Section 5: Project Description

1. **Project Objectives:**
   The primary objective of the Cornerstone Meadows Project at Foster Meadow and Mattley Meadow is to restore ecologic function to 72 acres of degraded dry mountain meadow habitat. Project outcomes are expected to include: increased soil carbon sequestration; increased groundwater elevations and shallow floodplain aquifer function; increased vegetative productivity and restoration of community balance toward wet meadow species; and improved wildlife habitat, particularly for migrating birds and waterfowl. Based on similar previous projects, quantified expected outcomes for greenhouse gas reduction of carbon dioxide include a 100% increase in sequestered soil carbon within three years. Based on early research in this field by Blankinship and Hart (2014), neither methane nor nitrous oxide are expected to significantly change. The objective of the research component of the project is to measure methane and nitrous oxide, and identify surrogate variables that can predict the effect that meadow restoration would have on these two GHGs.

   Based on similar previous projects, quantified expected co-benefit outcomes include: 1) a four-foot elevation increase (Foster Meadow) and an eight-foot elevation increase (Mattley Meadow) in spring and early summer groundwater elevations within one year; 2) a 126 acre-feet increase in shallow floodplain aquifer volume (the increases in shallow floodplain aquifer depth, divided by two for the conservatively expected cone-shape of affected groundwater, multiplied by 72 acres, and by 0.27 for porosity (Cornwell and Brown 2008)); 3) a 100% increase in vegetative meadow productivity within two years; 4) a 100% increase in the ratio of wet meadow plant species to dry meadow grass/forb species within three years; 5) increased flow duration into the summer; 6) enhancement of 64 acres of mountain meadow and 8 acres of aspen; achieve a target of focal species richness of 1.03 per acre and increase total species by 50% from 18 to 27 (Loffland, et. al., 2013). The project would also restore aquatic organism passage across the 9N14 road. An aquatic organism passage survey concluded that the crossing is in the red category, meaning impassable during portions of their life history. Restoring full function to these meadow/stream channel systems provides the most achievable resilience to the effects of climate change.

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

Similar to many montane meadow floodplains throughout the Sierra Nevada and Cascade mountain ranges, the Foster Meadow and Mattley Meadow floodplains no longer flood on a seasonal basis. Downcut stream channels profoundly alter floodplain meadow hydrology and ecosystem functions such as shallow aquifer retention and release, vegetative productivity, and wildlife habitat value. Project implementation would restore the basic hydrologic function of 72 acres of degraded montane meadow by eliminating downcut stream channels and allowing floodplain drainage to occur at floodplain elevation, often referred as the “pond and plug” technique. This technique has been used to successfully restore over 8,000 acres of channel/floodplain function throughout the Sierra Nevada, and beyond, since 1995.

The Big Flat pond and plug project area performed well with little damage in the 1997, 100+ year return-interval flood, two years after construction. The Big Meadows pond and plug project also performed well with no damage in another 100+ year event in 2009 twoyears after construction. Pond and plug projects restore the characteristically resilient processes within intact channel/floodplain systems. Climate change predictions include an increase in the extremes of precipitation (frequency, intensity and drought). Conceptually, functional mountain meadow floodplains can incrementally attenuate flood flows, and release shallow floodplain aquifer moisture during periods of drought.

In both meadows, stream flows are confined to 4’ to 8’+ deep incised channels, with eroding banks, and little to no riparian habitat. The Foster Meadow area encompasses 27 acres on the Middle Fork Cosumnes River, with a watershed area of 1.6 mi^2. Mattley Meadow encompasses 45 acres in the headwaters of Mattley Creek, tributary to the North Fork Mokelumne River with a cumulative watershed area of 1.2 mi^2. The valley gradient within Foster Meadow varies from 1.0% to 3.5%. The valley gradient of Mattley Meadow varies from 2% to 8%. There is well defined remnant channel on the surface of Foster Meadow. Mattley Meadow was a sheet flow (no defined channel) system prior to degradation. Channel incision appears to be primarily due to the synergistic effects of the roads, skid trails, intensive grazing and channel manipulation. The following photos document existing conditions.

Figure 1a. Cosumnes River incised channel at Foster Meadow where channel was moved into timbered high ground.

Figure 1b. Cosumnes River functional channel in Foster Meadow.

The Foster Meadow Restoration Project is located along a 1+ mile reach of the Middle Fork Cosumnes River. The project encompasses 27 acres of meadow floodplain in 3 discrete sections connected by reaches of functional channel. The meadow gradients vary from 1% to 3.5%.

Mattley Meadow, prior to degradation, combination of sheet flow (i.e. no channel) and defined shallow swales on the surface of the meadow. Channels generally only develop where the accretion of streamflow and sediment supply is sufficient to form and maintain a defined channel. The effects of roads, skid trails and historic livestock use allowed for sheet flows from the adjacent hillslopes to concentrate and form three large gully channels. One each on the east and west edges as well as one in the middle.

