Section 5: Project Description

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

Our proposed project is intended to support research and information needs of the planned Upper Truckee River and Marsh Restoration Project (UTM Project) that is sponsored and led by the California Tahoe Conservancy (CTC), US Bureau of Reclamation (BOR) and Tahoe Regional Planning Agency (TRPA). In addition, the data, methods and deliverables from this project will be aligned and shared with those proposed by CalTrout under this CDFW grant solicitation for other meadow restoration projects under the Sierra Meadow Restoration Research Partnership (SMRRP) and will be coordinated with the local Upper Truckee River Watershed Advisory Group (UTRWAG).

The specific objectives of our proposed project are to:

- Objective 1 - Develop scientifically robust methods for quantifying above (biomass) and below (soil) ground meadow carbon.
    - *Expected Outcome* – provide clear guidance for measuring and assessing above and below ground carbon levels within meadow ecosystems throughout the Sierra Nevada Ecoregion.

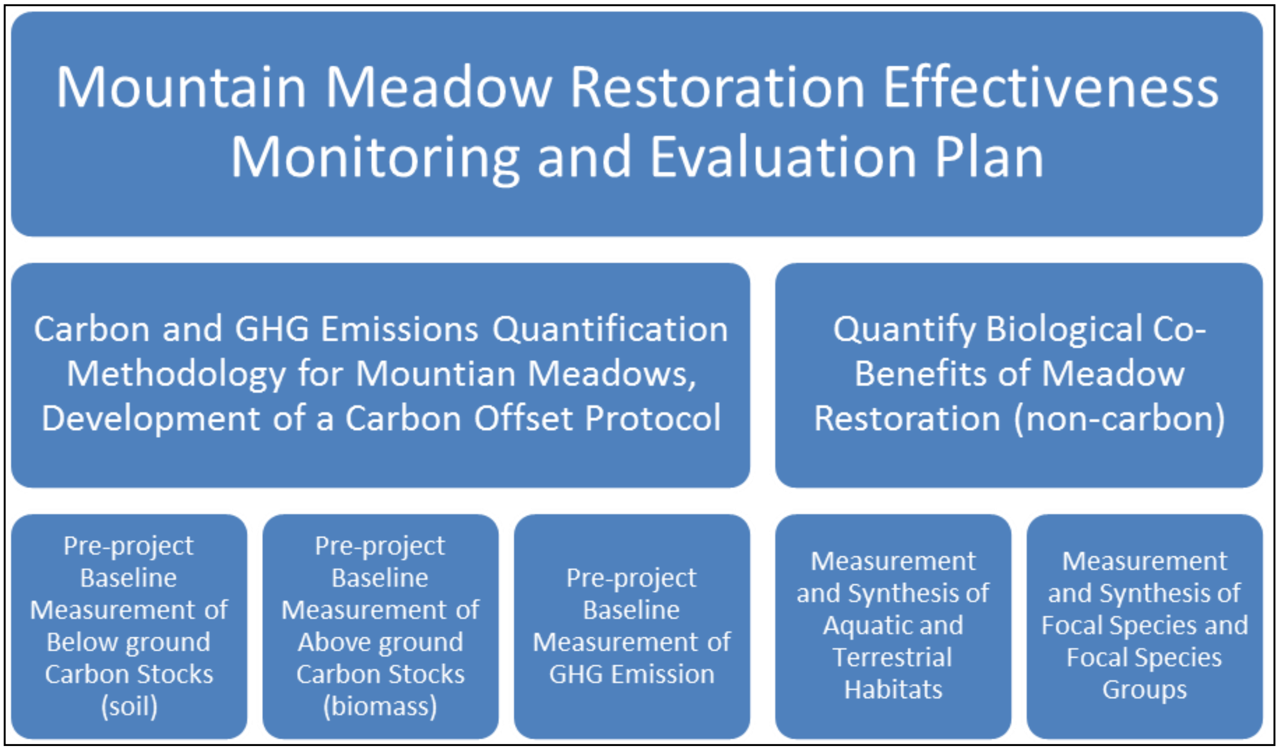


Figure 2 – Major Project Elements

- Objective 2 - Develop scientifically robust methods for quantifying GHG emissions (i.e., CO_2, CH_4 and N_2O) associated with mountain meadow ecosystems.
    - *Expected Outcome* – provide clear guidance for measuring and assessing GHG emission levels within meadow ecosystems throughout the Sierra Nevada Ecoregion.
- Objective 3 - Measure and asses pre-project conditions for above and below ground carbon (soil and biomass carbon) and GHG emissions at Upper Truckee River and Marsh Restoration Project (UTM project) area and other control areas. This information will be used to calculate the pre-project net carbon sequestration conditions for the UTM project.
    - *Expected Outcome* – Establish project area baseline levels for above and below ground carbon and GHG emissions that can be used to assess UTM Project restoration effectiveness (i.e., change detection).
- Objective 4 - For co-benefits, utilized established and accepted inventory protocols to measure and assess pre-project conditions for fisheries and wildlife habitats and focal species at the UTM Project, and synthesize existing restoration effectiveness monitoring results for fisheries and wildlife from the Upper Truckee River and Trout Creek watersheds.
    - *Expected Outcome* – 1) Establish project area baseline levels for aquatic and terrestrial habitats and focal species that can be used to assess UTM Project restoration effectiveness (i.e., change detection), and 2) utilize previous and existing investments in project- and regional-level biological monitoring efforts to provide a watershed-wide quantification of restoration benefits for fisheries and wildlife resources. This information will be valuable for managers and policy makers as it will evaluate pre- and post-restoration data for project that are planned or have been completed for greater than 10 years.
- Objective 5 - Use acquired information from project area and past monitoring efforts to develop comprehensive restoration effectiveness monitoring and evaluation plan for the

UTR Project that can be used to guide the measurement and assessment of net carbon sequestration, and fisheries and wildlife co-benefits over time at the project area and at other meadow restoration project areas within the Sierra Nevada Ecoregion.
    - *Expected Outcome* – These guidelines will be valuable for UTM Project leads because they will provide consistent methods for collecting and assessing the UTM Project post-restoration, over time. Thus, managers will have a means to quantify restoration effectiveness with respect to net carbon sequestration and the biological community. The monitoring and evaluation plan will also benefit other meadow restoration practitioners throughout the Sierra Nevada Ecoregion.
- Objective 6 - Share data, information, and results from this effort with Sierra Meadow Restoration Research Partnership (SMRRP) and the Upper Truckee River Watershed Advisory Group (UTRWAG), and significantly participate with the SMRRP to develop a mountain meadow carbon offset protocol.
    - *Expected Outcome* – The mountain meadow net carbon sequestration methodology we develop will comply with American Carbon Registry (ACR) or Verified Carbon Standard (VCS) that could eventually be approved by ARB. Similarly, the information we generate and share with the SMRRP will contribute to our overall understanding mountain meadows within the Sierra Nevada.

The UTM project itself is expected to expand the area of functional wet meadow, wetland, and riparian vegetation; increase the number of temporary pools; and enhance the vigor of deciduous riparian vegetation. These changes are expected to affect wildlife species composition and abundance in several ways. In riparian meadows, a general shift from more upland species to more mesic and wetland species can be expected. Small mammal communities are expected to experience an increase in desirable wet meadow species such as Broad-footed Mole (Scapanus latimanus), Western Jumping Mouse (Zapus princeps), and Belding's Ground Squirrel (Spermophilus beldingi). Herpetofauna species dependant on wet meadow conditions, such as Western Toad (Bufo boreas), Western Aquatic Garter Snake (Thamnophis couchii), and Common Garter Snake (Thamnophis sirtalis), are expected to increase in abundance and distribution. Desirable bat species, including Western Red Bat (Lasiurus blossevillii), Long-eared Myotis (Myotis evotis), and Fringed Myotis (Myotis thysanodes), may potentially increase in abundance and distribution due to restoration activities. Restoration is also expected to substantially reduce or eliminate invasive plant and animal species, reduce threat of wildfires, and expand aspen stands by removing conifer encroachments.

