Section 5: Project Description

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

The Bean Meadow Restoration Project will repair 3500 feet of eroded streambed through a pond and plug type restoration project. The project will construct a series of berms in the channel that will slow flows, and raise the local water table, allowing flows to spread out and infiltrate across the meadow, re-watering the meadow's natural floodplain. This will enhance the meadow's ability to capture and store peak flows resulting from storm events and to act like a natural reservoir, recharging groundwater and improving late season water supply downstream. This improved late season water supply will result in cooler water temperatures that benefit fish and wildlife. The project will also stabilize the current eroding banks, reducing the amount of sediment entering the system and improving water quality. The project will improve water quality by increasing the amount of time in which groundwater and/or surface water interacts with meadow soils, enhancing the meadow's ability to reduce nutrient concentrations (Naiman et al. 2005). The project is expected to increase soil carbon and increase carbon sequestration by increasing overall biomass through a shift in vegetation community toward wet meadow specie, increasing primary productivity, decreasing aerobic decomposition rates of fine roots and above ground litter. In addition the project will enhance the open space preserved as part of the Bean Creek Preserve.

The overall goal of this project is to restore the ecosystem function of Bean Meadow, which is expected to achieve the following eight objectives. Specific outcomes are included below each objective. Quantitative outcomes are listed where it is appropriate; other outcomes are qualitative. All outcomes will be tracked by the project team.

Objective 1: Restore hydrologic function of Bean Meadow, a critical mountain meadow ecosystem
- Associated Outcomes:
  - Extent of functional wet meadow within the project area is increased to include all 39 acres of project impact area
  - 39 acres of climate refugia is protected

Objective 2: Reduce downstream sedimentation
- Associate Outcomes:
  - Approximately 3500 feet of eroded stream channel is repaired
  - Extent of actively eroding stream banks is decreased

Objective 3: Improve water quality
- Associated Outcomes:
  - Amount of time in which groundwater and/or surface water interacts with meadow soils is increased, thereby enhancing the meadow's ability to reduce nutrient concentrations

Objective 4: Increase water storage capacity
- Associated Outcomes:
  - Peak flows downstream of project are reduced

Objective 5: Improve habitat for native plants, fish, and wildlife
- Associated Outcomes:
  - Wetland and riparian vegetation communities are increased
  - Habitat quantity and quality is increased for migratory and special status species birds, such as Great Grey Owls and Bald Eagles.
  - Habitat quantity and quality is increased for aquatic biota

Objective 6: Increase carbon sequestration in meadow soils
- Associated Outcomes:

Dense sedge and willow species vegetation communities and net primary productivity is increased, and aerobic decomposition rates of fine roots and above ground litter are decreased, resulting in increased soil organic matter content (soil carbon) and increased net carbon sequestration

Increase soil carbon by 975 tonnes, thereby increasing carbon sequestration by approximately 3,575 tonnes of carbon dioxide

Objective 7: Contribute site-specific data toward development of methods for estimating net carbon (CO2-equivalent) sequestration under pre- and post-restoration conditions for mountain meadows

Associated Outcomes:

Soil carbon and peak GHG emissions data collected over 4 years

Final greenhouse gas monitoring report

Objective 8: Contribute to Sierra-wide partnership of meadow research and restoration efforts that will improve knowledge of ecological benefits and GHG sequestration in mountain meadows

Associated Outcomes:

Participate in trimester or quarterly meetings regarding mountain meadows and restoration efforts

Prepare and circulate reports and presentations of findings at Bean Meadow

2. ***Background and Conceptual Models:***

Bean Meadow Background and Conceptual Model for Restoration

Bean Meadow is a 275-acre meadow located in Mariposa County, between the historic gold country and Yosemite National Park. Sierra Foothill Conservancy (SFC), a 501(c)3 land trust, acquired 80 acres of the meadow in 2010. SFC now manages the property, known as the Bean Creek Preserve, with the goal of conserving open space and natural resources and instituting highly valuable restoration practices. Bean Creek drains a 5 square-mile montane watershed, flows through the meadow and then eventually drains into the North Fork Merced River. As an uncommon low-elevation Sierra meadow (located at approximately 3,000 feet), Bean Meadow provides especially important habitat for many Sierra species, including Species of Special Concern like Bald Eagle, Great Grey Owl and Western Pond Turtle. The meadow is also part of a working cattle ranch and provides important rangeland resources for the local cattle ranching economy.