Figure 2. Mattley Meadow east gully October 2014.

Figure 3. Mattley Meadow west gully October 2014.

The likelihood of successful project implementation, with expected GHG reductions and co-benefits is high, based on the implementation of similar projects by Plumas Corporation since 1995. Following are monitoring data collected from various pond and plug projects since 1995:

Figure 4 displays soil carbon differences in three restored versus unrestored meadows. Pre-project carbon samples will be collected in 2015 at Foster Meadow and Mattley Meadow. Root depths of six inches or less indicate that pre-project conditions for soil carbon in the proposed treatment areas, and subsequent project-related soil carbon sequestration, will be comparable with other project areas.

Figure 5 compares groundwater elevations in pre-project, versus post-project conditions, averaged over a number of years at Clarks Creek. Groundwater wells will be installed in the both project areas in June 2015. Similar benefits in groundwater elevation, and seasonal groundwater retention and release, is expected at the proposed treatment areas.

Figures 6 and 7 display an increase in vegetative productivity and shift to more wet meadow species from a pond and plug project in Red Clover valley, and a riffle augmentation project on Little Last Chance Creek, respectively. NRCS (Natural Resource Conservation Service) surveyed vegetation transects in 2014, with plans to re-survey in the post-project condition.

In a paper presented at the western snow conference in 2010 (Tracking the Impact of Climate Change on Central and Northern California's Spring Snowmelt Subbasin Run-off, unpublished), Gary Freeman stated that climate change is already affecting the timing and quantity of run-off in the North Fork Feather River watershed, due to a decreased snow pack in the Sierra Nevada. The project would incrementally address summer flows by retaining water later into the season in shallow mountain meadow floodplain aquifers, thus contributing to climate change adaptation from the loss of water retention in the snowpack. Figure 8 displays pre- and post-project summer water temperature change on Last Chance Creek in Ferris Fields in 2007 as a proxy for groundwater recharge to streamflow..

Figure 9 displays restored/unrestored bird populations on a suite of meadows in the upper Feather River watershed. Institute for Bird Populations has previously surveyed the Foster Meadow project in 2010-2012.

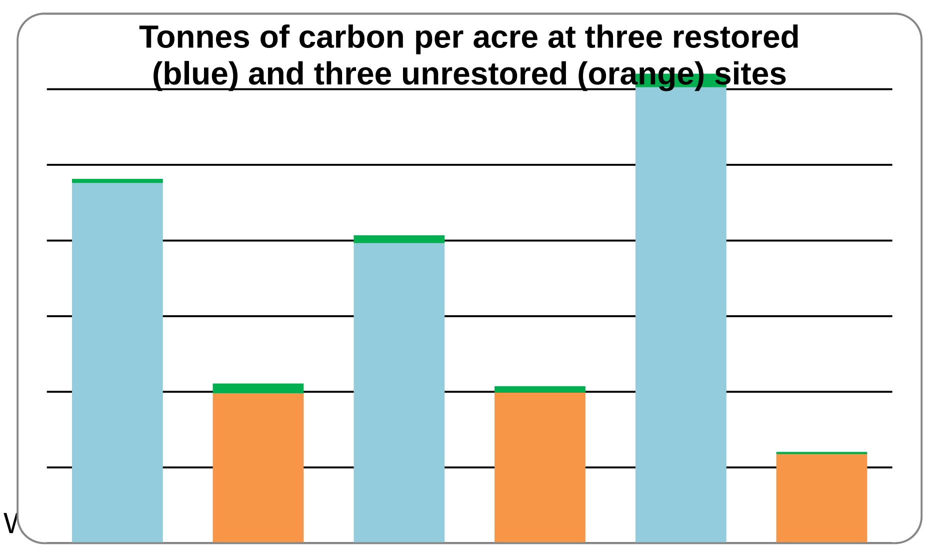

Figure 4. A comparison of soil carbon found in restored versus unrestored meadows. Post-project samples were collected on the Red Clover Poco project in 2014, with analysis planned for early 2015. From: Technical Report: Quantification of Carbon Sequestration Benefits of Restoring Degraded Montane Meadows by Feather River Coordinated Resource Management 2010.