Although we expect measurable changes in the biological community at the UTM Project area, it is unknown whether if changes in net carbon sequestration will be realized. With increased meadow wetness and subsequent vegetation response, net carbon sequestration can be predicted to increase (see conceptual model discussion below). Information generated from this project, in concert with other Sierra Nevada meadow investigation as part of the SMRRP is expected to help answer whether this prediction is true. According to the UTM Project Draft EIR/EIS/EIS the following was noted with respect to the project's effect on carbon sequestration:

> *"Quantification of sequestration of carbon by vegetation is not feasible without an accurate inventory of vegetation types and sequestration rates. Nonetheless, it was assumed that carbon sequestration would remain similar to existing conditions because the site would remain in natural vegetation, and although some changes in vegetation type would likely reduce sequestration rates in small areas (e.g., where*

Jeffrey pine forest would be replaced with other vegetation), other changes in vegetation type in large areas would likely increase carbon sequestration rates (e.g., conversion of montane meadow to willow-scrub). Mobile-source GHG emissions would be generated by the slight increase in project-related vehicle trips associated with the improvements to public access infrastructure in the study area attracting some additional visitors."

This statement provides justification for our proposed project objectives – to provide scientifically robust methodologies, data and analysis to enumerate the multiple benefits (or lack thereof) of meadow restoration projects.

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

Background

In the last 150 years historic landuse and development has eliminated more than half of the original 1,300 acre freshwater marsh/meadow complex at the mouth of the Upper Truckee River. The most significant impact to the marsh/meadow system occurred with the residential and marina development of the Tahoe Keys area starting in the 1960s, where the marsh/meadow complex was bifurcated and the lower reach of the Upper Truckee River was channelize along the western periphery – disconnecting the lower reach of the river from the remnant meadow and marsh system. The result of channelizing the river to the meadow periphery, growth of native meadow vegetation has been stunted and allowed for the encroachment of upland associated species. Under each action alternative evaluated in the project draft EIR/EIS/EIS, the proposed UTM project will re-establish river's hydrologic connection at the lower reach of the Upper Truckee River to the marsh and meadow system shared with Trout Creek in order to enhance ecosystem services – such as improve water storage and quality, and providing for high quality wildlife and fisheries habitats. Through the reestablishment of river meanders through the meadow, it is additionally expected to increase native meadow vegetation vigor and thus expected to increase the net carbon sequestration capacity throughout the project area.

Conceptual Model of Net Carbon Sequestration (from CalTrout and SMRRP)

The distribution of vegetation types in mountain meadows reflects seasonal differences in ground water levels and litter decomposition (Allen-Diaz 1991, Merrill et al. 2006, Loheide and Gorelick 2007). Thus, hydrologically degraded Sierra meadows experience a radical change in plant community type distribution and overall plant biomass after restoration. In many cases, sparse cover of sagebrush, annual grasses, and forbs is replaced with dense thatch of sedge and willow species with similarly dense rooting structures (Chambers and Miller 2004, Lindquist and Wilcox 2000). In restored wet or very moist meadows, this change in meadow plant community structure co-occurs with an increase in net primary productivity and a decrease in aerobic decomposition rates of fine roots and above ground litter. These two changes (high NPP rates and slow decomposition) result in increased soil organic matter content represents carbon sequestration (Figure 2). Preliminary measurements of soil carbon in restored versus unrestored meadows in the Feather River watershed show that restoring meadows could provide a one-time increase in below ground C stores by 110 to 220 CO_2e tons per acre over a 2 to 10 year post-restoration period (Wilcox et al. unpublished project results 2009). During the initial post-restoration years, these C sequestration numbers are very large and comparable to estimated rates of CO_2e sequestration reported for Delta fresh water wetlands and redwood forests (Miller et al. 2008, Miller et al. 2011, Knox et al. 2014).

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

In soils and sediments, nitrous oxide emissions typically occur as a result of two processes: nitrification and denitrification (Davidson et al. 1986). Nitrification is an aerobic, oxidative process that converts ammonium to nitrate. Nitrous oxide is produced by nitrification during the incomplete oxidation of ammonium to nitrate. On the other hand, denitrification is a reductive process, meaning it occurs in anaerobic environments by which nitrate is reduced to nitrous oxide and eventually to di-nitrogen gas. In well drained soils, nitrification is an important source of nitrous oxide, but in wet, anaerobic sites, denitrification is the primary source of nitrous oxide (Davidson et al. 1986). However, even under optimal conditions for both processes, denitrification usually produces more nitrous oxide than nitrification, all else being equal (Wrage et al. 2001). Thus, restoration from a dry and well drained meadow to a moist and more productive meadow could cause a shift in nitrous oxide sources from nitrification to denitrification, and increase nitrous oxide emissions (Figure 3). Areas of a hydrologically restored meadow where soil saturation remains high and organic matter is biologically available could support denitrification and associated nitrous oxide emissions. Similarly, in anaerobic conditions, decomposition of organic matter by soil microbes produces methane (methanogenesis; Figure 3). Therefore, any increase in soil C accumulation due to restoration must also carefully consider the production of methane and nitrous oxide to the environment. We do not mean to suggest that methane or nitrous oxide production are likely to cause restored meadows to be a net source of GHGs (measured in carbon dioxide equivalents to the atmosphere); however nitrous oxide and/or methane emissions (or uptake aka Blankinship and Harart 2014) could be a significant part of the overall meadow GHG budget, and therefore the importance of their contribution needs to be determined and if needed, included in any predictive models used to assess carbon credits gained through mountain meadow restoration.

carbon credits gained through mountain meadow

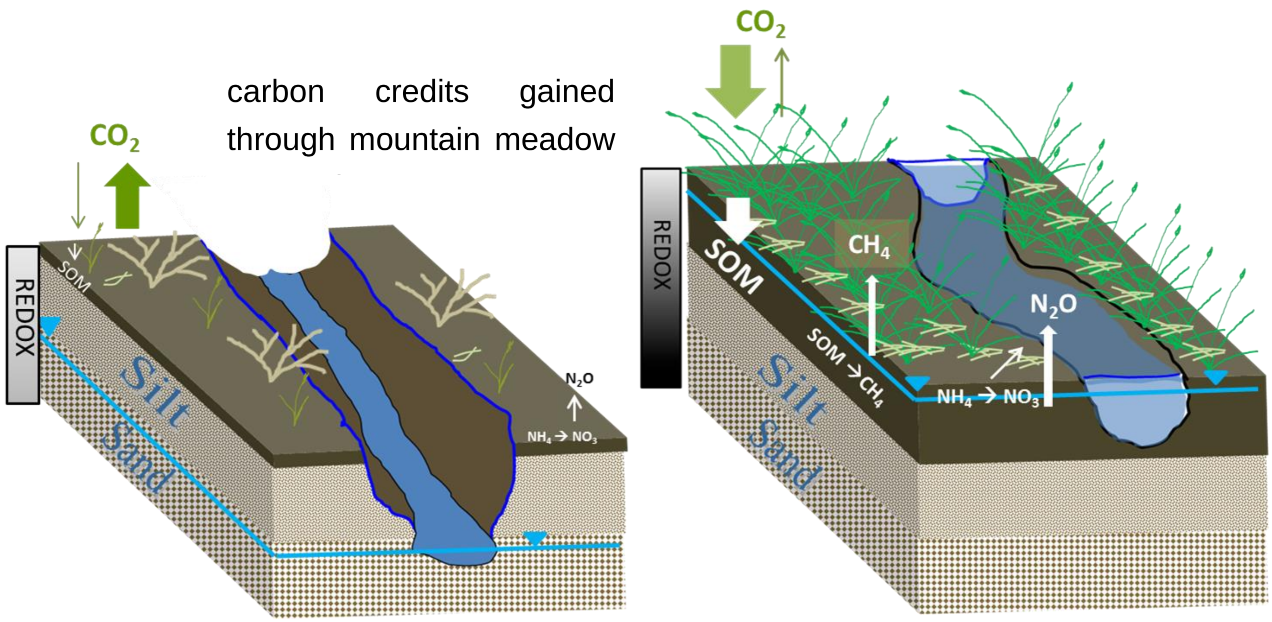


Figure 3. Conceptual model of meadow restoration effects on C sequestration and GHG dynamics (a) Hydrologically degraded meadow to the left with a groundwater table below the rooting zone during the growing season, supporting plant community with overall low productivity. Most of litter is rapidly decomposed, leaving little soil organic material (SOM). Small amounts of litter is mineralized, supporting low rates of nitrification and no or small N2O emissions as an intermediate by product of nitrification. (b) Restoration raises growing season water table to support much more productive plant community; saturated soils support very slow anaerobic decomposition, leading to rapid buildup of soil organic material (SOM), and potentially supporting reductive processes of denitrification and methanogensis.

