta-volcanics	Eastside Pine	RLG
Sheatsley Meadow	810	114.3	44.2	Granite, basalts	Valley foothill riparian	D
Truckee Meadows	5850	80.3	6.22	Glacial outwash, volcanic source	White fir zone	DS
Upper Goodrich	5200	63.5	10	Mixed volcanics-granitics	Eastside Pine	RLG
Upper Loney	6031	178	4.4	Mixed volcanics-granitics	Sierra Mixed Conifer	RLG
Upper Truckee River Meadow	6240	44.2	5.72	Granite	Subalpine	RLG

*RLG = riparian low gradient, RMG = riparian moderate gradient; RHG = riparian high gradient; DS = discharge slope, D= Dry; per Weixelman et al. 2011.

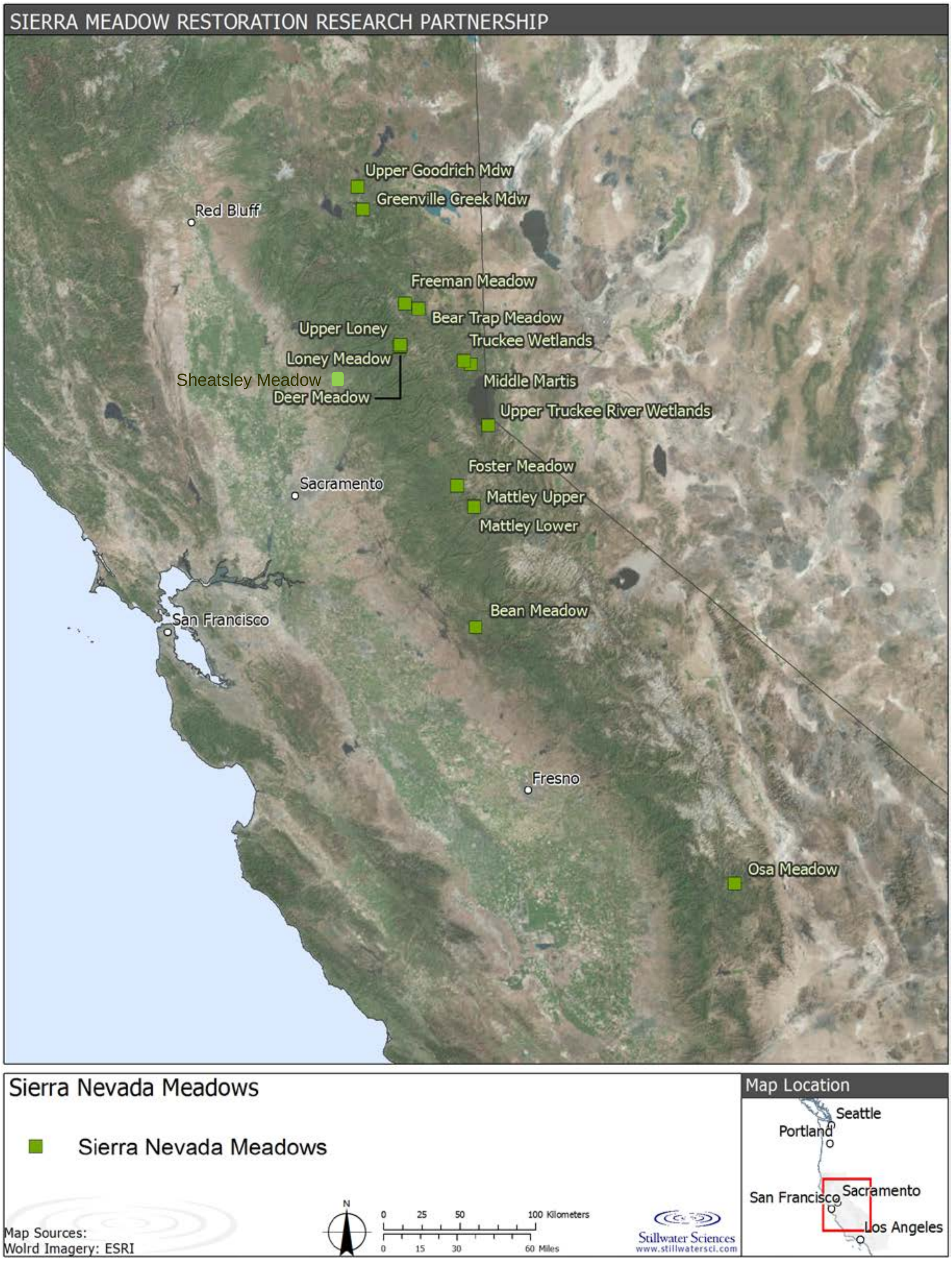


Figure 2. Meadows in proposed as part of the SMRRP represent a wide range of geographies in the Sierra Nevada.

Tasks
CalTrout, with core partners Stillwater Sciences, Plumas Corporation and the US Forest Service – will help to establish the science and regional capacity to in undertake GHG work on the ground in the Sierras. Over four years, CalTrout will facilitate the quarterly meeting of a technical advisory committee (TAC) of Academics, Scientists, Practitioners and Resource Agents - to review best practices and regulatory requirements, identify variables, test hypothesis and refine sampling procedures. One meeting annually will bring the broad meadows community together to compare data, identify trends and adapt our process. In the fourth year, our methodology will be developed into a protocol and vetted for approval by registered credit agencies – providing a cost-saving, scalable proxy for GHG measure in Sierra meadows and with it, the opportunity to sustain healthy meadows through future credit sales.