Unfortunately, urban development and poor historic land management have greatly impaired the hydrologic function of Bean Meadow. Documents obtained from the Coulterville History Center indicate that Bean Meadow was heavily grazed as a dairy starting in 1878. The landowner at that time reported cutting “timothy” hay in the project area, which was in the water, and then raking it out to cure (McCarthy oral history, 1968)—a good indication that a much larger portion of the project area once functioned as a wet meadow during the summer.

Bean Creek is now steeply eroded and the channel depth averages eight feet below the meadow surface (Wilcox, 2014). Design consultants estimate that erosion of the main channel and the tributaries within the project area has removed approximately 80,600 cubic yards of soil. This incised channel drains groundwater from the surrounding meadow, lowering the local water table and impairing the natural hydrology. The historic wet meadow area now consists of a few wetland swales among predominantly drier soils where invasive grasses and weeds thrive. (See Attachment Bean Creek photos)

The project team proposes to raise the water table in Bean Meadow using the pond-and-plug restoration technique (see attachment Bean Creek Preserve Meadow Restoration Map . The pond-and-plug technique involves constructing a series of earth plugs and redirecting flow from the existing incised stream into a stable channel, with reduced dimensions, that is connected with a broad floodplain during annual peak flow events and maintains a higher water table (Wilcox, 2010). Ponds are excavated in the original channel to provide the fill material for the plugs. This result of this technique is reconnection of the stream to the floodplain and re-watering of the meadow.

Based on case studies of the pond-and-plug technique since 1995, using this technique to reconnect the channel to the floodplain in Bean Meadow is expected to result in the broad suite of benefits identified in Section 5.1 above, including reduced downstream sedimentation and improved water quality, increased water storage capacity resulting in improved baseflows and reduced peak flows, improved habitat for migratory birds and wildlife, and increased soil carbon and net carbon sequestration

Conceptual Model for Establishing net Carbon Sequestration in Bean Meadow
The distribution of vegetation types in mountain meadows reflects seasonal differences in groundwater levels and litter decomposition (Allen-Diaz 1991, Merrill et al. 2006, Loheide and Gorelick 2007). Thus, degraded Sierra meadows experience a radical change in plant community type distribution and overall plant biomass after restoration. In many cases, sparse cover of 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 and represent carbon sequestration. 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 carbon stores by 110 to 220 CO_2-equivalent 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 carbon sequestration numbers are very large and comparable to estimated rates of CO_2-equivalent sequestration reported for Delta freshwater 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 carbon-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, CO_2-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. Thus, net CO_2-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-year 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).

Through the proposed project in Bean Meadow, we will test the hypothesis that re-establishing the hydrological connectivity between the stream and the surrounding meadow using the pond-and-plug technique will increase net carbon sequestration, taking into account net GHG emissions, compared to non-restored conditions. To test this overarching hypothesis, we will measure net carbon sequestration in Bean 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 Bean Meadow, compared to changes in the unrestored meadow, is due to restoration.

The same protocol will be applied to partner meadow-restoration projects in 2015 across the Sierra, 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

Climate Change and Regional Planning Considerations
Bean Meadow is located on the Western Slope of the Sierra Nevada at an elevation of approximately 3,200 feet, making it particularly vulnerable to experiencing a shift to a predominantly rainfall driven hydrologic regime as a result of climate change. This type of shift would result in increased peak flows associated with downstream flooding and increased erosion and a reduced snowpack resulting in decreased late season flows and increases in water temperature. The Bean Meadow Restoration Project aims to address the very same impacts that climate modelers predict (see Section 5.1 above), and is expected to increase the meadow and the wider watershed's resiliency to climate change.