Through this research, we will test the hypothesis that: re-establishing the hydrological connectivity between the stream and the surrounding meadow will increase net carbon sequestration, taking into account net GHG emissions, compared to non-restored conditions. To test this over-arching hypothesis, SMRRP will measure net carbon sequestration in Osa meadow under pre and post-restoration conditions and at the same time measure net carbon sequestration in a similar degraded and unrestored meadow, completing a before-after-control-impact experimental design. We will assume that the change in net carbon sequestration in Osa meadow, compared to changes in the unrestored meadow, are due to restoration.
We will develop and apply the science to measure GHG (carbon, methane, and nitrous oxide) gains from restoration on UTM Project. The same protocol will be applied to partner meadow-restoration projects in 2015 across the Sierras, and to 3 type-matched degraded control meadows to clearly demonstrate effects of restoration on net sequestration. Other meadows will be added in subsequent years to include a full range of meadow types. Peer reviewed findings will be shared at an annual conference, developing a protocol to measure GHG dynamics and quantify the impact of restoration strategies on GHG capture in Sierra meadows.

Wildlife and Fish Co-benefits Conceptual Framework

Results of pre- and post-restoration studies conducted in multiple meadows and wetlands within the Lake Tahoe Basin have shown that appropriately designed studies can achieve substantial enhancements of terrestrial and aquatic systems and associated animals. Work conducted by members of our research team identified, tested, and refined sampling methods for terrestrial and aquatic animals, and based on study results prescribed specific restoration activities to enhance the distribution and abundance of focal species. These previous studies also incorporated consideration of travel corridors for terrestrial animal species that allowed various focal species to expand beyond the specific restoration site. These studies showed that expanding the spatial extent of meadow wetness and prolonging the duration of wet meadows through the summer had substantial positive benefits for multiple species, while decreasing habitat potential for less desired species (e.g., exotic plants and animals). Some introduced species, such as the bullfrog, can effectively negate any structural improvements in meadow and wetland habitat because of their predation on native species. Thus restoration must incorporate consideration of more than "habitat". Our previous research thus provides a solid foundation of information that will be applied to the proposed study, and will help us evaluate and adjust restoration activities and sampling methods as the project progresses.

Wildlife are understood to select habitat on a species-specific basis, with the location that a species ultimately occupies determined by a series of spatially-link decisions (see Morrison et al. [2006] for a review). Researchers have been able to make predictions on species occupancy along a spatial scale from broad-spatial extent (i.e., "landscape") down to local habitat conditions (i.e., "micro") as depicted here:

LANDSCAPE → PRESENCE/ABSENCE

MESO → ABUNDANCE

MICRO → PRODUCTIVITY

As described below, we will implement this conceptual framework for gathering and analyzing data on wildlife species responses to environmental conditions, including those associated with restoration activities.

Broad spatial extent.—Also known as the "landscape" scale, predictions can be made about the distribution (occurrence; presence-absence) of wildlife species based on metrics such as vegetation type and broad geomorphic descriptors. We will use tools such as those available through GIS to develop a broad understanding of how wildlife species are distributed across the landscape, and how we predict they will respond when the amounts and types of these broad descriptors of the landscape are altered through natural (e.g., fire, drought) and human-planned (i.e., restoration) activities. This is thus the first in the stepwise and ordered understanding of wildlife distribution.

Meso scale.—We will use this intermediate scale to quantify the abundance (and related metrics depending on the species) of species within the broad spatial environmental categories identified in the previous step. These analyses directly address the variability that will be observed across vegetation types and start to provide understanding of why certain species are more abundant than others. These analyses help direct specific management actions and restoration plans for multiple species and species groups where the goal is increasing or decreasing the abundance of particular species.

Micro scale.—We will use this final and most detailed scale to understand how selected focal (i.e., rare, sensitive) species respond to environmental conditions. We will apply this scale to the UTM Project. Productivity or indicators thereof (e.g., nest success, presence of egg masses, age distribution) are frequently used at this spatial scale, resulting in an indication of the quality of habitat available. These data allow researchers and managers to fine-tune restoration projects to address the needs of specific species.

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

According to the UTM Project Draft EIR/EIS/EIS, the proposed UTM Project will re-establish river's hydrologic connection at the lower reach of the Upper Truckee River to the marsh and meadow system shared with Trout Creek in order to enhance ecosystem services – such as improved water storage and quality, and providing wildlife and fisheries habitats. In total, it is expected that about 500 acres will be restored or enhanced. Through the reestablishment of river meanders through the meadow, it is expected to increase native meadow vegetation vigor and thus expected to increase the net carbon sequestration capacity throughout the project area.

We have joined with the Sierra Meadow Restoration Research Partnership because we believe the size and uniqueness of this opportunity requires collaboration at the regional scale. The partnership leverages the considerable experience and expertise of Academic and Consulting Scientists, Practitioners and Resource Agencies to (1) establish the scientific foundation for what drives variation in GHG emissions and net carbon sequestration across a range of Sierra meadow types, (2) standardize field sampling, lab methodologies, and data analysis procedures for GHG measurements, (3) develop a predictive model for net carbon sequestration in Sierra meadows and an associated quantification protocol. The partnership also leverages a wide range of meadow types, locations, and conditions that will provide a 'gold mine' of information on the range of variability and associated controls on GHG emissions in the Sierras. Information on GHG emissions and their proximate controls will be collected at these sites and used to develop a predictive model for meadow carbon sequestration that is robust for the entire Sierra region. Finally and very importantly, through the process of implementing this project, the partnership will build regional and local capacity to monitor (and predict, using quantitative models) carbon sequestration and GHG emissions in meadows across the Sierras.

The proposed research will address the basic question: How does restoration of mountain meadows alter carbon sequestration in these ecosystems? We will address this broad question by combining data with other data sets collected by the SMRRP team; data from the SRMMP team will be collected at two complimentary temporal and spatial scales. The first methodology, which we will use for the Upper Truckee River Marsh project, will also be used at what we refer to as the 'state factor meadows'. This methodology will address the site-specific question of net carbon sequestration change with restoration at the project site, but also when combined with data from the other state factor meadows, 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 project and control-site meadows. Sierra Meadow Restoration Research Partnership meadows represent a wide range meadows and state factors across the Sierra Nevada (Table 1; Figure 4). 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 with the SRMMP team. Data from the proposed project will be made available to the entire SMRRP team to support development of this predictive model for meadow carbon sequestration.