CalTrout's staff of Conservation managers, Project manager, Field Technicians, Videographer, Accountants and Book Keepers will fulfill the identified tasks below. Contracted positions will fulfill science, restoration, design and vetting tasks. Contributions from Federal and State Resource Agencies and volunteer groups will provide restoration, monitoring and science assistance to the project.

Science and Application
Task 1: Formalize the Technical Advisory Committee

- CalTrout will contract with leading Scientists in the area of GHG quantification: Dr. Amy Merrill of Stillwater Sciences will lead the protocol development, in consultation with Dr. Ben Sullivan of UNR and Dr. Stephen Hart of UCM, US Forest Service experts Dr. Nina Hemphill and Dr. Dave Weixelman, and practitioner Jim Wilcox who brings decades of restoration experience on Sierra Meadows. SRRMP members – representing an inter-disciplinary range of PhD's and expertise will be invited to join the quarterly meetings.
- Meeting agendas, goals and support materials will be developed one month prior to each meeting by CalTrout and Amy Merrill and distributed to the TAC.
- CalTrout will lead the web-cast quarterly meeting and transcribe the discussions.
- A living document – presented as a task flow diagram – will map the TAC thought process, including all decision points, next steps, reference links and research tangents (for follow up by grad students at SMRRP four member Academic Institutions). The document will be updated quarterly and made accessible to all Partners by CalTrout.

Task 2: Create a Resource Archive

- The living document will constitute one part of a Resource Archive, created and maintained by CalTrout and accessible to all Partners.
- A literature archive of up to 50 seminal texts and methods will be collected through contributions from the TAC scientists including a summation of key findings
- A communications archive, logging critical e-mail exchanges between TAC members will also be summarized and archived according to keywords.
- A collection of Partner meadow maps will be archived.
- A literature review will be compiled by CalTrout and distributed to all Partners.
- CalTrout will maintain the Resource Archive online and ensure Partner access.

Task 3: Initiate Methods and Establish Protocols

- TAC experts will provide the expertise and experience to establish best practices in sampling procedures and construct a standardized method for GHG measurement across 22 Partner meadows.

- Amy Merrill will design and trial run standardized field data forms for use by all Partners
- Amy will develop the database with built in functionality
- Amy Merrill, with Ben Sullivan, and Stephen Hart will test field equipment (chambers)
- Amy Merrill will lead the TAC to standardize vegetation mapping protocol

Task 4: Provide Training

- CalTrout will host a two-day training seminar, run by Amy Merrill, Ben Sullivan and Steve Hart, to build local GHG measuring capacity in the Sierra Nevada. This hands-on training will be open to Partners wanting to participate in GHG sampling on their meadows, USFS active on these projects and graduate students from affiliated Academic Institutions.
- CalTrout will support a video documentary of this training and compile a training module for reference by current and future practitioners

Task 5: Manage and Analyze Data

- CalTrout will receive, shepherd and input seasonal data from 22 Partner meadows
- Amy Merrill will integrate, summarize and model data to present to the TAC for discussion, prioritization and pattern identification.
- Amy Merrill will develop, refine and validate a quantification tool with Ben Sullivan and Steve Hart.

Task 6: Present Annual Conference

- CalTrout will conduct outreach, manage logistics and host an annual conference open to the public.
- SMRRP members will present their project data and insights.
- All attendees will participate in data comparison and trend-spotting discussion

Task 7: Integrate Contributed Assets

- CalTrout will acknowledge and integrate the data contributed by SMRRP Partners, including:
    - A chromos-sequence study conducted by UNR and Plumas Corp on meadows restored 13, 8 and 1 year ago to investigate GHG benefits from restoration over time.
    - Visual-spatial mapping of increasing GHG on all partner meadows contributed by SIG – NAL.
    - Detailed meadow typing contributed by Dave Weixelman.
    - GHG and co-benefits data contributed by all SMRRP partners

Task 8: Develop a Proxy Protocol

- CalTrout will consult with and review the regulatory requirements of the CAR, ACR and VCS
- CalTrout, working with SMRRP partner SIG – NAL will define compliance parameters for the meadow GHG protocol
- Based on the range of findings and variables, Amy Merrill, in consultation with TAC Scientists will develop and test a predictive model for GHG sequestration in Sierra meadows.
- CalTrout will engage a third party to vet the protocol
- CalTrout will submit the protocol to CAR ACR VCS for approval

- CalTrout will work with the USFS to establish the capacity to measure, vet and trade carbon credits to fund ongoing meadow restoration

Task 9: Report Findings

- CalTrout will complete annual project and financial reporting requirements to DFW.
- CalTrout will submit annual data and summary findings to UC Davis for inclusion in the Meadow Clearing House
- CalTrout and Amy Merrill will complete a final report on the complete TAC process and all products.

