Monitoring Meadow Vegetation Response to Restoration in the Sierra Nevada

Technical Memorandum

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1 PURPOSE AND NEED FOR A COMMON PROTOCOL FOR MONITORING MEADOWS

The call for a consistent set of monitoring protocol(s) for both public and private meadows emerges from the need for rigorous, tractable and consistent monitoring at all rehabilitation[1] sites to ensure that effects of management actions are well documented. Findings from designed and documented monitoring programs can be used to (1) guide adaptive management; (2) enable sharing of lessons learned among practitioners; (3) demonstrate benefits to local community members; and (4) demonstrate benefits of altered management to future funders. The purpose of this document is to present a vegetation survey protocol that can be applied across the Sierra Nevada to assess the short-term and long-term effects of meadow rehabilitation efforts. The overarching goal, as stated in the text of the National Fish and Wildlife Foundation (NFWF) proposal that funded this project, is to articulate methods for:

> …. how to efficiently collect, analyze and report standardized data related to monitoring project impacts so that these data can be comparable across meadow projects. [With the ultimate goal that] results of meadow restoration efforts in the Sierra are quantified and reported in a consistent and comparable manner so that the benefits can be clearly articulated at a state and national policy level. [And so that] long-term comparable data sets revolving around key indicators are populated so that we can learn about long term restoration impacts, and adaptively manage these systems over time, particularly in light of climate change predictions.

Specific objectives and strategies stated in the NFWF proposal include coming to consensus on (emphasis added):

1. Data collection protocols for monitoring short-term (1–3 years) and long-term (4–10 years) project impacts on a *small set of key indicators*; and
2. Protocols for data analysis and reporting.

The background discussion, decision tree, recommended methodology, field instructions, and field data sheets are the product of multiple discussions and email communications among the Vegetation Monitoring Review Committee, the members of which are listed below.

The Vegetation Team has, to the degree possible, coordinated its methods and goals with the Hydrology and Wildlife Protocol Teams, such that these pieces can be brought together to produce an integrated understanding of a meadow system's response to changes in management and/or actions intended to restore or rehabilitate meadow functions (hereafter referred to generically as "restoration").

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[1] Throughout this document, we use the term 'rehabilitation' to include preservation, enhancement, passive and active restoration.

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2 INTRODUCTION TO MEADOW VEGETATION MONITORING

There are many reasons one might want to monitor meadow vegetation response to restoration, as listed below (Pellant et al. 2005; Weixelman et al. 2003; Bombay et al. 2003; Craig and Williams 1998; Feather CRM 2010; Schlesinger 1997; Micheli and Kirchner 2002a, b).

- Plant species diversity
- Special status species population monitoring
- Forage production rates
- Carbon sequestration rates
- Vegetation response and effect on the fire regime
- Vegetation as indicator of ground water level
- Vegetation as indicator of wildlife habitat quality
- Vegetation density and rooting as indicator of erosion and sediment retention capacity

Tractable monitoring information is critical for a particular restoration site for several reasons. Few if any restoration or enhancement projects require no management adjustments once the initial actions are complete. Monitoring can provide the critical information on which adaptive management decisions can be made; without such information, management becomes a combination of educated guesses and "seat of the pants" actions, which can produce unexpected results. One of the main purposes of monitoring is to provide an early warning for negative or unexpected changes in the meadow and to help identify ecological thresholds, beyond which changes in meadow processes can be more difficult to redirect. Examples of such "threshold" changes include channel incision, which once beyond a certain point (specific for each meadow) may continue, increasing channel depth and width unless major actions are taken (Chambers and Linnerooth 2001, Menke et al. 1996, Ratliff 1985). Another example is invasive plant species: beyond a threshold level of invasion (cover) species such as giant reed, *Arundo donax*, create physical habitat conditions that preclude growth and regeneration of other species while favoring expansion of *Arundo* (Coffman 2007). Identifying and incorporating these thresholds in a monitoring program make is possible for the manager to track when such thresholds are being approached, and thus to take early, preventative actions.

Pre- and post-implementation monitoring information also provides evidence on how the restoration actions are affecting the site, including whether or not restoration goals and objectives are being achieved. The restoration and response story constructed of well collected monitoring

data is far stronger and more convincing than one that is based upon photographs and personal observations. These kinds of evidence-based analyses are important for gaining support from funders, as well as local communities and other stakeholders.

Findings from well planned and executed monitoring across many meadows also can be extremely valuable for understanding how and why meadows might vary in their responses to different management actions. Monitoring data collected using the same protocols can be used to compare meadow responses to management actions across sites with much higher resolution than when different protocols are applied because data will not have to be simplified into broader, common categories for analysis. This higher resolution of comparing and analyzing process responses across sites is important within a planning area or watershed, where understanding the condition and restoration effects of multiple meadows informs managers about habitat availability for mobile species (such as the great gray owl or willow fly catcher), basin-level effects on meadow ground water storage, and where restoration programs can be linked to other metrics, such as the cumulative downstream flow and sediment delivery effects of multiple meadow restoration projects within a single reach or tributary (ICF Jones & Stokes 2008). Systematic monitoring across multiple sites also supports the development of a more accurate understanding of how meadow responses can vary given differences in geology, alluvium, management history, hydrology, etc. This better scientific understanding can feed directly back into improved meadow management and predictions of what restoration actions might or might not be able to deliver. Funding mechanisms that recognize the importance of well-planned and executed pre- and post-project monitoring are needed to make such monitoring feasible for many practitioners.

3 RESTORATION RESPONSE MONITORING STRATEGIES

3.1 Develop Restoration and Monitoring Plans Together

In some cases, such as the San Joaquin-Sacramento Delta Levee Maintenance Subventions Program, long-term success (specifically defined) for wetland and riparian habitat restoration projects designed to mitigate for habitat destroyed during levee maintenance and repair must be documented in reports approved by California Department of Fish and Game (CDFG) and California Department of Water Resources (CDWR) within 3 years of receiving state funding; in these cases restoration project plans are developed in hand-in-hand with a monitoring plan (CDWR 2011). Funding for both is tied together. Pre-project monitoring provides essential information for developing restoration plans. In developing restoration and monitoring plans, it is helpful to keep three points foremost in mind: (1) start monitoring with pre-implementation data collection, (2) let project goals guide monitoring plans; and (3) tie monitoring design and metrics to restoration actions. These three points are elaborated upon below.

Understand the kind of meadow with which you are working: Functional meadows in the Sierra Nevada and Southern Cascades of California are defined as landscape features with the following characteristics: (1) A meadow is an ecosystem type composed of one or more plant communities dominated by herbaceous species; (2) It supports plants that use surface water and/or shallow ground water (generally at depths of less than one meter) at some point during the growing season; (3) Woody vegetation, like trees or shrubs, may occur and be dense but are not dominant (Weixelman et al. 2011). Areas that have met these criteria in the past, but are currently in another ecological state due to alterations in hydrology and/or vegetation, but where changes in the current state could result in a land form that does meet the criteria listed above, are referred to as potential meadows.

Different kinds of meadows (including fens with peat soils, lacustrine fringe [lake edge] meadows with sandy soils, and low gradient riparian meadows) are governed by different kinds of processes and process controls (e.g. types of ground or surface water input) and are subject to different kinds of impacts. Changing the management of mountain meadows in order to rehabilitate or restore meadow these various functions requires interpretation of site-specific information within the context of the meadow type and its potential. An excellent source for placing a meadow in a process-based classification is Weixelman et al. 2011.

Do pre-implementation monitoring: Restoration plans need to be based on information about the site that has been gathered for as many years as possible prior to implementation. For meadows, it is especially important to understand the sources of existing stress on the system, as well as important structural features (texture of the underlying alluvium, ground water hydrology, and channel slope, geometry, etc.). When restoration directly or indirectly affects meadow hydrology, as is most frequently the case, collecting ground water and vegetation data during high, normal, and low water years is needed in order to provide a basis for comparison for the post-implementation observations. When pre-project NEPA/CEQA documentation data are required, use the same design and protocols planned for post-monitoring data collection; thus accomplishing two tasks in a single effort.

Tie monitoring to goals: Meadow restoration goals are defined early in the project planning process and should be the starting point for development of any monitoring and adaptive management plan. These goals should be tied to improving or rehabilitating the natural meadow processes that create and maintain the desired conditions and/or structures.

Tailor monitoring to restoration actions: There are a wide range of actions or alterations in management that fall under the rubric of meadow restoration. The expectation that certain management actions will affect specific outcomes in the meadow (structures and/or processes) represent hypotheses that need to be clearly articulated and monitored as directly as possible, before and after implementation, in order to ascertain whether or not the management actions had the desired effect. For example, monitoring the response to restoration of a floodplain that relies on passive revegetation will require tracking recruitment and survival of native and invasive plant species in the recreated floodplain. In contrast, monitoring a restored floodplain that has been actively revegetated will also require an assessment of the health and survival of the plantings as well as naturally recruited vegetation. Appropriate monitoring methods are dictated both by the restoration goals and the restoration actions. This is discussed in greater detail under Level 2 Monitoring in Section 6.

3.2 Gage Your Scale of Monitoring to the Expected Scale of Response

The need to detect important changes, as defined according to the project goals and objectives, requires matching pre- and post-implementation monitoring to the spatial and temporal scales at which these changes are expected to occur.

Vegetation type conversion and large changes in forage production in response to broad scale changes in ground water levels would likely be best detected and monitored through stratified sampling within mapped polygons of vegetation type or using belt-transects with widely spaced vegetation plots. In contrast, plant biodiversity response to controlled burns could occur at the finer scales of pre-project fuel distribution, pre-existing soil moisture, and subtle variations in soil topography. Detection of such responses would require a finer-scale, spatially-focused sampling design.

Similarly, the precision and associated sampling density needed for monitoring can be determined based on the expected degree of change or response of the meadow to restoration activities. For example, if restoration plans call for raising the ground water table from 10 to 2 ft below the surface throughout the growing season of a 100-ac meadow, the vegetation response expected would be extensive and profound, requiring a relatively low sampling density of dominant species cover to detect the change. In contrast, if restoration actions involve changing the grazing intensity or season, more subtle shifts in species composition might be expected and require more intensive monitoring such as permanent plot monitoring of all species occurrence in quadrats, or rooted density, to detect and track vegetation response.

In order to assess the effects of restoration, baseline pre-implementation data must be collected across multiple water year types to document the natural inter-annual variation in species composition and productivity during wet vs. dry years. Monitoring programs should also be designed to accommodate the seasonal timing of plant response, and importance of vegetation response to specific events, such as flooding, fire, or grazing. In high elevation meadows, the growing season is so short and condensed, that it is generally possible to capture the majority of plant species in or near to flowering or fruiting between mid-July and mid-August; seasonal differences in early, mid and late bloomers increases as you descend towards sea level, and become much more important at and below 4,000 ft. Changes in response to grazing and other pressures or disturbances (e.g., flood, fire, forest clearing adjacent to or in the contributing area of the meadow) can be very important. For most cases, monitoring the site directly following a disturbance is an excellent way of observing how the restoration actions affected the meadow's response to disturbance (and therefore effects on vulnerability and resilience). However interpretation of response to disturbance should be made with some understanding of the long-term trajectory and controls on the system. For example, over grazing and roads have exacerbated incision in many meadows in the Great Basin, but efforts to 'restore' channel form in these meadows should be performed and monitored with an understanding that the channels are also responding to a Holocene influx of sediment (Miller et al. 2011). Acknowledging and accommodating for event-driven monitoring in the budget and general project planning helps make these important data collection events happen.

The duration of monitoring can also be tailored to expected response duration and to the timing of large events that can "test" the efficacy of restoration actions. You will be able to measure different changes over each time scale, for example, installed plant survival can be measured over a 1 to 3 year time scale, changes in conifer establishment rates will require longer time scales, such as 5 to 10 years, while changes in soil organic content might require even longer time scales. At a minimum, post-implementation vegetation monitoring should be performed for 3 continuous years, followed by less frequent monitoring, such as at 5-year intervals, as well as event-based monitoring. Monitoring directly following management changes can be targeted on the success of those management actions and coupled with frequent qualitative observations so that small negative changes are detected, and corrected, quickly; for example actively planted areas should be checked frequently for desiccation and herbivory.

On-going effects of climate change, expected to include increasing temperatures and decreasing snow pack, are likely to continue, but with year to year variation, over the long-term and some climate change effects will be punctuated or, event-based, such as increased frequency of wild fire and rain on snow events. (Cayan et al. 2001, Mote 2006). Long-term monitoring at infrequent intervals, such as every five years, should be sufficient to capture meadow system responses to continuous effects of climate change; but event-based monitoring during or at an appropriate

period following punctuated events will be required to measure responses to 'pulse' effects of climate change, such as catastrophic fires, rain on snow, or large floods.

3.3 Use Reference Sites to Inform Monitoring Plan

Identification, characterization and monitoring of one or several reference site(s), which represent(s) what is believed to be the target condition of the restoration site meadow is critical for establishing realistic restoration objectives and monitoring goals. Information from the reference site(s) can be used to understand composition, structure, and spatial and temporal variation of a 'properly functioning' meadow of the same type as the restored meadow. This information can be used to estimate acceptable levels of temporal and spatial variation in plant community composition and structure, and to help interpret vegetation responses to change. Specific characteristics and processes to measure in the reference site(s) need to be developed according to project needs. At a minimum, plant community composition in relation to plant water availability and soil texture should be assessed.

Identification of appropriate reference site(s) must be done carefully and with a thorough understanding of both the project site and reference site(s) hydrology, geomorphology, and vegetation dynamics. As an initial framework, the hydrogeomorphic meadow classification developed by Weixelman et al. 2011 should be used.

3.4 Establish Monitoring Before Changes to Management

It is important to think through the monitoring design several years prior to implementation so that pre-implementation field measurements can be made during one or multiple season prior to implementation. These data will be extremely valuable for demonstrating meadow response to changes in management – the more years of pre-implementation data collected, the stronger the case for assigning meadow response to the management change rather than other time-related variables (e.g. climate). If possible a control site, which is as similar as possible to the target meadow but receiving no changes in management, can be monitored. Comparisons between the restoration site and the control site can help isolate responses to management from responses to interannual climatic variation. Use of a control site is suggested but not required for Level 1 monitoring. Such a design framework, in which a control and treatment (e.g., restored) area are monitored before and after treatment, is particularly powerful because it controls for effects due to both climatic variability and treatment (Stewart-Oaten, Murdoch, and Parker 1986, Stewart-Oaten and Bence 2001, Underwood 1994; Smith 2002).

3.5 Adaptive Management

The important relationship between restoration goals and objectives, monitoring, and adaptive management is depicted in Figure 1. Project goals for increased or decreased process rates or structural characteristics need to be translated into metrics with specific thresholds for action. For example, if a project goal is increased extent of Tahoe yellow cress (*Rorippa subumbellata*), then metrics, such as percent cover of that species overall and number of separate populations in the meadow, would be established, with specific action-thresholds, such as less than 3 separate populations within the meadow or less than 5% cover overall, that would trigger an adaptive management response. Within this framework, hypotheses about causal relationships among indicators and processes (e.g., seed production, germination, survival) can be articulated and

tested in order to inform and refine management actions. Similarly, a project goal might be reduced bank erosion and the extent and cover of rhizomatous bank vegetation might be used as a metric with an adaptive management action threshold of less than 20% of channel extent with 50% or more cover of rhizomatous plant species.

Monitoring designs are directed by overall restoration goals. If monitoring results indicate that meadow processes are not changing in the targeted direction, then alternative management strategies can be applied. If monitoring indicates that meadow processes are moving in the target direction, then there is no change in management, but continued monitoring and assessment. Monitoring can also be designed to test hypotheses in order to inform improved, alternative management strategies. The overall process of developing project goals, selecting appropriate management/restoration or enhancement methods, and tailoring the pre- and post-implementation monitoring plan to those goals and methods with an "iteration loops" for on-going monitoring and adaptive response, is depicted in Figure 1.