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

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

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

Upper Truckee River Meadow	6240	44.2	5.72	Granite	Sierra Mixed Conifer	RLG

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

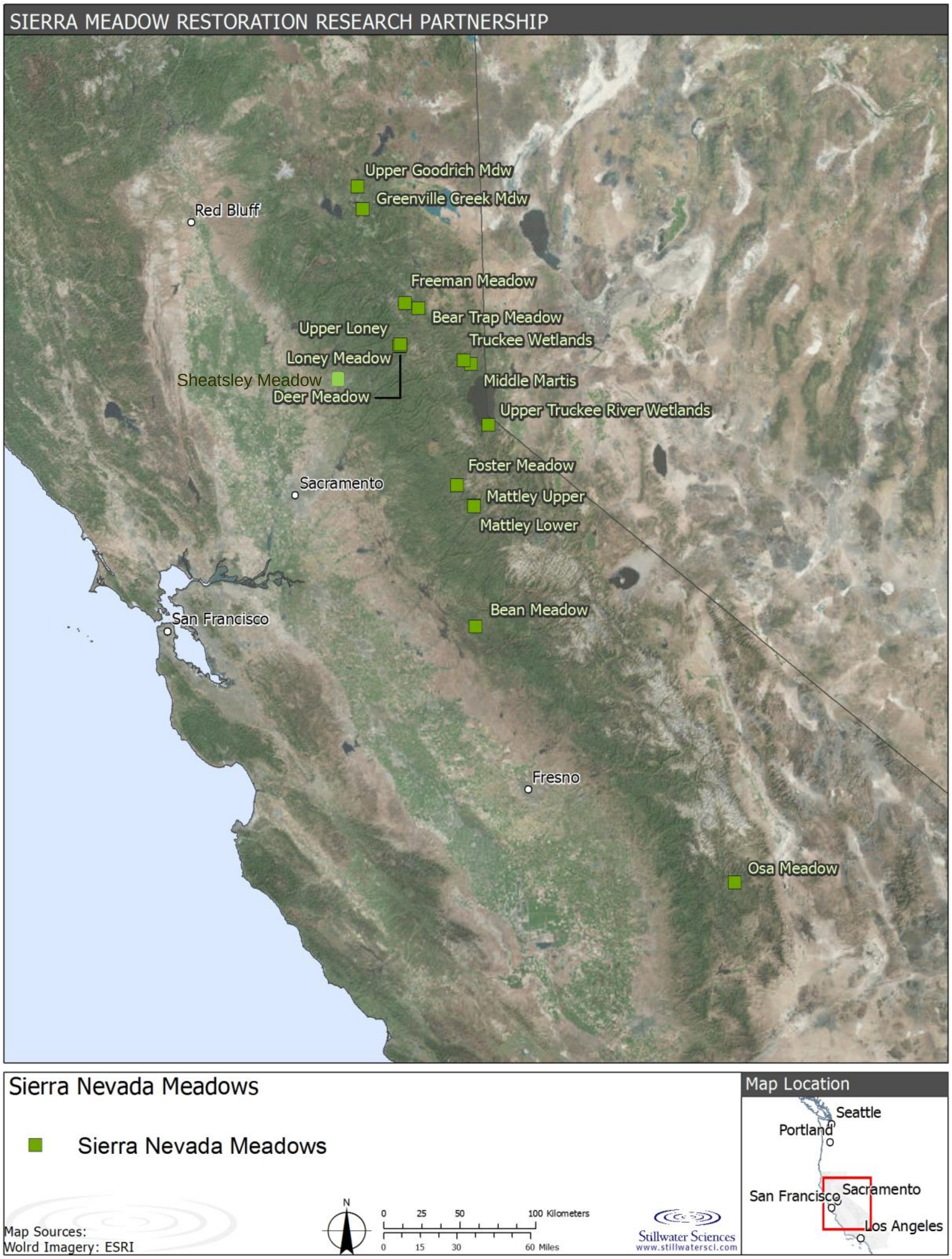


Figure 4. Meadows in proposed as part of the SMRRP represent a wide range of geographies in the Sierra Nevada.

We propose the following task to fill information gaps:

Task 1 – Develop methodologies, measure and asses pre-project conditions for below ground carbon (soil carbon) at UTR Project area and other control areas.

Task 1a. Identify control meadows and establish transects
Control meadows, with the same hydrogeomorphic class and in close proximity to the target restoration meadow, will be selected in the spring of 2015 for each restoration meadow. Paired control sites will be selected as meadows that have experienced hydrologic alteration and degradation similar to the target restoration meadow. Pairing of control degraded meadows with treatment (meadows to be restored) will also provide controls on inter-annual variability that could confound effects of restoration. Restoration and control degraded meadows will be stratified according to hydrogeomorphic type as described in Weixelman et al. 2011 and then by dominant vegetation type (Sawyer et al. 2009). 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 1b. Soil carbon and biomass production
We propose using the soil carbon sampling methodology developed and piloted by Plumas Corp and UNR soil scientist Dr. Dale Johnson (Wilcox et al. unpublished 2009). However before imitating field data collection, this methodology will be reviewed with the SIG-NAL team and SRMMP team scientists and adjustments made if appropriate. According to this methodology, soil carbon samples are collected along transects established across the meadow. Four one-foot square plots are chosen along each transect, with each plot representing a soil/vegetation type. In the un-restored meadows, it will be necessary to ensure that plot locations do not interfere with potential design features where earth movement activities are planned. The three or four vegetation/soil types covering the majority of the meadow area will be sampled in each meadow. Within these parameters, sample plot locations will be randomly selected. Soil surface is defined as the top of the O horizon; therefore this material will included in each soil sample. In moist and dry sites, the O horizon will be bagged and labeled by plot number for an entire square foot area plot. In wet sites, a 4" auger-size sample of the O horizon will be taken. In the center of the square, an auger will be used to sample the top three feet of soil. A representative sample of each foot of depth will be collected down to 3 feet below the soil surface. Approximately 20% of the soil in the auger will be removed for analysis, with an attempt made to collect material from the upper, middle and lower portion of the core. During augering, a representative bulk density sample (Blake, G.R., and K.H. Hartge, 1986) will be collected for each foot of depth. Bulk density samples will be collected at 9", 18" and 27" depth. Dried and sieved (2mm 8" brass sieve) soil samples, with large organic material (roots) removed and added to the biomass measurements as belowground biomass, will be well mixed, and a subsample for each foot of soil depth sent to the Soil, Water and Forage Analytical Lab at Oklahoma State University, Stillwater, Oklahoma. Samples will be tested for soil C content using a LECO TruSpec Carbon and Nitrogen Analyzer, as well as soil total N, pH, nitrate, total phosphorus, and potassium. The bulk density sample data will be used to convert all soil carbon samples to a per m2 area basis.

Task 2 – Develop methodologies, measure and assess pre-project conditions for GHG Emissions (CO_2, CH_4, and N_2O).

Task 2a. Measure net carbon and GHG in State Factor Meadows

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), as presented in Table 1. 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. 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 (Mosier et al. 1993, Merrill and Benning 2006). 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 (Merrill and Benning 2006, Blankinship and Hart 2014,), 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 (Merrill and Benning 2006), 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 CH_4 and N_2O production, means that much of the annual CH_4 and N_2O 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.

Task 2b. 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). 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 ground water 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.

Task 2c. 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. We will measure expected site-scale predictor variables from ground water wells and piezometers in each meadow, soil chemical and physical analyses, and assessments of vegetative productivity, soil carbon, and plant community composition. Specifically, these parameters include soil pore water and soil temperature, which will be collected at the same time that GHG emission measurements are made at each site along the meadow transects. Vegetation composition plots will also be recorded each year along each of the meadow transects using the CNPS rapid assessment protocol (CNPS 2004).

Task 2d. 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 refrence 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. Data and reports from this project and the SMRRP will be uploaded to the Sierra Meadows Data Clearing House (http://meadows.ucdavis.edu/), hosted at U.C. Davis upon completion of this project.

Task 3 – **Develop and implement methodologies, to measure and assess pre-project conditions for above ground carbon (biomass associated carbon).** This task specifically includes several subtasks, which are listed below and described in detail in Section 7 "Protocols." In addition, field data will be collected using common forest and meadow vegetation assessment methods (see protocol section). The field data will be utilized to for both calculating field based above ground carbon on a per acre basis and to spatially quantify carbon across the entire project area.

Task 3a -Acquisition and pre-processing of Light Detection and Ranging (LiDAR) National Agricultural Imagery Program (NAIP) imagery.

Task 3b- Collection of field based data to characterize carbon in meadow, wetland, riparian, and forest vegetation

Task 3c- Summarization of field data, including estimation of above ground carbon

Task 3d- Analysis of remotely sensed data, including estimation of above ground carbon.

Task 3e - Assessment of conifer encroachment using NAIP imagery

Task 4 – Develop a technical memo that summarizes findings and recommendation from pre-project above and below ground carbon and GHG emissions measurements. The memo will document the statistical parameters of estimates and make recommendations for refining estimates with either changes in sampling methodologies or sizes.