Task 10: Manage Scheduled Progress

- CalTrout will receive, compile, submit and pay all related invoices.
- CalTrout will conduct all internal external project coordination
- CalTrout will present, publish and post findings from this effort
- CalTrout will manage the scheduled progress of the TAC

Sampling and Measures (Conducted by Amy Merrill, CalTrout, Plumas Corp, CUM and UNR)
Task 11: Identify reference meadows and establish transects

- A degraded Control meadow, with the same hydrogeomorphic class and dominant vegetation type, in close proximity to Osa meadow will be identified by the TAC – to measure GHG gains against
- A pristine Reference meadow exhibiting "desired conditions and co-benefits" with the same hydrogeomorphic class and dominant vegetation type, in close proximity to Osa meadow will be identified by the TAC – to measure potential GHG gains against.
- Four to five transects will be established across each of the three meadows to position sampling-sites.
- A detailed vegetation map will be ground-truthed and refined for each of the three meadows
- Piezometers will be installed and maintained in three meadows

Task 12: Develop a robust annual budget of net carbon sequestration and net GHG flux

- GHG fluxes will be measured using static chamber methodology (incubation sampling) on three meadows every 2 weeks during the snow free season and every 2 months during the snowy season
- Soil carbon and biomass sample collection on three meadows will follow the same timetable
- Soil temperature, moisture content and soil oxygen content collection on three meadows will follow the same timetable
- Samples will be sent for lab analysis
- Incubation data will be uploaded and processed.
- Site-scale hydrologic, geomorphic, vegetative, and edaphic parameters will be quantified in relationship to meadow GHG fluxes
- GHG emissions will be summarized annually and reported to the TAC and SRRMP team, along with measurements of biomass production, groundwater levels, soil carbon and water content, and soil temperatures for each GHG sampling date.
- Statistical comparisons of the pre vs. post restoration GHG emissions and net carbon sequestration will be made using both reference sites data and reported annually

Restoration
Kern River Rainbow is a golden trout endemic to the Kern River in California, however introgression, lack of genetic variability and habitat degradation have reduced the species to a remnant populations in a high elevation refugia. Progress has been made toward restoring this species to the upper Kern River, and stocking has stopped in preparation for the planting of Kern River Rainbow within historic habitat. Osa Creek has 3.5 kilometers of habitat for Kern River Rainbow before waterfalls block native fish passage, however, erosion and warming of stream temperatures occurs upstream in Osa Meadow. From the late 1800s up until 2003, the Osa Meadow area was used for seasonal grazing of sheep and cattle. The combination of the past gullying, the 2002 McNally Fire, and the November storm that followed, increased downcutting in Osa Meadow. Osa Meadow Restoration would restore 2,000 feet of degraded meadow and stream for mountain yellow legged frogs; while improving water quality for Kern River Rainbows downstream by reducing fine sediment loading and moderating temperatures. A recovery effort for Kern River Rainbows is currently underway and this project will compliment that effort. Reducing stressors on the fish and increasing genetic integrity will improve resilience to climate change, and offer a strong long term prognosis when the genetically pure Kern River Rainbows are reintroduced into high quality habitat. We anticipate that reconnecting the stream channel to its naturally-evolved floodplain will provide the following ecosystem benefits: 1) establish a single-thread, low flow channel, 2) reduce peak flows and increase/extend summer base flows, 3) increase in-stream cover and shading, 4) enhance aquatic and terrestrial habitat, 5) improve water quality, and 6) raise the local groundwater level within the meadow. These benefits will improve downstream fish habitat by cooling and extending the flows longer into the dry season. Reducing gullying and erosion as well as inundating the meadow in the spring and summer will reverse the declines in the quality and quantity of aquatic habitats for native fish and amphibians.

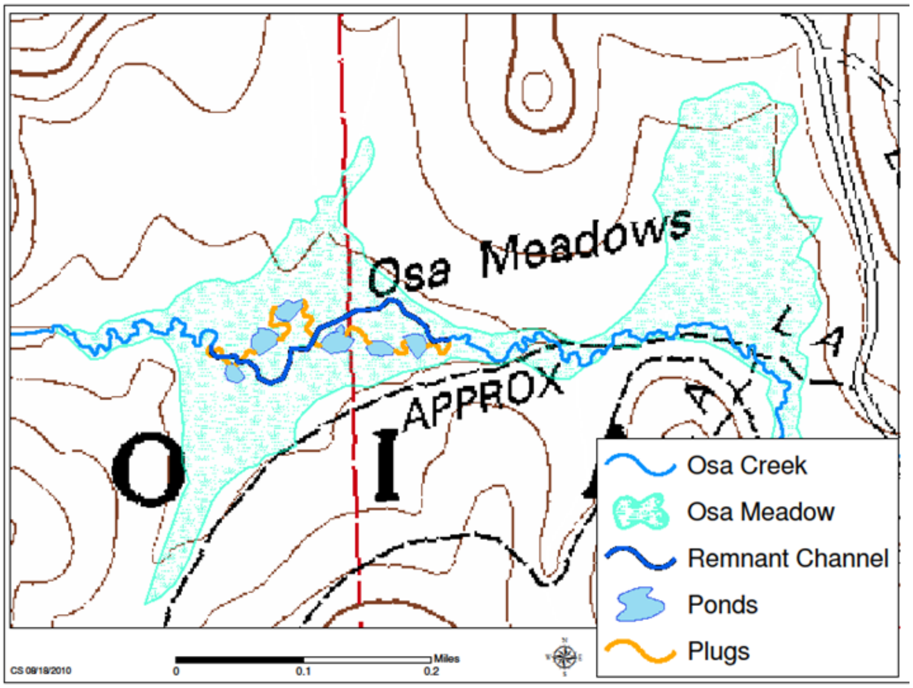
Task 13: Assessments, Design and Permitting