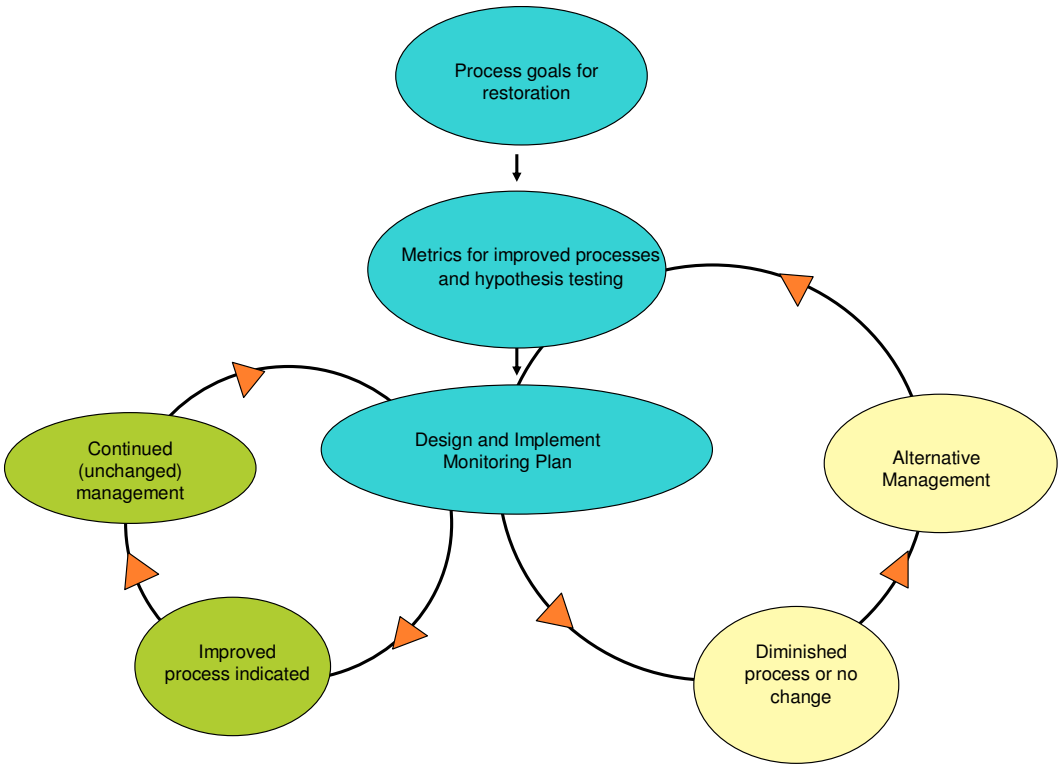

Figure 1. Process-directed monitoring goals and metrics are used to monitor restoration or enhancement effects. Iterative loops of continued monitoring occur when indicators reflect desired responses; whereas adaptive management is performed when indicators reflect undesired process responses.

4 LEVELS OF MONITORING: THE MONITORING PYRAMID

Meeting the objective of developing a single protocol for assessing vegetation changes with restoration is complicated by the many different types of meadows, types of restoration goals and methods behind different restoration projects. Other concerns about the "one vegetation response protocol fits all" approach include differences in project needs regarding temporal and spatial

scales, levels of precision, and budget. Instead, the Review Team proposes a pyramid approach to monitoring meadow vegetation response to restoration. The pyramid (Figure 2) has three levels that, when applied, can yield increasing degrees of process-related information as well as require increasing levels of effort, technical expertise, and budget. The overall intent of the pyramid approach is to provide, at the first level, a consistent and informative but "low cost" common denominator monitoring method that could be applied across a wide array of meadow restoration efforts to coarsely characterize vegetation response to changes in management. This pyramid approach allows for increasingly focused levels of monitoring, from basic characterization (Level 1), to understanding system responses (Level 2), to testing specific hypotheses about meadow processes (Level 3).

At Level 1, we propose a single universal method for describing general vegetation conditions that could be easily and inexpensively applied across all restoration sites expected to have large effects on meadow vegetation (e.g., purely in-stream restoration and/or measures not expected to affect ground water or floodplain conditions would not apply here). The Level 1 characterization would be useful for coarsely characterizing whole meadow vegetation under pre- and post-implementation, and, combined with other variables such as elevation, latitude, parent material and hydro-geomorphic context, will be useful for classifying unrehabilitated and restored meadows into like groups. We have made the Level 1 characterization as accessible and low-cost as possible while still providing important information that can support basin and region-wide meadow assessments.

Level 2 monitoring targets meadow response to restoration actions and is, therefore, a fundamentally important part of adaptive management. Findings from these monitoring efforts, combined across different meadows where similar restoration goals and methods were applied, can provide critical information for improving restoration techniques. Level 3 methods, in which specific hypotheses about meadow processes (e.g., evapotranspiration rates, ground water-plant community interactions, plant community responses and controls, etc.) are articulated and then tested, can inform restoration methods, models and projections of meadow response to management actions, and changes in ecosystem services with differences in restoration actions.

Each field protocol described in this document is also inextricably linked to methods for data analysis, reporting, and adaptive management. As discussed above, appropriate analysis, interpretation, and presentation of findings are critical and often under-appreciated steps of monitoring since without access to well-documented monitoring efforts, experiences cannot be shared and cannot evolve into lessons learned and improved management decisions. Thus, this final step, making monitoring reports and data available to others is crucial. In the following pages, we describe Level 1 monitoring methods for characterizing pre and post restoration meadow vegetation (Section 5); introduce and provide guidance on navigating the Level 2 decision tree for selecting appropriate response monitoring methods (Section 6); and describe reporting requirements and propose an approach to more open report and data sharing (Section 7). Level 3 monitoring methods are not prescribed since they are by nature specific to a project and the types of processes and questions being tested. Finally we provide Level 1 field data sheets in Appendix A.

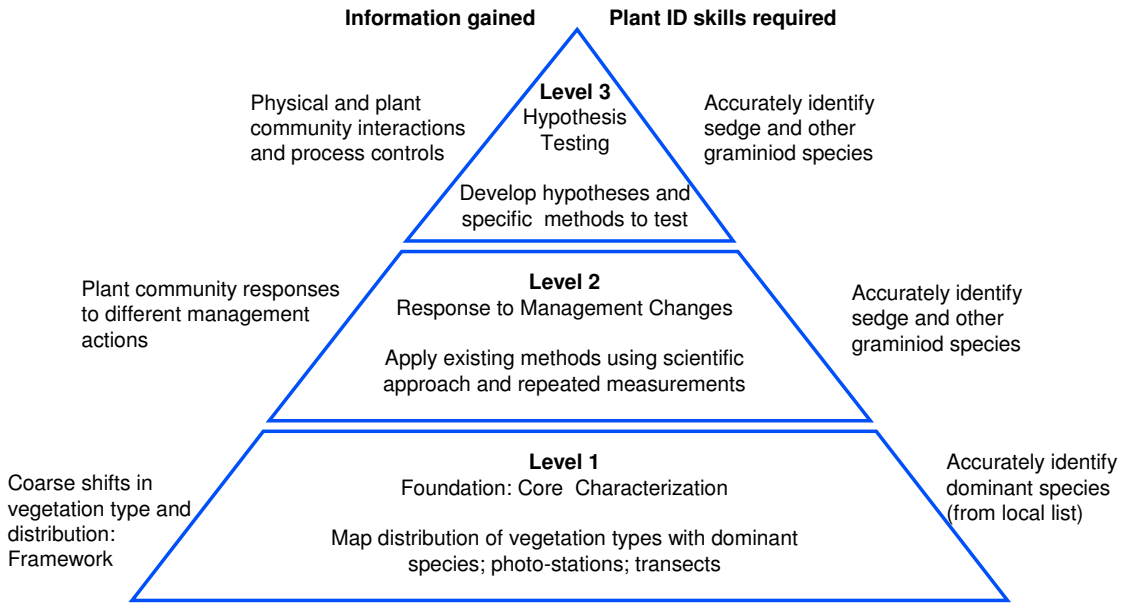

Figure 2. Three-tiered approach to vegetation monitoring for meadows in the Sierra Nevada (conceptual design of pyramid scaled approach to monitoring is adapted from Land EKG, spring 2011 newsletter).

Although the Level 1 core characterization and Level 2 decision tree have been structured to accommodate a range of meadow sizes, complexity, budget capacity and botanical expertise, the group recognizes that the approach and methods for vegetation monitoring described in Sections 5 and 6 might require some changes and/or adaptations. We are hopeful, however, that such adaptations will be made conservatively and with broad communication among users in the Sierra Nevada, bearing in mind the importance of having consistently collected data sets for cross-comparison (in space and time) and to support broader understanding of meadow processes and response to restoration actions.

5 LEVEL 1: CHARACTERIZATION OF MEADOW VEGETATION

5.1 Introduction

The Level 1 characterization of meadow vegetation is basically a mapping exercise in which the distribution and boundaries of the different plant communities that make up the meadow mosaic are mapped, described, and linked to elevation transects. When applied over time, including one to several years before treatment as well as for multiple years following treatment, this level of monitoring can provide a powerful record of change. This Level 1 monitoring for meadow vegetation response to restoration should be performed in concert with the Level 1 monitoring for hydro-geomorphic response to restoration in which groundwater levels are recorded (American Rivers et al. 2011).

Some of the questions that will be answered with this level of monitoring include:

- What are the dominant vegetation alliances in this meadow?
- What is their areal extent?
- What are relative elevations above channel baselevel associated with these alliances?

- How has the extent and distribution of these vegetation alliances changed between pre- and post-project implementation, and as the project matures?
- At what rate have these changes occurred?

In addition to answering the above questions, the information gathered through the Level 1 characterization will help land managers develop more specific management questions and hypotheses, such as: were observed changes in vegetation a response to management changes, or to particular weather patterns?; or to observed distribution of special features, such as springs, sediment deposits, etc.? Thus, the Level 1 characterization plant community type maps can be used as a framework for stratifying the meadow and pursuing more specific management response and process-oriented questions through Levels 2 and 3 monitoring.

It is important for all restoration effects monitoring to clearly define the potentially affected area. In general, these should include all of the areas where any kind of treatment or change in management is planned and areas where the effects of such change will affect the physical template (water and or sediment availability and transport).

5.2 Timing, Frequency and Expertise Required

At a minimum, Level 1 Characterization monitoring is performed one year prior to initiation of changed management practices and/or restoration actions. Subsequent monitoring should occur at least during Years 1, 2, and 3 post-implementation and then at 5 yr intervals thereafter. Monitoring should be timed to plant phenology (e.g., flowering periods of the dominant plants species), so that changes in plant species composition can be attributed to management rather than seasonal differences among survey dates. Similarly, if the meadow is grazed, surveys should be performed either consistently prior to grazing, or consistently over one month following grazing so that plant flowering parts are available for plant identification and so that variability in inter-annual grazing effects do not confound findings on plant community extent and characterization. If possible a control site, which is as similar as possible to the target meadow but receiving no changes in management, can be monitored also. Comparisons between these sites can help isolate responses to management from responses to interannual climatic variation. Use of a control site is suggested but not required for Level 1 monitoring (refer to Section 3.3 above).

5.3 Data Collection Methods

There are five primary steps to collect data for characterizing meadow vegetation: (1) office preparation, (2) field delineation of plant community type boundaries, (3) plant community type data collection, (4) field survey representative cross-sections; (5) photo-point monitoring. These steps are described in greater detail below.

5.3.1 Office preparation

Prior to going out in the field, the team should acquire either most recent aerial imagery of the meadow to use as a field base photograph. NAIP or similar images (of equal or finer resolution) will be used to as a basis for delineating distribution of plant community types in the meadow. National Agriculture Imagery Program (NAIP) images have 1-m^2 resolution and are produced under the auspices of the USDA's Farm Service Agency (FSA), to provide aerial imagery of productive lands of the continental U.S. during the agricultural growing seasons. NAIP imagery is free and publically available in GIS-compatible format; other NAIP image formats that do not require GIS software can be purchased at low cost from private vendors. For more information on

NAIP imagery coverage, format, frequency, cost, and websites from which to download NAIP imagery, see http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai.

Prior to going out in the field, the team should print out a field base photo on 11x17 paper with a clear scale bar and north arrow. For large meadows (>100 ac) use several sheets of paper (< 50 ac per sheet) so that the hard copies are of sufficient resolutions for precise mapping. We recommend a map scale of at least 1:1,500 or finer for the field base photo. The field personnel should also familiarize themselves with local plant species common to meadows and grasslands and be familiar by sight with any potential threatened, endangered, or special status TES) species that might be encountered in the field. TES species found in the area can be listed by performing database search of the CNPS Inventory of Rare and Endangered Plants (http://www.rareplants.cnps.org/). The CNDDB and USFWS databases could also be queried following standard procedures[2] and, if the meadow is on or near Forest Service lands, the local Forest Service botanist and wildlife biologist can be contacted for lists of potential species of concern. The field equipment, listed below, should be organized and made ready.

5.3.1.1 Field Equipment for Level 1 Monitoring

- Camera
- Clip board
- Compass
- Data Sheets
- Field Base-Photo
- Hand-held GPS
- Survey equipment
- Local plant species list
- Logging tape
- Pencils
- Permanent fine-tipped markers
- Plastic bags (for unknown plant samples)

5.3.2 Delineation of plant community type boundaries

Once in the field, the monitoring team should first walk through the meadow to understand the range of vegetation types (e.g. vegetation alliance and/or association per Sawyer, Keeler-Wolf and Evens 2009; see Section 5.5) and their distribution within the meadow mosaic. Based on this preliminary assessment, the team then identifies "stands[3] representative of tentative vegetation

[2] For standard CNDDB and CNPS database 9-quad search queries, see CNPS 2001:The CNPS Inventory of Rare and Endangered Plants; also available at: http://cnps.site.aplus.net/cgi-bin/inv/inventory.cgi.

[3] Stand: A stand is a basic physical unit of vegetation in a landscape. It has no set size. A stand is defined by two main unifying characteristics: (1) It has compositional integrity. Throughout the site, the combination of species is similar. The stand is differentiated from adjacent stands by a discernable boundary that may be abrupt or indistinct. (2) It has structural integrity. It has a similar history or environmental setting that affords relatively similar horizontal and vertical spacing of plant species. In the case of meadows, look for areas with similar topography and access to ground and surface water. Areas along the meadow edge are also subject to different physical conditions (shade, conifer litter, etc.) (from CNPS 2011).

types," which are homogeneous in plant composition and structure. Within the meadow mosaic, you might have multiple stands (continuous patches) that are representative of different vegetation types.

Mark vegetation type boundaries using an ultra fine point sharpie or similar permanent marker on the field base photo. If you have GPS and GIS capabilities, record the polygon outlines using a handheld GPS unit, noting the spatial precision and accuracy of your GPS at the site. For each polygon, locate easily visible points of reference in the field and on the aerial image, such as a lone conifer in the meadow, a large boulder, a road or trail, etc., and record the bearing and distance to the polygon's closest edge from these reference points to tie your field location to points on the field base photo. The minimum mapping unit for these stands is suggested at 200 m^2 (0.05 ac or 2,178 ft^2). On the base photo (and if possible, in GPS), record the location of major stream channels as well as other important features such as gullies[4], roads, trails, salt blocks, exclosure fencing, springs, etc. Based on field observations of dominant plant species, code the polygons on the field base photo according to a preliminary classification (e.g., beaked sedge, Lemon's willow, Kentucky blue grass and slender wheat grass, corn lily and other dry forbs, etc.).

5.3.3 Plant community type data collection

Ground truth the plant community type polygon boundaries as delineated on the field base photo using the CNPS rapid assessment protocol (CNPS Vegetation Committee 2004). Select several polygons of each preliminary plant community type. At each of these polygons—or stands—record the occurrence and total percent cover of each of five plant groups as well as the percent cover of the dominant and characteristic plant species[5]. These plant groups are: (1) sedge and rush species; (2) other graminoid species; (3) forb species; (4) shrub (multiple stems) species; and (5) tree (single stem) species. In addition, record total percent cover of all moss and other non-vascular species. It is also very important to record total percent vegetation cover, as well as percent cover of bare mineral soil, bare organic soil, rock (gravel to boulder), and litter or thatch (see field base sheets in Appendix A).

Ancillary information to collect for each representative stand could be extremely useful for interpreting vegetation response to management actions. Although not required at Level 1 monitoring, some easy and yet useful observations to record include surface soil moisture; surface soil texture (is it organic?); depth of organic or peat soil (using shovel, trowel or auger); slope and aspect; elevation relative to channel bottom (if site is along an elevation transect); presence or absence of rills and gullies and surface soil disturbance from rodents; and finally notes on land use and other sources of disturbance (see Appendix A for sample ancillary data sheet).

While in the field, collect unknown plants that are important by their percent cover and/or frequency of occurrence. Be sure to know TES plant species so you don't accidentally collect them. Press samples of the unknown species carefully in the field or put in a baggie and cooler until that evening. Identify or press within 24 hrs.

[4] Gullies can be distinguished from channels because gullies do not have associated floodplains or well-vegetated banks; instead gully sides are made up of unsecured bare soil.

[5] Dominant species include those with the greatest percent cover that also exceeds 10% per plant group; Characteristic species include those that occur with greatest consistency among stands – these do not have to have a high percent cover.

5.3.4 Field survey representative cross-sections

Development of several cross-sections, spanning from meadow edge to meadow edge and located at well chosen positions throughout the meadow, can provide the manager with rough estimates of plant community elevations above the groundwater. Placing the mapped plant community types along some or all of these transects increases the interpretive power of the mapped community types a great deal.

Selecting transect locations is an important first step and should be done carefully, based on knowledge of the hydrology, geomorphology, and vegetation communities and with close attention to the planned on-the-ground restoration activities and restoration objectives for vegetation. The number of transects needed is a function of the complexity and size of the meadow. The smallest and simplest meadow would require three transects (top mid and lower meadow) but almost all meadows are likely to require more in order to capture the range of topographic variability in each meadow.

Once transect locations are chosen, install permanent markers at the meadow edges of each transect and record the GPS points. Survey elevation changes along each transect; plant community type boundary positions should be recorded along each transect, as well as elevations on either side of each boundary. All transect elevations should be tied to a single reference elevation.