Task 5 – **Measure and assess pre-project conditions for the biological community at the UTM Project area (and other appropriate control locations). Synthesize existing restoration effectiveness monitoring results for fisheries and wildlife from the Upper Truckee River and Trout Creek watersheds.**

For the synthesis component of this tasks the project team will work with agencies conducting meadow restoration to acquire monitoring reports and/or any biologically relevant data collected in relation to their project. There are greater than 8 meadow restoration projects we can draw from within the Upper Truckee River and Trout Creek watersheds for the synthesis component of this analysis. For the UTM Project we will utilize existing and accepted protocols (see section 7 "Protocols" of the proposal or additional details) to sample the project area and other relevant control locations. We will target the following biological communities and species to character pre-project conditions at the UTM Project:

- Meadow and riparian vegetation – data captured as part of Task 3.
- Small mammals – following Borgmann and Morrison (2005).
- Bats – following Borgmann and Morrison (2005).
- Upland birds and waterfowl – following Borgmann and Morrison (2005).
- Butterflies – following Borgmann and Morrison (2005).
- Herpetofauna - following Borgmann and Morrison (2005).
- Benthic macroinvertebates – Leverage existing bioassessment efforts lead by TRPA, using California Aquatic Bioassessment Lab sampling protocols. This project proposes to work with TRPA to densify sampling effort at the UTM Project study area

We will explore three complementary study designs to frame the effectiveness monitoring and evaluation effort and subsequent monitoring plan: (1) modified BACI (Before-After-Control-Impact), (2) After-only, and (3) retrospective. Morrison et al. (2008) discussed the advantages and weakness of each of these designs in the context of wildlife and habitat restoration, and we will follow the guidance provided in that book. Within the context of the monitoring and evaluation plan, data gathered for this project and other restoration projects within the Upper Truckee River watershed will be used to analyze the response of wildlife to environmental conditions, including those currently existing and predicted to exist in the future as a result of climate changes and restoration activities. Data currently available through our past research activities in the project region, along with those gathered during this new project, will be analyzed and interpreted in the spatial framework outlined above.

Modified BACI

The BACI or optimal design requires pre-treatment (i.e., pre-restoration) and post-treatment data. The “modification” we will use enhances the basic BACI with multiple rather than a single control (similar, non-treated areas). We successfully used this design during our previous work in the project region. Restoration projects for which we will have pre- and post-restoration data, including data from multiple control sites, are Cookhouse Meadow, Trout Creek, and most restoration efforts through the Upper Truckee River watershed. We will increase sampling intensity as appropriate (see Methods, below) in some of these areas along with their associated controls to provide a longer-term understanding of how the restoration activities implemented on these sites have or have not worked. Our project is thus in the unique position of already having both temporal and spatial replication based on a rigorous study design.

After-only

Many situations are encountered where an activity has occurred but for which no pre-treatment data are available; these are termed “after-only” designs (Morrison et al. 2008). These situations can provide valuable information if they are properly designed, which includes the use of multiple non-treated control or “reference” sites. Morrison (2009) discussed the use of such designs in wildlife restoration. We will implement this design within our project region for any site that has been restored (plus similar non-treated sites) but for which no or inadequate data were collected prior to treatment. These sites will include the Lower Westside Project at the mouth of Upper Truckee River and Lake Christopher at Cold Creek.

Retrospective

Retrospective studies are similar to after-only designs in that no pre-treatment data are available and are frequently used in wildlife research (Morrison et al. 2008) including wildlife restoration (Morrison 2009). These studies usually sample multiple locations at specific times in the past, such as 5-, 10, and 15-years post treatment. Given adequate replication of the time series, they can provide an understanding of how environmental conditions and associated wildlife species have changed through time. Without such studies, it would be extremely difficult to obtain data on a time series (e.g., a study with 10 years post-treatment study). Virtually any location within our project region would qualify for inclusion in such a design. We have initially identified meadow restoration projects along Angora Creek as likely study locations.

Analyses

We will use a series of analyses to address wildlife occurrence and habitat use across the series of spatial scales outlined above (conceptual framework). Occupancy models, based on presence-absence data, will be developed to understand those factors (including key covariates) driving the distribution of species at the landscape scale. Occupancy models are a necessary first step in understanding how various factors, including various predicted scenarios following climate change (e.g., drought severity and frequency), will impact wildlife distribution.

Habitat selection analyses will then be used to examine how variations in animal abundance and frequency of occurrence are related to conditions within various vegetation types and more meso-scale habitat conditions. Typical analyses here include correlations predicted to occur between the amount of canopy cover by tree species and animals species abundance. These analyses allow us to understand how animals respond to predicted changes in cover that are caused purposefully through restoration activities or through predicted changes in climate (e.g., drought). If likely outcomes include a reduction in canopy cover due to increasing drought frequency, then these analyses can directly shape restoration activities that seek to promote cover (e.g., modifying the ability of meadows to remain wet longer into the summer).

The more detailed information collected on selected focal species (e.g., productivity) allow predictions to be made concerning the likely persistence of these species under varying future conditions. Because these species are often rare (e.g., Willow Flycatcher, Northern Goshawk, various amphibian species, Western Red Bat), changes in environmental conditions that in turn increase competitors and predators of them must be identified and considered in restoration planning. For example, Willow Flycatcher productivity in the Sierra Nevada can be negatively impacted by the nest parasite, the Brown-headed Cowbird (*Molothrus ater*) (Green et al. 2003). By knowing current productivity and cowbird impact, we can model population trends of the flycatcher under various future scenarios of drought severity and frequency and what those conditions will have on both the flycatcher and cowbird populations. Knowing these likely outcomes provides direct guidance in restoration planning.

Task 6 – Co-benefits: Develop a technical memo that summarizes results and findings from pre-project fisheries and wildlife sampling and from synthesis of existing restoration effectiveness monitoring.

We will use data derived from UTM Project area (and other control locations) sampling efforts to quantify pre-project conditions related wildlife and fisheries resources. The technical memo will also include a synthesis of pre- and post- monitoring efforts and regional monitoring efforts that coincide with the boundaries of the Upper Truckee River and Trout Creek watershed boundaries. The memo will be designed to effectively communicate findings and recommendation to managers and practitioners engaged in meadow restoration.

Task 7 - Develop comprehensive restoration effectiveness monitoring and evaluation

plan for the UTR project that can be used to assess net carbon sequestration and fisheries and wildlife co-benefits over time.

To complete this task our interdisciplinary team proposes to use the following monitoring plan template to capture relevant information needed to guide effectiveness monitoring of indicators associated with net carbon sequestration and biological co-benefits for the UTM Project and other meadow restoration projects:

Monitoring Background - Section
This section should be completed with the overall monitoring and evaluation program in mind. It acts as an introduction and basis for the indicator-specific monitoring details in the next section.

Clear Articulation of Purpose – A brief and definitive statement of the goals and objectives that must be achieved by collecting data, carrying out analyses and reporting results. Included in this section is an articulation of the monitoring questions that will be answered or addressed by the monitoring plan.

Synthesis of Previous Research Findings – A summary of previous work done and conclusions reached that are relevant to monitoring restoration project.

Conceptual Model – This conceptual model should represent the system to be measured. It should contain, objectives and drivers within the system, and the actions designed to achieve the project outcomes. The model should be a visual representation that is created in collaboration with agencies and major stakeholders. It should capture the most updated scientific understanding of the system.

Monitoring Approach Rationale – A discussion justifying the methods and techniques selected to measure this indicator or group of indicators. This section should clearly explain why it is important to use the selected approach. Factors of the rationale may include scientific norms, resource availability, collaboration requirements, legal constraints and more.

Indicator Monitoring Information - Section
This section should be completed for each indicator that is being monitored as part of the effectiveness monitoring program.

Indicator Selection Rationale – A description of the reasons that the indicator or indicators were selected to represent meadow conditions and why it is important to measure this indicator. Factors of the rationale may include scientific norms, resource availability, collaboration requirements, legal constraints and other.

Description of Indicator Limitations – A discussion of the ways in which the indicator could potentially be misinterpreted or may not accurately represent conditions.

Sampling Design – A complete sampling design indicates the number of samples and identifies the particular geographic positions and times where these samples will be collected. This element should also include parameters to be measured at sites if applicable. Along with this information, a sampling design will also include a map and justification that the samples represent environmental conditions. References to standard methods are appropriate in the sampling design.

Inventory of Resource-Specialized Equipment and Personnel Skills – Tables and supporting narrative that include specialized equipment required and particular skills or experience of monitoring staff. The equipment table should include a maintenance and calibration schedule for each piece. The personnel skills table should include training classes required, years of required experience and other necessary qualifications.

Data Collection Protocol – An explanation of the specific approach to collecting the necessary information or reference to standard methods cited in literature.

Data Management and Storage Protocol – A description of the specific personnel, process and locations that will contain information during data collection, reduction and reporting.