Initial scoping, hydrologic assessments and preliminary designs have been prepared for the Osa Meadow and stream restoration. Fish and amphibian occupancy and habitat surveys will be done both downstream and within the meadow. Hydrology, archeology and vegetation surveys all need to be conducted and reports written. With the preliminary design (see figure below) the surveys can proceed to evaluate potential effects of proposed restoration activities. With all data collection and survey reports completed the NEPA will be prepared identifying priority conservation needs to improve summer habitat for Kern River Rainbow Trout and to restore habitat for mountain yellow legged frogs. Restoring habitat for genetically pure Kern River Rainbow Trout is a priority for the Sequoia National Forest, Kern River Foundation, Kern Fly Fishers, the State of California, and the Southern Sierra Integrated Regional Water Management Plan, and will likely qualify for funding from the Sierra Nevada Conservancy, and the Kern River Foundation, once NEPA is finished and implementation can begin.

Once NEPA is finalized, the USDA Forest Service will obtain all required state and federal permits. A Nationwide Permit 27 Aquatic Habitat Restoration, Establishment and Enhancement Activities will be obtained from Army Corps of Engineers. A Clean Water Act Section 401 Water Quality Certification will be submitted to the State Water Quality Control Board and a request to certification of CEQA compliance will be submitted. Permits should be in place in July when implementation is scheduled to begin.

More detailed topographic and engineering surveys will be completed to develop a 100% design: In addition to hydrologic designs, other aspects of restoration will be included such as use of large woody debris necessary to provide immediate in-stream and overhead cover.

Figure 3: Osa Meadow early design of plug and ponds: Plan View



Task 14: Gully Elimination, Pond Construction, Large Woody Debris Reintroduction and Re-vegetation

Restoration of Osa Meadow and stream would be implemented to improve habitat for mountain yellow legged frogs and downstream native Kern River Rainbows. Restoration treatment focuses restoring natural, ecological functions and particularly on reconnecting the stream channel to its naturally-evolved floodplain by means of the following treatments: gully elimination using the pond and plug technique; incorporating whole trees (large woody debris) into the meadow channel and ponds; 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 channel characteristics, and vegetation components.

The restoration project would include cut and fill of approximately 13,000 cubic yards of existing gullies to eliminate the downcutting that is rapidly draining and lowering groundwater levels the lower portion of Osa Meadow (See Figure 1). Material would then be used to fill portions of the gully up to the original meadow elevation, or plug the existing gully system through creation of the ponds to help raise the water level and restore historic hydrologic conditions necessaryto restore the meadow. All ponds are designed and constructed with irregular shapes, points, islands and varying depths to provide numerous habitat niches for waterfowl, native amphibians, emergents and other aquatic or riparian associated species. The design is meant to fill in over time, and allows the creation of a natural stream channel or shallow ponds. The exact number of “ponds” and plugs will not be known until the design is field-staked for review in June or July 2015, though an estimated 6 ponds and 8 plugs should result from this project. Stream flow would be re-directed into the well-defined, relic channels in the meadow, which would require minimal treatment. The restoration would resemble Big Meadows, Hume Lake Ranger District, Sequoia National Forest which was restored in fall 2007.

Large woody debris, in the form of whole trees, was likely a structural component of the original meadow channel system and is noticeably absent at present. As part of this restoration project, woody debris would be added to the stream to provide immediate instream and overhead cover and enhance pool scour. An estimated 16 whole lodgepole pines (<30 inches diameter), with limbs and rootwads attached, would be placed at strategic locations. Use of the whole trees would provide a short term enhancement to the existing historic remnant channels while willow, alder and other woody plants become reestablished. Pines would be uprooted from a designated 10-acre area along the southern margin of Osa Meadow where pines have been encroaching into the meadow.

Seeds would be collected the year before implementation and grown to enable planting of native grasses, sedges and herbaceous plants. Local willows would be harvested and grown the previous year, occurring after the willows set bud for dormancy in late summer/early fall, to help ensure successful propagation. Vegetation, in the form of sod and additional willows established in the gully bottom, would be recovered and transplanted to the pond edges, plug surfaces and any high stress areas of the restored channel before ponds are created. Topsoil would stock-piled adjacent to areas designated to be plugged. When plugs are finished, they would be cross-ripped to reduce any compaction from project implementation, and topsoil spread to inoculate the plugs with soil organisms and the native seed bank. Native herbaceous and woody plants would be planted to start the process of stabilization. The willows will develop shade within several years. Volunteers will help with these plantings in the fall following restoration.

An estimated 150 cubic yards of .5- 2.0 foot diameter rock (15 loads) would be needed to provide a buttressing armor at the lower end of the meadow, and would provide elevational stability at the lower end of the project area. Placement of the rock near the bottom of the meadow would allow water to filter through, but stop the larger soil particle movement and down cutting of the channel grade that has been occurring. This area will be covered with soil and native plants within the meadow and a more natural steep stream channel will be designed.