Survey these transects before and after restoration activities, following any major storm or other disturbance events that affect meadow topography, and every 5 years following restoration.

5.3.5 Photo-point monitoring

Photographs from multiple permanent points will be taken during each monitoring event. These are excellent sources of information when taken consistently from the same point and direction over time. Establish at least three permanent photo-monitoring points that capture the sweep of land in each meadow area of 25–30 ac. Photo-point positions and bearing (direction in which photographer is facing while taking picture) can be recorded on field base photo, using a hand-held GPS, and using permanent in-field markers such as fence stakes or wooden posts. However, realize that permanent field markers can be lost or destroyed during project implementation. During each monitoring event, record the date, location, and bearing of each photograph. It is very useful to place a white board with the date, location code, and bearing in the photograph itself (close enough to be legible on the photograph). Include the sky line at the top of each photograph. Photographs can be presented in a time-series in monitoring reports to illustrate overall change in vegetation cover and type (See Herrick et al. 2005a for details on a photo-point monitoring procedure).

5.4 Data Management and Analysis

Once collected, field data must be carefully preserved, analyzed, and reported in order to be of any use. The field base photo should be scanned and stored in digital form in a project folder. Most of the analysis for the Level 1 Characterization involves assigning plant community types to the stands identified in the field, recording and assessing the areal extent of each vegetation alliance either using GIS or by tracing polygons delineated on the base field photos, developing graphics showing elevation transects, and reporting relative elevations of plant community types.

5.4.1 Recording field data

Once back from the field, unknown plant species should be identified and corrected species names recorded along side the field recorded names on the field data sheets. All plant names for dominant species need to be recorded to the species level using the Jepson Manual naming conventions (Hickman 1993, or as updated on the Jepson online interchange: http://ucjeps.berkeley.edu/interchange.html; Rosatti 2003). The botanist should record their initials and date next to each plant name correction or update. Once these corrections have been made to the field data sheets, these should be scanned and stored in digital form. Species names and percent cover estimates per stand should then be entered into an excel file according to the format provided in Appendix B, Tables B-1 and B-2.

If GIS capabilities are available, it is best to digitize the polygon outlines recorded in the field on the field base photo using the NAIP imagery as a backdrop and to attribute each polygon with a unique polygon code and with a plant community type code, as described in the next section. Name this GIS layer to include the field dates of data collection. This layer can be used to quantify the extent of each community type in the meadow, and by comparing such layers over time, to quantify changes in extent and distribution of plant community types.

5.4.2 Plant Community Type Assignment and Description

Use field information on the most consistent and/or dominant plant species per stand to make a determination of the alliance level names according to the Manual of California Vegetation (Sawyer et al. 2009). To assign plant community types to your field polygons, match the published plant community type descriptions based on geographic distribution, and dominant and co-occurring species. Use the second edition of the Manual of California Vegetation (MCV2; Sawyer et al. 2009) as a first reference for plant community types and assign vegetation community class names to at least the alliance level; in some cases it may be possible to assign to the association level[6]. Other more local classifications might be available through the Forest Service (e.g., Potter 2005, primarily presented at the association level), and can also be used. Be sure to fully cite the sources of each published plant community type used.

Because the classification for meadow vegetation for the Sierras is incomplete, some observed plant communities will not fit those described in the MCV2 or other published meadow classifications. In these cases, names should be applied according to the CNPS naming convention in which characteristic species of the upper most important vegetation layer are used in the alliance name and the most characteristic species in two vegetation layers are used to assign the association name. For example a stand dominated by showy sedge (*Carex spectabilis*) sod belongs to a well-documented alliance referred to as the *Carex spectabilis* Herbaceous Alliance (Sawyer et al. 2009); and *Salix jepsonii/Senecio triangularis* is a plant association described in Potter (2005). Include the word "Proposed" in any alliance or association you name yourself; e.g., *Carex simulata/ Oreostemma alpigenum*[7] Proposed Association. Record the level of confidence you have in the assigned alliance or association name (high, medium, or low confidence).

[6] Alliance (or series) level vegetation classes are identified by the plant species that is dominant in the layer with the greatest cover (tree, shrub, or herbaceous layers). Associations are classified at a finer scale than alliances and are classified based on groups of commonly co-occurring species which generally includes characteristic species in more than one vegetation layer Sawyer et al. 2009).

[7] Formerly *Aster alpigenus.*

Summarize the cover categories for each community type observed in the meadow by presenting the mean (and standard error if possible) of each for the stands measured. These can be presented in a single table (see Tables 1 and 2 below).

Table 1. Summary vegetation data for three plant community types sampled within Meadow 8 during late summer 2010 in the Eldorado National Forest.

Meadow	Community code	Sedge and rush	Grass	Forb	Shrub	Tree	Bare ground	Rooting density	sum %FACW OBL	Meadow community type
		Percent Cover								
8	A	5–15	1–5	25–50	1–5	1–5	1–5	High	89	Wet
8	B	25–50	0–1	50–75	0	0	1–5	High	90	Wet
8	C	25–50	0–1	5–15	1–5	0	0–1	High	80	Wet

Table 2. Five plant species with the greatest absolute percent cover in the plant community types observed in Meadow 8 during late summer 2010 in the Eldorado National Forest.

Meadow	Community code	Species 1	Species 2	Species 3	Species 4	Species 5
8	A	*Aster alpigenus*	*Mimulus primuloides*	*Carex nebrascensis*	*Polygonum bistortoides*	*Vaccinium uliginosum* ssp. *occidentale*
8	B	*Carex nebrascensis*	*Polygonum bistortoides*	*Potentilla gracilis*	*Senecio triangularis*	Moss
8	C	*Aster alpigenus*	*Polygonum bistortoides*	*Saxifraga aprica*	*Carex illota*	*Senecio triangularis*

5.4.3 Elevation transect data

Once in the office, completed transect data sheets should be copied and electronically scanned and the originals safely stored. Data should then be entered (with a QA/QC check) and elevations calculated for each point relative to the channel base level along the associated transect (each of these values should also be linked to a single reference point elevation). Calculate relative elevations (average and standard deviation) for each community type polygon with at least three surveyed points along each transect. Report the relative elevation for each polygon by vegetation type (average, standard deviation, number of points per vegetation type within a polygon). These data can be further summarized to the vegetation type level by presenting averages and standard deviations per vegetation type. An example results table is presented below (Table 3).

Table 3. Relative elevations recorded by plant community types in a hypothetical meadow average (standard deviation, number of samples); elevations given in feet above channel base level within the transect, as recorded on June 11, 2011.

Meadow	Plant community type	Polygon 1a, Transect 1	Polygon 1d, Transect 1	Polygon 3c, Transect 3	Polygon 6d, Transect 6	Combined Polygons
Golden Meadow	*Veratrum californicum-Polygonum bistortoides*	3.2 (+1.4, 3)	4.1 (+2.2, 4)	2.5 (+1.1, 5)	3.1 (+0.8, 5)	3.2 (± 1.4, 4)
Golden Meadow	*Artemisia tridentata/Poa secunda*	6.1 (+2.1, 4)	6.5 (+2.8, 5)	5.8 (+2.1, 4)	na	6.1 (± 2.3, 3)
Golden Meadow	*Artemisia tridentata/ Leymus cinereus*	8.5 (+3.4, 5)	9.1 (+3.4, 4)	8.8 (+2.8, 3)	10.1 (+4, 3)	9.1 (± 3.4, 4)

5.4.4 Plant Community Type Distribution and Extent

Measurements of plant community distribution can be made by either querying the polygon layer created in Section 5.4, or by measuring the polygon areas the "old fashioned way" with an acetate sheet of squares of known size (e.g., 4 m^2 based on the scale of the field base map) overlaid on the field base photo and counting the total number of squares in each vegetation type (Dunne and Leopold 1978). Once completed, the aerial extent of each vegetation type can be reported in a summary table. These values can be presented to show change with implementation and over post-implementation years, as illustrated in Table 4.

Table 4. Hypothetical plant community type extent as measured pre and post restoration for a 100-ac meadow; areas presented in acres.

Plant community type	Y 2 Pre	Y 1 Pre	Y 1 Post	Y 2 Post	Y 3 Post	Y 8 Post
	Acres					
Artemisia tridentata/Poa secunda	77	80	10	4	5	2
Artemisia tridentata/ Leymus cinereus	20	17	5	2	3	1
Juncus nevadensis	2	1	15	12	12	12
Carex nebracensis	1	2	35	42	40	45
Veratrum californicum-Polygonum bistortoides	0	0	15	12	14	12
Senecio triangularis-Athyrium filix-femina	0	0	12	20	20	22
Open water	1	1	8	8	8	8
Total	**100**	**100**	**100**	**100**	**100**	**100**

A figure, showing the plant community type polygons, as coded in the associated tables is also an excellent way to present the distribution and extent of vegetation types. For example, Figure 3 illustrates the distribution and extent of meadow plant community types in one meadow on the Eldorado National Forest. This figure also shows roads and trails, hydro-geomorphic features, as well vegetation community types summarized in Tables 1 and 2.

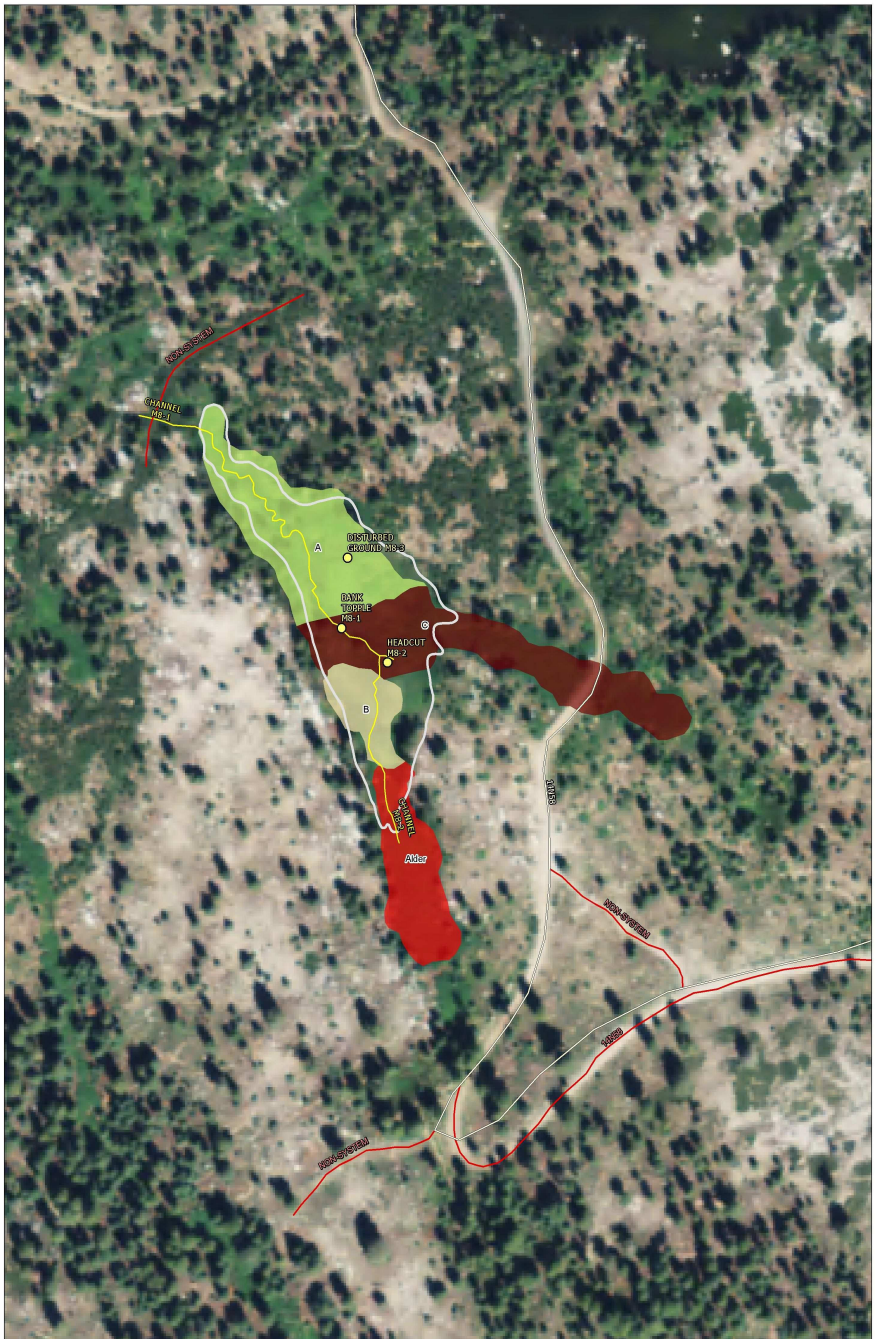

Figure 3. Plant community types and other features for a meadow on the Eldorado National Forest.

5.5 Reporting

Pulling monitoring information into a well-documented report, including field data, photographs, figures of the plant community type polygons and a summary assessment, is a critical step. We recommend that monitoring reports be updated annually for at least the first three years following a major change in management and at five year intervals thereafter. Each year of monitoring data should be added into the previous report, so that the full history of monitoring and response is in a single document.

A possible format for such a report is:

1. Title, including date, authors and any associated institution, contact information
2. Introduction: Location, size, ownership, brief overview of restoration and/or management history.
3. Purpose, goals, and implementation dates for change in management.
4. Methods used for monitoring (this can briefly refer to this or other document while providing details on specific methods applied in the field).
5. Results section should provide a discussion of problems encountered in the field or analysis, as well as
    a. Summary tables of plant community types for each year of monitoring;
    b. Plant community type information, per year of monitoring;
        i. Areal extent;
        ii. Dominant species and vegetation; and
        iii. Bare ground, litter, and rock cover.
    c. Figure(s) showing aerial photograph or NAIP image with delineated plant community type boundaries and codes;
    d. Ancillary data on ground water levels, elevation, soil texture, etc.; and
    e. A map of the meadow showing location of permanent photo-points and photograph series from permanent photo-monitoring sites.
6. Discussion, including interpretation of plant community types in relation to management conditions, possible explanations for any observed changes in plant community types and/or distributions.
7. Literature cited.
8. Appendices (with scanned field data sheets, full plant species lists, other photographs, etc.).

Vegetation field data, photo-monitoring images, NAIP images with community type boundaries, and GIS layers should be archived in a safe and accessible location. Preferably, several hard copies of the report that include CD's with the associated data could be submitted to a Meadow Database and Library for off-site safe storage (See Section 7).

5.6 Personnel Requirements and Training

For meadows that are roughly 40 ha or less (100 ac), this level of monitoring should require a total of two days of both office and field time including transect surveys. We recommend that the Level 1 field monitoring be performed by a team of at least two personnel to increase efficiency and to provide two perspectives at the junctures where judgment is required (e.g., delineating plant community type boundaries). Moreover, it is simply helpful to have two sets of hands to set up transects and to observe/record field data. At least one of the field people must have strong

local botanical skills, including knowledge of local graminoid (sedge) species. Having GIS software and some entry level to moderate GIS capability would also make some of the spatial analysis easier, but is not necessary.

6 LEVEL 2: DECISION TREE FOR SELECTING METHODS TO MONITOR PLANT COMMUNITY RESPONSE

Level 2 monitoring targets meadow response to restoration actions and is, therefore, a fundamentally important part of adaptive management. Findings from these monitoring efforts, combined across different meadows where similar restoration goals and methods are applied, can also provide critical information for improving restoration techniques.

The decision tree in Figure 4 is based on management goals and techniques, and is designed to guide the meadow manager to information resources useful for developing appropriate monitoring protocols. In many cases, the protocols might require tailoring to the specific needs and characteristics of the meadow.

6.1 Decision Tree

Following the decision tree diagram, we discuss common monitor design issues, such as size, shape, intensity and distribution of measurement areas, monitoring frequency and timing, and offer a tool box of commonly applied vegetation measurement methods. In the last part of Section 6, we review specific existing vegetation monitoring methods tiered to the decision tree, and discuss how they can be best applied to meadow vegetation response monitoring. For each method, the reader is referred to existing publications and protocols for detailed discussion and field data sheets.