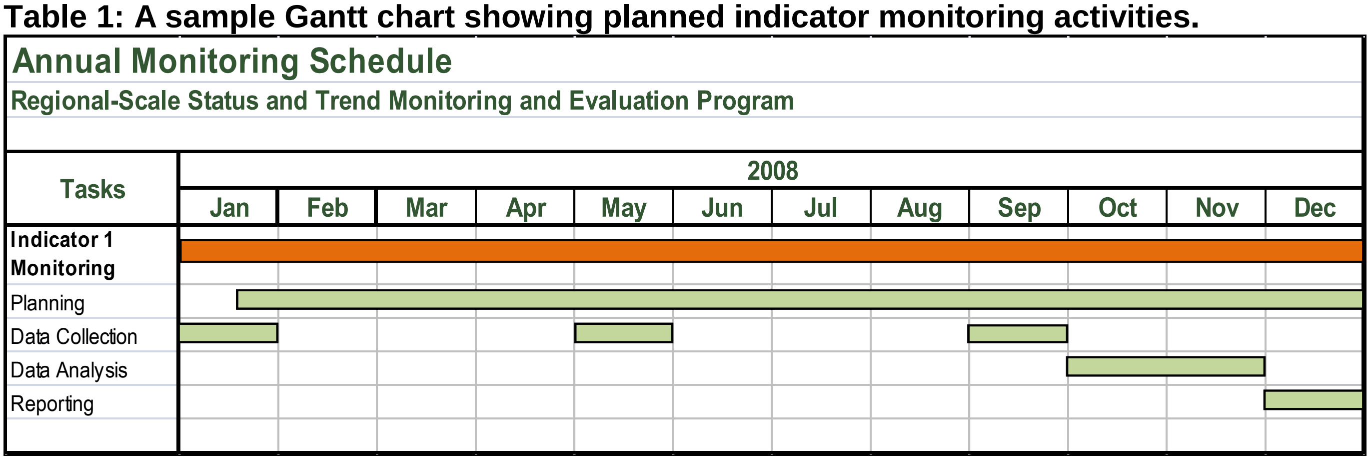
Analysis Protocol – Documentation that explains the specific approach to processing data and making conclusions. This element should contain information regarding the responsible parties, resources needed and available, and timeframes for analysis. Equations and techniques should be reproduced as necessary. Assumptions and limitations of the analysis should also be captured.

Analysis of Statistical Confidence or Uncertainty – Documentation of the ways uncertainty and/or confidence will be expressed for technical audiences. This information should be explicitly addressed when selecting the indicator. If confidence or uncertainty is explicitly discussed in the analysis protocols, it should be referenced in this section.

Reporting Protocol and Format –This protocol should describe the personnel, documents and timeframe for communicating results. A good example of a useful format document would be a previously released version of a report that will be used to communicate the conclusions of the indicator monitoring to key audiences.

Monitoring Schedule – A generalized schedule that describes the time periods for each portion of the data collection, data analysis and reporting processes. Narrative information could include guidance as general as “collect water quality samples yearly during maximum spring runoff” to information as specific as “the vegetation data is released every five years on June 19th.” A Gantt chart is the recommended visual representation of this schedule. **Table 1** shows a very simple example of a possible Gantt chart. Actual charts submitted should express greater detail.

Table 1: A sample Gantt chart showing planned indicator monitoring activities.



Quality Assurance and Quality Control (QA/QC) Plan– A description of the techniques and processes that are used to check the validity of data collected and analyses performed.

Estimated Time and Cost Budgets – A table that includes periodic costs (typically yearly) in several categories, agency staff requirements and other needs. Suggested cost categories include cash costs for supplies/equipment and contractual work. Staff requirements should be categorized by broad skill and experience requirements of staff. The recommended split of staff time is between technical staff and senior staff based on the significant differences between their costs. Table 2 shows the format for an indicator monitoring budget. The electronic version of this file allows the user to double-click the table for a live spreadsheet that can be used during budgeting. Anticipated accuracy of the values is within 15%.

Table 2: A sample indicator monitoring budget.

	Indicator Development	First Year	Recurring		Indicator Development	First Year	Recurring
Internal Personnel*	(Hours/PYs)	(Hours/PYs)	(Hours/PYs)	(Rate)			
Type A	10	50	30	$20	$ 200	$ 1,000	$ 600
Type B	10	20	10	$40	$ 400	$ 800	$ 400
Type C	0.25	0.25	0.1	$100,000	$ 25,000	$ 25,000	$ 10,000
				subtotal	$ 25,600	$ 26,800	$ 11,000
Equipment & Supplies					$ -	$ 10,000	$ 1,000
Consulting Fees					$ 30,000	$ 10,000	$ 3,000
				subtotal	$ 30,000	$ 20,000	$ 4,000
				Total	**$ 55,600**	**$ 46,800**	**$ 15,000**

* Internal personnel costs should include all costs (e.g. overhead, g&a, fringe, etc).

Program Documentation - Section

This section applies to the overall effectiveness monitoring program overall. The information in this section will be particularly useful for managers and decision makers.

Peer Review of Plans and Protocols – Documentation of the peer review process that was used for evaluation of the monitoring and evaluation plan design. This element should contain peer comments and responses or outcomes of these comments.

Historic Changes in Effectiveness Monitoring Program – A narration of the significant events of the effectiveness monitoring program's history. Events captured should include adjustments to the indicator used, changes in measurement approach, data gaps, sampling locations, etc. A timeline diagram could be used to summarize this element.

Monitoring MOUs or Agreements – Agencies are often encouraged to take a collaborative approach and divide information collection, analysis and reporting tasks. Memorandums of understanding (MOUs) will be important agreements to ensure that clearly defined agreements for collection responsibilities; resources committed, data sharing, data analysis and reporting exist.

Information Distribution Lists – A list of all stakeholders that have expressed interest in receiving information about restoration monitoring efforts and results. The lists should contain organization name, position titles, regularly updated personnel names and contact information, as shown in **Table 3**.

Table 3: Stakeholder information distribution list format.

Information Distribution List					
Name	Title	Organization	Phone	Email	Information Interest
					Sample collection, status reporting
					Data analysis, status reporting

Glossary of Specialized Terminology – An explanation of any terminology, acronyms or phrases that have specific meaning in this monitoring program.

Citations – A set of complete citations for all literature referenced in the monitoring plan documents.

Task 8 – Share data, information and results with Sierra Meadow Restoration Research Partnership (SMRRP)[2] and the Upper Truckee River Watershed Advisory Group (UTRWAG), and participate with the SNRRP to develop mountain meadow carbon offset protocol.

Our team will regularly coordinate our project activities with the SMRRP and UTRWAG. We will hold quarterly meetings to exchange understanding and other project related findings and recommendations. Our team will take a lead role in the development of the mountain meadow carbon offset protocol.

4. ***Timeline:***

The project will be initiated immediately after agreement is signed between California Department of Fish and Wildlife and Spatial Informatics Group – Natural Assets Laboratory. Two years of pre-project data will be collection at the UTM Project study area (and other control location) for GHG emission and below carbon starting in late spring 2015 and concluding fall of 2016. Co-benefit data will be collect in late spring through early fall of 2015. Data organization and report preparation will initiate at immediately follow each field season with draft final reports delivered prior to the end of the project. We will participate in quarterly meetings with the SMRRP and as appropriate with the UTRWAG to share results of project efforts.

The following schedule is proposed for 2015

	May	June	July	August	September	October	November	December
Task 1								
Task 2								
Task 3								
Task 4								
Task 5								
Task 6								
Task 7								

2

Task 8								

The following schedule is proposed for 2016

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Task 1												
Task 2												
Task 3												
Task 4												
Task 5												
Task 6												
Task 7												
Task 8												

The following schedule is proposed for 2017

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Task 1												
Task 2												
Task 3												
Task 4												
Task 5												
Task 6												
Task 7												
Task 8												

5. ***Deliverables:***

We propose the following deliverables for this project:

- Monthy invoices and quarterly progress reports.
- All field data collected and organized into a functional database. Projected completion date, December 2017
- Technical Memo – Summary of data and findings from pre-project sampling efforts for above and below ground carbon and GHG emission measurements at the UTR project. Projected completion date, December 2016
- Technical Memo - Summary data and findings from pre-project fisheries and wildlife sampling and from synthesis of existing restoration effectiveness monitoring. Projected completion date, April 2017.
- Restoration effectiveness monitoring and evaluation plan for GHG emissions, carbon sequestration, fish and wildlife indicators. Projected completion date, December 2017.
- Mountain meadow carbon offset protocol for the Sierra Nevada Ecoregion. Projected completion date, December 2017.
- Meeting notes from SMRRP and UTRWAG meetings will be included in quarterly progress reports.