Reducing gullying and erosion, inundating the meadow throughout the year, will reverse the declines in the quality and quantity of aquatic habitats for mountain yellow-legged frog suitable habitat within Osa Meadow and downstream for Kern River Rainbow. Restoration of 2,000 feet of degraded stream within the meadow is anticipated to provide the following ecosystem benefits: 1) establish a single-thread, low flow channel, 2) reduce peak flows and increase/extend summer base flows downstream 3) increase in-stream cover and shading, 4) enhance aquatic and terrestrial habitat, 5) improve water quality, 6) increase carbon sequestration rates and 7) raise the local groundwater level within the meadow.

Habitat for Kern River Rainbows will improve as water quality improves. Reconnecting the stream channel to its naturally-evolved floodplain will improve downstream fish habitat by cooling and extending the flows longer into the dry season. Reducing stressors on the fish will improve resilience to climate change, and support a strong long term prognosis when the genetically pure Kern River Rainbows are reintroduced into high quality habitat. This project is consistent with the CDFW and USFWS recovery efforts underway for Kern River Rainbows.

Task 15: Monitoring

This area has undergone extensive surveying to document the existing hydrologic and soil conditions within the meadow. Amphibian surveys were initiated in August of 2010. Amphibian surveys using Visual Encounter Survey protocol (Keeler and Freel, 1995) will take place in 2015, and immediately after the restoration tasks are completed. Breeding, resting habitat conditions will be assessed using USFWS habitat definitions as we anticipate this to change with restoration. Soil moisture and moisture depth across the area meadow are predicted to change with restoration. Twenty psiometers would be installed and monitored beginning in 2015 to document existing conditions and changes over 4 years. A staff gauge will be added and stage discharge measurements taken to calibrate the gauge will be done before and after restoration. Discharge from the meadow will be monitored on a monthly basis and if possible during high flow events. To validate changes in stream temperatures, stream temperatures will be monitored prior to restoration and then for 5 years after. Water temperatures will be taken at twenty locations within feeder streams of the meadow, within psiometers and downstream to the Kern River confluence. A detailed topographic survey of the meadow and stream will be conducted to support the design of the project. We anticipate increasing woody and herbaceous wetland and riparian associates through planting. In-stream habitat condition assessments employing an enhanced USFS protocol (Proper Functioning Condition) developed with prior NFWF funding and applied to several Sierra meadow systems will be conducted prior to and after the restoration. Vegetation will be monitored for wetland and riparian obligates and associates, including woody species upstream, within the meadow and in downstream fish habitat both before and 3 and 5 years after restoration.

We have many fly fishers who are eager to assist us. Additionally, there are two World Resource Institute interns who will be working on the surveying of Osa Meadow in 2015. We will train interns and volunteers to: (a) plant wetland and riparian species, (b) monitor the staff gauge, (c) monitor the planting (measuring mortality), (d) monitor for fish presence in the meadow, and (e) participate in monitoring fish habitat once maps are completed. In doing so, interns and volunteers will gain first-hand experiences in habitat monitoring and restoration.

To better understand GHG dynamics in Sierra meadows and to more comprehensively understand how meadow restoration can holistically enhance meadow ecosystems, monitored co-benefits of improved (a) habitat for listed species, (b) increased water storage and quality and, (c) increased resilience to extreme climatic events will be documented along with measures of increased GHG sequestration.

4. *Timeline:*

Task 1: Formalize the Technical Advisory Committee – July 2015 through June 2019
Task 2: Create a Resource Archive – July 2015 through June 2019
Task 3: Initiate Methods and Establish Protocols – July through Dec, 2015
Task 4: Provide Training – July through Dec, 2015
Task 5: Manage and Analyze Data – July 2015 through June 2019
Task 6: Present Annual Conference – 2015 (after July), 2016 and 2018
Task 7: Integrate Contributed Assets – July 2015 through June 2019
Task 8: Develop a Proxy Protocol – July 2015 through June 2019
Task 9: Report Findings – July 2015 through June 2019
Task 10: Manage Scheduled Progress – July 2015 through June 2019
Task 11: Identify reference meadows and establish transects – July 2015 through Dec 2016
Task 12: Develop a robust annual budget of net carbon sequestration and net GHG flux – July 2015 through June 2019
Task 13: Assessments, Design and Permitting – July through Dec, 2015
Task 14: Gully Elimination, Pond Construction, Large Woody Debris Reintroduction and Re-vegetation – July 2015 through Dec 2016
Task 15: Monitoring – July 2015 through June 2019

5. *Deliverables:*

Project deliverables include:

- Resource archive with a flow chart diagram of the TAC process and discussion in developing a meadows protocol for GHG measure; a literature review of up to 50 recommended texts; a collection of maps.
- Standardized methods for GHG measurement, standardized data form s and mapping protocols.
- 2-day, hands-on, training seminar, a training video and module
- Quantification tool to manage and model data
- 3 annual public conferences
- Predictive model and protocol for crediting carbon sequestered through meadow restoration

- Annual reports and data provided to DFW, SMRRP members and UC Davis Meadow clearing house
- Detailed maps of Osa Meadow (topography; vegetation etc)
- Annual budget of net carbon sequestration and GHG flux for Osa meadow, a control meadow and a reference meadow.
- Statistical analysis of pre vs post restoration GHG emissions and net carbon sequestration.
- Surveys - Fish, amphibian, aquatic habitat, hydrology, archeology, vegetation and topography complete
- Permits - NEPA, CEQA, 401 water quality and Federal Permit 27 secured
- Monitoring – of amphibians, fish, soil condition, meadow discharge, stream temperature, vegetation for up to 5 years
- 90 acres of Osa meadow restored through gully elimination, pond construction, large woody debris reintroduction, valley grading and re-vegetation

6. ***Expected quantitative results (project summary)***:

1) Erosion Control– erosion control would be monitored before and after project implementation. Prior to the project, water quality (turbidity) and sediment in the water column would be sampled on the rising hydrograph during spring snow melt or spring rains. These measurements would be taken starting in 2015 and continue through a five year period. A trend in decreased sediment moving down river is predicted after restoration.