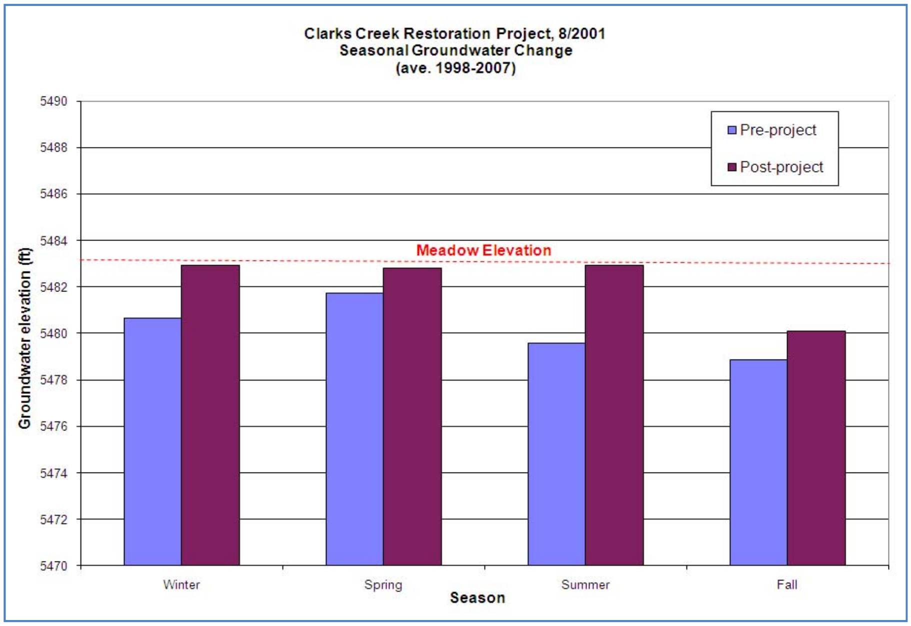

Figure 5. Seasonal average groundwater elevation changes from a pond and plug project on Clarks Creek in the upper Feather River watershed (unpublished monitoring data).

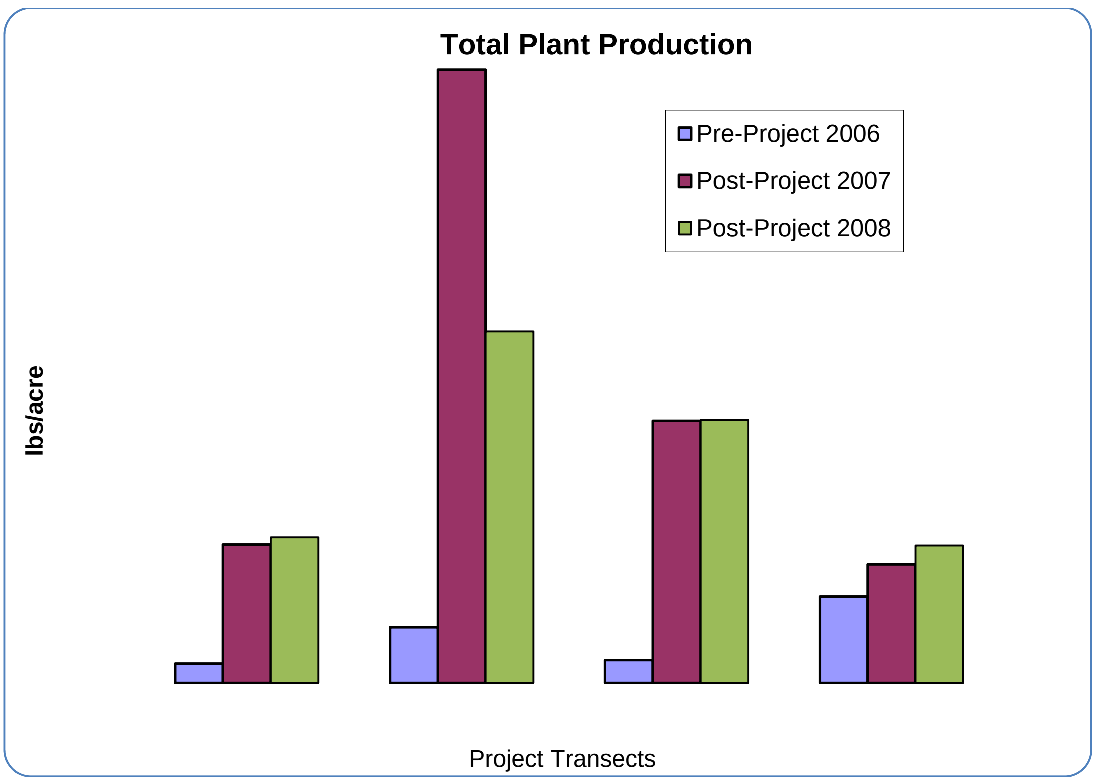

Figure 6. Vegetative productivity in years one and two after meadow restoration in the Red Clover McReynolds pond and plug project area (from unpublished project monitoring data available on the Plumas Corporation website).