The Bean Meadow Restoration Project is particularly important in this region. The Yosemite-Mariposa Integrated Regional Water Management Plan, which calls for improvement of the health and ecological function of mountain meadows to increase water storage capacity and long-term water release, lists the Bean Meadow Restoration project as a top-5 priority project.

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

Bean Meadow Restoration
This project is offered by a strong partnership that includes Sierra Foothill Conservancy, the Sierra Meadow Restoration Partnership (SMRRP), American Rivers, Point Blue, Plus Corporation, Stillwater Sciences, and the National Resources Conservation Service. The project was designed to proceed in two phases: 1) planning, design and environmental permitting; and 2) restoration, monitoring and communication of benefits. Phase 1 is nearly complete. With support from the National Fish and Wildlife Foundation and the Gaft-Pulvino Foundation, we completed restoration designs in May 2014. To inform project designs, the team completed baseline assessments and pre-project monitoring, including detailed topographic surveys, streamflow and groundwater measurements, invasive and native vegetation assessments and bird surveys. The Sierra Foothill Conservancy is currently working with the California Department of Fish and Wildlife, the Army Corps of Engineers, and Mariposa County to complete the appropriate permits for the project, including CEQA. We expect permitting to be complete in winter 2014-2015, making the project shovel-ready for the 2015 field season.

The overall goal of this project is two-fold: 1) to restore the hydrologic and ecosystem functions of Bean Meadow and 2) to increase knowledge of carbon sequestration in restored meadow ecosystems. Restoration of the site will provide soil carbon and greenhouse gas emissions data, reduce downstream sedimentation and improve water quality, increase water storage capacity resulting in improved baseflows and reduced peak flows, and improve habitat for migratory birds and wildlife. It is also expected to result in a net sequestration of CO_2-equivalents. The Bean Meadow Restoration Project will repair 3,500 feet of eroded streambed through a pond and plug type restoration project. The project will construct a series of berms in the channel that will slow flows, and raise the local water table, allowing flows to spread out and infiltrate across the meadow, re-watering the meadow's natural floodplain. This will enhance the meadow's ability to capture and store peak flows resulting from storm events and to act like a natural reservoir, recharging groundwater and improving late season water supply downstream. This improved late season water supply will result in cooler water temperatures that benefit fish and wildlife. The project will also stabilize the current eroding banks, reducing the amount of sediment entering the system and improving water quality. The project will also improve water quality by increasing the amount of time in which groundwater and/or surface water interacts with meadow soils, enhancing the meadow's ability to reduce nutrient concentrations (Naiman et al. 2005).

GHG 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 factors that control emissions at micro-site to plant community scales 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 in Sierra Meadow Restoration Research Partnership meadows representative of the range meadows across the Sierra Nevada. 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.

Through the Bean Meadow Restoration Project, we will collect GHG emissions according to the 'state factor' meadows methodology.

Project Activities: Below we describe a detailed workplan that includes specific tasks and subtasks. Each task describes the project partners who are responsible for implementing the tasks and the methods that will be used.

Task 1. Project Management

Under this task, Sierra Foothill Conservancy will take the lead in fiscal management and reporting, finalizing the workplan, developing and managing subcontracts, convening project team meetings, and developing and disseminating project information. American Rivers will provide project management guidance based on extensive previous experience managing similar projects.

