Section 5: Project Description

1. Project Objectives:

Restore and monitor 3 mountain meadows and monitor an additional 3 reference meadows to achieve the following goals and objectives:

Project objectives:

- Help meet the goals of AB 32 by achieving net greenhouse gas emission reductions through the restoration of mountain meadows;
- Improve the understanding of greenhouse gas emissions from mountain meadows; and
- Support the development of a predictive model that will allow for the use of proxy variables (such as depth and duration of saturation, soil texture and carbon content, plant community type, and length of growing season) to estimate carbon sequestration and GHG emissions in mountain meadows.

Co-benefit objectives:

- Restore and expand habitat for native plants, fish, and wildlife (including Federally-listed species such as willow flycatcher, foothill yellow-legged frog and mountain yellow-legged frog);
- Restore and enhance the connectivity of associated wetland and riparian communities;
- Increase late-season flows in meadow streams;
- Reduce and delay peak flows in meadow streams;
- Decrease sedimentation downstream of mountain meadows;
- Improve water quantity and quality for native fish and wildlife;
- Increase water storage capacity in mountain meadows; and
- Protect climate refugia in meadows, such as aspen communities and floodplain habitat.

2. Background and Conceptual Models

Conceptual Model for Greenhouse Gas Emissions Impacts of Mountain Meadow Restoration

Background information was compiled to develop a conceptual model that details the impacts of mountain meadow restoration on carbon storage and greenhouse gas emissions. The conceptual model was completed by consulting the available literature on this topic and by following the guidelines and criteria set forth in Appendix C of the Delta Plan (Delta Stewardship Council 2013). The scientific literature review was conducted using the Criteria for Best Available Science, and information included based on its: relevance, inclusiveness, objectivity, transparency and openness, timeliness, and peer review.

Mountain meadows in the Sierra Nevada provide multiple ecosystem services. As natural water retention basins, meadows attenuate floods, sustain stream baseflows, improve water quality and support vegetation that stabilizes stream channels and promotes biodiversity. In addition, mountain meadows provide natural storage of atmospheric carbon (Xu 2003). Research has shown that healthy mountain meadows contain at least two times more carbon, nitrogen, dissolved organic carbon and dissolved organic nitrogen than degraded meadows (Norton 2011).

Management activities and impacts from climate change have degraded Sierra Nevada meadows by altering surface water and groundwater dynamics. In many meadows, overgrazing, road-building, mining, fire suppression and/or development has resulted in localized stream incision, degradation, and partial conversion from wet to dry meadow conditions (Ratliff 1985). Climate change impacts, such as earlier snowmelt, lead to further degradation of meadows through accelerated channel erosion and depletion of groundwater, which in turn decreases carbon sequestration and greenhouse gas (GHG) uptake in montane meadows (Blankinship and Hart 2014). Impacted meadows have slowly become drier, and shorter, warmer winters will result in accelerated vegetation and habitat loss, the mineralization of soil organic matter, and an increase in GHG emissions, specifically the loss of carbon and nitrogen and the release of methane from the system.

In their current state, mountain meadows in the Sierra Nevada store approximately 31% of the Sierra Nevada region's total soil organic carbon due to the densely growing wetland vegetation and low decomposition rates (Norton 2011). Norton et al. (2011) found that almost 2/3 of meadows in the Sierra Nevada region were degraded and states that restoration efforts will increase local soil organic carbon by 25%, improve nitrogen storage, and improve a myriad of other co-benefits that are indicative of a healthy, functioning meadow (Lal 2003). Restoring mountain meadows has the potential to increase soil organic carbon sequestration, creating a region-wide carbon sink that will help offset CO_2 emissions from fossil fuel use.

GHG emissions in Sierra Nevada meadow ecosystems, specifically CO_2, CH_4, and N_2O , are poorly understood. While some have hypothesized that GHG emissions are correlated with the meadows' hydrological gradient or soil moisture content (Blankinship and Hart 2014), this relationship remains uncertain. Blankinship and Hart (2014) were not able to prove that this hydrologic or wet gradient relationship exists for CO_2 emissions and their findings suggest that CO_2 emissions are more correlated with plant respiration, as indicated by plant species richness. Methane consumption has been found to have a negative relationship with soil moisture, where drier meadows are hypothesized to uptake more methane (Blankinship and Hart 2014). Blankinship and Hart (2014) further suggest that methane emissions are most prevalent during the spring thaw. There is very limited information about nitrous oxide fluxes in Sierra Nevada Meadows, however nitrification, or the breakdown of N_2O to N_2, is most prevalent in wetter conditions and we predict that N_2O emissions may be reduced upon restoration of wetter conditions to meadow ecosystems.

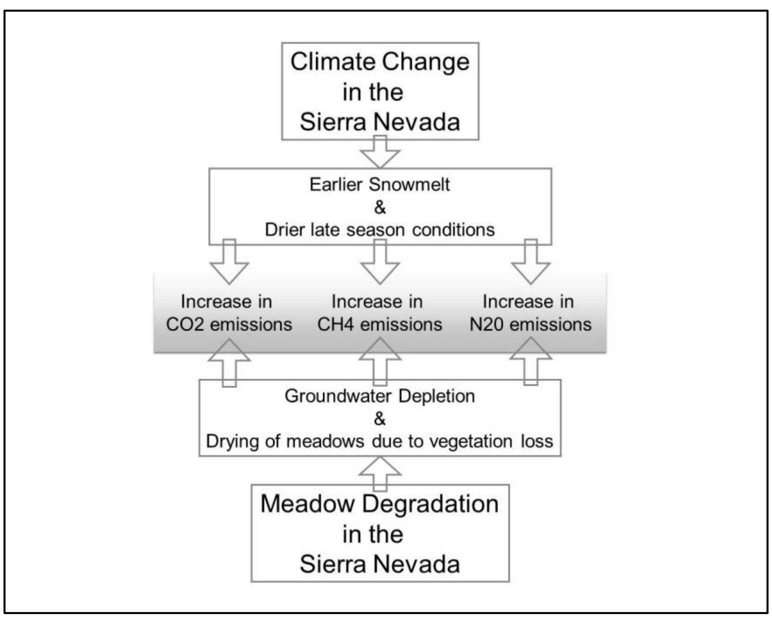

Figure 1. A model of the interaction between climate change and meadow degradation in the Sierra Nevada.