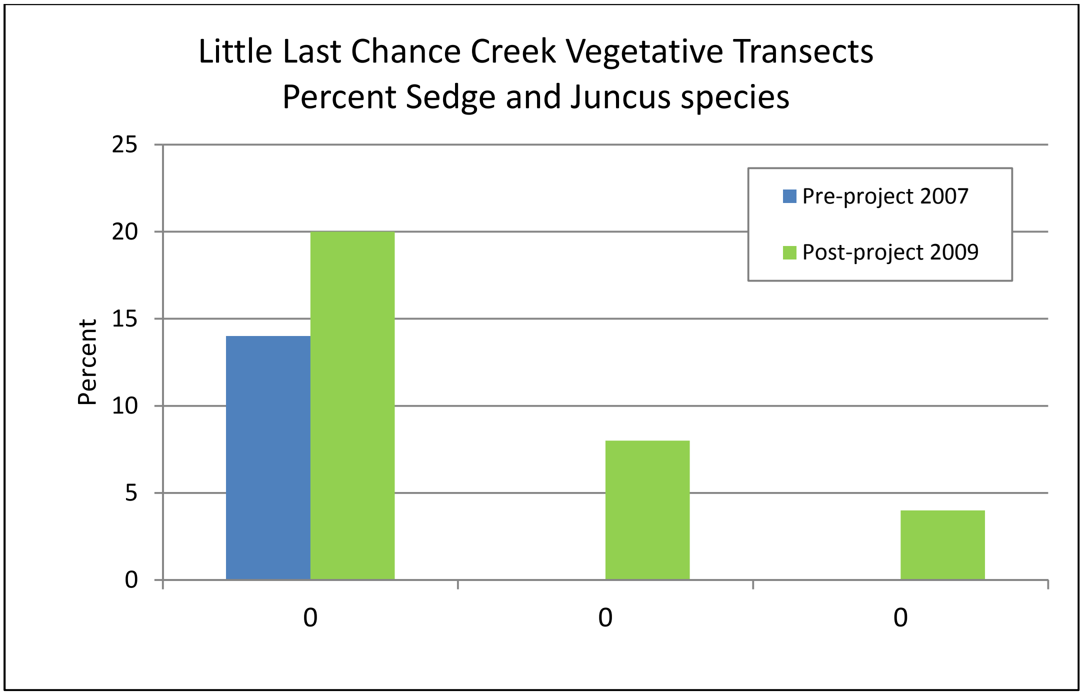

Figure 7. Comparison of plant community composition before and after a meadow re-watering riffle augmentation project on Little Last Chance Creek.