Subtasks include:

1.1 Convene project team meetings
1.2 Finalize workplan and budget
1.3 Draft and finalize subcontracts/grants
1.4 Manage project budget
1.5 Submit financial and performance reports
1.6 Draft and submit final report
1.7 Outreach and dissemination of project materials and results

Task 2. Implement Restoration

Under this task, Sierra Foothill Conservancy will contract with Plumas Corporation to implement a pond and plug restoration of Bean Meadow. This will involve excavating eight borrow areas (ponds) to construct 12 plugs within a gully that is approximately 3500 feet long. This will prevent the existing channel from acting as a drain to the meadow hydrology. Streamflow will then be returned to one or more remnant channels on the historic meadow surface. The project will also eliminate seven active headcuts on the mainstream, tributary and remnant channels. (See Attachment Bean Creek Meadow Restoration Map)

Before ponds are created, vegetation established in the gully bottom will be recovered so it can be transplanted to the pond edges, plug surfaces and any high stress areas of the restored channel. Topsoil from all excavation areas will be removed and stockpiled adjacent to areas designated to be plugged.

All plugs and borrow ponds are configured to accommodate surface and subsurface through flow and to reduce the risk of cutting through the plug during infrequent, short duration flood events. Plugs are constructed with wheel loaders to provide wheel compaction of the fill at levels intended to match the porosity/transmissivity of the native meadow soils. This allows moisture to move freely within the plug soil profile and support erosion resistant meadow vegetation for long term durability as well as preventing preferential pathways for subsurface flows either in the plug or the native material. The project's terminal plug will have a rock and vegetation structure to armor the downstream end, as both channel and floodplain flows transition to the existing elevation. Habitat features and diversity with be incorporated into pond construction. (See Attachment Bean Creek Meadow Restoration Map)

The plugs will be designed to facilitate rainfall infiltration and topsoil will be spread and seeded with native seed. All native vegetation recovered from the fill and borrow sites will be transplanted to plug edges and key locations on the remnant channel. Any woody material not transplanted will be used structurally throughout the project or left as snag habitat. In addition, the recovery of native, wet meadow vegetation will be supplemented by planting of native sedges like the Santa Barbara Sedge and wetland and mesic graminoids.

The final result of this treatment will be a stream that can access the floodplain, spread out and reduce the energy of the water flow and re-water the nearby meadow. The seasonal water table is expected to stay higher for longer into the dry season, encouraging the growth of riparian vegetation and providing cooler water, later in the season for fish and wildlife downstream.

Subtasks include:
2.1 Site setup and mobilization
2.2 Construction of pond and plug system
2.3 Revegetation
2.4 Demobilization and site cleanup

Task 3. Measure Net Carbon and GHG in a State Factor Meadow

This task will be led by Sierra Foothill Conservancy, Plumas Corporation and Stillwater Sciences. Plumas Corporation will train the Sierra Foothill Conservancy to collect soil carbon data for the project. Stillwater Sciences will collect GHG emission data.

The paired project and control degraded meadows within the Sierra Meadow Restoration Research Partnership reflect the range of state factors in the Sierra (Jenny 1994).. At each of these site pairs, we will measure soil carbon content, above and below ground primary production, and GHG emissions during expected peak periods before and following restoration. Ancillary data on local factors, such as ground water level, vegetation and soil characteristics, and soil temperature, expected to affect GHG emissions will also be collected at these state factor meadows. To robustly determine the influence of restoration on these state factor meadows, we will use a before-after-control-impact experimental design. Briefly, reference meadows (unrestored degraded meadows) will be paired with treatment meadows (to be restored) to control for inter-annual variability that could confound the effects of restoration. Measurements will begin in degraded control and restoration project meadows prior to restoration in 2015, and continue at both sites throughout 2015 and into the spring of 2016. Although restoration activities, described under Task 2, will begin in the Fall 2015, changes in groundwater level and plant community composition are not expected to occur until the following spring when the large influx of water from winter snow melt recharges local groundwater levels and occupies the restored channel. GHG and associated measurements will occur throughout the project meadow before restoration activities begin. Following restoration activities in late 2015, we anticipate sampling the ‘pre-restoration conditions’ in Spring 2016 in areas of the meadow where no soil disturbance associated with restoration have occurred, and where the hydrology and geomorphology have not yet had time to respond to the restoration conditions (these conditions will be true for most of the meadow excluding areas immediately surrounding the incised channel). In this way, we will capture GHG emissions for one year prior to restoration while still implementing this project in late 2015. Other measurements, including groundwater level, soil bulk density and soil moisture, will be measured at the same time to provide insights on GHG emissions.