Because of the heterogeneity of individual meadows and lack of data on GHG emissions and comprehensive studies, further research is needed to understand the relationship between GHG emissions and meadow ecosystems. The collaborative, region wide effort proposed here will allow the scientific community to fill in the blanks and create a comprehensive conceptual model for GHG emissions in meadow ecosystems. Further, the scientific community seeks to validate the potential for mountain meadow restoration to decrease GHG emissions and increase carbon storage. This project will study GHG dynamics in restored and degraded Sierra Nevada meadow systems to fill in knowledge gaps and measure the benefits of a suite of restoration actions.

In particular, assessment of the net change in GHG emissions from mountain meadows in unrestored meadows and restored meadows needs to be expanded to include methane and nitrous oxide, in addition to measurements of soil carbon and carbon dioxide. Methane and nitrous oxide have 25 and 298 times the radiative forcing (i.e. climate change impact) of carbon dioxide, respectively (Forster et al. 2007). Unfortunately, the few studies that have measured methane and nitrous oxide emissions from meadows covered only a narrow range of meadow types (Mosier et al. 1993, Blankinship and Hart 2014). The literature suggests that restoration from a very dry, degraded, and well drained meadow to a moist and more productive meadow could increase the release of these two gases through an increase in anaerobic conditions, however all previous studies on this subject have concluded that this relationship may not be straightforward in the Sierra Nevada. While methane and/or nitrous oxide production are not likely to cause meadow restoration to be a net source of GHGs, these emissions could be a significant part of the overall GHG budget for these types of projects, 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.

Project Overview

The South Yuba River Citizens League (SYRCL), in collaboration with the Tahoe National Forest (TNF) and other partners, proposes to test the hypothesis that: re-establishing hydrological connectivity between stream channel and surrounding meadow will increase net carbon sequestration in degraded mountain meadow systems, taking into account net GHG emissions, compared to non-restored conditions. To test this hypothesis, we will measure net carbon sequestration in 3 mountain meadows in the TNF (Loney Meadow, Deer Meadow, and Bear Trap Meadow) under pre- and post-restoration conditions and at the same time measure net carbon sequestration in similar degraded and unrestored meadows (the lower portion of Deer Meadow, and Freeman Meadow), completing a before-after-control-impact experimental design. We will assume that the change in net carbon sequestration in the restored meadows, compared to changes in the unrestored meadows, are due to restoration and will validate that assumption by collect a series of abiotic data during each sampling event. Sampling will also be conducted on Upper Loney Meadow, which represents a relatively undisturbed meadow condition. This sampling will provide a benchmark for measuring restoration success. All project lands will be maintained by the US Forest Service for proposed purposes in perpetuity, as reflected in regularly updated Forest Plans for the TNF.

This project is part of a collaborative effort among many agencies and organizations in the Sierra Nevada, called the Sierra Meadow Restoration Research Partnership (SMRRP), which is developing an accredited proxy protocol for GHG sequestration in Sierra Meadows. A registered protocol has the potential to incentivize restoration actions in all of the Sierra Nevada's 17,000 meadows and the SMRRP's goal is to share data and provide a robust and coordinated regional response to the historic opportunity that AB 32 presents. SYRCL will bring data gathered as a result of this project to the group for analysis. Together, the

SMRRP represents a collaborative, regional effort sample, research, and conduct restoration in some 20 Sierra meadows. This unprecedented effort by the SMRRP partners will advance the understanding of GHG dynamics in Sierra Nevada meadows, climate change impacts, and address the meadow restoration needs prioritized in the CA State Water Action Plan. Currently, the SMRRP includes the following partners: American Rivers, California Trout (CalTrout), California State University, Chico, Plumas Corporation, Sierra Foothill Conservancy, Spatial Informatics Group – Natural Assets Laboratory (SIG-NAL), Sierra Streams Institute, South Yuba River Citizens League, Stillwater Sciences, Truckee River Watershed Council, University of Nevada at Reno, University of California at Merced, University of California at Davis, Tahoe National Forest, Sequoia National Forest, and others. The SMRRP will leverage data from a wide range of partners about meadow types, locations, conditions, and predictive variables for a robust assessment of variability on GHG emissions in the Sierra Nevada. The SMRRP will provide partners 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.

Over four years, CalTrout has agreed to 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 to be submitted for approval by CAR, ACR and VCS. As part of this project, SYRCL will participate in the TAC.

Expected Co-Benefits and Climate Change Considerations

Several of the expected co-benefits of the proposed restoration work detailed in this proposal will lead to the increased resiliency of the meadows in response to a changing climate. In particular:

- an **increased water storage capacity** will allow the meadows to endure larger storm events without an increase in channel erosion, and to maintain base flows during prolonged periods of drought;
- the **restoration and expansion of habitat for native plants, fish, and wildlife** will provide corridors and refugia to these species as environmental variables change; and
- the **protection of climate refugia** will conserve sensitive habitat types such as aspen communities and floodplain wetlands.

These benefits will be especially important in the conservation of rare and Federally-listed species, such as the willow flycatcher, foothill yellow-legged frog, and mountain yellow-legged frog. Suitable habitat for at least one of these species exists at all restoration meadows listed in this proposal. For example, both foothill yellow-legged frogs and willow flycatchers have been observed at Loney Meadow.

Linkages with Other Restoration Activities

Since 2011, SYRCL has been working with a variety of partners to restore the integrity of mountain meadows in the headwaters of the Yuba and American watersheds. SYRCL works primarily with the US Forest Service (Tahoe National Forest), American Rivers, American River Conservancy, UC Davis and the Sierra Native Alliance on meadow restoration projects. Primary funders are the Sierra Nevada Conservancy, the CA Dept of Water Resources, the National Fish and Wildlife Foundation, National Forest Foundation and Earthwatch. The Yuba Headwaters Meadow Restoration Project fits into SYRCL's and the USFS's goals to restore mountain meadows in the Yuba watershed. Specifically, this proposal will build on existing, funded work on 3 of the 5 meadows described in this proposal, as follows:

- In 2013, SYRCL received funding under an Integrated Regional Watershed Management Implementation Grant from DWR to improve the ecological integrity of Bear Meadow (invasive species removal), Deer Meadow (permitting for stream restoration and re-vegetation), Elliot Meadow (road decommissioning), and Gold Hill Meadow (stream restoration). Work started in late 2014 and will continue through 2016. Restoration activities will address the full range of impacts facing Sierra meadows and will establish a foundation for future restoration activities through a watershed-scale assessment and prioritization. The project represents a coordinated program with the USFS, American River Conservancy and American Rivers.