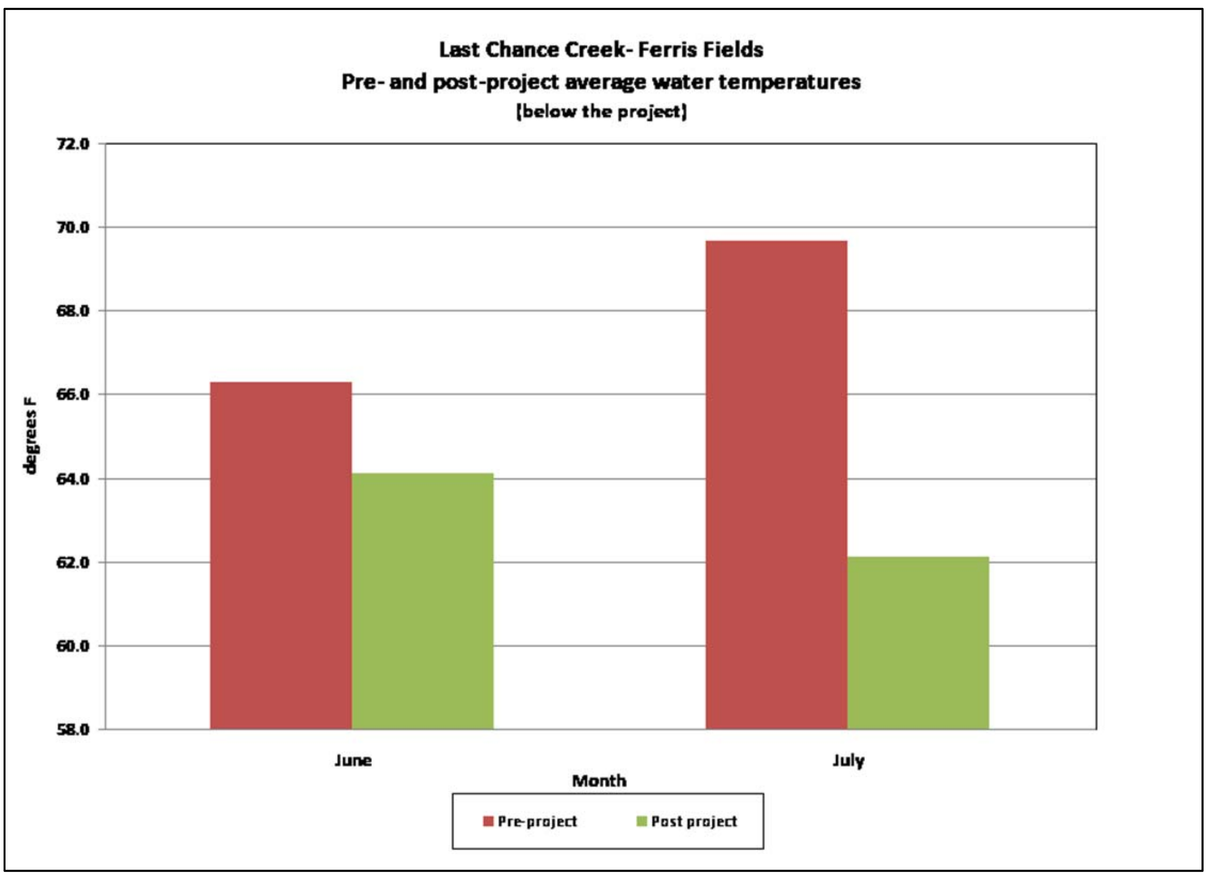

Figure 8. Summer water temperature change and below a pond and plug project at the Ferris Flat reach of Last Chance Creek.

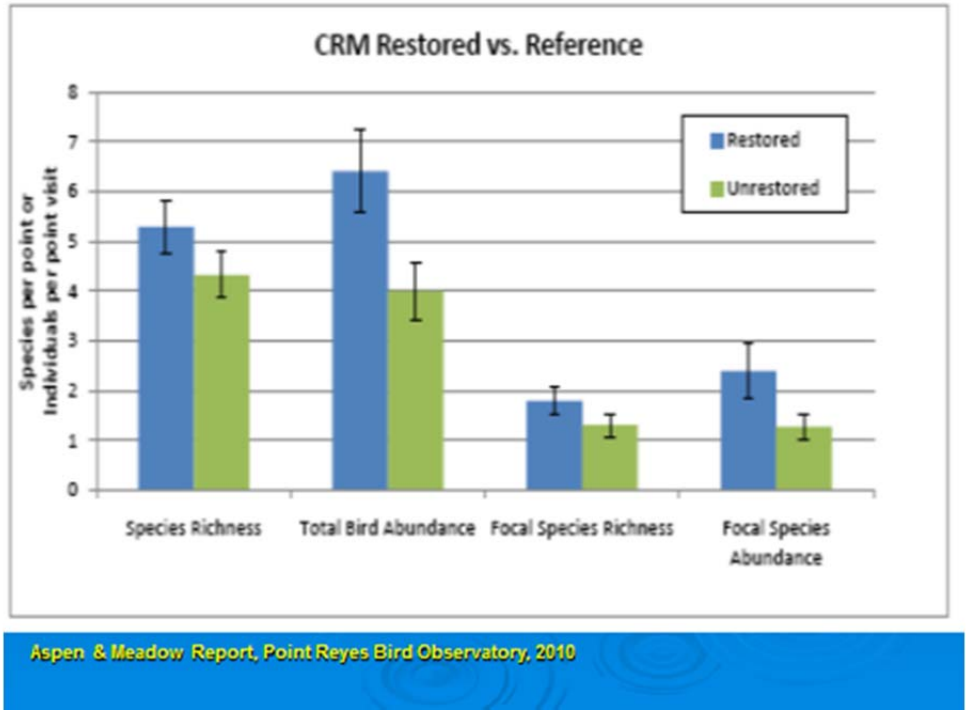

Figure 9. Meadow bird populations on restored versus unrestored meadows.

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

Tasks common to both treatment areas:

The pond and plug technique entails the use of heavy equipment to eliminate the incised channel as a drain on the shallow meadow aquifer. Since these two meadows have moderate to steep gradients, the design calls for near continuous fill of the gullies, with borrow ponds (ponds would fill with groundwater recharge) located at the meadow margins away from direct overland flows. The elimination of the gully allows better precipitation infiltration into the shallow floodplain aquifer, and slower seasonal aquifer drainage. Careful removal and replacement of top soil and meadow sod results in rapid re-vegetation of the plugs. Existing mature meadow sod, willows and aspen will be transplanted from the gully bottom prior to excavation or filling. Transplants will be used to line the lower margins of the plugs for overland flow protection. Native seed will either be hand harvested from nearby un-grazed meadows, or purchased, and spread by hand on finished plugs. Both project areas have short reaches of perennial flow. Some aquatic organism removal to safe havens will be required.