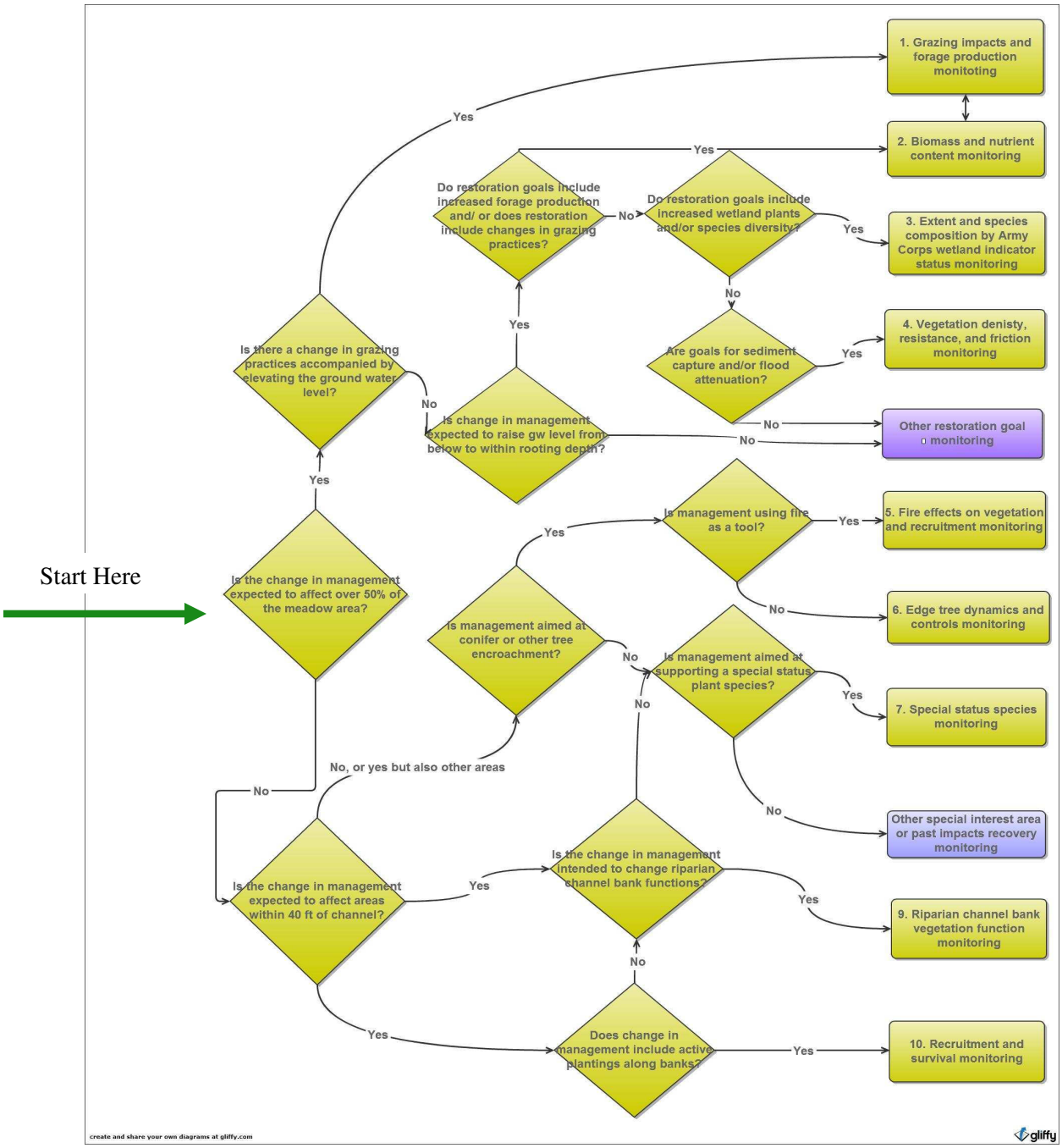

Figure 4. Decision tree to guide Level 2 monitoring for restoration effects on vegetation.

6.2 Study Design

Once the target set of vegetation responses (e.g., end points) in the Figure 4 decision tree have been determined, site selection is one of the next critical steps. The process of selecting sites to monitor should be tied directly to the response objectives and be well-documented. If possible, reference areas or "control" areas that are not affected by changes in management should also be included. Such a design framework, in which a control and treatment (e.g., restored) area are

monitored before and after treatment, is particularly powerful because it controls for effects due to both climatic variability and treatment. This design is referred to as the "Before-After-Control Impact" design (Stewart-Oaten et al 1986).

Sampling sites should also be well distributed throughout the affected (and control) areas using a stratified random sampling design so that you can infer that your measurements represent the greater affected or control area. Stratifying the meadow by vegetation type within the mosaic could, in most cases, capture the major drivers of variation in response to management since vegetation type distribution is an integration of hydrology, soils, and management history. However, if there are other variables within the meadow that are expected to explain more of the variation in response to management change, then use these with a clear and explicit rationale for why you are selecting this other variable over vegetation type for stratification. Once the monitoring sites have been identified, selecting specific plot locations within these areas should, generally, be done randomly.

Finally, choosing between permanent vs. temporary sampling locations can also have important implications for interpretation of the data you collect. Data collected from different, randomly selected plots on each sampling date are independent of one another but data collected from permanent plots are dependent on or linked, to the data collected on previous dates. Smaller changes in vegetation compared across sample dates in permanent plots will therefore be more likely to indicate a real response then will the same size changes in randomly located plots across sample dates. In short, permanent plots can give your monitoring system greater sensitivity to vegetation change. However, practical concerns also need to be considered; such as whether or not the pre-implementation site locations will be appropriate for monitoring under post-implementation conditions, the time required to install and remove permanent plot markers, and whether or not land owner permission for installing permanent markers will be granted. Some meadows, including fens, have peat soils that are easily compacted and therefore could be damaged by the repeated trampling associated with permanent plots. In these cases, temporary plots might be preferable. Alternatively, temporary boardwalks to the sampling sites can be erected to protect the soil and local hydrology from sampling damage.

The distribution and number of plots will affect and precision with which the data collected represent overall conditions; the need for having a sample size large enough to detect changes must be balanced with associated costs and labor. Generally, larger sample sizes increase the likelihood that smaller changes or responses will be detected. Methods exist for determining the appropriate sample size, given a target degree of precision needed (e.g., 10% change) and variation within the target vegetation types. Estimates of spatial variability can be developed based on other monitoring reports or published studies of the target or similar vegetation types. A description of these methods can be found in Chapters 7 and 8 and Appendix 7 of Elzinga et al. 1998. The size of the measurement areas or plots also importantly affects how well the data collected reflect the population response to treatment. Recommendations on sample plot size are provided below with specific methods, as well as in the sources referenced in this document.

Other aspects of the overall sampling design include the resolution of sampling itself. Do you sample all plant species or groups of species based on wetland indicator status, seral status, vegetation layer (shrub, tree, graminoid, etc.), specific morphology (e.g., rhizomatous or clonal species), or age cohort (tree seedling, sapling, pole, or "mature" sized), etc.? This decision has implications for the degree of training and experience required of the field personnel and of the amount of post-field plant identification time that might be required.

For each of the target responses, we provide guidance on these study design decisions in Section 6.4 below. More in-depth discussions and advice on how to best tailor these decisions to your particular project can be found in existing publications and will not be repeated here (see Elzinga et al. 1998 [Chapter 7]; Coulloudon et al. 1999 [Chapter 3]; and Herrick et al. 2005a,b).

6.3 Basic Vegetation Measurement Methods: the Tool Box

Many of the measurement methods for monitoring vegetation response to restoration or change in management are based on a few basic methods used to characterize or quantify changes in vegetation in a given area. These are listed and briefly described below. Suggestions on how and when to apply these methods in order to address target vegetation responses to management (Figure 4) are provided in Section 6.4. For more detailed descriptions of each method, including specific field gear required, field methods, field data sheets, and data analysis and reporting methods go to Elzinga et al. 1998; Coulloudon et al. 1999; or Herrick et al. 2005a,b.

6.3.1 Vegetation attributes to measure

6.3.1.1 Plant identification

This fundamental attribute is critical because it determines the level of resolution of your vegetation data and the level of expertise, and expense, for the field sampling effort. The expertise required will vary based on project needs but must be carefully considered. Options range from the general categories such as plant groups [(1) sedge and rush species; (2) other graminoid species; (3) forb species; (4) shrub (multiple stems) species; (5) tree (single stem) species and (6) bryophyte cover] requiring the least expertise, to plant species, subspecies and variety including bryophytes, requiring the highest level of expertise. Variations in between include identification of dominant species (over 10% cover) excluding bryophytes, or identification of genera present, etc. Identification to the species and subspecies or variety is usually required in order to determine the wetland indicator status[8] or seral status[9] of the plant. These categories are helpful in that they (generally) can be used to infer information about site conditions. A list of common meadow species, their wetland indicator and seral status is provided in Appendix D (developed by Region 5 of the USDA Forest Service; D. Weixelman, US Forest Service, pers. comm. with A. Merrill, Stillwater Sciences, 27 October 2010). In many cases in which plant species are measured as indicators of site conditions, and/or vegetation biodiversity, identification to the species level will be needed. In these instances, use nomenclature according to Hickman 1993 for all vascular plant species names, or when available, the 2011 Jepson Manual, 2nd Edition (see also Jepson Interchange: http://ucjeps.berkeley.edu/interchange.html; Rosatti 2003).

There has also been growing interest and expertise in non-vascular plants (mosses and other bryophytes) as indicators of site conditions, particularly in fens. To this extent, total bryophyte cover can be recorded in the field along with other plant information. Identification of bryophytes by species is an uncommon (but growing) form of expertise. If field personnel do not have this expertise, and it has been determined that bryophyte species differences are important monitoring

[8] Wetland indicator status of each species is published by the Army Corps of Engineers for each region of the Country. Categories are OBL [obligate], FACW [facultative wet], FAC [facultative], FACU [facultative-upland], and UPL [upland]) using the 1988 national list of plant species that occur in wetlands for Region 0 (Reed 1988).

[9] Region 5 of the USFS has developed a list of common meadow species and their associated seral status (early, mid, and late successional) when found in wet, mesic, and dry meadows.

targets, then distinctly different types of bryophytes can be given unique field codes and samples collected in the field. These samples can then be sent for identification by bryophyte experts (also, see Doubt and Belland 2000).

6.3.1.2 Frequency

Frequency reflects the number of times a species is present in a given number of sampling units, and is usually expressed as a percentage of the total number of samples collected (Elzinga et al. 1998). While rooted frequency is the most sensitive parameter of vegetation response, it does not reflect important differences in biomass or plant cover. Seedlings can also heavily skew data and seedling density should be collected separately or in such a way that seeding data can be separated from the rest of the numbers. Sample sizes need to be identical across areas being compared and must be large enough to incorporate "clumping patterns" of different species. When paired with cover or production data, frequency measurements can be very sensitive to small changes in vegetation.

6.3.1.3 Cover

In general, cover is the amount of a given area covered by one or all plant species in a plot. However, cover can be presented in multiple forms. Foliar cover is the area of ground covered by vertical projection of the aerial parts of plants, whereas basal cover is the area of ground surface occupied by the basal portion of the plants. Foliar cover is more sensitive to climatic variations and current-year grazing. Ground cover is the most stable since it is less responsive to current-year grazing and variations in climate, however measurements of basal cover require more time and labor, especially in herbaceous plant communities, than foliar cover. Once again, precision requirements must be balanced with available time and budget.

6.3.1.4 Density

Density refers to the number of individual plants in a given area. Density is therefore an indicator of proximity among individuals and can be interpreted with resource availability. Differences in individual size (e.g., seedling vs. mature tree), reproductive methods and structure (multi or single –stemmed) can make interpretation of results more difficult.

6.3.1.5 Production or Standing crop

Production refers to the amount of plant biomass produced in a given time period. Most frequently, only annual above-ground production is measured and in herbaceous communities. In such cases peak standing crop, the greatest amount of plant biomass present above ground during a given year, is typically used to estimate above-ground production. Peak standing crop generally occurs towards the end of the growing season, but different plant species peak at different times. Total forage is the total amount of herbaceous and woody palatable plant biomass available to herbivores. Variation in standing crop is introduced by climatic variability, grazing, insect herbivory, trampling, and time of sampling.

6.3.1.6 Structure

Vegetation structure describes the vertical and horizontal distribution of vegetation. Vegetation layers are generally defined by height above ground and measured by percent cover in each layer. Vegetation structure is important for fire as well as wildlife habitat needs.

6.3.1.7 Composition

Composition refers to the different plant species in a given area and the relative proportion of space (canopy or basal cover) and/or biomass that they comprise. Composition is measured using species-specific cover or frequency data collection methods.

6.3.1.8 Vigor

Growth rate, as measured either within a single growing season or for woody species, across growing seasons can be an excellent indictor of plant vigor and can be measured as vertical change and/or as an increase in canopy circumference, as measured by two orthogonal measurements of canopy width. Other metrics of overall plant vigor can also include number of leaves or whorls, percent of foliage that is healthy (with clearly defined categories for each vigor stratum), or number of inflorescences per plant (see Elzinga et al. 1998 [Chapter 8]).

6.3.1.9 Riparian canopy light interception

Riparian canopy interception is a less commonly used, but still an important metric for riparian restoration projects where channel water temperature is an important condition for aquatic species. Riparian canopy interception is measured based on the percent of channel surface area shaded by plants. Deciduous plants provide shade only during the growing season, where as evergreens provide year-round shade. The position of the vegetation in relation to the path of the sun importantly affects the amount of radiant energy the plants intercept above the water surface.

6.3.2 Methods for measuring vegetation attributes

Hundreds of specific field methods have been developed for particular riparian and rangeland monitoring applications. These can be grouped into a handful of methods categories that can be adapted to measure the vegetation attributes described above. Table 5 lists these types of methods and the vegetation attributes they can be used to measure. These can all be tailored to monitor the specific vegetation responses to management actions listed in Figure 4. A brief description of each method is provided below, along with a publication that offers more detailed descriptions, diagrams, and field sheets. A review of a similar set of methods for riparian areas in general is also publically available and should be reviewed along with this document (it is only 17 pages long; National Riparian Service Team. 2004).

Table 5. A matrix of monitoring methods (rows) and target vegetation attributes (columns).

Attributes (across) Methods (below)	Frequency	Cover	Density	Production	Population size and extent	Structure	Composition	Vigor	Riparian light interception
Photo-points									
Rooted frequency	x	x	x				x		
Line intercept		x					x	x	
Point intercept		x					x	x	
Belt transect		x					x		
Standardized unit effort					x				
Harvest				x					
Greenline		x				x	x		
Solar pathfinder™									X

6.3.2.1 Photo-points

Photo-points are pictures that are taken at the same time of year from the same location and bearing over multiple years. These pictures are useful for providing an overall view of coarse vegetation changes with time. (See Elzinga et al. 1998 Chapter 5, Section A, for more details).

6.3.2.2 Rooted frequency

Although there are several methods for measuring frequency, nested rooted frequency is the most accurate and appropriate for graminoid-dominated vegetation such as is found in meadows. Using different sample-size quadrats based on vegetation type (graminoid, shrub, forb, etc.) nested in one another; the number of rooted individual plants in each quadrat is recorded. These can be recorded by species or by plant type. See Weixelman et al. 2003 and/or Weixelman and Zamudio 2001 for more specific descriptions of these methods.

6.3.2.3 Line intercept

This method of recording the distance along a transect where a particular type of plant intercepts a transect line, is best suited for monitoring shrub species. See Elzinga et al. 1998 and Herrick et al. 2005a for more detail. This is a commonly applied method of measuring cover of shrub and tree species.

6.3.2.4 Point intercept

A pointed rod or stick is dropped through existing canopy layers at regular intervals along a transect in this method. At each point, the different species encountered with the pointed rod are recorded. See Elzinga et al. 1998 and Herrick et al. 2005a for more detail. This is a commonly applied method for measuring percent cover for herbaceous species.

6.3.2.5 Belt transect

This method of walking along a transect and recording plant species encounters across a swath of given length perpendicular to the transect is useful for recording seedling density and other plant species that occur in low density across fairly wide areas.

6.3.2.6 Standardized unit-effort

The standardized unit-effort survey consists of one surveyor conducting a timed search (e.g. 60 minutes per 200 m^2) count all individuals observed throughout the suitable habitat patch, with the timed search beginning once the first individual was located (USDA Forest Service 1999). The duration of the search should be established based on preliminary search times required to count 99% of all the plants in a given area; once determined, the duration of each search per unit area must be consistently applied. This method is used for estimating density of target species such as TES or invasive weed species that occur at low density or in small, discrete populations. If TES or weed species populations are large and/or extensive, then other methods, such as point intercept or belt transect methods, should be applied.

6.3.2.7 Harvest

Above ground harvest, in which all plant material in a given area and that is 1 cm above the soil surface is clipped, bagged, dried and weighed, is a useful but labor-intensive measure of productivity. See Coulloudon et al. 1999 and Pellant et al. 2005 for more detail.

6.3.2.8 Greenline

The greenline method involves walking along a channel and recording the number of steps one takes within different plant community types that occupy the area at or near bankfull. The final measurement is the percent of channel length occupied by each vegetation type. The different vegetation types provide insight on site conditions, particularly regarding bank stability. See Winward 2000 for details. This method has been modified to increase data quality and replicability such that plant species cover data are collected instead of plant community type descriptions (Coles-Ritchie et al. 2004). These vegetation data collected along permanent stream channel transects to allow for elucidation of relationships between vegetation, streambank, and in-channel characteristics. Information on species, abundance, and size of trees is collected in conjunction with vegetation cross-sections.

6.3.2.9 Solar Pathfinder™

The solar pathfinder ™, a device originally developed as a tool for solar panal installation planning, provides a fast and efficient means of determining changes in riparian canopy shade to a given area of stream channel. It can be used on any day to determine light input during any time of the day or year, or over the entire year. See Harris et al. 2005 for more detail.