2) Monitoring, Miles being monitored – 1.5 to 2.5 miles would be monitored for fish and amphibians. Prior to NEPA analysis and prior to restoration, fish would be monitored both in the meadow and downstream to the confluence with the Kern River, about a 2.5 mile stretch of stream. Amphibians would be monitored within the meadow and upstream as well, in a stretch of about 1.5 miles. We do not predict that the frogs would occur in the area with historic fish populations down below natural falls. All these areas would be monitored again just prior to restoration and 3 years after project. CalTrout, Kern River Fly Fishers, and the Forest Service (in full cooperation with California Fish and Wildlife) will monitor fish populations in Osa Creek before and after restoration of habitats and again after planting of native Kern River Rainbows.

3) Land, wetland restoration–90 acres are proposed for restoration to proper functioning condition and restored hydrologic connectivity. Both condition and hydrologic connectivity will be monitored. Vegetation could take longer to restore to wetland indicators except where planted as part of the project. Encroaching Conifers may die slowly and take several years to die from wet roots. Wells or psiometers would give us quick feedback on depth of water in the meadow as we move away from the stream and we could relate this to precipitation and stream flow.

4) In-stream restoration, Miles restored –1.5 to 2.5 miles would be monitored for fish and amphibians. Prior to NEPA analysis and prior to restoration, fish would be monitored both in the meadow and downstream to the confluence with the Kern River, about a 2.5 mile stretch of stream. Amphibians would be monitored within the meadow and upstream as well, in a stretch of about 1.5 miles. We do not predict that the frogs would occur in the area with historic fish populations down below natural

falls. All these areas would be monitored again just prior to restoration and 3 years after project. CalTrout, Kern River Fly Fishers, and the Forest Service (in full cooperation with California Fish and Wildlife) will monitor fish populations in Osa Creek before and after restoration of habitats and again after planting of native Kern River Rainbows.

5) Total net GHG reductions/sequestrations expected as a result of restoration activities- tons of CO2-equivalent per acre change due to restoration of Osa Meadow will be measured as the net carbon captured in plant biomass, litter and soil carbon, and net GHG losses to the atmosphere. Comparison of the pre and post-restoration conditions, with the effects of interannual variation controlled by a degraded control meadow, will be used to calculate the change in carbon storage due to restoration. Within site variability in change in net CO2-equivalent will be reported for each component of this carbon equivalent budget.

Current estimates of changes in estimated CO2-equivalent sequestration are based on soil carbon measurements for different meadow vegetation types reported by Wilcox et al. unpublished report. Under current conditions, Osa meadow supports primarily dry graminoid and shrub species and under predicted restored conditions, could convert to a moist sedge-dominated vegetation type (Henery et al. 2011). Wilcox and others report dry sage and graminoid dominated meadows store approximately 7 to 8.4 tonnes of carbon per acre, while restored sedge dominated meadows store 30 tonnes of carbon per acre. The roughly 20 tonne/acre difference suggests that with similar vegetation type conversion of the 25 acres restored in Osa meadow, 250 to 850 tonnes of carbon could be sequestered, overall. This estimate is extremely rough and will be refined enormously through the measurements and monitoring forwarded in this proposal.

7. ***Protocols:***

GHG reductions measurement protocols

Identify reference meadows and establish transects

Control meadows, with the same hydrogeomorphic class and in close proximity to the target restoration meadow, will be selected in the spring of 2015 for each restoration meadow. Paired control sites will be selected as meadows that have experienced hydrologic alteration and degradation similar to the target restoration meadow. Pairing of control degraded meadows with treatment (meadows to be restored) will also provide controls on interannaul variability that could confound effects of restoration. Restoration and control degraded meadows will be stratified according to hydrogeomorphic type as described in Weixelman et al. 2011 and then by dominant vegetation type (Sawyer et al. 2009). Four to five transects will be established across each meadow perpendicular to the dominant slope and to the degree possible, aligned with existing ground water well transects and positioned to capture the vegetation types covering the greatest surface area of the meadow.