- In 2014, SYRCL received funding from the National Fish and Wildlife Foundation (NFWF) to create a conceptual framework for meadow monitoring protocols and to design, permit, implement, and monitor stream restoration activities in Loney Meadow. Work on this project began in fall 2014 and will continue through 2017.

See below in Section 6 (3. Examples of similar work) for more examples of similar implementation work linked to and complementing this project. This proposed project builds on funded restoration activities in Loney and Deer Meadows by allowing the project partners to expand their restoration program and by fostering regional resilience from climate change impacts. This project will restore more meadows in the Yuba watershed and will collect and analyze meaningful data that will advance our understanding of the hydrological, biological and GHG benefits associated with restoring mountain meadows.

Specific planning activities that complement the work proposed in the meadows which are part of this project are described in these publications:

- American Rivers (2012). Evaluating and Prioritizing Meadow Restoration in the Sierra. Highlights Bear Trap, Deer, Freeman and Loney Meadows in the Yuba watershed as high priority meadows for restoration. Available at: http://www.americanrivers.org/initiative/water-supply/projects/meadow-restoration-assessment-publications/
- National Fish and Wildlife Foundation (2010). Sierra Nevada Meadow Restoration Business Plan. HIghlights Loney Meadow as a high priority meadow for restoration. Available at: http://www.nfwf.org/sierranevada/Documents/Sierra_Meadow_Restoration_business_plan.pdf
- USDA Forest Service, Pacific Southwest Region (2013). "Ecological Restoration Implementation Plan." States a goal of "restoring at least 50% of accessible, degraded forest meadows to improve their habitat function and ability to hold water longer into the summer and deliver clean water when most needed." Available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5411383.pdf
- USDA Forest Service, Pacific Southwest Region (1990). "Tahoe National Forest Land and Resource Management Plan." The Forest Plan for the Tahoe National Forest calls for maintenance and re-establishment of natural flows in all waterways, as well as reduction of sediment loads due to erosion. Available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5214243.pdf

Background on Yuba Meadows

Historic grazing and logging activities have seriously affected the many meadows in the Sierra Nevada. The meadows which are the subject of this proposal are degraded due to these and other impacts. The following paragraphs provide short description of each meadow proposed for restoration, as well as those proposed as reference meadows. For the purposes of this project, reference meadows have been chosen with similar attributes (such as proximity, slope, aspect, elevation, vegetation, geology, and hydrogeomorphic type) to restoration meadows. Monitoring data from these reference meadows will establish benchmarks for restoration success and controls when assessing changes in GHG emissions and other variables in response to restoration. The specific meadows which are the subject of this proposal are as follows:

Loney Meadow

Texas Creek runs through some of the most scenic highland areas of the Sierra Nevada and feed the beautiful wet-meadow complex of Loney Meadow. Loney Meadow is identified in the National Fish and Wildlife Foundation's (NFWF) Sierra Nevada Meadow Restoration Business Plan as one of only three priority restoration sites in the entire 1,340 square mile Yuba watershed. The Business Plan states that Loney Meadow is one of the few large meadows where complete restoration of hydrology and vegetation could be achieved at a reasonable cost. In addition, Loney Meadow has been prioritized by both SYRCL and the Tahoe National Forest (TNF), who have strengthened an existing partnership through the successful acquisition of funds for the first phase of restoration at Loney Meadow from NFWF. An additional benefit is that the site is easily accessible for restoration work and presents a unique educational opportunity for the general public.

Loney Meadow was under private ownership until 1989 (as was Deer Meadow, described in the following section). It has had a long history of intensive grazing, and was once the site of a dairy operation. There is evidence of Gold Rush-era mining nearby, and the area was intensively logged during the late 19th and early 20th centuries. The intensity of grazing has steadily decreased since the 1960s, but these activities have resulted in a partially incised stream channel, destabilized stream channels, an instream habitat that lacks complexity, compromised wetland vegetation communities, and encroachment by disturbance-tolerant plant species (see Figure 1 below). The greatest current threat to Loney Meadow is the continued incision of Texas Creek, which lowers the water table and disconnects the channel from its historic floodplain. Lesser threats are gully erosion at an abandoned roadbed and the encroachment of conifers.

Figure 2. Loney Meadow, clockwise from top left: overall view of the meadow; interpretive trail through meadow; example of channel incision; relatively intact stream channel in one portion of the meadow.

Deer Meadow

Deer Meadow is a 46-acre, high gradient meadow located near Bowman Lake in the TNF. The meadow has a mean elevation of 6250 feet and a gradient of approximately 7 percent. Historic land use in the area included mining, logging, grazing and the associated roads and trails. The TNF acquired this meadow in 1989 in a degraded condition. Sustainable grazing has continued under the current management, and the network of non-motorized trails in the watershed has been improved in recent years. The upper end of the meadow has thick alder on three wet slopes that reach down to the degraded portion of the meadow. Topsoil has largely been lost in the upper end, resulting in poor vegetative cover, potential for increases in GHG emissions, decreased carbon sequestration, rills and gullies from rainstorm and snowmelt runoff. Both old roads and ditches divert and concentrate water resulting in gullies down through the middle and lower portion of the meadow. A stock pond in need of maintenance is located on the southwest side of the meadow and may provide habitat for sensitive amphibians.

Bear Trap Meadow

Bear Trap Meadow is approximately 30 acres in the headwaters of Chapman Creek, a tributary to the upper reaches of the North Yuba River. This high gradient (5%) site is around 7000 feet elevation. The meadow condition inventory conducted by American Rivers (2012) rated Bear Trap Meadow as fair to good. The channel in the upper portion of the meadow has split into multiple channels and is downcut for over 700 feet in length. The instability is hydrologically connected to a channel originating at the outlet of the culvert, on the road that traverses the upland north of the meadow. There are several additional locations along the middle and lower portion of the meadow that also have culvert outlets directly connected to the meadow channel, causing localized instability, direct sediment input and increases in peak flows. The road drainage in this meadow has been identified as a threat to meadow condition for many years. Also, this northern hillslope has large areas of bare soils and concentrated surface flow paths that are supplying sediment and increased flows to the meadow. Lands within and adjacent to this meadow have been intensively managed for many decades. Past and uses include heavy sheep grazing, mining and timber logging in the late 1800's and early 1900's. Recent management has continued grazing and forest treatments, along with recreational use, but at a more sustainable level.