6.4 Level 2 Monitoring Method Recommendations

In the following sections, basic approaches to address the monitoring questions anticipated and summarized in Figure 4 are presented. Rather than prescribe specific monitoring methods, we offer recommendations on how to tailor existing methods for monitoring meadow vegetation response to restoration, enhancement or other changes in management. Following a brief discussion of the issues associated with each monitoring question, we review decisions on timing, site selection, and field methods. We direct the reader to existing sources for more in-depth discussions on each method, specific field and data analysis procedures, and sample data sheets.

6.4.1 Changes in meadow plant community type composition and distribution

This monitoring method can be used in order to track and quantitatively document changes in plant community types and their distribution in the meadow. The information produced from this monitoring method is similar to that obtained in the Level 1 characterization, but it will also provide higher resolution information on the rates of change in the surveyed community type boundaries and changes in plant species composition within the plant communities themselves. This method is designed to address the following questions:

- Has the percent cover of dominant and characteristic plant species changed in each vegetation type between pre and post-project implementation, and as the project matures?
- At what rate have these changes occurred?
- Do these changes reflect differences in wetland conditions based on percent cover of dominant species and wetland indicator status species groups?

- Do these changes reflect differences in community seral status, based on the Region 5 classification provided in Appendix D?
- What are the characteristic physical site conditions for these plant community types (such as groundwater level, relative elevation above channel, and soil texture)?

Many other questions can also be explored with the data collected using this monitoring method and might help the managers better interpret how the restoration site is evolving; these should be pursued at the manager's discretion. One such question might be: Based on changes in dominant and characteristic plant species cover along the vegetation type boundary edge, are the boundaries changing over time and at what rate?

Greater detail is provided for these methods since they are tightly linked to the Level 1 monitoring. For areas where changes in vegetation are expected to occur over short distances, such as along channel banks or the meadow edge, more spatially intensive methodologies, such as described under Section 6.4.10 Riparian channel bank functions and 6.4.7 Edge tree dynamics, might be a better fit than this methodology, which is intended for changes in distribution of broader, floodplain and terrace vegetation. Other Level 2 monitoring methods are more briefly described and detailed method development is left to the discretion of the user.

6.4.1.1 Timing

Monitoring should begin at least one and preferably several years before the change in management, enhancement or restoration is implemented. It is generally best to monitor frequently following implementation (at least one time per year) in order to catch and correct or redirect any unexpected or undesired responses to change. The timing of these measurements should be kept consistent to minimize the confounding effects of plant phenology on classification of different meadow plant community types. Mid-July through mid-August is recommended to capture peak flowering time of most high elevation meadow species; exact flowering times will vary by water year.

6.4.1.2 Site selection

Using the base map of community type boundaries delineated in Level 1, select at least one stand of each plant community type that appears most representative of its type. Where ever possible, select stands for representative data collection that overlap with survey transects (Section 5.3.4), and, if possible, establish the radial plot centers along elevation transects that also include established groundwater wells and/or piezometers (see monitoring protocol for hydrology and water quality). Record the plot distance from the meadow edge transect point (where the meadow edge is permanently monumented with rebar). For plant community type polygons that do not intersect elevation transects, semi-permanently mark a center point using a well-flagged fence stake or post, record the location of the transect center based on the bearing and distance from a permanent point or using a GPS and finally, on the aerial photograph. A radial plot sampling design makes it possible to record vegetation vs. bare soil cover and dominant species composition in a fast but also representative and objective manner (Figure 5).

Because some changes in restoration management are expected (intended) to alter the type and distribution of meadow vegetation, permanent plots that capture the variability in meadow vegetation cannot always be established. However, if pre-project site selection is made with careful consideration of the hydrology, geomorphology, vegetation communities and planned restoration activities on the ground, the areas with greatest expected response can be included and in many cases, permanent sites can be kept intact. Semi-permanent markers, such as fence stakes

or fence posts, or natural features such as boulders or trees, can be established as radial plot centers; if destroyed during implementation, these semi-permanent markers may be replaced.

6.4.1.3 Methods

Once the location for the radial plots have been selected, set up the sampling subplots at each site. This is done by extending three transects at 2:00, 6:00, and 10:00 O'clock (the orientation of the 'clock' can be set to maximize coverage of the polygon) and beginning 3 m out from the plot center, with each transect running at least 15 meters and extending to the outer edge of the plant community type boundary (Figure 5).

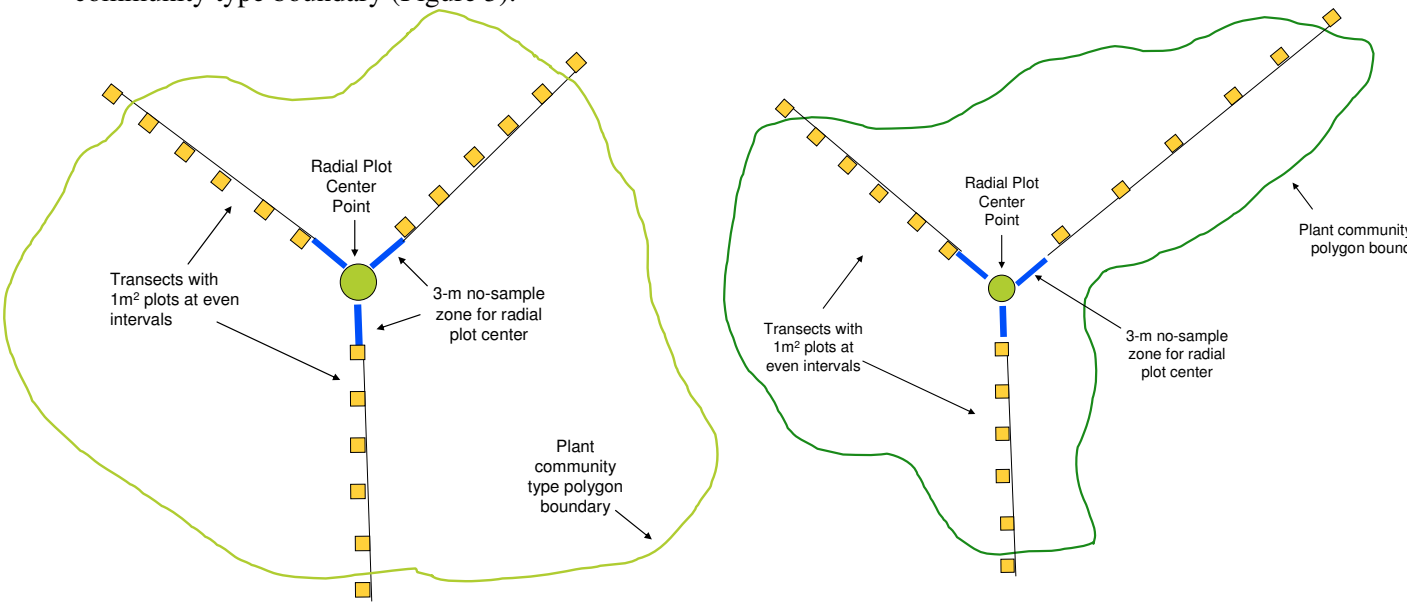

Figure 5. Radial plot design for collecting data on vegetation cover and plant species composition in delineated meadow polygons.

Record the bearing and length of each transect, facing out from the radial plot center. Divide the length of each of the three transects into 5 equal intervals; you will collect data at each of these intervals. For example, if a transect runs 15 meters, you will collect data every 3 m with 1 m^2 plot located within 3 m of the edge of the stand; if the transect runs 100 meters then you will collect data every 20 m. Also, you will collect vegetation information for one beyond-the-boundary plot at the outer extent of each transect so that you have three beyond-the-boundary plots per polygon (Figure 5).

Record the following information for one square meter to the left (facing out from the plot center) of each transect at each of these six points. Use nomenclature according to Hickman 1993 for all plant species names, or when available, the 2011 Jepson Manual, 2nd Edition (see also Jepson Interchange: http://ucjeps.berkeley.edu/interchange.html; Rosatti 2003). For each square meter subplot, record total percent cover of each of five plant groups as well as the percent cover of the dominant (>10% cover) and what you believe are the characteristic[10] plant species for the

[10] Characteristic species refers to plant species that have high fidelity to a particular vegetation type and therefore the presence of that species sets the stand apart from other similar stands. These are also referred to as indicator species and can be identified quantitatively through frequency of occurrence in many plots

vegetation type. These plant groups are: (1) sedge and rush species; (2) other graminoid species; (3) forb species; (4) shrub (multiple stems) species; and (5) tree (single stem) species. In addition, record total percent cover of all moss and other non-vascular species. It is also very important to record total percent vegetation cover, as well as percent cover of bare mineral soil, bare organic soil, rock (gravel to boulder), and litter or thatch.

Ancillary information to collect for each subplot includes surface soil moisture; surface soil texture (is it organic?); depth of organic or peat soil (using shovel, trowel or auger); presence of mottling; elevation relative to channel bottom (if site is along an elevation transect).

While in the field, collect unknown plants that are important by their percent cover and/or frequency of occurrence. Be sure to know TES plant species so you don't accidentally collect them. Press samples of the unknown species carefully in the field or put in a baggie and cooler until that evening. Identify and press plant specimens within 24 hrs. Keep the pressed specimen, marked with sample plot, location and crew name as well as species identification in a safe location so that future year and location sampling crews can refer to this sample and avoid false species composition changes due to changes in species identification methods, changes in plant key interpretation, name changes, etc.

6.4.1.4 Data analysis

In performing your data analysis, be sure to keep the questions you are trying to address foremost in mind. As stated at the top of this Section, these questions include:

- Has the plant species composition, as reflected in percent cover of dominant and characteristic plant species, changed in each vegetation type between pre and post-project implementation, and as the project matures?
- Do these changes reflect differences in wetland conditions based on percent cover of dominant species and wetland indicator status species groups?
- Do these changes reflect differences in community seral status, based on the Region 5 classification provided in Appendix D?
- Has there been a change in percent bare ground?

What are the plant community types?
For each transect and vegetation layer, calculate the average, or in the case of very skewed data, median percent cover, for each dominant and characteristic species. Rank the species in each layer according to (1) number of plots in which they occur; and (2) percent cover. The most frequent and highest percent cover species in each layer will be used in order to assign plant community types as described in Section 5.4.2.

Is the species composition changing?
These semi-permanent radial plots can also be used to track changes in the plant community composition over time. One must first check the percent cover data for each sampling date to see if it is normally distributed using a normal probability plot or histogram (play with the bin sizes), and check to see if the variance for each date can be considered similar. Instructions for how to perform and interpret these tests are described in Elzinga et al. 1998 Chapter 11, Section A.

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of that vegetation type where species data were collected and that cover the geographic range of the vegetation type ('percent constancy').

If your data are normally distributed, you can use the generally more powerful parametric statistical tests. Changes in the percent cover of dominant and characteristic species and plant groups can be detected using the paired t-test for repeated measures over two sampling dates, and a repeated-measures analysis of variance (ANOVA) can be used for detecting significant differences among multiple sampling dates. Significant ANOVAs can be followed by a post-hoc multiple comparisons test to identify which pairs of dates are significantly different from one another. If the same number of samples were collected on each comparison date, the Tukey test can be applied. If there are a different number of samples collected on the sampling dates (i.e. some plot data were destroyed or had to be thrown out), then the Bonferroni post-hoc comparison test can be applied. More information on how and when to apply these statistical tests can be found in Elzinga et al. Chapter 11 Section E. If your data are not normally distributed and or do not meet the requirements of homogeneity of variance, you can use non-parametric statistical tests (See Elzinga et al. Chapter 11, Section G), For the nonparametric paired comparisons, the Wilcoxin's signed rank test is recommended, followed by the Bonferroni correction post-hoc test.

In what direction and at what approximate rate is the species composition changing?
This question can be addressed by a simple graph, showing changes in percent cover of dominant and characteristic species over the monitoring period. One can expect these data will be 'noisy' with climatic and site specific factors, as well as management changes, affecting each measurement.

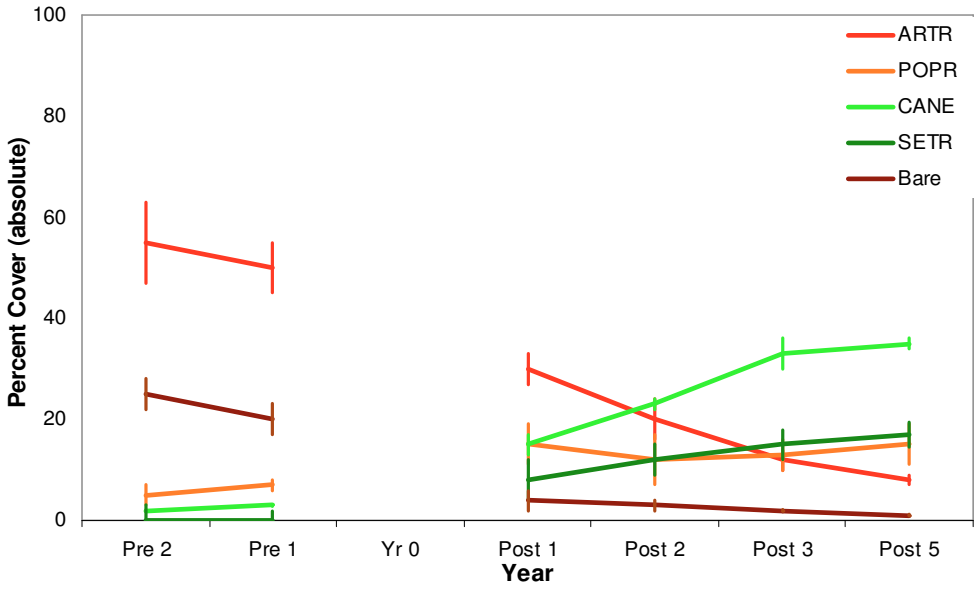

Figure 6. Sample (hypothetical) graphic to display rates of change in percent cover of dominant plant species and bare ground over time.

Is the distribution of plant groups (sedge, grass, forb, shrub) changing?
The above tests can also be performed using combined percent cover of different plant groups (sedge, other graminoid, forb, etc.).

Do these changes reflect differences in community seral or wetland status?
The above tests can also be performed using combined percent cover of seral status and wetland indicator status groups.

Has there been a change in percent of bare ground and/or overall vegetation cover?
The above tests can also be performed using percent bare ground and total vegetation cover as the main 'response' variable.

What physical site conditions are characteristic of this plant community type?
Ancillary data collected in each plot can be summarized by presenting the mean and standard deviation values of data collected in the quadrats of each radial plot. For categorical characteristics, such as soil texture, the range of textures and perhaps the percent frequency of each (number of quadrats with a particular soil type divided by the total number of quadrats, times 100) can be presented. These values can be used to describe site characteristics associated with each polygon and vegetation type. As a hypothetical example, one could report that the *Veratrum californicum-Polygonum* vegetation type was found in areas where mid-July groundwater levels averaged 12 $\pm$15 cm below the surface, organic soil depths averaged 20 $\pm$ 12 cm, and soil textures ranged from silty loam (85% of quadrats) to silty clay loam (15% of quadrats).

6.4.2 Grazing impacts on vegetation composition

The primary concerns associated with grazing impacts to meadows include (1) selective pressure of grazing on the plant community and resulting change in plant community composition; (2) overall reduced vegetation production and coverage due to excessive grazing; (3) effects of trampling on soil fertility (compaction) and meadow hydrology and resulting changes in plant community composition and distribution.

6.4.2.1 Timing

Monitoring should begin at least one and preferably several years before the change in management, enhancement or restoration is implemented. It is generally best to monitor frequently following implementation (at least one time per year) in order to catch and correct or redirect any unexpected or undesired responses to the management change. In order to capture the responses of both early and late blooming species to changes in the grazing pattern, monitoring must be performed during both early and late growing season for meadows at elevations below 4,000 feet.

6.4.2.2 Site selection

Include areas of the meadow that have been subject to the change in management as well as areas that have not been affected but that have similar levels of grazing. That way, you will control for the effects of the restoration and climate variability. Establishing an exclosure, or small fenced-in area that precludes stock animals, within the area affected by restoration will help you see and quantify the effects of grazing on the restored area.

6.4.2.3 Methods

Vegetation attributes most sensitive to grazing impacts include above ground biomass (harvesting—see next section), basal cover, percent bare ground, and rooted frequency (Coles-Ritchie et al. 2004). Basal vegetation cover and rooted frequency are well correlated to production rates and somewhat less time-consuming. Other non-vegetation effects associated with grazing can include soil compaction, water quality impacts, and surface erosion. Several excellent sources with detailed information on measuring forage production and other grazing impacts include Herrick et al. 2005 (Chapter 9), and Weixelman et al. 1997.

6.4.2.4 Further information

See Coullouden et al. 1999 (Chapter 5; Section D), Herrick et al. 2005b (Chapter 9), Weixelman et al. 1997, Elzinga et al. 1998 (Chapter 8; Section H), Cole et al. 2004; Menke et al. 1996.