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

The UTM project is expected to expand the area of functional wet meadow, wetland, and riparian vegetation; increase the number of temporary pools; and enhance the vigor of deciduous riparian vegetation. These changes are expected to affect habitat quality, species composition and abundance, and net carbon sequestration at the UTM Project site. We propose to develop measurement and assessment methods for above and below carbon and GHG emissions and implement those methods at the Upper Truckee River and Marsh Restoration Project site (and control sites) to quantify pre-project conditions. In addition, to quantify biological co-benefits of meadow restoration, will we measure a suite of parameters related to aquatic and terrestrial habitats and focal species at the project site to characterize pre-restoration conditions. We will also synthesize all available meadow restoration effectiveness monitoring reports and data for the Upper Truckee River and Trout Creek watershed to improve understanding on combined effect of restoration on biological communities. Because we are only proposing to collect pre-project data at the UTR Project site, we proposed to develop a comprehensive effectiveness monitoring and evaluation plan that lead agencies can use to guide post-project monitoring efforts. To address needs associated with verifying mountain meadow restoration carbon offsets, we propose to take a lead role in coordination with the CalTrout sponsored SMRRP to develop a mountain meadow restoration carbon offset protocol. Our proposed work would initiate in May of 2015 and conclude December 2017.

7. ***Protocols:***

Task 1 Methodology: *Develop methodologies, measure and asses pre-project conditions for below ground carbon (soil carbon) at UTR Project area and other control areas*

Soil carbon and biomass samples are collected along transects established across the meadow, as described above. Four one-foot square plots will be chosen along each transect, with each plot representing a soil/vegetation type. In the un-restored meadows, it will be necessary to ensure that plot locations do not interfere with potential design features where earth movement activities are planned. Within these parameters, sample plot locations are randomly selected. The best representation of all vegetation/soil types is sampled in each meadow; however, not all types may be sampled and some may be sampled more than once. In an effort to make between-meadow comparisons, attempts to duplicate soil/vegetation types among similar meadows will be made.

Samples are removed within the one-foot square plot in the following pre-determined, definable layers:

1. All above-surface biomass material within the square is clipped to ground level. Soil surface is defined as the top of the O horizon. Material is removed, bagged and labeled by plot number for the entire square foot area. Documentation of meadow use, i.e. grazed or un-grazed is made, and percentage of utilization is estimated.

2. In wet sites, a 4” auger-size sample of the O horizon is taken. In dry sites, the O horizon of the entire square foot is taken. O horizon material consists of duff, litter and residual live plant material, down to a bare, mineral soil surface. Material is removed, bagged and labeled, including a notation of whether the wet or dry site method is used.

3. In the center of the square, an auger is used to sample the top three feet of soil. A representative sample of each foot of depth is collected. Approximately 20% of the soil in the auger is removed for analysis, with an attempt made to collect material from the upper, middle and lower portion of the core.

4. During augering, a representative bulk density sample (Blake, G.R., and K.H. Hartge, 1986) is collected for each foot of depth. Bulk density samples are collected at 9”, 18” and 27”. Soil cores are collected using an Oakfield 3-ft. Model B 36” Soil Sampler (mud augers worked best in wet sites). Bulk density samples are collected with a 0200 soil core sampler manufactured by 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 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 using an ASTM#10 (2mm) 8” brass sieve. 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.

Task 2 Methodology: *Develop methodologies, measure and assess pre-project conditions for GHG Emissions (CO_2, CH_4, and N_2O).*

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 ground water 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.

Task 3 Methodology: *Develop and implement methodologies, to measure and assess pre-*

project conditions for above ground carbon (biomass associated carbon).

Above ground carbon is sequestered in both live and dead vegetation within several forest (conifer and hardwood) and grassland vegetation types. Above ground carbon will be assessed utilizing a combination of both field and remotely sensed data, as described below, allowing for the creation of a spatially explicit map of carbon across the project area.

Subtask 3.1 Methodology: Acquisition and pre-processing of Light Detection and Ranging (LiDAR) data and National Agricultural Imagery Program (NAIPP) imagery

LiDAR data will be collected within the same year and season as the field based vegetation measurements to best facilitate data interpretation using ground based methods. High density (at least 8 points per square meter) will be utilized. The airborne LiDAR data will be processed using the Toolbox for LiDAR Data Filtering and Forest Studies (Tiffs) (Chen, 2007) to 1) filter the LiDAR point cloud into ground returns and non-ground returns, if this had not been done when the data were delivered from LiDAR vendors, 2) generate DTM (Digital Terrain Model) by interpolating the ground returns to raster grids of 1 m resolution, 3) compute the canopy height of every laser point by taking the difference between its Z Cartesian coordinate and the corresponding terrain elevation, and 4) overlay the field plot boundary with the point cloud to extract the LiDAR metrics from the canopy height of laser points within each plot. The generated LiDAR metrics include mean, standard deviation, skewness, kurtosis of height, quadratic mean height, height bins at 5 m intervals, and 10% percentile heights (Chen et al., 2012).

National Agricultural Imagery Program (NAIP) imagery will be downloaded from the Natural Resource Conservation Service site (http://datagateway.nrcs.usda.gov/). Data is currently available for the area for the years 2004, 2005, 2006, 2009, 2010, 2012, 2014 at no charge. Both NAIP and LiDAR imagery will be assembled into a single geodatabase at the project scale.

Subtask 3.2 and 3.3 Methodology: Collection of field based data to characterize carbon in meadow, wetland, riparian, and forest vegetation and summarization of field data, including estimation of above ground

Field assessments will be conducted during the same season as LiDAR image acquisition to facilitate use in LiDAR data interpretation. Field assessments will be conducted on up to 75 400m^2 (~1/10th acre) plots for the tree, shrub, and grassland vegetation types as described below. Plots will be stratified by vegetation type to adequately capture variability represented by each type across the landscape.

Tree or shrub-dominated vegetation types

The California Air Resources Board (ARB) Compliance Offset Protocol U.S. Forest Projects (Forest Offset Protocol v3.2) will be utilized for above ground conifer carbon estimates. Fixed area (400m^2) continuous forest inventory plots will be used to quantify tree and shrub biomass which will then converted to estimates of carbon based on accepted allometric equations for Sierra Nevada species. A sufficient number of plots will be established to meet the statistical precision requirements of the protocol (i.e., the standard error of biomass estimates are within 10% of the mean at a 90% confidence interval).

Field sample plots will be .04 ha fixed-radius, monumented plots set on a stratified random design, with all plots GPS'd to at least sub-meter accuracy or better, depending on signal quality. All trees >12.7cm diameter at breast height (DBH; stem diameter at 1.37m) will be tallied by species, status, DBH, and distance and azimuth from plot center. At least two of the above trees from each sampled species in each plot quadrant will be sampled for total height, height to live crown, and two perpendicular crown diameters. Sapling trees ≤12.7 cm and >1.37m height will be tallied by species in the .04 ha plot and seedlings (≤1.37m height) tallied on a .002 ha subplot from the same plot center (Collins et al. 2011 and Hudak et al. 2012). Biomass of trees and saplings will be calculated by species using allometric equations from Jenkins et al. 2003 and McGinnis et al. (2010). Downed dead woody material and litter will be sampled on 3 random transects (11.4m length) originating from plot center and biomass calculated by Brown (1974, 1981).

Perennial and Annual Grassland

In marsh/meadow areas, simple linear transects will be installed to facilitate sampling of shrubs and grass. Along these transects 1m² quadrats will be systematically placed and all live grass will be cut and weighed fresh in the field and weighed again after oven-drying in the lab at the University of San Francisco (USF) to develop on-site allometric equations for grassland biomass. Shrub biomass will also be calculated by species using allometric equations from McGinnis et al. 2010.

Subtask 3.4 Methodology: Analysis of remotely sensed data, including estimation of above ground carbon.