Within each meadow, up to three hydrogeomorphic/ vegetation types will be monitored for soil carbon, net primary production, and peak GHG emissions. Peak emissions are expected to occur during three periods: (1) directly following spring snow-melt; (2) during mid-summer with peak vegetative growth; and (3) during early fall rains following senescence, when the ground-water table is high and anaerobic conditions are optimal for methane and nitrous oxide production. GHG emissions during spring snow melt have been reported to be highly variable, but nitrous oxide emissions during this period can be important parts of the annual GHG budget. To capture these peak fluxes, GHG emissions will be measured over 3 to 4 days during the end of spring snow melt at each site. Summer GHG emissions are also expected to be high relative to other times of the year but less variable in time. Therefore, mid-summer emissions will be sampled from sites during a single mid-day sampling effort. Because a third peak in annual GHG emissions is expected in early fall with new litter input, reduced evapotranspiration and the onset of fall rains, GHG emissions will be sampled during this period as well. Finally, to establish a baseline for non-peak periods, GHG emissions will be measured during a one-day data collection effort during the snow-free non-growing season, when fluxes are expected to be low. The pulse-driven nature of soil GHG emissions (particularly $CH4$ and $N2O$ production, means that much of the annual $CH4$ and $N2O$ flux could occur during relatively short, but important, periods of the year. Therefore, our experimental design in these state-factor sites seeks to characterize these peaks, so as to capture the most dynamic and significant fluxes of the year in meadow ecosystems.

This monitoring approach is intended to (1) specifically quantify the most important temporal and spatial variation in GHG emissions in each target meadow before and after restoration, and in each reference meadow during the same time period; (2) contribute to development of coarse annual GHG emission and net carbon sequestration estimates for each restoration and reference site; and (3) provide data on GHG emissions from meadows representative of the state factors to support development of a quantitative model for estimating net carbon sequestration in Sierra meadows. Information gained from the more intensive focus meadows will be used to help inform annual GHG emission estimates for the state factor meadows.

Subtasks include:

Task 3a. *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. Likely, an area upstream of The Bean Creek Preserve will be chosen. Pairing of control degraded meadows with treatment (meadows to be restored) will also provide controls on interannual variability that could confound effects of restoration. Three to four 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.

Task 3b. GHG measurements

UNR and UCM will work with Stillwater Sciences to refine chamber sampling techniques and protocols for measuring GHG emissions. Stillwater, with assistance from UNR 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. (See Section 7: Protocols for more information)

Task 3c. 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 randomly chosen along each transect, with each plot representing a soil/vegetation type. 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. (See Section 7: Protocols for more information)

Task 3d. Ancillary data

Ground water piezometers will be established across at least 4 transects in each restoration and reference meadow. Ground water levels will be recorded during each GHG measurement period. Sierra Foothill Conservancy or Plumas Corp 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. PointBlue will conduct avian surveys. (See Section 7: Protocols for more Information)

Task 3e. Data analysis and reporting

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. 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.