6.4.3 Biomass and nutrient content

A primary concern of ranchers regarding meadow vegetation is how much palatable vegetation (forage) is produced, what is its nutrient content, and do the production and high nutrient levels remain high throughout the late summer and early fall when other rangelands are at very low production? Although laborious, measuring above ground biomass is the most direct means for assessing effects of grazing and restoration on forage production.

6.4.3.1 Timing

Biomass production should be measured at peak production time for the dominant species. So that production rates can be compared across years, the grazing and monitoring schedules should be coordinated such that grazing occurs consistently after, or (less optimally) a set number of weeks (and intensity) prior to monitoring. Forage nutrient content changes importantly over the growing season with the growth, maturation, and senescence of the flowering and fruiting (protein-rich) parts. Therefore, in order to get exact information on the change in protein and other nutrient content of meadow forage, samples must be collected during early, mid and late points in the growing season.

6.4.3.2 Site selection

See above section on Grazing Impacts.

6.4.3.3 Field methods

Measuring biomass can include both above and below ground biomass. For most purposes, measuring above ground biomass is sufficient. This is most effectively done through harvesting all live vegetation above ground at peak production time within a given quadrat (Coullouden et al. 1999). The size and number of quadrat samples collected needs to capture the variation within the plant community type you are sampling. A series of preliminary samples can be collected and analyzed to determine the range of variability in your meadow, allowing you to adjust the quadrat size and number according (Coullouden et al. 1999 details methods for selecting appropriate sample number and quadrat size). It is important that you do capture this range of variability since it can be large for production rates in meadow plant communities. Once collected, samples must be dried, weighed and analyzed to estimate production rates per acre according to methods detailed in Coullouden et al. 1999.

In order to test for nutrient and protein content of the forage produced in your meadow, collect a parallel, smaller set of samples alongside the above ground production samples, air dry, and send to an approved forage testing laboratory (use a lab that is certified by the National Forage Testing Association (http://www.foragetesting.org/). More detail on forage sample collection and analysis testing can be found in Appendix C.

If direct analysis of vegetation is not an option, several sources exist that can provide rough estimates of the nutrient content of different common forage species. These are also listed below.

We found these lists to be very incomplete regarding the nutrient content of many native California meadow species.

6.4.3.4 Further information

See Coullouden et al. 1999, Herrick et al. 2005b, Appendix C, Weixelman et al. 1997, Elzinga et al. 1998 (Chapter 8), Cole et al. 2004.

6.4.4 Plant composition by Army Corps of Engineers wetland indicator status and/or species diversity

6.4.4.1 Timing

Generally, monitoring should be timed to the flowering periods of the sedge and other species that are most common or characteristic of the meadow; this allows for accurate species identification. In some cases early and late season site visits might be required.

6.4.4.2 Site selection

Sites should be selected to represent the range of diversity within the affected and control or reference areas. To capture the range of community types and species with different wetland indicator statuses, differences in soil moisture due to flooding and other water inputs and drainage should be considered. If the target attribute is species diversity, as measured by species richness, see the plot size layout that is described in Chapter 10 of Herrick et al. 2005b.

6.4.4.3 Methods

Although species percent foliar cover based on ocular estimates (Daubenmire 1959) is usually considered adequate for Clean Water Act Section 404 wetland delineations (USACE 1987, 2001; Lichvar and Kartesz 2009; Reed 1988), differences in plant species cover can vary dramatically with water year, season and other climatic variations. Vegetation attributes least sensitive to climatic variability are rooted frequency and basal cover; therefore these two metrics will provide a more consistent measure of the relative cover of wetland indicator species over multiple seasons and years.

Assessing biodiversity at a site entails some measure of plant species richness. The most exhaustive approach to assessing species richness is the modified Whittaker Approach (Stohlgren et al. 1995, Bull et al. 1998); however, this method is time intensive and requires censusing all species present in a series of nested plots that are 10x30 m to 2x5 m to 0.5x2 m in size along the radial transects described for Level 1. These methods are detailed in Chapter 10 of Herrick et al. 2005b).

6.4.4.4 Further information

See Herrick et al. 2005b (Chapter 10), as well as Coullouden et al. 1999 (Chapter IV, Section F), Weixelman and Zamudio 2001, and Weixelman et al. 2003.

6.4.5 Floodplain vegetation sediment filtering and flood attenuation

6.4.5.1 Timing

Vegetation density within the floodplain, along with floodplain surface roughness and slope, affects on-site sediment filtering capacity and downstream flood attenuation. Sediment particles are captured on the floodplain when lateral flow velocity, which reflects the flood water's capacity to carry particles, is reduced. Flow velocity is reduced with longer flow paths across the floodplain, lower slope, and increased friction. Surface roughness (e.g., boulders and topographic relief) and vegetation increase friction on flood waters, thereby increasing flood duration and sediment deposition. Therefore, vegetation attributes most directly tied to sediment filtering and flood attenuation are the lateral extent and density of vegetation in the flood prone area during flooding. Since flooding frequently occurs from snow melt through early summer (roughly May through June), measurements of vegetation density should be made during that period.

6.4.5.2 Site selection

Delineate the boundaries of the flood prone area within the restored/enhanced and control reaches of the meadow. Establish transects across the floodplain, perpendicular to the channel, that fall within the affected (restored/enhanced/protected) areas and an equal linear extent of transects that fall within the control (unaffected) area.

6.4.5.3 Methods

Establish a minimum of four transects per treatment, such that the range of dominant conditions are covered by these transects. Along each transect, measure vegetation cover, by species or to genus should be sufficient of these purposes. Daubenmire or Point Intercept methods, as described in Herrick et al. 2005a (QuickStart: Line-Point Intercept Method), Herrick et al. 2005b (Chapter 15: Quadrat-Point-Intercept), and Elzinga et al. 1998 (Chapter 8).

6.4.5.4 Further information

See Herrick et al. 2005a (QuickStart: Line-Point Intercept Method), Herrick et al. 2005b (Chapter 15: Quadrat-Point-Intercept), and Elzinga et al. 1998 (Chapter 8).

6.4.6 Fire effects on vegetation

6.4.6.1 Timing

For monitoring the effects (vs. risk) of fire, it is best to collect monitoring data during the same time of the growing season for both pre- and post-fire periods.

6.4.6.2 Site selection

Locating monitoring transects throughout the burned area, to capture the range of variability in burn intensity, should be a goal. Variation in burn intensity can be roughly estimated before the fire based on fuel load, surface and fuel (vegetation) moisture, and topography (Sugihara et al. 2006).

6.4.6.3 Methods

Many questions about meadow vegetation response to fire can be addressed by collecting pre- and post-fire data on species cover, richness, and tree (e.g., conifer, aspen) seedling density

(Swanson et al. 2007). For species cover and richness, the line-point intercept method described in Herrick et al. 2005a (QuickStart: Line-Point Intercept Method) can be applied with the addition of collecting pre-burn data on fuel loading. A broader discussion of measuring species cover and richness is provided in Elzinga et al. 1998 (Chapter 8). Tree seedling recruitment rates pre- vs. post-burn can be collected using the Quadrat-Point Intercept method described in Herrick et al. 2005b (Chapter 15). For tree mortality data collection methods, see the next section on Meadow Edge Tree Dynamics.

6.4.6.4 Further information

Swanson et al. 2007, Haugo and Halpern 2007; Herrick et al. 2005a (QuickStart: Line-Point Intercept and Belt Transect Methods), Herrick et al. 2005b (Chapter 15: Quadrat-Point-Intercept, and Chapter 22: Fire), Elzinga et al. 1998 (Chapter 8); and other reports on conifer invasion of meadows (Helms 1987, Dunwiddie 1977, Arno and Gruell 1986, among others).

6.4.7 Edge tree dynamics

The authors located no existing protocols for monitoring meadow edge dynamics. Therefore, the following approach is provided as a suggestion, to be tailored to the site's particular needs.

6.4.7.1 Timing

Begin monitoring as many seasons before treatment as possible and continue monitoring after treatment on an annual basis for the first 3 years. After this, monitoring can be less frequent, such as at 3 to 5 year intervals and, if possible, following events such as particularly wet or dry water years or fire.

6.4.7.2 Site selection

To monitor for tree encroachment into a meadow, permanent transects should be anchored at a point well within the adjacent forest where woody and herbaceous understory species reflect upland forest, rather than edge conditions. Each transect should then extend, perpendicular to the meadow edge, to a point well within the open meadow, where no forest or edge species are found. Along these transects, sampling can occur within a continuous (or intermittent) series of rectangular plots (6x3 m or 10 x 20 ft), situated with the long axis perpendicular to these transects. Transects should be established in areas where change is expected or has been observed and, if possible, in areas where no changes in tree density and composition have been observed or are expected.

6.4.7.3 Methods

Within each (or every other, depending on the resolution desired) rectangular plot, collect data on tree seedling density (number of seedlings per plot), tree species density (additional information could include tree size (dbh) and status [live/dead]), and percent cover of riparian shrubs, upland shrubs, forbs and graminoids. Ancillary measurements along these transects could also be collected and to improve understanding of observed dynamics; these include soil moisture, ground water level and litter thickness, among other possibilities. Comparisons of tree and seedling density as well as shrub and herbaceous cover along the transect and over time can be made using various statistical models to reveal relationships between changes in seedling density and other factors such as time, distance from the forest center, time since a change in management, flood, burn, or other event.

6.4.7.4 Further information

See Swanson et al. 2007,Haugo and Halpern 2007, and Herrick et al. 2005b (Chapter 15: Quadrat-Point-Intercept, and Chapter 22: Fire), and Elzinga et al. 1998.

6.4.8 Special-status species

6.4.8.1 Timing

The special-status plant species that are being monitored need to be assessed at an appropriate phenological stage, when the plant species is readily identifiable. Each year, an effort should be made to return to the site when the plants are at this same stage of development; this means adjusting the timing based on the water year type, average temperatures, etc. Monitoring should begin as many seasons before treatment as possible and continue after treatment on an annual basis for a minimum of three years. Ideally, there should also be a control that is not subjected to the treatment. After at least three consecutive years of monitoring (prior to treatment or using the control if necessary), field surveys results can be evaluated in order to develop a minimum acceptable threshold population size for each species. If treatment has already begun and management had no apparent effect on the species population sizes and extents as compared to the control, then surveys can be conducted less frequently (e.g., every five years) following completion of the baseline monitoring. If the change in meadow management coincided with significant changes in the species population during the first three years post-implementation, a monitoring plan can be devised that addresses potential sources of change (e.g., by targeting particular areas or conditions), including additional monitoring if necessary.

6.4.8.2 Site selection

If possible, include areas of the meadow that have been subject to change in management as well as areas that have not, as described for the BACI design (Smith 2002). Depending on the size of the population, a complete census may be appropriate or sub-sampling may be necessary. If a complete census is feasible, the sites will be selected based on the locations of the special-status plants. If a complete census is not feasible, a variety of methods of sub-sampling can be applied. However, generally speaking the site selection should capture enough of the population(s) to appropriately characterize the entire population(s). This may entail setting up multiple transects through one or individual populations, establishing a set number of quadrats, or delineating a search area parameter around more diffuse populations (standardized unit-effort [timed search] survey). For more detail, see methods below.

6.4.8.3 Methods

There are a variety of methods for assessing a special-status plant population through time. Characteristics of the plant species to monitored, such as size (tree versus herb) and life form (annual versus perennial) as well as the extent of the population (less than 100 individuals versus over 1,000 individuals) will determine the most appropriate sampling techniques. Quadrats of variable sizes, point intercept method, permanent belt transects, and standardized unit-effort (timed search) of the survey site are examples of methods that can be utilized, depending on the above. Quadrants of variable size and shape can be used to sample a population; decisions on dimensions are dependent upon features of the population such as the spatial distribution of species within the population (see Elzinga et al. 1998 for more information). The point intercept method entails estimating percent cover by recording the number of "hits" of each species at points along a transect. "Hits" are determined by vertically dropping a 0.25 in-diameter dowel,

sharpened at the tip, at regular intervals along the transect; the first plant touched by the pointed tip was recorded as the "hit" for that point (Elzinga et al. 1998). Belt-line transects entail counting the number of plants per segment, each of which is made up of an appropriate-sized (e.g., 1x1 m) cell on both sides of the center line, and recording associated variables. The standardized unit-effort survey consists of one surveyor conducting a 60-minute timed search counting all individuals observed throughout the suitable habitat patch, with the timed search beginning once the first individual was located (USDA Forest Service 1999).

Regardless of plot type, photographs should be taken and the following information types of information should be recorded:

- number of individuals;
- information on phenology (i.e., vegetatative, flowering, fruiting);
- signs of disturbance such as herbivory;
- canopy cover;
- plant community characteristics (e.g., dominant species and percent cover using modified Daubenmire [1959] cover class categories); and
- hydrologic characteristics and soil pH where applicable.

Plant counts and plant condition should be recorded for each survey unit (e.g., each transect segment). Canopy cover and plant community characteristics can be recorded where there appeared to be a transition from one community type to another along a transect. The sampling frequency for other attributes, such as hydrologic characteristics and soil pH, can be adjusted based on the scale and variability within/amongst populations.

6.4.8.4 Further information

See Elzinga et al. 1998 and USDA Forest Service 1999.

6.4.9 Invasive Species

6.4.9.1 Timing

The targeted weed species that are being monitored need to be assessed at an appropriate phenological stage, when the plant species is readily identifiable. Prior to treatment (specifically of the weeds or of the site), a baseline assessment of the population extent (i.e., patch size, percent cover, and number of individuals) should be documented. After treatment, monitoring should continue on an annual basis. Depending on results of the survey (e.g., targeted species' populations responding to treatment or population increasing in size), monitoring thereafter can be tailored in order to assess the overall effects of the treatment on weed species extent and distribution

6.4.9.2 Site selection

If possible, include areas of the meadow that will be subject to change in management as well as areas that will not, as described for the BACI design (Stewart-Oaten, Murdoch, and Parker 1986, Stewart-Oaten and Bence 2001, Underwood 1994, Smith 2002). Within these areas, if they are large and/or complex, prioritize those areas that support the most populations or greatest extent of the targeted weed populations.

6.4.9.3 Methods

First, a list of priority or targeted weeds needs to be developed. A number of sources, including Cal IPC, CDFA, and the local USDA Forest Service office can provide information on weeds of concern. Once a list of priority weeds has been established and sites have been selected to monitor chosen populations, data on the extent of the population/ infestation needs to be recorded and compared through time. Data should be collected on sighting forms with the location and population boundaries recorded in the field using a GPS or mapped onto an orthophoto field base map. Information on the forms should include the following:

- Gross area of infestation (i.e., overall patch size);
- Percent cover;
- Weighted area of infestation (i.e., gross area multiplied by percent cover);
- Estimated number of individuals using, for example, the following abundance categories:
  - Sparse (1–10 plants observed),
  - Patchy (11–50 plants observed),
  - Widespread (50–100 plants observed),
  - Infested (100+ plants observed);
- Habitat description, including associated species and physical features of the site; and
- Phenology of the population.

In the office, weed data should be uploaded into a GIS layer of point and/or polygon locations and attribute data should be entered into a database. This data can then be contributed to organizations tracking weeds locally (e.g., local USDA Forest Service district or National Park Service district) or throughout the state (e.g., California Early Detection Network), or even nationwide (NAWMA).

6.4.9.4 Further information

California Department of Food and Agriculture (CDFA) Plant Pest Diagnostics Center (http://www.cdfa.ca.gov/plant/PPD/botany_sampling.html); The Invasive Species Council of California (http://www.iscc.ca.gov/index.html), California Invasive Plant Council (Cal IPC; http://www.cal-ipc.org/), California Early Detection Network (http://californiaedn.org/), and the North American Weed Management Association (NAWMA; http://www.nawma.org/).

6.4.10 Riparian channel bank vegetation functions

Channel bank vegetation can perform several important functions. These include (1) shading the channel and thereby preventing additional warming which can negatively affect aquatic habitat; (2) stabilizing banks to prevent excessive erosion and sediment loading to the channel; and (3) providing in-channel coarse woody debris that create structural and habitat complexity for aquatic species. Riparian vegetation, particularly plant species with stoloniferous, rhizomatous, or other kinds of massive root structures, can stabilize channel banks and reduce sediment inputs. Plants such as Nebraska sedge and Geyer's willow stabilize stream banks and slow flood waters by increasing floodplain roughness for flood waters (Winward 2000). Shading can be measured quite directly; however, direct measurement of the other functions is difficult and more frequently assessed using indirect measures.

6.4.10.1 Timing

As described for other meadow characteristics, monitoring should begin at least one and preferably several years before the change in management, enhancement or restoration is implemented. It is generally best to monitor frequently following implementation (at least one time per year) in order to catch and correct or redirect any unexpected or undesired responses to the change. Although measurements of channel bank vegetation are not particularly sensitive to differences in timing during the growing season, the timing of these measurements should be kept consistent to minimize the confounding effects of plant phenology on classification of different meadow plant community types.