Figure 3. Bear Trap Meadow. Photo shows headcut erosion in the stream channel and previous attempts to stabilize the degraded channel with large wood.

Reference Meadows
Upper Loney Meadow is an 18.6 acre meadow located approximately 600 ft. from Loney Meadow. It is relatively undisturbed, with minimal stream channel incision. Its similarity to Loney Meadow regarding a number of attributes (slope, aspect, elevation, vegetation, geology, and hydrogeomorphic type) presents a unique opportunity to compare the results of a meadow restoration with an "undisturbed" reference meadow. Upper Loney Meadow will be included in the

Deer Meadow, described above, will represent a degraded, "unrestored" reference meadow to compare with Loney Meadow.

Freeman Meadow will represent a degraded, "unrestored" reference meadow to compare with Bear Trap meadow. Freeman Meadow is in the North Yuba watershed and has incised stream segments in the upper meadow, which comprises the majority of the meadow area. This instability was caused by various factors including existing road alignment and drainage. This meadow also contains several cobble-filled gabion grade control structures, which range from stable to unstable. These structures were installed within the past 40 years to control erosion.

As part of this project, another meadow (TBD) will be located to serve as a degraded, "unrestored" reference for the restoration implementation at Deer Meadow.

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

Improving stream channel conditions is critical to the improvement of meadow ecosystem function, habitat health, GHG emissions and carbon sequestration where channel incision is present. With the exception of Upper Loney Meadow, which represents a fairly stable undisturbed meadow state, all the meadows in this proposal are all in some stage of degradation, driven by impaired hydrology, land use history, and now earlier snowmelt as a result of climate change. If existing channel incision is not remediated it will continue to increase in size and extent, further degrading meadow ecological function and habitat and making these meadows more vulnerable to impacts from climate change.

This proposal includes both **implementation components** (restoration of 3 mountain meadows: Loney, Deer, and Bear Trap) and **research components**. The proposed research will address the basic question: "How does restoration of mountain meadows alter carbon sequestration in these ecosystems?" Focused research will occur at Loney Meadow and 2 reference meadows (Upper Loney and the lower part of Deer Meadow, prior to restoration) 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 (proxy variables) that relate to soil GHG fluxes. These parameters include: depth and duration of saturation, soil texture and carbon content, plant community type, and length of growing season.

Data from Loney Meadow and its reference meadows will be made available to the entire SMRRP team to support development of a predictive model for meadow carbon sequestration. Data from meadows across the Sierra Nevada 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 at other meadow restoration project in the partnership. The quantitative model will become part of the carbon credit protocol developed for meadow restoration through the SMRRP and under the leadership of CalTrout.

In addition to the focused GHG assessment at Loney Meadow and its reference meadows, this project also proposes to restore and monitor 2 additional meadows: Deer and Bear Trap. The determination of whether or not net GHG emissions reductions have occurred as a result of restoration in these meadows will be assessed through the use of the proxy variables mentioned above. This sampling will occur in the later part of the grant period (2017-2019), after the SMRRP has developed the predictive model and established the relationship between proxy variables and GHG emissions. In this way, Deer and Bear Trap Meadows will serve as "test cases" for the model.

The meadows in this project, their role in the study, GHG flux sampling method, and timing of implementation and sampling are summarized as follows:

Meadow	**Type**	**GHG Flux Sampling Method**	**Implement-ation Year**	**Sampling Years**
Loney	Restoration	Focused	2016	2015, 2017
Upper Loney	"Undisturbed" Reference	Focused	n/a	2015, 2017
Deer (lower)	"Degraded" Reference	Focused	n/a	2015, 2017
Deer	Restoration	Proxy Variable(s)	2018	2017, 2019
TBD	"Degraded" Reference	Proxy Variable(s)	n/a	2017, 2019
Bear Trap	Restoration	Proxy Variable(s)	2018	2017, 2019
Freeman	"Degraded" Reference	Proxy Variable(s)	n/a	2017, 2019

This project is comprised of the following tasks and subtasks:

<u>Task 1. Project Administration (SYRCL)</u>

SYRCL Project Manager and administrative staff will complete all administrative tasks including: preparation of Requests for Proposals, selection of contractors, preparation of contracts and invoices, contractor management, data (GIS and monitoring data) management, reporting and any other administration associated with the project.

<u>Task 2. Existing Data Compilation (SYRCL)</u>

SYRCL Project Manager and staff will compile all existing data (e.g., data from USFS, UC Davis, SYRCL and American Rivers) into a geodatabase that will be shared with the UC Davis Sierra Meadows Data Clearinghouse and the Sierra Meadow Research Restoration Partnership.

<u>Task 3. Meadow Assessment and Monitoring (see responsible parties in subtasks below)</u>

SYRCL Project Manager and SYRCL staff will work with project partners create a Monitoring Plan to assess whether each meadow restoration is meeting project objectives and co-benefit objectives. See

Section 5 (1. Project objectives). After Monitoring Plan has been prepared, SYRCL Project Manager will oversee a team of project partners to survey the implement the Plan, monitoring meadows for pre- and post-restoration conditions (See Section 7: Protocols for assessment and monitoring protocols). Monitoring subtasks are as follows:

Subtask 3.1 - Focused Greenhouse Gas Flux Sampling (SYRCL, Stillwater Sciences, TNF)

Scientific Consultant Stillwater Sciences will train SYRCL staff to implement an intensive greenhouse gas flux sampling protocol at 3 meadows: Loney Meadow (restoration), Upper Loney Meadow (reference), and Deer Meadow (reference). See Section 7: Protocols for sampling protocols.

Subtask 3.2 - Meadow Soil Carbon Sampling (SYRCL, Plumas Corporation)

Plumas Corporation will train SYRCL staff to implement soil carbon sampling at all meadows. The percentage of soil carbon will be monitored following the USFS Forest Inventory Act Forest Health Monitoring protocol for soils. See Section 7: Protocols for sampling protocols.