Sampling Methodology

GHG fluxes will be measured using static chamber methodology (Hutchinson and Mosier 1981) used by others to measure GHG emissions in mountain meadows in the Sierra Nevada and Intermountain West, including by SMRRP participants Sullivan (UNR) and Hart (UC Merced) in various ecosystem types (Sullivan et al. 2008, Blankinship and Hart 2014). Boardwalks will be erected each year along these transects in wet areas to avoid trampling meadow soils and to minimize methane ebullition (bubbling) into the chambers during incubation measurements (Megonigal et al. 2004, Teh et al. 2011). Use of chambers vs. the eddy covariance method (Hutchinson and Mosier 1981; Baldocchi et al. 1988) will enable us to measure both nitrous oxide and methane emissions, and to link emission differences to sub-meadow scale varation in site conditions. Chambers will be constructed of polyvinyl chloride (PVC) tubing and be approximately 30 cm in diameter to reduce the inherent spatial variability associated with soil gas fluxes (Sullivan et al., 2010). In the field, the vented static chambers will rest on PVC collars that are permanently installed 2-3 cm deep in the soil to reduce soil disturbance and plant root mortality associated with repeated chamber-based flux sampling. Collars will be installed at least one month prior to the first measurement to allow stabilization of the surrounding soil and vegetation. Collars will be beveled on the soil-facing edge to minimize soil disturbance during installation. Soil fluxes of carbon dioxide, methane, and nitrous oxide production will be measured as part of a complete soil GHG flux estimate. Ancillary data on ground water level, soil temperature, and water filled pore space will also be collected with the gas samples.

The first major objective of this task is to generate robust annual estimates of soil GHG fluxes for the focus meadow sites. Therefore, we will measure in situ fluxes every two weeks during the growing (frost-free) season, and bi-monthly in the non-growing season in each plant community/hydrogeomorphic zone on each transect. We will also measure GHG fluxes from seasonally and perennially inundated sediments, including the created ponds in restored sites, using floating chambers.

Soil carbon and biomass production

Soil carbon and biomass samples are collected along transects established across the meadow, as described above. Four one-foot square plots will be chosen along each transect, with each plot representing a soil/vegetation type. In the un-restored meadows, it will be necessary to ensure that plot locations do not interfere with potential design features where earth movement activities are planned. Within these parameters, sample plot locations are randomly selected. The best representation of all vegetation/soil types is sampled in each meadow; however, not all types may be sampled and some may be sampled more than once. In an effort to make between-meadow comparisons, attempts to duplicate soil/vegetation types among similar meadows will be made. Samples are removed within the one-foot square plot in the following pre-determined, definable layers: 1. All above-surface biomass material within the square is clipped to ground level. Soil surface is defined as the top of the O horizon. Material is removed, bagged and labeled by plot number for the entire square foot area. Documentation of meadow use, i.e. grazed or un-grazed is made, and percentage of utilization is estimated. 2. In wet sites, a 4” auger-size sample of the O horizon is taken. In dry sites, the O horizon of the entire square foot is taken. O horizon material consists of duff, litter and residual live plant material, down to a bare, mineral soil surface. Material is removed, bagged and labeled, including a notation of whether the wet or dry site method is used. 3. In the center of the square, an auger is used to sample the top three feet of soil. A representative sample of each foot of depth is collected. Approximately 20% of the soil in the auger is removed for analysis, with an attempt made to collect material from the upper, middle and lower portion of the core. 4. During augering, a representative bulk density sample (Blake, G.R., and K.H. Hartge, 1986) is collected for each foot of depth. Bulk density samples are collected at 9”, 18” and 27”. Soil cores are collected using an Oakfield 3-ft. Model B 36” Soil Sampler (mud augers worked best in wet sites). Bulk density samples are collected with a 0200 soil core sampler manufactured by Soil moisture Equipment Corp. All samples are stored in plastic bags, and labeled with meadow, plot number, depth, and date.

Biomass testing is conducted by a comercial lab. All above ground biomass material recovered from the one foot square is dried in a hot-air oven at a constant 105oF. Soil samples, separated for each foot of depth, are dried as described above and sieved using an ASTM#10 (2mm) 8” brass sieve. Large organic material (roots) are removed and added to the biomass measurments as below ground biomass (smaller organic particles go through the sieve and became part of the soil sample). Biomass samples dried until bagged samples can be placed in a standard freezer for 30 minutes without creating condensation on the bag interior.

Approximately one teaspoon of each well mixed and sieved soil sample (per foot of depth) is sent to the Soil, Water and Forage Analytical Lab at Oklahoma State University, Stillwater, Oklahoma to test for soil C content using a LECO TruSpec Carbon and Nitrogen Analyzer. Other soil information reported per sample includes soil total N, pH, nitrate, total phosphorus,and potassium. The bulk density sample data are used to convert all soil carbon samples to a per m2 area basis.

Identify site-scale sources of variation

The second major objective of this study is to measure important site-scale hydrologic, geomorphic, vegetative, and edaphic parameters and quantify their relationship to meadow GHG fluxes. In order to meet this objective, we will measure expected site-scale predictor variables from ground water wells and piezometers in each meadow, soil chemical and physical analyses, assessments of vegetative productivity, soil carbon, and plant community composition. Specifically, these parameters include soil pore water and soil temperature, which will be collected at the same time that GHG emission measurements are made at each site along the meadow transects. Vegetation composition plots will also be recorded each year along each of the meadow transects using the CNPS rapid assessment protocol (CNPS 2004).