Task 4. Monitoring of Co-benefits and Adaptive Management

Under this task, Sierra Foothill Conservancy will work with American Rivers, Plumas Corporation and Point Blue to conduct ongoing and post-restoration monitoring and surveys to quantify co-benefits of the project. Specifically, water quality, streamflow, groundwater, vegetation, forage quantity/quality, grazing effects and bird species and populations will be monitored to gauge project success and inform long-term management of the site. Vegetation change will be measured by change in ground cover, herbaceous species and ecological condition; hydrologic function and water retention will be measured pre- and post-project with an array of piezometers and measurements of stream discharge; and changes in bird species and abundance will be quantified with transects and point counts. Point Blue will conduct bird surveys during nesting season and post-nesting season on the property, doing point counts in the dawn hours. Their protocol is designed to capture the diversity of species on the property, and relate species density to habitat types. In addition forage quantity and quality measurements will be taken before and after project implementation to help American Rivers validate a model that predicts forage improvements as a result of this type of meadow restoration. SFC will also conduct residual dry matter analyses annually to guide grazing management decisions. Monitoring information will be used to measure project success toward the objectives identified in Section 5.1, as well as to inform adaptive management. Ten percent of the construction budget will be earmarked for any post-implementation repairs or tweaks needed to ensure long term success of the project.

Subtasks include:

4.1 Develop and finalize monitoring plans
4.2 Install monitoring equipment
4.3 Conduct and complete monitoring and surveys
4.4 Draft and finalize monitoring report

Task 5. Outreach and Communication

The goal of this task is twofold: 1) to build recognition and support for meadow restoration within the local community, wider Central Sierra region and Land Trusts as meadow practitioners; and 2) to disseminate the findings of greenhouse gas reductions as a result of the project, in order to contribute to improving the understanding of carbon sequestration potential in mountain meadows. The restoration of Bean Meadow will provide an opportunity to showcase the pond and plug technique to ranchers in the neighboring foothills and to engage other land trusts in potential meadow restoration projects on their properties. The property is perfectly located for this endeavor, as it is easily accessible. The project will also provide a well-documented case study of the potential for pond-and-plug meadow restoration to reduce greenhouse gas emissions. It will provide a particularly powerful case study due to the scarcity of similar projects in the Central Sierra. The Sierra Foothill Conservancy and American Rivers will lead this task, which will include developing outreach materials in the form of multiple press releases, webpages, social media campaigns, presentations and several community meetings. We will develop materials based on ecological, forage, and greenhouse gas monitoring results to suit a variety of audiences, as well outreach directly to local ranchers, land trusts and the meadow practitioner community.

Subtasks include:
5.1 Design and finalize outreach and communications materials based on monitoring results
5.2 Create and distribute materials
5.3 Reach out to local ranchers, land trusts and meadow practitioner community
5.4 Work closely with the Sierra Meadow Restoration Research Partnership SMRRP to develop statewide outreach efforts.

4. ***Timeline:***

Task	Subtasks/Deliverables	Timeframe
Task 1. Project Management	Finalized workplan and budget	May 1, 2015
	Signed subgrants/contracts with project partners	May 20, 2015
	Interim progress reports/ invoices as required	Ongoing
	Final project report/invoice	November 1, 2018
	All permits complete	June 1, 2015
Task 2. Site Restoration	Site set up and mobilization	August 30, 2015
	Construction of borrow areas and plugs	September 1, 2015 - October 15, 2015
	Revegetation	September 30, 2015 – October 30, 2015
	Demobilization and cleanup	October 30, 2015
Task 3. Measure Net Carbon and GHGs	Reference meadow identified/transects established	Spring 2015
	Pre-project emissions summary report	December 31, 2015
	Post-project emissions summary report	November 1, 2018
Task 4. Co-benefit Monitoring and Adaptive Management	Monitoring plan complete	Spring, 2015
	Begin pre-restoration monitoring	Spring, 2015
	Field data collection complete (pre- and 3 years post-project)	August 30, 2018
	Final monitoring report	September 30, 2018
Task 5.Outreach and Communication	Develop outreach materials	May 15, 2018
	Create, purchase, and distribute outreach materials	September 30, 2018

5. ***Deliverables:***

Task 1. Project Management

- Signed subgrants/contracts with partners
- Interim progress reports/invoices
- Final Report and Final Invoice

Task 2. Site Restoration

- Final construction design plans and budget
- Photos of each phase of construction at multiple sites within the project area
- Any additional GIS or GPS data produced as a result of construction activities, such as plug elevations, or as-built designs