Subtask 3.3 - Topographic Surveys (Contractor, TNF, SYRCL)

A consultant or USFS staff will be hired establish topographic cross-sections, using a total station or a real time kinematic survey station (RTK), at 3 restoration meadows: Loney Meadow, Deer Meadow, and Bear Trap Meadow. TNF will use the resultant data to refine their 2014 LiDAR surface data, and to establish baseline meadow topography and stream channel conditions. The TNF and SYRCL will use these topographic surveys to inform the restoration design for each meadow and to assess restoration success through pre- and post-restoration monitoring of stream incision.

Subtask 3.4 - Surface and Groundwater Hydrologic Monitoring (SYRCL)

SYRCL will install a network of groundwater monitoring stations (stage logger instrumented piezometers) at two to six locations in each of the meadows to determine the groundwater level and gradient across the meadow. The exact location of the piezometers will be co-located with the topographic survey cross-sections developed in Task 3.3 above. In addition, channel surface flows will be recorded by taking discharge measurements (with 15-minute stage loggers) at the outlet of each streamline at each meadow. SYRCL staff will place loggers at new or USFS-established hydrologic cross-section locations to establish a rating curve and flow through each meadow. The project team will use these measurements as a basis for the restoration plan for each meadow and to assess the success of stream channel restoration.

Subtask 3.5 - CO-BENEFIT: Wildlife and Amphibian Surveys (SYRCL, TNF, UC Davis)

TNF staff will monitor all meadow sites to detect wildlife species of concern, including those that are federally listed as Threatened or Endangered. Amphibian surveys will be conducted by UC Davis researchers, TNF staff, and trained SYRCL volunteers before and after stream channel restoration activities in the 3 restoration meadows to establish baseline conditions, detect sensitive species, and to help assess restoration success. Visual encounter surveys (for tadpoles and adults) and egg mass identification will be used to determine the diversity and abundance of amphibian species.

Subtask 3.6 - CO-BENEFIT: Vegetation Surveys (TNF, SYRCL)

TNF staff will survey all restoration project sites for rare or federally-listed plant species prior to initiation of restoration work. In addition, TNF, SYRCL staff and trained volunteers will complete vegetation surveys in all meadows along each topographic cross-section as point-intercept transects with nested 0.25 m^2 plots. For each plot, presence or absence and percentage cover will be noted for each species. In addition, plant biomass will be estimated to contribute to our understanding of net primary productivity (NPP) using the USDA protocol for total plant production described in chapter nine of the Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems (Herrick et al 2005). To determine community composition, species will be grouped into wetland status following the Army Corps of Engineers State of California 2014 Wetland Plant List (Lichvar et al 2014), with the percentage of wetland plants compared before and after treatment. Transects will be monitored in early summer at least once before and for 2 years after project implementation.

Subtask 3.7 - CO-BENEFIT: Water Quality Monitoring (SYRCL)

SYRCL staff and trained volunteers will conduct water quality monitoring of the project sites to establish conditions before, during, and after restoration. Water quality measurements will focus on parameters that are crucial for fish and amphibian health, including: water and air temperature, conductivity, salinity, reduction potential (ORP), dissolved oxygen, pH, and turbidity. These parameters will be measured with a YSI 556 meter.

Subtask 3.8 - Archeological Surveys (TNF)

TNF will conduct archeological surveys to prepare for the environmental review and permitting process.

Subtask 3.9 - Photo Point Monitoring (SYRCL, TNF)

SYRCL staff and trained volunteers, in conjunction with TNF, will establish photopoints and take photographs before, during, and after the stream channel restoration to establish baseline and post-restoration conditions.

Task 4. Restoration Design (TNF, SYRCL)

SYRCL and the USFS will complete meadow restoration designs for Bear Trap, Deer, Freeman, and Loney Meadows using available conceptual models, data from topographic surveys and monitoring data listed above, and by drawing on other existing hydrologic or vegetation data collected in Task 2 above. Each restoration design will be tailored to the 3 meadows included as restoration meadows in this proposal and will focus on improving the hydrologic function of these meadows to support the benefits and co-benefits which will result from this project. Once the design is complete, SYRCL will work with the USFS to bid out and select a contractor to implement the proposed work. Preliminary field surveys of existing conditions have yielded the following likely restoration actions for each meadow:

Subtask 4.1: Loney Meadow

Restoration actions will include stream channel and gully restoration and road drainage improvements for Loney Meadow, re-routing the upstream portion of the main channel in Loney Meadow and post construction re-vegetation of the channel margins. Funding was secured in 2014 to fund all phases of the restoration implementation.

In the early 1900's prior to USFS ownership, the natural channel flow path in Loney Meadows was diverted into one, and likely more, peripheral channels to dewater the center of the meadow. One of these diversion channels still contains the bulk of stream flow, especially during non-flood flows. Flood flows have exited the diversion channel as random locations, resulting in unnatural flood flow paths, head cutting, and new channel alignments in the lower and middle portions of the meadow.

The restoration plan for this meadow will likely involve filling in portions of the diversion channels in multiple locations in order to direct flows back into historic channels and swales that traverse the meadow. In lower and middle portions of the meadow, unstable channel sections will likely be filled as well. This will disperse the flows from one, deep, unstable channel into multiple shallow ones with lower energy and higher infiltration, leading to an increase in the local water table. The exact location and extent of these partial channel fills will be determined onsite using a combination of field survey data and recently collected LiDAR data for the site. Once identified, borrow material from adjacent uplands will be hauled in to construct the channel fills. Prior to disturbance, any available topsoil, along with sod and brush will be stockpiled and replaced. Borrow sites, haul roads and disturbed ground will be rehabbed to a stable, pre-project condition.

At the lower end of the meadow a trail crossing the main channel has fill material in the flood plain. This fill constricts the channel during flood flows, resulting in deeper, more erosive flows, which is contributing to head cutting in the lower meadow. This crossing will be modified or moved, in order to restore natural channel processes at that site.

Lastly, old road and trail alignments at the upper end of the meadow have resulted in flow off the uplands being concentrated into small gullies. These flows would naturally have dispersed across the upland and not establish a single channel. This site will be restored by filling in the gully and redirecting flows up the slope.

Funding was secured in 2014 from NFWF for the restoration design, environmental review/permitting, and implementation phases of this meadow restoration.