Carbon footprint

A close measure of emissions produced by the restoration and sampling effort will be tallied and included in the annual GHG budget. GHG emissions, above and below ground production will be summarized annually as net change in tonnes of CO2-equivalent per acre for the restoration site, degraded control, and for the undisturbed reference meadow. Summarized as well as detailed findings will be reported to the TAC and SRRMP team after each year of monitoring, along with measurements of expected control variables such as groundwater levels, soil carbon and water content, and soil temperatures. Net change in CO2-equivalent will also be summarized by vegetation/hydrogeomorphic type, for each meadow as a whole, and by season (sample date), and for the full year. Statistical comparisons of the pre vs. post restoration GHG emissions and net carbon sequestration will be made using the unrestored control site data as controls for inter-annual variation in climate. Findings will be prepared in annual reports (submitted by end of calendar year) and distributed to the SRRMP team and TAC members. It is anticipated that one or several peer reviewed publications on mechanisms that control GHG emissions and carbon sequestration in meadows also will be produced through this task.

Performance evaluation of Co-benefits

Restoration actions will 1) establish a single-thread, low flow channel, 2) reduce peak flows and increase/extend summer base flows downstream 3) increase in-stream cover and shading, 4) enhance aquatic and terrestrial habitat, 5) improve water quality, 6) increase carbon sequestration rates and 7) raise the local groundwater level within the meadow. Reducing gullying and erosion and inundating the meadow throughout the year will reverse the declines in the quality and quantity of aquatic habitats.

Specifically, habitat for Kern River Rainbows will improve as water quality improves, temperatures are reduced, flows are extended into the dry season and the stream channel is reconnected to the naturally-evolved floodplain.

In addition to the above mentioned outcomes, the proposed project will provide additional benefits including pertaining to the ecological/biological health and condition of Osa Meadow and associated flora and fauna as well as building scientific capacity in the fields of climate change/GHGs and meadows restoration. They include the following:

- Physical habitat & vegetation data.

Data collection for this co-benefit will be derived by implementation of pre and post restoration monitoring of Osa Meadow using the Proper Functioning Condition (PFC) methodology (Pritchard et al, 1998). PFC is a methodology for assessing the physical functioning of riparian-wetland areas. The term PFC is used to describe both the assessment process, and a defined, on-the-ground condition of a riparian-wetland area. In either case, PFC defines a minimum level or starting point for assessing riparian-wetland areas. The PFC assessment provides a consistent approach for assessing the physical functioning of riparian-wetland areas through consideration of hydrology, vegetation, and soil/landform attributes. The PFC assessment synthesizes information that is foundational to determining the overall health of a riparian-wetland area. The on-the-ground condition termed PFC refers to how well the physical processes are functioning. PFC is a state of resiliency that will allow a riparian-wetland area to hold together during a highflow event, sustaining that system's ability to produce values related to both physical and biological attributes.

- Species and condition data for Kern River Rainbow.

Population and condition of Kern River Rainbow (KRR) will be assessed by determining the number of KRR/mile of stream. The condition of KRR will be determined based on calculation of K-Factor which is a qualitative measure for fish condition based on a ratio of weight to length of a given fish. To determine both population numbers/mile and K-Factor (condition) of KRR, streams within and below Osa Meadow will be electro-shocked allowing for project partners (including DFW and CalTrout) to count and take appropriate fish measurements.

- Species population data for Mountain Legged Yellow Frog.

Species population data for Mountain Legged Yellow Frog will be collected using a modified version of the Visual Encounter Survey (VES) methodology (Keller and Freel, 1995). This methodology surveys all aquatic habitats within the survey area, e.g., the entire length of all streams and rivers, and all ponds, lakes, and meadows. The VES methods are designed to determine the presence, distribution, habitat utilization, and relative abundance of all life stages including: egg masses, tadpoles, juveniles/subadults, and adults. This approach is used by the CA Dept of F&W's High Mountain Lakes team.

- Increased water storage and quality.

Increased water storage will be determined by installing and monitoring 20 piezometers throughout Osa Meadow. Monitoring of piezometers will allow determination of changes in groundwater levels and by extension water stored in Osa Meadow. Water quality will be monitored using a YSI Sonde instrument to measure an array of parameters that include but not limited to turbidity, pH, temperature and dissolved oxygen.

- Increased regional capacity to achieve meadow restoration.

Through the development of the Sierra Meadows Restoration and Research Partnership (SMRRP) and the TAC, this project will bring together leading scientist and practitioners on a regular to basis to disseminate knowledge and understanding regarding meadow restoration practices, lessons learned and best management practices. The TAC will meet quarterly and convene an annual meeting to share respective experiences with findings being collated in to a report form and made available to the public through the UC Davis Meadows Clearinghouse. In doing so, regional capacity within and outside of the SMRRP will be realized.

- Increased scientific understanding of GHG dynamics in Sierra Meadows and for their potential to sequester CO2 as a result of restoration actions.

Through the development of the Sierra Meadows Restoration and Research Partnership (SMRRP) and the TAC, this project will bring together leading scientist and practitioners on a regular to basis to disseminate knowledge and understanding regarding meadow restoration practices, lessons learned and best management practices. Additionally data collected from the respective projects associated with the SMRRP will be shared amongst each other, enabling partners to analyze how carbon sequestration may vary resulting from different meadow restoration practices. The TAC will join efforts to develop a The TAC will meet quarterly and convene an annual meeting to share respective experiences with findings being collated in to a report form and made available to the public through the UC Davis Meadows Clearinghouse. In doing so, regional capacity within and outside of the SMRRP will be realized.

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