Design work for both meadows has been completed by Plumas Corporation under a grant contract with the National Fish & Wildlife Foundation. All construction work would be implemented by a construction contractor, chosen through a competitive bid process. Equipment to be contracted includes an excavator, wheel loader, track loader, and water truck or pumps. Construction would occur under the supervision of Jim Wilcox, of Plumas Corporation, and is expected to last 2.5 months total for both meadows, occurring in late summer or early fall.

All monitoring data would be recorded in a spreadsheet, summarized, analyzed and would be documented in a project final report, and available to the public on the Plumas Corporation website. Pre-project monitoring field data would be collected in 2015 and early 2016. Some parameters are already being collected. Post-project field data would be collected for three years following construction. GHG monitoring would be conducted by

Gia Martynn and Leslie Mink of Plumas Corporation. Co-benefit monitoring would conducted by USFS staff. Aquatic organism recovery will constitute one portion of the co-benefit monitoring and be performed by certified USFS staff. Avian point count surveys will be conducted by the Institute for Bird Populations.

Foster Meadow: The Foster Meadow treatment would entail the excavation of 22,500 yds^3 to eliminate the gully as a conduit for flow. This material would be excavated from 8 borrow areas, 4 borrow ponds and 4 terrace re-grading areas, with the resultant material used to construct the plugs. The total pond water surface area created would be 0.8 acres. Total terrace re-grading area is 4.9 acres. Total plug surface area would be 4.5 acres. The remnant channel(s) are 5,240 feet long with an average floodplain width greater than 142 feet.

In addition to the gully fill treatment, the following two project design features would ensure a seamless transition for flows into, and out of, the Foster Meadow treatment area: 1) modify the existing Forest Road 9N14 crossing by installing a rock/soil valley grade structure with riffle/pool channel to provide for both channel and floodplain aquatic organism passage. The valley grade structure channel would have a slope of 3.5% to meter out the current 30” drop from water surface to existing culvert outlet. Install additional floodplain elevation culverts to augment the single 36” culvert currently in use. The floodplain culverts would be installed at an elevation 1 foot higher than the existing channel culvert to be accessed only during floodflows; 2) install 10 rock/soil riffles, each of 40 yds^3 of 1 foot minus rock, in the lower channel to accommodate the transition of gradient back to native grade at the downstream end of the meadow.

Mattley Meadow: The Mattley Meadow treatment would entail the excavation of 51,200 yds^3 to eliminate three gullies as conduit for flow. This material would be excavated from 13 borrow areas (ponds) with the resultant material used to construct 10 plugs. The total pond water surface area created will be 6.01 acres. Total plug surface area will be 4.5 acres. The remnant channels total 3,010 feet in length with an average floodplain width of 610 feet. Existing down large woody debris will be re-distributed for short-term water velocity control.

GHG Research:
The Foster Meadow and Mattley Meadow projects will be included in the larger research effort of the Sierra Meadow Restoration Research Partnership (SMRRP). The SMRRP 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 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 of 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.

Foster Meadow and Mattley Meadow will be monitored using the **'state factor meadow'** methodology. Soil carbon samples will be collected in 2015. GHG emissions will be sampled to 'state factor' intensity in 2015 and again in 2018. Plumas Corporation staff will participate in the SMRRP Technical Advisory Committee (TAC) via quarterly meetings and annual conferences.

Co-benefit monitoring:

- Groundwater elevation monitoring will be initiated in 2015 the installation of a total of seven groundwater wells. Groundwater levels within the wells will be measured monthly when the project area is accessible, from June 2015, through three years after restoration construction.
- A total of three vegetative transects would be monitored at each meadow. The transects would be located along existing topographic cross-sections, and would follow 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). Species would 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 would be monitored in mid-summer on an annual basis.
- Stream water temperature would be measured at the bottom of each project area with a HOBO data logger placed in the channel. Dataloggers would be installed in June each year and recovered in September.
- Wildlife habitat value would be measured with bird point counts. Two years of point count has been conducted at Foster Meadow (2010- 2012) and a control meadow (Sand Shed) with one year of pre-project point count proposed for Mattley Meadow. One year of post project point counts would be conducted for both projects and again at the Sand Shed control meadow nearby.
- GPS'ed photo points would also document overall changes in the vegetation and landscape. Photos would be taken annually in mid-summer.

Data Analysis and Reporting:

GHG emissions will be summarized annually and reported to the SRRMP team, along with biomass, groundwater levels, soil carbon and water content, and soil temperatures pertinent to each GHG sampling date. Project personnel will coordinate with the SRRMP team to review summarized data from all participating projects. It is anticipated that one or several peer reviewed publications on mechanisms that control GHG emissions and carbon sequestration in meadows will be produced through this task. Reports will also be made available to the public on the Plumas Corporation website.