6.4.10.2 Site selection

Include areas of the meadow that will be subject to change in management as well as areas that will not be, as described for the BACI design ((Stewart-Oaten, Murdoch, and Parker 1986, Stewart-Oaten and Bence 2001, Underwood 1994, Smith 2002). Within these areas, if they are large and/or complex, prioritize those stream lengths that support the most common vegetation type along their green line (or bankfull position). The extent of community types along both sides of the bank will be measured.

6.4.10.3 Methods

Two completely different methodologies will be applied in order to monitor shade and bank stability.

Channel Shade: The solar pathfinder ™ is a non-electronic and affordable (under $300) device that provides a fast and efficient means of determining changes in channel shade due to changes in riparian canopy cover; it can be used on any day at any time of day to determine light input during any time of the year or over the entire year. See Harris et al. 2005 and the solar pathfinder website (http://www.solarpathfinder.com/) for more detail.

Bank Stability: Bank stability can be indirectly assessed and monitored based on the extent of different plant community types along the channel banks that have been subjected to a change in management or that are part of the control set. See Winward 2000 (Greenline) for more details.

6.4.10.4 Further information

See Coullouden et al. 1999, Elzinga et al. 1998, Harris et al. 2005, and Winward 2000.

6.4.11 Plant recruitment and survival

6.4.11.1 Timing

Begin monitoring as many seasons before treatment as possible and continue monitoring after treatment on an annual basis for the first 3 years. After this, monitoring can be less frequent, such as at 3- to 5-year intervals and, if possible, following events such as particularly wet or dry water years or fire.

6.4.11.2 Site selection

In cases where monitoring is to determine survival rates of installed plants, no control site or pre-implementation monitoring is necessary. However, permanent transects should be established within the actively planted area that reflects the range of variation in physical site conditions. If

possible, establish permanent natural recruitment transects in areas of the meadow that will and will not be subject to the change in management.

6.4.11.3 Methods

Survival of installed plants can be measured using permanent transects in the actively planted area (see Elzinga et al. 1998, Coulloudren et al. 1999). Survival and vigor (e.g., height, percent of live foliage, etc.) of individual plants, located at a recorded point along each transect, can be surveyed at the end of each growing season. Naturally recruiting individuals within 1 meter to either side of the permanent transect can also be included and used to indicate recruitment rates as changes in density (transect length x 2 m) over time. See Winward 2000 (Woody Species Regeneration). Rules will need to be established on how to count multiple stemmed species, such as willow, as well as stoloniferous and rhizomatous species.

6.4.11.4 Further information

See Coullouden et al. 1999, Elzinga et al. 1998, and Winward 2000.

7 REPORTING AND SHARING FINDINGS

7.1 Monitoring Reports

As discussed in Section 5.7, reporting your findings is a critical step for all monitoring efforts. The process of organizing, describing, and interpreting your findings forces one to ferret out the important implications of the monitoring data—to be applied to improve management strategies and / or to adjust the monitoring program (see Figure 1 in Section 3.3). As described in Section 5.7, we recommend that monitoring reports be updated annually for at least the first three years following a major change in management and at five year intervals thereafter. Each year of monitoring data should be added into the previous report, so that the full history of monitoring and response is in a single document. Please refer to the general outline in Section 5.7 for guidance in the composition of Level 2 monitoring reports.

7.2 Sharing Findings in Monitoring Reports

Who should receive the monitoring reports? In many cases, you will need at least to submit reports to the funding source for the restoration project. However, it is generally beneficial to share findings in the monitoring reports (and the reports themselves) with a broader community of people and institutions involved in meadow restoration and management. In that way, we can all learn from each other's accomplishments and challenges and meadow management in the Sierras can be done more effectively with fewer surprises.

One way to make monitoring reports available to other interested parties is to post a PDF version of each annual updated report on a webpage for your host institution, ranch or funding agency. One can also make reports available in hard copy or other digital form (e.g., email attachment or CD) to local watershed groups, the local District office of the Forest Service, the local UC Agricultural Extension, local Resource Conservation District, and to local academic institutions.

7.3 Data Storage and Data Sharing

Once data have been collected, summarized and analyzed, do not discard the source data files (e.g., excel or access). These source data files should be kept in a well-placed and named folder so that they can be found and retrieved easily. When computers are replaced, these data files should be moved onto the new hard drives (which are backed up frequently in case of hard disk-damaging power surges, etc.).

In addition to storing data within the home institution that performed the restoration and monitoring, there have been multiple calls for a publically available website that is maintained by permanent (likely part-time) staff, to house information on meadow condition, restoration, and monitoring in a spatially explicit and retrievable manner. We are hopeful that such website will be created, along with long-term funding to sustain it, such that it can be searched for documents and accompanying data using web-based software.

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Appendices

Appendix A

Level 1 Field Data Sheets

Plant Community Type Plots: Descriptive Information

Page of

Date:

Project Name/No:

Meadow Name: Meadow ID:

Meadow Number: Crew Members:

General comments:

Aerial Photo Number with notes:

Other photo numbers and descriptions

Vegetation Descriptions per Plant Community Type

			Absolute Percent Cover												
Community Type Code	Polygon number	Total Vegetation	Sedge and rush species	Other Graminoids	Forbs	Shrubs (seedlings)	Tree seedlings	Bare mineral soil	Bare organic soil	Rock	Litter	Rooting Density	Saturated soil/standing water	**Notes**

Plant Community Type Plot: Plant Species List with Percent Cover

Page ____ of _____

Date: _____

Project Name/No: _____

Meadow Name: _____ Meadow ID: _____

Meadow Number: _____ Crew Members: _____

Plant Species list

Community Type Code	Polygon number	Specimen collected?	Scientific name	Common name	Layer	Percent cover (absolute)

Appendix B

Data Entry Forms

Table B-1. Field data entry form for plant species composition.

Field Date	Field Crew	Meadow Code	Community Code	Stand Number	Species name	PrctCov
8/9/2010	etb, agm	2	A	A1	Pteridium aquilinum	20
8/9/2010	etb, agm	2	A	A1	Lupinus fulcraetus	10
8/9/2010	etb, agm	2	A	A1	Carex fracta	5
8/9/2010	etb, agm	2	A	A1	Sidalcea malvaeflora	20
8/9/2010	etb, agm	2	A	A1	Veratrum californicum	5
8/9/2010	etb, agm	2	A	A2	Pteridium aquilinum	15
8/9/2010	etb, agm	2	A	A2	Veratrum californicum	15
8/9/2010	etb, agm	2	A	A2	Senecio triangularis	5
8/9/2010	etb, agm	2	A	A2	Lupinus fulcraetus	25
8/9/2010	etb, agm	2	A	A3	Carex fracta	10
8/9/2010	etb, agm	2	A	A3	Pteridium aquilinum	15
8/9/2010	etb, agm	2	A	A3	Lupinus fulcraetus	25
8/9/2010	etb, agm	2	A	A3	Sidalcea malvaeflora	5
8/9/2010	etb, agm	2	A	A3	Senecio triangularis	5
8/9/2010	etb, agm	2	B	B1	Abies concolor	8
8/9/2010	etb, agm	2	B	B1	Elymus glaucus	8
8/9/2010	etb, agm	2	B	B1	Ceanothus cordulatus	15
8/9/2010	etb, agm	2	B	B1	Carex abrupta	6
8/9/2010	etb, agm	2	B	B1	Ribes roezlii	10

Table B-2. Field data entry for summary vegetation cover.

Meadow	Community Code	Stand	% Sedge & Rush	% Grass	% Forb	% Shrub	% Tree	% Moss	% Total Veg Cover	% Bare mineral	% Bare organic	% Rock, gravel	% Litter	Surface Moisture	Rooting Density
2	A	A1	10	5	60	2	1	4	75	15	0	5	5	Med	Low
2	A	A2	15	5	60	5	2	2	80	10	0	5	10	Med	Low

Appendix C

Forage Nutrient Content Sampling and Analysis

F-2589

OKLAHOMA COOPERATIVE EXTENSION SERVICE

Collecting Forage Samples for Analysis

Hailin Zhang
Director
Soil, Water, and Forage Analytical Laboratory

Daren Redfearn
Forage and Pasture Management Specialist

John Caddel
Extension Forage Agronomist

Oklahoma Cooperative Extension Fact Sheets are also available on our website at: **http://www.osuextra.com**

Forages furnish essential energy, proteins, vitamins, minerals, and fibers in livestock diets. Many factors (e.g. variety, maturity, growing conditions, handling practices, etc.) affect forage quality prior to the time it is fed. As a result, predicting forage quality values from standard books often grossly overestimates or underestimates feeding value. A better way to determine feeding value is to have a representative forage sample tested by a laboratory that uses proven and accepted methods of forage analysis. The first and most important step in obtaining a meaningful analysis is to collect a representative forage sample. This fact sheet describes proper methods for collecting representative samples. If one is not willing to properly sample their forage, the benefits of forage testing will not be realized.

Sampling Equipment

Equipment required for collecting forage samples includes a forage probe, a mixing bucket, and sample bags. If a forage probe is not available, sampling can be done by hand, but increased leaf loss is likely due to shattering. When sampling by hand, use shears or scissors to cut the sample into 2-3" pieces, then subsample the composite sample using the quartering method. Sampling with a probe is preferred since it is faster and a better sample is obtained.

Several types of forage probes can be purchased from farm supply companies. Most are operated using a hand brace or electric drill (Figure 1). Some include a collection canister to make sampling faster. Probe design does not significantly affect sampling accuracy. The more important factor is to use the proper sampling method.

Sampling Methods

When to Sample

Forage should be sampled as near to the time of feeding or sale as possible. Allow enough time for test results to be returned for inspection by a buyer or for ration formulation. Approximately 2-3 weeks should be allotted if submitting samples by mail. Samples take from 1-5 days to be processed by a laboratory depending on the tests requested, the methods used, and the overall number of samples received. July through October tend to be the busiest times of year for forage analysis. Some laboratories have very short turnaround times (an hour) when everything is analyzed by NIRS (near infrared reflectance spectroscopy).

Quarting a Sample

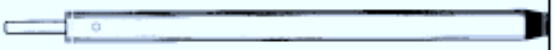
Quarting is used to reduce a sample to a smaller, more manageable size in an unbiased manner. Prior to quartering, forage samples collected by hand must be cut into 2-3" pieces with shears or scissors and thoroughly mixed. Care must be taken to prevent leaf loss. Cored samples can be mixed as is. Pour the entire sample evenly into a pile on a clean surface, preferably paper, plastic, etc. Level the pile and divide into equal quarters (see diagram). Select and save two opposite quarters including the fines. If the sample is still too large, repeat the entire quartering procedure until the proper sample size is obtained. Always use the quartering method when reducing sample size to obtain a

Forageurs Hay Probe

This probe can be ordered from Forageurs Crop., 20788 Holycke Avenue W., Lakeville, MN 55044 (phone: 612-469-2596). It is made of stainless steel with a resharpenable hardened-steel tip. The probe has a canister attached where up to 25 cores can be collected as bales are sampled. Both 14" and 24" tubes are available that cut cores 0.6" in diameter. The probe is designed for use with a hand brace but can be used at slow speeds with an electric drill.

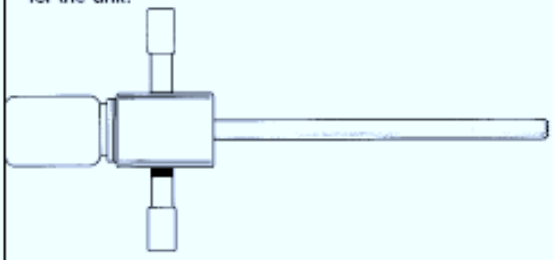
Penn State Forage Sampler

This probe can be ordered from Nasco, 901, Janesville Avenue, P.O. box 901, Fort Atkinson, WI 53538-0901 (Phone: 414-563-2446). It is made of stainless steel with a replaceable hardened-steel cutting tip. The tube is 18" long and cuts a core 0.75" in diameter. The probe is available for use with an electric drill or hand brace and must be disassembled and emptied between each core. Extension adapters are available for deeper sampling.



Hay Chec Sampler

This probe can be ordered from Hodge Products Inc., P.O. Box 1326, El Cajon, CA 92022 (Phone: 619-444-3149) It is made of stainless steel with a resharpenable serrated, hardened-steel tip. The tube is 12" long and cuts a core 0.44" in diameter. The unit has a large body with handles for pushing the sampler into a bale by hand rather than drilling. A canister is attached where cores are collected as bales are sampled. No extensions are available for the unit.

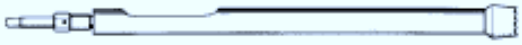


Utah Hay Sampler

This probe can be ordered from Jody Gale, County Agent, Utah State University, Loga, UT 84322-7820 (Phone: 801-864-4377). It is made of steel with a resharpenable, serrated, hardened-steel tip. The tube is 15" long and cuts a core 0.5" in diameter. External threads on the tube help pull the sampler into the bale. A canister is attached where up to 20 cores can be collected as bales are sampled.

Oakfield Probe

This probe can be ordered from Oakfield Apparatus Inc., P.O. Box 65, Oakfield, WI 53065 (Phone 414-583-4114). It is made of stainless steel with a replaceable serrated screw-on tip. The tube is 18" long and cuts a core of 0.75" in diameter. Cores are removed from an open area on the side of the tube between samplings. The Probe is available for use with an electric drill or hand brace. Extension adapters are available for deeper sampling.



Homemade Probes

Forage probes can be made at home to avoid the expense of purchasing commercially available types. Research shows homemade probes work just as well as commercial probes when proper sampling techniques are used. One way to make a homemade probe is to cut off the ends of a golf club leaving a shaft at least 15" long and 0.4" in diameter. A plastic bag can be attached to the larger end with a rubber band, and the shaft driven into a bale for sampling. This type of homemade probe is effective for sampling compact bales. For more loosely packed hay, farmers often build homemade probes with 1-2" diameter tubes. The larger diameter reduces problems with sifting of the probe through the hay and increases sampling speed. These types of homemade probes often mimic commercial probes in that they are used with an electric drill or hand brace.

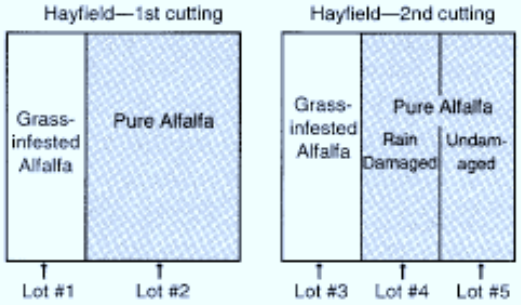


Figure 2. Selecting uniform lots of hay.

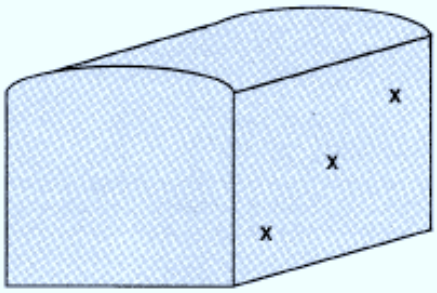


Figure 3. Recommended sample locations for a loose hay stack.

Small Square Bales

Select a minimum of 20 average-looking bales for coring. Collect a core from each bale by probing into one end of the bale at right angles to the surface. Do not slant the probe at an up, down, or sideways angle. Combine the 20 cores in a bucket and mix thoroughly.

To hand sample, reach inside each bale and remove one handful of forage. Be careful not to lose leaves. Cut the sample into 2-3" pieces. Combine all samples in a bucket and mix thoroughly.

Small square bales are normally stored in a barn or under a cover, making sampling difficult. Some producers sample bales during or immediately after stacking. Others wait until near feeding time, then select representative bales from throughout the stack. The first method is acceptable if no damage occurs during storage, in which case the lot must be retested. The second method is also acceptable. Choose the method that satisfies your needs.

Large Round Bales

Select a minimum of 10 representative bales and collect two cores from the circumference of each. Combine the cores in a bucket and mix well. Large round bales should be sampled to the center using a long probe or one with a extension adapter. Angle the probe in an upward direction to reduce the potential for water entering the core holes.

To hand sample, reach inside each bale and remove two or three handfuls from different locations. Take care not to lose leaves. Combine the grab samples in a bucket after cutting them into 2-3" pieces, and mix well.

Because round bales are normally stored outside and subjected to weathering, collect samples 2-4 weeks before the hay is sold or feeding begins rather than sampling immediately after harvest.

Large Square Bales

Select a minimum of 10 representative bales. Collect two cores from each bale, one from each end, by probing at right angles to the surface. Use a long probe or a regular probe with an extension adapter. If a probe is unavailable, sample by extending from the top to bottom corner (Figure 3). The top sample should be collected approximately two feet from the top edge of the stack and the bottom sample approximately two feet above the ground. If a forage probe is not available, sample by hand as described for large round bales. Combine cores or grab samples in a bucket and mix well.

Because hay stacks are stored outside after harvest, collect samples as near to the time of selling or feeding as possible (approximately 2-4 weeks).

Cubes of Pellets

Hay cubes or pellets are dense, bite-size hay packages. They are very susceptible to weather deterioration and should be stored inside. Because they are suitable for mechanized handling, cubes and pellets are generally dropped from an overhead elevator into a covered storage area forming a cone-shaped pile. Collect a handful of cubes or pellets from at least 6 locations around the pile and place into a bucket. Avoid collecting fines since they are only a small percentage of the total.