Subtask 4.2: Deer Meadow

Restoration actions will likely include reclaiming old roads, restoring natural flow paths, raising the water table, restoring soil productivity and re-vegetating the upper portion of the meadow. The stock pond will be evaluated to determine the best course of action which would restore the meadow and retain amphibian habitat. Funding was secured in 2013 through DWR for the restoration design and environmental review/permitting phase of this project.

Subtask 4.3: Bear Trap Meadow

Restoration actions in Bear Trap Meadow will likely focus on addressing road drainage channel down cutting and hillslope re-vegetation. Several road crossings are causing channel instability in the meadow. Additional drainage features will be added to the road to disperse hillslope runoff and encourage infiltration. Unstable channels will be filled in various locations to disperse energy and reconnect historic, abandoned channels. Existing areas with little to no ground cover will be treated to reduce erosion and runoff. Treatment will include a combination of applying organic material to provide ground cover and amend the soil along with planting and seeding grasses, shrubs, and tree species to further stabilize the slope.

TNF personnel will survey the site and select locations of road treatments and channel filling. A planting and mulching plan for the unstable slope will be developed by TNF and SYRCL personnel. Private contractors, overseen and directed by the TNF, will implement the design.

<u>Task 5. Environmental Review and Permitting (SYRCL, TNF)</u>

Environmental review and permitting will be conducted by SYRCL and the TNF. NEPA will be prepared by the TNF and SYRCL will complete all CEQA and permitting required based on the designs developed in Task 4. A list of expected permits is available in Section 7 of this proposal.

<u>Task 6. Implementation (Contractor, TNF, SYRCL)</u>

Once permitting is complete for each meadow, SYRCL staff will work with USFS staff to issue an RFP for a contracted restoration specialist company to complete the restoration work and to ensure speedy implementation of each restoration project. SYRCL staff and TNF will prepare a construction bid package for advertisement to procure a contractor using public bidding procedures. The TNF has established policies and protocols for advertising, opening, and evaluating bids for construction services, as well as for awarding and developing contracts with construction companies. These policies and procedures will be used to identify the construction contractor from the pool of bidders. Pre-construction activities include but are not limited to: developing technical specifications to support publication of the bid materials, a pre-bid meeting to respond to contractor questions (as required), review of submitted materials for completeness and qualifications/experience, and award of the contract in accordance with the applicable with the applicable Public Contract Codes. More than one contractor may be used throughout the duration of the project. Project completion dates are dependent on permitting.

Task 6. Data Analysis, Management and Public Access (SYRCL, SRRMP)

Data collected during this project will be summarized annually and reported to the TAC, the SRRMP team, and CDFW. The data analysis component of this project will allow us to determine (1) whether the restoration efforts are working to improve meadow habitat and ecosystem function, (2) measure GHG emissions and carbon sequestration in unrestored and restored meadows through time, and (3) correlate GHG emissions and carbon sequestration with biotic and abiotic monitoring data. SYRCL and partners will report out on vegetation cover and biomass production, groundwater and surface water levels, soil carbon and water content, air temperature, and soil temperatures for each GHG sampling date. Emissions will be summarized by vegetation/hydrogeomorphic type and for the meadow as a whole, and by season (sample date) and if feasible, estimated to the full year. Statistical comparisons of the pre vs. post restoration GHG emissions and net carbon sequestration will be made using the reference 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. Other abiotic and biotic monitoring data, outlined in Task 3, including stream channel depths at key cross sections, hydrologic conditions, water quality data, vegetation composition and amphibian diversity will be analyzed and reported out on an annual basis.

All data collected during this project will be reviewed by the SMMRP Partnership Technical Advisory Committee (see above Section 2) before submission to the UC Davis Sierra Meadows Data Clearinghouse (http://meadows.ucdavis.edu/) and any other state databases for review. SYRCL will enter and quality control all monitoring and GIS data, which will be stored in an Access database and a project geodatabase which will be backed up on SYRCL servers. The SMMRP will create a shared website that all partners will use to share their data. In addition, the SYRCL team will make all data collected by this project available on SYRCL's web-based portal (www.yubashed.org), an information system that provides data, documents, photos, maps and tools for people interested in the condition of the Yuba River watershed. YubaShed is designed to facilitate collaborative work among organizations, and to promote a science-based understanding of the entire Yuba River watershed.

Task 7. Final Report and Invoice (SYRCL)

SYRCL Project Manager will work with SYRCL administrative task to send a Final Report and Invoice to the Department of Fish and Wildlife in a timely manner at the completion of the project.

4. Timeline:

Task	START DATE	END DATE
1.0 Project Administration	6/1/2015	2/28/2020
2.0 Existing Data Compliation	6/1/2015	9/30/2015
3.0 Meadow Assessment and Monitoring		
3.1 Focused Greenhouse Gas Flux Sampling	6/1/2015	9/30/2017
3.2 Meadow Soil Carbon Sampling		
Loney, Upper Loney, Deer (lower)	6/1/2015	9/30/2017
Deer, TBD, Bear Trap, Freeman	4/1/2017	9/30/2019
3.3 Topographic Surveys		
Loney, Upper Loney, Deer	6/1/2015	9/30/2015
Deer, TBD, Bear Trap, Freeman	4/1/2017	9/30/2017
3.4 Surface and Groundwater Hydrologic Monitoring		
Loney, Upper Loney, Deer (lower)	6/1/2015	9/30/2017
Deer, TBD, Bear Trap, Freeman	4/1/2017	9/30/2019
3.5 Wildlife and Amphibian Surveys		
Loney, Upper Loney, Deer (lower)	6/1/2015	9/30/2017
Deer, TBD, Bear Trap, Freeman	4/1/2017	9/30/2019
3.6 Vegetation Surveys		
Loney, Upper Loney, Deer (lower)	6/1/2015	9/30/2017
Deer, TBD, Bear Trap, Freeman	4/1/2017	9/30/2019
3.7 Water Quality Monitoring		
Loney, Upper Loney, Deer (lower)	6/1/2015	9/30/2017
Deer, TBD, Bear Trap, Freeman	4/1/2017	9/30/2019
3.8 Archeological Surveys		
Loney	6/1/2015	9/30/2015
Deer, Bear Trap	6/1/2017	9/20/2017
3.9 Photo Point Monitoring		
Loney, Upper Loney, Deer (lower)	6/1/2015	9/30/2017
Deer, TBD, Bear Trap, Freeman	4/1/2017	9/30/2019
4.0 Restoration Design		
Loney	10/1/2015	2/28/2016
Deer, Bear Trap	10/1/2017	2/28/2018
5.0 Environmental Review and Permitting		
Loney	1/1/2016	5/30/2016
Deer, Bear Trap	1/1/2018	5/30/2018
5.0 Implementation		
Loney	6/1/2016	9/30/2016
Deer, Bear Trap	6/1/2018	9/30/2018
6.0 Data Analysis, Management, Reporting and Public Access	10/1/2017	12/31/2019
7.0 Final Report and Invoice	1/1/2020	2/28/2020

Dates of deliverables: see Section 5. Deliverables (below).