4. ***Timeline:***

Activity	Timeline	Completion Date
Coordinate with project partners	On-going Spring 2014	on-going (non-match & grant)
Complete topographic surveys	Summer 2014	Aug 2014 (non-match)
Preliminary project design	Fall 2014	Nov 2014 (non-match)
Finalize project design and layout	Fall 2014	Jan 2015 (non-match)
Botany, wildlife, and archeology surveys & reports	Spring/summer 2014-15	December 2015 (non-match, match & grant)
Finalize project monitoring plan	Winter 2015	April 2015 (non-match)
Collect pre-project monitoring data	Summer/fall 2015 (wells); 2015 (photos, veg, wildlife, GHG)	November 2015 (non-match, match & grant)
Complete CEQA/NEPA documentation	2015	February 2016 (grant)
Signed CEQA Declaration	Spring 2016	April 2016 (grant)
Complete permit applications	Winter 2015/16	February 2016 (grant)
Receive permits	Spring/Summer 2016	June 2016 (grant)
Develop land management plan	Spring/summer 2015	February 2016 (grant & match)
Construct project	Summer 2016	Oct 2016 (grant & match)
Collect post-project monitoring data	Fall 2016 through Fall 2018	November 2018 (grant & match)
Final report & invoice	Winter/Spring 2019	June 2019 (grant)
Continued visual project monitoring	2019-2025	November 2025 (match)

****Non-match above is survey, data collection, analysis, design develoment and layout performed by Plumas Corporation under a grant contract with the National Fish & Wildlife Founndation from May 2014 through March 2015. Total design costs were $60,000.00 Additional non-match has been contributed by USFS for resources surveys. Total amount is not yet available from USFS.**

5. ***Deliverables:***

Deliverable	Timeline	Completion Date
Quarterly reports and invoices	September 30, 2015, and 30 days after every calendar quarter through June 2019	on-going
Land management and long-term monitoring plan	Spring/summer 2016	Feb 2016 (grant & match)
Project construction photos	Summer 2015	Aug 2015 (grant & match)
Final project and monitoring report, including all data & final invoice	Winter/Spring 2019	June 2019 (grant)
Final invoice		June 2019
Continued visual project monitoring performance updates	2019-2025	November 2025 (match)

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

The project is expected to reduce carbon dioxide (CO_2) by 23,189 metric tons (tonnes). Expected project effects on nitrous oxide (N2O) and methane (CH_4) are not sufficiently well understood to be quantifiable. 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 CO_2 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 Mountain Meadows treatment sites versus the sites used in the FRCRM 2010 study, warrant a 50% reduction in the expected outcome. Based on the 2010 study, existing carbon stores are estimated at approximately 50 tonnes of carbon per acre at the two treatment areas. 72 acres x 50 tonnes is 3,600 existing tonnes of carbon at the two sites. The project is expected to conservatively increase carbon by 50%, or 1,800 tonnes of carbon. To convert this sequestered carbon to the equivalent carbon dioxide GHG, multiply the ratio of the molecular weights of carbon to carbon dioxide (3.6663) to give an estimated 6,599 tonnes of carbon dioxide to be sequestered in the meadow, minus estimated emissions of 51 tonnes generated during design, construction, and monitoring, leaves a net of 6,548 tonnes of carbon dioxide. The sequestration of carbon is expected to last in perpetuity as long as the hydrology of the meadow remains in a restored state.

7. ***Protocols:***

- <u>GHG – Soil carbon</u> – Soil carbon will be sampled and analyzed following a protocol developed by the FRCRM 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.

Sample Testing

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.

- GHG – This project will collect GHG emissions according to the "state factor meadow" methodology used by other projects involved in the SMRRP, with data collected at high spatial and temporal resolution. Two treatment meadows have been identified for GHG and soil carbon sampling, described in the project description. A control meadow will be identified to match the treatment meadows in early summer, 2015.

  The three meadows to be sampled in addition to the two treatment meadows will allow a robust analysis of data, over time and space. Pre- and post-treatment sampling in Foster Meadow and Mattley Meadow will provide a same-site time comparison. The two paired restored meadows will not only allow a spatial substitution for time comparison with the treatment meadows, but will also enable analysis of sequestered carbon stocks over time, under typical montane meadow management (i.e. grazing).

  For GHG sampling, static chambers will be installed at each site, within the major hydrologic zones (dry, moist, and inundated) identified along five surveyed topographic valley-wide cross-sections (i.e. 10-15 chambers per meadow) in June 2015, with soil GHG flux sampling to begin one month after installation, using the protocol described by Hutchinson and Mosier (1981), (also Blankinship and Hart (2014)), and other Sierra Meadow Restoration Research partners. Chambers will be constructed of polyvinyl chloride (PVC) tubing, approximately 30 cm in diameter (to reduce the inherent spatial variability associated with soil gas fluxes and optimize for continued ecosystem functions at a scale appropriate for understanding driving variables (Sullivan et al., 2010)). In the field, the vented static chambers will rest on bevel-edged PVC collars that are permanently installed 2-3 cm deep in the soil. 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 evapotransporation 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. Samples will be analyzed at the UNR Soil Science and Ecosystem Ecology laboratory using a gas chromatograph.