Task 3. Measure Net Carbon and GHGs

- Reference (control) meadow identified and transects established
- Analyzed datasets of GHG measurements, soil carbon and biomass productio, and ancillary data for each sampling date
- Annual GHG emissions summary report (pre- and post- project), summarized by vegetation/hydrogeomorphic type and by season.
- Data and reports distributed to SMRRP and uploaded to UC Davis Sierra Meadows Data Clearing House (http://meadows.ucdavis.edu/), upon project completion

Task 4. Co-benefit Monitoring and Adaptive Management

- Final monitoring plan describing all ecological, forage, and GHG reduction monitoring to be conducted during the project
- Analyzed data sets for streamflow, groundwater, vegetation, forage, bird populations, and GHG and carbon monitoring
- Final map(s) of monitoring points
- Final monitoring report summarizing results of all data collected pre- and post-implementation

Task 5. Outreach and Communication

- Press release, blog and webpage describing project once constuction has completed
- Factsheets describing project results developed for at least 3 audiences: ranchers, Land Trusts and climate adaptation practitioners.
- Agenda and photos from site visit with potential meadow practitioners.
- All outreach materials will be available on the Sierra Foothill Conservancy website and through SMRRP

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

The project is expected to reduce carbon dioxide (CO2) by 3,574 metric tons (tonnes). Currently; expected project effects on nitrous oxide (N2O) and methane (CH4) are not sufficiently well understood to be entirely quantifiable; however the research component of the project is expected to provide quantitative figures on the effects of meadow restoration on these two GHGs.

The expected reduction in CO2 is based on a conservative estimate of a 50% increase in soil carbon. Restored versus unrestored meadow soil carbon comparisons (FRCRM 2010) have shown a 100%

increase in soil carbon at the restored sites, however, known existing vegetative and hydrologic conditions in the Bean Meadow treatment site versus the sites used in the FRCRM 2010 study, warrant a 50% reduction in the expected outcome.

Carbon samples have been collected in the project areas, but have not yet been analyzed. Based on previous pre-project sample collection, and the known condition of vegetation, existing carbon stores are estimated at approximately 50 tons (tonnes) of carbon per acre at the two treatment areas. Bean Creek will effectively restore 39 acres, so this example using the acreage from Bean Creek Meadow restoration is as follows: 39 acres x 50 tons (tonnes) is 1,950 existing tons (tonnes) of carbon. The project is expected to increase carbon by 50%, which is 25 tons (tonnes) of additional carbon per acre, or 975 tons (tonnes) of carbon. Multiply that amount by the ratio of the molecular weights of carbon to carbon dioxide (3.6663) to give 3,574 additional tons of carbon dioxide.

7. ***Protocols:***

GHG Measurements

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). If necessary, 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). 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. 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.

Soil Carbon and Biomass Production

Soil carbon and biomass 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. Material is removed, bagged and labeled by plot number for the entire square foot area. 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. 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. All samples are stored in plastic bags, and labeled with meadow, plot number, depth, and date.

Biomass testing is conducted by a commercial 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. Large organic material (roots) are removed and added to the biomass measurements 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.

Ancillary Data and Co-benefits
Vegetation composition plots will also be recorded each year along each of the meadow transects using the CNPS rapid assessment protocol. Vegetation change will be measured by change in ground cover, herbaceous species and ecological condition; hydrologic function and water retention will be measured pre- and post-project with an array of piezometers and measurements of stream discharge. Point Blue will conduct bird surveys during nesting season and post-nesting season on the property, doing point counts in the dawn hours. Their point-count protocol is designed to capture the diversity of species on the property, and relate species density to habitat types. PointBlue identifies random points in each area of the property (in each pasture if the property is a working ranch), and records all avian species seen and heard at each point. They also conduct a vegetation survey on the point, to account for variable habitat types. Forage production and quality will be measured in accordance with NRCS protocols.

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