5. Deliverables:

	Detail	Loney	Deer	Bear Trap	Upper Loney	Freeman
Project Reports & Invoices; Contracting Materials	Quarterly reports and invoices will be sent to CDWF, along with copies of all contracts.	Quarterly				
Monitoring Plan	A detailed plan will be completed to outline methods to monitor the biological, hydrological, physical, and GHG parameters outlined in the project description.	12/31/2016				
Final Restoration Designs	Restoration designs will be produced by TNF staff.	2/28/16	2/28/18	2/28/18	n/a	n/a
NEPA/CEQA & Permits	To be obtained by TNF and SYRCL	5/30/16	5/30/18	5/30/18	n/a	n/a
Monitoring Report	A monitoring report will be compiled from all of the pre- and post-monitoring conducted. The report will include results from all of the monitoring outlined in the monitoring plan.	12/31/2019				
Publicly Accessible Data	All existing data, project monitoring data, including GPS locations of monitoring equipment and monitoring locations, will be uploaded to yubashed.org, UC Davis Sierra Meadows Data Clearinghouse, and shared with project partners.	Annual Data Submission Final Submission 12/31/2019				
Final Report	A final report will be prepared according to CDFW guidelines.	2/28/2020				

6. Expected quantitative Results (Project Summary)

The Yuba Headwaters Meadow Restoration Project will result in the hydrologic restoration of over 165 acres across three meadows in the North and South Yuba watersheds. Restoration of meadow ecosystems have a myriad of additional benefits including habitat improvements, increases in groundwater storage, increased carbon sequestration, and reduced GHG emissions, among others. This project seeks to collect and analyze data to better understand a series of meadow restoration co-benefits:

- Improvements in late season base stream flows;

- Increased groundwater levels;
- Increase in vegetation cover and wetland plant diversity;
- Increase in net primary productivity measured through vegetation biomass sampling;
- Increased carbon sequestration rates;
- CO_2, N_2O and CH_4 emissions reductions;
- Improved water quality conditions in meadow streams: decreased turbidity, TSS, increased dissolved oxygen, and stable temperatures; and
- Stable amphibian diversity and reproduction rates.

Greenhouse Gas Reductions – Predicted Reductions

This project is expected to reduce the total tonnes of carbon dioxide (CO_2), tonnes of methane, (CH_4) and tonnes of nitrous oxide (N_2O) being emitted at each of the meadows restored during this project.

Carbon samples collected in Oso Meadow (Plumas National Forest, data provided by Plumas Corporation) suggest that existing carbon stores are approximately 50 tonnes of carbon per acre at each meadow. This project is expected to increase carbon sequestration by 50%, which is 25 tonnes of additional carbon per acre, or 4132.5 tonnes of carbon. Multiply that amount by the ratio of the molecular weights of carbon to carbon dioxide (3.6663) to give 15,151 additional tonnes of carbon dioxide sequestered as a result of this project.

(Tonnes/acre)	Acres	Carbon Current	Carbon Expected	Carbon Total
Loney	47.2	2360	1180	3540
Deer	46.1	2305	1152.5	3457.5
Bear Trap	72	3600	1800	5400
Total	165.3	8265	**4132.5**	12398

Research to date is not adequate to make predictions regarding the effects of meadow restoration on emissions of nitrous oxide (N_2O) and methane (CH_4).

By improving the hydrologic function of Loney, Deer, and Bear Trap Meadow in the Yuba watershed, SYRCL and partners will be ensuring that these meadows can sustain themselves in the years to come and that project benefits will be measurable for the next 100 years or more. These meadows will be more resilient to changes in climate and specifically to the earlier snowmelt that has already begun to impact meadow ecosystems. Greenhouse gas emissions are expected to stabilize within five years of project completion as groundwater levels are restored, vegetation is fully restored and soil carbon begins to accumulate.

7. Protocols:

Project performance will be evaluated based on the findings of monitoring subtasks outlined in Task 3. Each subtask is designed with very specific protocols that will allow the project partners to evaluate the success of the restoration effort, whether GHG emissions are being reduced, and to increase our understanding of the restoration response and linkages between one or more of the direct benefits or co-benefits of this study.

Subtask 3.1 - Focused Greenhouse Gas Flux Sampling (SYRCL, Stillwater Sciences, TNF)

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 variation 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 groundwater level, soil temperature, and water filled pore space will also be collected with the gas samples.

UNR (Sullivan) and UCM (Hart) will work with Stillwater Sciences in order to refine chamber sampling techniques and protocols for measuring GHG emissions. Stillwater, with assistance from UNR (Sullivan) if needed, will train Plumas Corp field personnel in GHG sample collection. Both Stillwater and Plumas Corp will collect GHG samples from the state factor meadows. GHG gas samples generated in this effort will be sent to and analyzed by the Sullivan lab at UNR and the Hart lab at UC Merced using gas chromatography.

Subtask 3.2 - Meadow Soil Carbon Sampling (SYRCL, Plumas Corporation)

Soil carbon will be sampled and analyzed following a protocol developed by the Plumas Corporation (formerly the Feather River CRM) in 2010. Each meadow is surveyed to delineate Level 1 soil types and existing vegetation communities. An existing surveyed topographic cross-section is chosen that provides the best characterization of each meadow's vegetation/soil types. Four one-foot square plots are chosen along the cross-section, each plot representing a soil/vegetation type, ensuring that plot locations will not interfere with project design features, such as pond location. Within these parameters, sample plot locations are randomly selected by tossing the square behind the back. (Note: 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 protocol's 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 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 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 Soilmoisture Equipment Corp. All samples are stored in plastic bags, and labeled with meadow, plot number, depth, and date.