Tree or shrub-dominated vegetation types:

We will utilize two approaches for biomass modeling and mapping. The first one is to map individual trees and estimate individual tree biomass on a per acre level, based on field sampling described above with application of the Jenkins et al. (2003). Spatial Informatics Group has completed a similar previous project in the Lake Tahoe Basin (Saah, 2013). Secondly, we will extract the LiDAR metrics at the individual tree level to develop models to predict individual tree biomass and corresponding carbon content. We will conduct both assessments at the species level, so that the developed biomass prediction models are species-dependent and readily scaled or utilized in other coniferous regions of the Sierra Nevada.

At the plot level, we will develop representative regression and machine-learning models for predicting AGB. Regression models construct explicit model structure often based on a few lidar features, which are selected or transformed from a large number of lidar metrics (e.g., Lu et al., 2012; Vaglio Laurin et al., 2014; Asner and Mascaro, 2014. To increase the model generality, we will test parametric regression models that are based on a few lidar metrics such as include mean, quadratic mean, coefficient of variance, canopy cover, etc. (Chen, 2013). For example, the mean height has been used in boreal (Lim et al., 2003), temperate (Lefsky et al., 2002), and tropical (Asner et al., 2012; Asner and Mascaro, 2014) forests. The quadratic mean height has been used in Sagehen in a previous study (Chen et al., 2012) and in temperate forest of the eastern U.S. (Lefsky et al., 1999).

Machine-learning models are usually data-driven and thus produce implicit model structure (e.g, Chen and Hay, 2011; Gleason and Im, 2012; Mascaro et al., 2014). The machine-learning model chosen is support vector regression (SVR). The relationships between avobe ground biomass (AGB) and lidar predictors are usually nonlinear. A few studies found that SVR can outperform regression (Chen and Hay, 2011) or other machine-learning algorithms (Gleason and Im, 2012) for AGB modeling. The radial basis function kernel was used and the model parameters were determined by coarse- and fine-grid search similar to Chen and Hay (2011). A Five-fold cross-validation will be used to produce model fitting statistics, including R2 (coefficient of determination) and RMSE (root mean square error).

Perennial and Annual Grassland:

The biomass estimates from field sampling will be used to calibrate the LiDAR data to develop a grass depth to biomass allometric equation, which will be utilized to map biomass across the project area. Remotely sensed biomass estimates will be compared with field based samples for accuracy, with the goal of remotely sensed estimates to be within the acceptable range of variability as per the American Carbon Registry (ACR) Avoided Conversion of Grasslands to Croplands methodology (excerpted below):

> *"Above-ground biomass is highly variable in grassland systems, both geographically and temporally, and is highly dependent upon precipitation. A conservative estimate of peak annual above-ground biomass shall therefore be assumed to remain at a steady state for the duration of the Project Crediting Period. Initial carbon stocks in woody and non-woody biomass pools may be based upon direct field measurement or remote sensing for each biomass type, in a year where growing season precipitation is within 30% of average annual growing season precipitation, or averaged over three years. Remote sensing data should be calibrated to the Project Area with field samples." (Dell et al. 2013)*

Subtask 3.5 Methodology: Assessment of conifer encroachment using NAIP imagery

The conditions of the meadow prior to restoration are important, but also crucial to interpreting the current conditions are an understanding of past and recent management history and trends. Conifer encroachment and its potential effects on Sierran meadow ecosystems has been previously documented in previous studies (Fites et al. 2007; Heath, 2004). With the availability of NAIP imagery back to 2004, it is possible to document the encroachment of conifers over the past decade. NAIP imagery will be used to digitize the locations of conifers for each year available, with the most recent year of digitizing being confirmed by field assessments. This information can be used for long-term monitoring, to determine over time, using future NAIP imagery, if restoration projects modify the rate or area of conifer encroachment.

Task 5 Co-Benefits Methods

We will generally follow the methods we used in our previous and on-going monitoring activities within the Upper Truckee River watershed because 1) they are regularly used in wildlife monitoring efforts, 2) we have found them to be efficient and effective for application in our project area, and (3) they will allow us to directly compare existing datasets from the project area. Below we briefly summarize our proposed methods by major species groups. We will gather data at two levels of specificity: 1) data on the distribution and abundance (or frequency of occurrence) on the overall wildlife community to quantify biodiversity, and 2) data on reproductive activity for selected focal species. We implemented, tested, and refined the methods outlined below during our previous restoration monitoring work in the Upper Truckee River watershed.

Butterfly Surveys
Observers work in teams of two-to-three and walk slowly in a zig-zag pattern through a predefined search area twice a month June through August. Observers record the species and the number of individuals detected. Vegetation within 5m of each butterfly detection are recorded based on the dominant shrub species and dominant ground cover. Ground cover is categorized as either a mixture of grasses and forbs with no soil moisture (grass/forb dry), as a mixture of grasses and forbs in wet or moist soils (grass/forb wet), bare soil containing no vegetation, or areas covered by rocks. Shrub cover is categorized by the dominant plant species in the mid-story. During each visit, observers search each survey area for at least 30 minutes, stopping the timer to record observations. Butterflies that cannot be identified from a distance are captured with a sweep net and released after identification.

Bird Surveys
Point counts will be conducted to estimate changes in avian population size and diversity. Permanent point-count stations are located at 200-meter intervals. To have sufficient comparable data to detect changes and trends, all surveys within the watershed are conducted using the exact same protocol. Point counts are done in June and sites are surveyed a minimum of three times. Surveys are conducted at least a week apart and should begin fifteen minutes before sunrise and end no later than four hours after sunset. Point counts are conducted for five minutes. Observations are recorded at three distance intervals, 0-50 m, 51-100m, and >100 m. See Borgmann and Morrison (2005) for more information on survey protocols.

We will also conduct call-playback surveys to monitor owls and raptors. We will follow the methods used in our project region during previous restoration studies by Groce and Morrison (2010) for owls, and those by Keane et al. (2006) and Morrison et al. (2011) for the Northern Goshawk (Accipiter gentilis).

We will also conduct more intensive surveys of each study site for breeding activities of focal, sensitive species. Although the presence of a species indicates use of a location, counts and other broad-scale surveys do not usually indicate the type of use. As such, we will conduct nest searches for selected sensitive species such as Willow Flycatcher (Empidonax traillii). We have previously conducted intensive work on Willow Flycatchers and other sensitive bird species in our study region; see Bombay et al. (2003), Vormwald et al. (2011), and Mathewson et al. (2013) for results and methods.

Small Mammals
Population estimates and species composition for small mammals will be quantified using live traps. Trapping will be done following standard capture-recapture techniques from June through August. Traps are placed along established transects at 25-m intervals. At each location, large Sherman live traps are placed in the nearest appropriate location ensuring that the trap is sufficiently protected from the elements (e.g., sun). At alternating sites both large and extra-large traps are used. All traps are baited with a mixture of rolled oats and peanut butter and checked twice daily (morning and dusk) for a minimum of three consecutive days. Captured animals are identified to species, sexed, and aged if possible. The vegetation type and local micro-habitat conditions are recorded for each trap. For more information on

protocols see Borgmann and Morrison (2005).

Bats
Surveys for bats will be conducted prior to assess habitat conditions and as an indicator of overall meadow habitat conditions. Acoustic surveys are conducted using Pettersson ultrasonic detectors (model D240X) and analyzed using SonoBat to assess bat species composition. At each site, two Pettersson recorders are placed at each site in suitable openings, near habitat transition zones, or in likely movement corridors. Bats are recorded at each site on three different nights separated by at least one week from June to August. Detectors are placed in different locations upon subsequent visits to ensure that the entire site has been adequately sampled, with each location at least 100 m apart. We used these methods previously in our study region (Morrison et al. 2010) and also have additional and substantial experience in species identification using SonoBat (e.g., Morrison and Fox 2009, Stuemke et al. 2015).

Herpetofauna
Reptile and amphibian diversity and population estimates are collected using Visual Encounter Surveys (VSE). Observers walk slowly through the project area (including wetlands) visually searching for amphibians and reptiles for a set period of time (e.g., 30 to 60 min depending on the location). Observers may turn over rocks, logs, and other moveable debris. When an individual animal is located, time is stopped and data on the general vegetation type and micro-site are recorded.

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