- Groundwater elevation – monthly measurements (when the project area is accessible), with a hand held water level reader, in ½" perforated pipe wells to be installed in June 2015, through three years after construction.

- Vegetative productivity - Three vegetative transects would be monitored at each meadow, located along existing topographic cross-sections, and following 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).

- Community composition - Species would 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 would be monitored in early summer on an annual basis.

- Water temperature - Would be measured at the bottom of each project area with a HOBO data logger placed in the channel within a stilling well. Dataloggers would be installed as early as the project area is accessible in 2015, and downloaded monthly through the summer months until the channel is dry. 2015 would provide one year of pre-project data. The data loggers would be deployed for three years after construction.

- Wildlife habitat - Would be measured with bird point counts. Two point counts were conducted within the Foster Meadow project area in 2010- 12. Pre-project point counts will be conducted in Mattley Meadow in 2015, with post project points counts conducted in both project areas. All point count surveys will be conducted by the Institute for Bird Populations.

- Photo documentation - GPS'ed photo points would document overall changes in the vegetation and landscape. Pre- and post-project photos would be taken annually in early summer, and recorded with compass bearings.

Value of Co-benefits- Mountain meadows are among the most important habitats for birds in California (Burnett et al. 2005); they support several rare and declining species in the Sierra Nevada and are utilized at some point during the year by almost every bird species that breeds in or migrates through the region. Meadows also perform a vital role as watershed wetlands that store and purify drinking water for millions of Californians.

8. *Literature Cited:*

Amador-Calaveras Consensus Group Cornerstone Project, 2011, Amador-Calaveras Consensus Group. https://acconsensus.wordpress.com/2011/03/02/accg-cflra-cornerstone-proposal/

Blankinship, J.C., and S. C. Hart. 2014 Hydrologic control of greenhouse gas fluxes in a Sierra Nevada subalpine meadow. Arctic, Antarctic, and Alpine Research, 46(2):355-364.

Burnett, R.D., D.L. Humple, T. Gardali, and M. Rogner. 2005. Avian Monitoring in the Lassen National Forest. 2004 Annual Report. PRBO report to the U.S. Forest Service.

Cornwell and Brown, 2008. Physical and hydrological characterization of Clark's meadow. California State University, Sacramento. 38 pp. Master's Thesis, unpublished.

DeWald, S., S. Josiah, and B. Erdkamp. 2005. "Heating With Wood: Producing, Harvesting and Processing Firewood," Scott DeWald, , University of Nebraska – Lincoln Extension, Institute of Agriculture and Natural Resources..

Feather River Coordinated Resource Management (FRCRM). 2010. Technical Report: Quantification of Carbon Sequestration Benefits of Restoring Degraded Montane Meadows. 15 pp. Unpublished, available at: http://feather-river-crm.org/images/stories/Publications/CarbonTechlRpt.pdf

Feather River Coordinated Resource Management. 2010. Final Report Upper Middle Fork Feather River Complex, 2005-2006 Consolidated Grants Proposition 40 – Nonpoint Sourse Pollution Control Program. 87 pp. Unpublished, available at: http://feather-river-crm.org/pdf/MFFR%20Complete%20Final%20Report.pdf

Feather River Coordinated Resource Management-Plumas Corporation. 2008. Final Report Red Clover/McReynolds Restoration Project. 16 pp. Unpublished, available at: http://feather-river-crm.org/project-files/RCFinal01_08.pdf

Feather River Coordinated Resource Management-Plumas Corporation. 2010. Red Clover/McReynolds Restoration Project Monitoring Report. 19 pp. Unpublished, available at: http://feather-river-crm.org/pdf/RedCloverMonitoringRpt2009.pdf

Freeman, G.J. 2010. Tracking the Impact of Climate Change on Central and Northern California's Spring Snowmelt Subbasin Run-off. Paper presented at Western Snow Conference. 12 pp. Unpublished, available from gjf2@pge.com

Herrick, JE, JW Van Zee, KM Havstad, LM Burkett and WG Whitford. 2005. Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems. USDA-ARS Jornada Experimental Range. ISBN 0-9755552-0-0.

Lichvar, RW, M Butterwick, NC Melvin, WM Kirchner. 2014. The national wetland plant list

2014 update of wetland ratings. Phytoneuron. 2014-41:1-42

Loffland, H.L., Siegel, R.B., Wilkerson, R.L. 2013. Assessing the effects of meadow restoration on bird populations in the greater Sierra Nevada: report for the 2012 field season. Available from www.birdpop.org