Biomass testing is conducted by a contracted lab. All biomass material recovered from the one foot square is dried in a hot-air oven at a constant 105°F. Dry weights are determined from a digital scale to a resolution of one gram. Dry weights are multiplied by 0.48 to determine total carbon of the sample (carbon makes up approximately 48%-50% of the dry weight of organic matter, Pluske, et al, 2007). Soil samples are also dried as above and sieved using an ASTM#10 (2mm) 8" brass sieve. Large organic material (roots) are removed and tested as above (small organic particles go through the sieve and become part of the soil sample). Approximately one teaspoon of each sieved soil sample is sent to the Soil, Water and Forage Analytical Lab at Oklahoma State University, Stillwater, Oklahoma for soil C tests using a LECO TruSpec Carbon and Nitrogen Analyzer. The following is excerpted from the Lab's QA protocol:

"Accuracy and precision of test results are assured through daily analysis of quality control samples, a three step internal data review process, and participation in external certification and sample exchange programs. All instruments are calibrated with certified standards and maintained according to the specification.

"Internal quality control standards listed below are included in each sample run. The permissible ranges are set at two times the standard deviation (mean ± 2 std.). If results are outside the permissible ranges, corrective action is taken. One check sample is included in every 9 samples for soil pH, carbon, nitrate, phosphorus and potassium analyses."

Subtask 3.3 - Topographic Surveys (Contractor, TNF, SYRCL)

Topographic surveys will establish pre- and post-restoration conditions across the meadow and within the streamline. A total station or a real time kinematic survey station (RTK) will be used to walk transects at regular intervals, along the thalweg of the streamline, and at 3-5 hydrologic cross-sections. This information will be uploaded into a GIS and used to refine the 2014 LiDAR digital elevation model (DEM). This detailed information will be used baseline meadow topography and stream channel conditions required to finalize restoration designs for Loney, Deer, and Bear Trap Meadows. Finally, these data will be used to assess restoration success through pre- and post-restoration monitoring of stream incision. Success will be evaluated by comparing stream incision depths (using elevation changes) at specific cross-sections.

Subtask 3.4 - Surface and Groundwater Hydrologic Monitoring (SYRCL)

SYRCL will install a network of groundwater monitoring stations (stage logger instrumented piezometers) to determine the groundwater level and hydrologic gradient across each meadow. Two to six piezometers will be installed in each meadow and the exact location of the piezometers will be co-located with the topographic survey cross-sections developed in Task 3.3 above and based on local geologic and streamline features. Groundwater levels will be analyzed to determine the groundwater level and flow through the meadow and to

In addition, channel surface flows will be recorded by taking discharge measurements (with 15-minute stage loggers) at the outlet of each streamline at each meadow. SYRCL staff will place loggers at new or USFS-established hydrologic cross-section locations to establish a rating curve and flow through each meadow. All surface and groundwater monitoring equipment will be downloaded on a weekly or biweekly basis through the duration of the project. This frequency will decrease in the winter months due to access issues and snow depth. The project team will use these measurements as a basis for the restoration plan for each meadow and to assess the success of stream channel restoration.

Subtask 3.5 - CO-BENEFIT: Wildlife and Amphibian Surveys (SYRCL, TNF, UC Davis)

TNF staff will monitor all meadow sites to detect wildlife species of concern, including those that are federally listed as Threatened or Endangered. This monitoring will occur through a review of past data and site surveys at times of year when listed species are most likely to be present.

Amphibian surveys will be conducted by UC Davis researchers, TNF staff, and trained SYRCL volunteers before and after stream channel restoration activities in the three restoration meadows to establish baseline conditions, detect sensitive species, and as an indicator of restoration success. Visual encounter surveys (for tadpoles and adults) and egg mass identification along streamlines in will be used to determine the diversity and abundance of amphibian species. During the spring, amphibian monitoring will occur weekly once snow has melted and will continue until water temperatures are too high to support amphibian breeding or no egg masses have been found for two consecutive weeks.

Subtask 3.6 - CO-BENEFIT: Vegetation Surveys (TNF, SYRCL)

TNF staff will survey all restoration project sites for rare or federally-listed plant species prior to initiation of restoration work. In addition, TNF, SYRCL staff and trained volunteers will complete vegetation surveys in all meadows along each topographic cross-section as point-intercept transects with nested 0.25 m^2 plots. For each plot, presence or absence and percentage cover will be noted for each species. This will be repeated twice during the project, once to establish pre-restoration conditions and again one year following restoration actions. Data from the vegetation sampling will be used to establish vegetation communities across each meadow and diversity will be correlated using regression models to GHG emissions data and groundwater levels. To determine community composition, species will be grouped into wetland status following the Army Corps of Engineers State of California 2014 Wetland Plant List (Lichvar et al 2014), with the percentage of wetland plants compared before and after treatment. Transects will be monitored in early summer at least once before and for 2 years after project implementation.

In addition, plant biomass will be estimated to contribute to our understanding of net primary productivity (NPP) using the USDA protocol for total plant production described in chapter nine of the Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems (Herrick et al 2005). See Subtask 3.2 for more detailed description of this methodology.

Subtask 3.7 - CO-BENEFIT: Water Quality Monitoring (SYRCL)

SYRCL staff and trained volunteers will conduct water quality monitoring of the project sites to establish conditions before, during, and after restoration. Water quality measurements will focus on parameters that are crucial for fish and amphibian health, including: water and air temperature, conductivity, salinity, reduction potential (ORP), dissolved oxygen, pH, and turbidity. These parameters will be measured with a YSI 556 meter on a monthly basis throughout the project after snow melt has occurred.

Subtask 3.8 - Archeological Surveys (TNF)

TNF will conduct archeological surveys to prepare for the environmental review and permitting process. A TNF archeologist will compile detailed historical information and conduct field surveys to look for archeologically significant sites in each of the three restoration meadows.

Subtask 3.9 - Photo Point Monitoring (SYRCL, TNF)

SYRCL staff and trained volunteers, in conjunction with TNF, will establish photopoints and take photographs before, during, and after the stream channel restoration to establish baseline and post-restoration conditions. Photopoints will occur at each of the hydrologic cross-sections (see Subtask 3.4) and at the inlet and outlet of each meadow.

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