Hay cubes and pellets are sometimes bagged. If a guaranteed analysis is not available, select at least 6 bags and collect a handful of sample from each. Combine samples in a bucket and mix well.

Sampling Standing Forage

Standing forage is sometimes tested to determine if it is worth cutting for hay or to determine if grazing animals require supplemental feed. Select at lease 8 representative locations and clip the forage at grazing or harvest height from a one square foot area at each location. In grazing situations try and select the species being selectively grazed. Cut the samples into 2-3" pieces, combine in a bucket and mix well. Spread the sample on paper and allow it to air-dry for 2 days or place in a pan and dry overnight in an oven at 150°F before mailing it to the laboratory. Molding may occur if wet samples are mailed.

Sampling Forage for Nitrate

problem. A nitrate test is only good for the bales or field location from which the sample came.

Select bales from hay that is suspected of containing excessive nitrate. Sample the bales using coring procedures outlined previously. When sampling fields, clip at least 20 representative plants at grazing height from the suspected area. Cut into 2-3" pieces, combine, and mix well in a bucket.

A qualitative field test, the diphenylamine test, can be used to determine suspect bales or field locations. This test indicates the potential for nitrate poisoning but does not give the amount of nitrate present. If excessive nitrates are indicated by the diphenylamine test, a sample should be collected for laboratory analysis. See your local OSU county Extension Educator for detailed information on the diphenylamine test.

Silage Sampling

The same general care must be exercised in collecting silage samples as in collecting hay samples. Forage probes cannot be used for sampling silage, so one must rely on grab samples.

Fresh Cut

The advantage of sampling silage as it is placed in the silo is that the test results will be known when the silage is ready to feed. When the moisture content of forage going into the silo is in the range of 64 to 72%, the test results of the fresh sample are very similar to those of the fermented product. Exceptions include silage that is heat damaged, moldy, or has undergone considerable seepage. Retesting is required in such cases.

Remove 2-3 gallons of silage from different sections of a load and save about a quart using the quartering method. Freeze the samples until all loads are sampled. Combine samples, mix thoroughly, and reduce to about one quart by quartering. The final sample should be placed in the cloth forage sample bag, and the full forage bag inserted into a plastic bag to prevent moisture loss during mailing. Remove excess air from the plastic bag before sealing. Do not insert the plastic bag inside the cloth forage bag since damage may result when it is processed by the laboratory. Freeze the sample prior to mailing and mail samples early in the week to avoid weekend delays and reduce chances of molding.

Upright Silos

If a silo unloader is used, catch at least 12 handfuls of silage as it is discharged from the silo. Do not sample the top or bottom 2 to 3' in order to avoid unrepresentative, moldy, or otherwise damaged silage. Place the silage in a clean tub or other suitable container, mix thoroughly, and reduce the sample size to approximately one quart using the quartering method. Place the sample in a forage bag and mail as described for fresh cut samples. If an unloader is not used, the same type of hand grab technique can be used from the silage thrown down for feeding. Silage in the silo can only be sampled to the depths one can reach. The sample only represents that portion of silage. Other parts of the silo may have silage of very different quality.

Horizontal Silos

Horizontal silos can be sampled using the hand grab method as described for upright silos. The silo should be well-opened before sampling and care taken not to include spoiled silage from the top and sides. Grab samples should be taken from different areas across the entire surface of the open face of the silo. Combine samples, mix thoroughly, and quarter to reduce the size to about one quart.

Submitting a Sample for Analysis

Samples can be submitted for analysis by the OSU Soil, Water, and Forage Analytical Laboratory through the local county extension office. The county office will provide sample collection bags and either loan a forage probe or provide information for ordering one.

Completely fill the forage bag with sample (approximately one quart) and mark the attached tag in pencil with all appropriate test and sample information. Comments or observations about the sample or sampling conditions can be noted directly on the tag. The tags are returned to the sender with the test report and will provide interpretive information when consulting with the Extension Educator. Avoid using pens or markers when writing on the tags since these tend to smear or run if the sample is moist or the tag gets wet.

Results are reported on a wet, as fed, and dry matter basis. For accurate moisture determinations, special submission procedures are required. Place the forage sample inside the cloth bag, then place the full cloth bag within a plastic bag. Press the sample firmly to remove excess air, and seal the plastic bag. A plastic bag is not necessary if the sample is already air dry or the sender is interested in results on a dry matter basis only. Never place a plastic bag inside a cloth bag since damage will occur during processing.

Other questions about submission procedures can be directed to your local county Extension Educator.

Problem and Solution:

Obtaining the necessary number of cores with a hand brace from each lot of hay requires much physical labor. An obvious (but incorrect) solution is to reduce the number of lots and/or reduce the number of cores per lot. These shortcuts result in quality estimates that are not representative of the forage. A much better solution is to use a 1/2" electric drill to turn probes. However hay is sometimes stored far from electric outlets. Most cordless (rechargeable) electric drills are not suitable for forage probes because some models lack power and some single-speed models turn too fast. A portable generator may be a good way to run conventional drills. If many samples are taken each year, the investment will pay for itself quickly.

Colorado State University

Hay Forage Analysis

Drs. Robert J. Callan, Stacey R. Byers, and Timothy N. Holt
James L. Voss Veterinary Teaching Hospital

What Is a Hay Forage Analysis?

Hay Forage Analysis provides the nutrient content of the hay that you are feeding to your animals.

- **Forage Nutrient Content Varies Between**
  - Seasons
  - Geographic Locations
  - Cuttings
  - Storage Conditions.

By knowing the nutrient content of the hay, you can better manage the nutrition of your animals for better health and productivity

Why Should I Perform a Hay Forage Analysis?

Nutrient requirements of livestock vary with age, use, season, and production status. Forages generally make up the primary feed for most livestock.

- Knowing the **ENERGY** and **PROTEIN** content of forages is important to provide optimum nutrition for your animals.
- Forage analysis can determine **MINERAL LEVELS** in the forages.
- **Different areas of the country** have different availability of minerals in the soil and thus result in forages that may or may not meet the requirements of the animal for specific minerals.
- Knowing the nutrient content of your forages, allows you to better **tailor additional supplements** to meet the needs of your animals

How Do I Collect Hay for Forage Analysis

The most important aspect of collecting a hay sample for forage analysis is obtaining a representative sample of the entire lot of hay. This means randomly sampling several bales and obtaining a representative sample from each bale. While it is possible to simply grab some hay from several bales, this often results in a composite sample that is not representative of the hay because of over representing stems versus leaves. This is particularly true with alfalfa or alfalfa-mix hays. In addition, hand grab samples tend to collect forage from the exterior of the bale where the nutrient content of the forage may be affected by exposure to the environment.

Core Hay Samples

Core Samples are the preferred method of sampling hay for forage nutrient analysis. Quality hay core probes are made of a sturdy metal tube with a sharpened or serrated end to cut through the hay when obtaining the core. The length of the probe should be at least 14 inches and 18 to 24 inches is preferred. The probe diameter should be between 3/8 and 3/4 inches. This will provide about ½ pound of hay from 20 samples. The purpose is to collect a representative sample of stems and leaves.

Obtaining A Core Hay Sample For Analysis

- Sample each "lot" or cutting of hay separately.
- Obtain core samples from at least **20 bales** selected at **random** throughout the entire lot. If there are less than 20 bales, take multiple cores from all of the bales until you have 20 core samples.
- Collect core samples from the side of the bale that is most resistant to puncture.
  - **Square Bales:** Sample from the small ends.
  - **Round Bales:** Sample from the side.
- Drive the entire probe into each bale.
- Empty the core chamber into the collection canister (multi-bore probes) or into your collection bag (single-bore probes) between each bale.
- Collect the sample into a **1 Quart Ziploc Bag**.
- Squeeze out the air and seal the bag.
- **Label** the bag accordingly.
- Send the sample to the lab the same day as collection or as soon as possible.

StarQualitySamplers.com

Where Can I Get a Forage Sample Probe?

Hay core probes are available from multiple sources. Information on several quality hay core probes is available at the **National Forage Testing Association.**

http://www.foragetesting.org

- **Colorado Hay Probe:** Nasco - http://www.enasco.com
- **Penn State Forage Sampler:** Nasco - http://www.enasco.com
- **AMS Hay & Forage Probe:** http://www.ams-samplers.com/
- **Best Harvest Hay Sampler Probe:** http://bestharveststore.com/11.html
- **Star Forage Sampler:** http://www.starqualitysamplers.com/forage.php
- **Hart Forage Sampler:** Hart Machine Company, 1216 SW Hart St, Madras, OR 97741, 541-475-3107

Where Do I Send Hay for Forage Analysis

There are many laboratories across the country that perform forage nutrient analysis. The first way to ensure a quality analysis is to utilize a laboratory that is certified by The National Forage Testing Association (NFTA, http://www.foragetesting.org/). Certification means that this laboratory meats specific quality testing standards and demonstrates proficiency and accuracy for reporting percent dry matter, crude protein, acid detergent fiber, and neutral detergent fiber. A list of certified labs can be obtained from the NFTA web site.

Wet Chemistry or

There are two general methods typicall
analysis, **Near Infrared Reflectance S**
and **Wet Chemistry**. While NIR analys
is not considered as accurate as wet ch
determining basic nutrient analysis incl
is often not suitable for accurate determ

What Do the Forage Ana

- **Percent Dry Matter (DM):** The perce
For hay, this is typically around 87-95
require higher as fed intake to deliver
- **Crude Protein (CP):** An estimate of t
nitrogen of the feed and reported as a
hay is 8 to 20% on a DM basis.
- **Neutral Detergent Fiber (NDF):** Mea
consisting of hemicelluloses, cellulose
carbohydrates that make up the cell w
material. NDF predicts voluntary intal
more fiber to the forage which takes l
decreases voluntary intake. A normal
DM basis.
- **Acid Detergent Fiber (ADF):** A meas
and leaves out the more digestible he
of digestibility of the hay. As ADF incr
normal range in hay is 25 to 45% on a
- **Relative Feed Value (RFV):** A calcul
digestibility (ADF) and intake (NDF).
the forage. RFV is primarily used for
cattle. It will routinely give a low valu
accurately reflect their feed value. Th
have a higher NDF (limits total feed in
time, they have a lower lignin concent
digestible. What this does in the RFV
feed intake and energy value of grass
RFV relative to alfalfa hay.
- **Nonstructural Carbohydrates (NSC**
carbohydrates in the plant including s
primary carbohydrate energy source
- **Crude Fat:** The amount of fat and oth
the forage. Fat provides about 2.25 ti
compared to carbohydrates and prote
(>5%) in the total diet can adversely a
- **Total Digestible Nutrients (TDN):** TI
of the available energy density of the
digestible protein, digestible NSC, dig
digestible fat.
- **Minerals:** Minerals are critical for the
in the body. Too little (deficiency) or t
minerals can result in poor growth, po
Mineral content of feed can vary grea
good to evaluate some of the importa
help select an appropriate supplemen
you are feeding

VETERINARY TEA
970-297-5000 http:

Appendix D

List of Common Meadow Plant Species with Wetland Indicator Status and USFS R5 Functional Group Information

SPECIES	SCIENTIFIC NAME	WETLAND	WET	MOIST	DRY	FUNCTION	N FIXER	GRASS	GRASSLIKE	FORB	WOODY	LIFEHIST	ROOT	HT	LATERALS
ABCO	Abies contorta	APL	E	E	E	WOODYDRY	0	0	0	0	1	2	10	100	2
ABMA	Abies magnfica	FACU	E	E	E	woodydry	0	0	0	0	1	2	15	100	2
ACMI2	Achillea millefolium	FACU	E	E	E	rhizforbdry	0	0	0	1	0	2	15	4	4
ACHNA	Achnatherum	FACU	E	M	L	gramupl	0	1	0	0	0	2	10	5	2
ACLE	Achnatherum lettermanii	FACU	E	M	L	gramupl	0	1	0	0	0	2	4	5	2
ACLE8	Achnatherum lettermanii	FACU	E	M	L	gramupl	0	1	0	0	0	2	4	5	2
ACLE9	Achnatherum lettermanii	FACU	E	E	L	gramupl	0	1	0	0	0	2	12		
ACNE9	Achnatherum nelsonii	UPL	E	M	L	gramupl	0	1	0	0	0	2	7	5	2
ACCO4	Aconitum columbianum	FACW	L	L	L	taprootwet	0	0	0	1	0	2	18	5	2
AGAU2	Agoseris aurantiaca	FACU	E	M	M	taprootdry	0	0	0	1	0	2	11	4	2
AGGL	Agoseris glauca	FACU	E	E	E	taprootdry	0	0	0	1	0	2	5	4	2
AGGR	AGOSERIS GRANDIFLORA	FAC	E	E	E	taprootdry	0	0	0	1	0	2	7	4	2
AGHE2	Agoseris heterophylla	FAC	E	E	E	taprootdry	0	0	0	1	0	1	8	4	1
AGOSE	Agoseris sp.	FAC	E	E	E	taprootdry	0	0	0	1	0	2	13	4	2
AGIN2	AGROPYRON INTERMEDIUM	UPL	E	E	E	gramdry	0	1	0	0	0	2	4	3	4
AGEX	Agrostis exarata	FACW	E	E	L	gramshallow	0	1	0	0	0	2	14	4	4
AGGI2	Agrostis gigantea	FAC	E	E	M	gramshallow	0	1	0	0	0	2	12	4	4
AGHA2	Agrostis hallii	FACW	E	E	E	gramshallow	0	1	0	0	0	2	5	4	5
AGTH2	Agrostis humilis	FACW	M	M	L	gramshallow	0	1	0	0	0	2	14	4	4
AGID	Agrostis idahoensis	FACW	L	L	L	gramshallow	0	1	0	0	0	2	24	4	3
AGOR	Agrostis oregonensis	FACW	L	L	L	gramshallow	0	1	0	0	0	2	11	4	2
AGDI	Agrostis pallens	FACW	L	L	L	gramshallow	0	1	0	0	0	2	14	4	4
AGPA8	Agrostis pallens	FACW	L	L	L	gramshallow	0	1	0	0	0	2	14	4	4
AGSC	Agrostis scabra	FAC	E	E	E	gramshallow	0	1	0	0	0	2	19	4	3
AGSC5	Agrostis scabra	FAC	E	E	E	gramshallow	0	1	0	0	0	2	19	4	3
AGROS	Agrostis sp.	FAC	E	E	L	gramshallow	0	1	0	0	0	2	20	4	2
AGST	Agrostis stolonifera	FACW	E	E	E	gramshallow	0	1	0	0	0	2	15	4	5
AGST2	Agrostis stolonifera	FACW	E	E	E	gramshallow	0	1	0	0	0	2	15	4	5
AGST8	Agrostis stolonifera	FACW	E	E	E	gramshallow	0	1	0	0	0	2	13	4	5
AGTH	Agrostis thurberiana	OBL	M	M	L	gramshallow	0	1	0	0	0	2	12		
AGVA	Agrostis variabilis	FACW	L	L	L	gramshallow	0	1	0	0	0	2	10	4	4
AICA	Aira caryophyllea	FAC	E	E	E	annual	0	1	0	0	0	1	1	4	1
AIRA	Aira sp.	FAC	E	E	E	annual	0	1	0	0	0	1	1	4	1
ALLIU	Allium sp.	FAC	L	L	M	taprootdry	0	0	0	1	0	2	9	4	3
ALAE	Alopecurus aequalis	OBL	E	E	E	gramshallow	0	1	0	0	0	2	8	5	2
ALOPE	Alopecurus sp.	FAC	E	E	L	gramshallow	0	1	0	0	0	2	8	5	2
AMPS	Ambrosia psilostachya	FACU	E	E	E	taprootdry	0	0	0	1	0	1	6	4	1
ANAR	Anagallis arvensis	FAC	E	E	E	taprootdry	0	0	0	1	0	1	6	2	1
ANDE3	ANEMONE DELTOIDEAE	UPL	E	E	E	taprootdry	0	0	0	1	0	2	3	1	2
ANCA10	ANEMOPSIS CALIFORNICA	OBL	M	M	M	rhizforbwet	0	0	0	1	0	2	4	1.5	4
ANCO	Antennaria corymbosa	FAC	E	E	M	taprootdry	0	0	0	1	0	2	8	3	3

SPECIES	SCIENTIFIC NAME	WETLAND	WET	MOIST	DRY	FUNCTION	N FIXER	GRASS	GRASSLIKE	FORB	WOODY	LIFEHIST	ROOT	HT	LATERALS
ANDI2	Antennaria dimorpha	FAC	E	E	M	taprootdry	0	0	0	1	0	2	12	3	3
ANME2	Antennaria media	FAC	E	E	M	taprootdry	0	0	0	1	0	2	10	3	3
ANRO2	Antennaria rosea	FAC	E	E	E	taprootdry	0	0	0	1	0	2	8	3	3
ANTEN	Antennaria sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	6	3	3
ANTENNARIA	Antennaria sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	8	3	3
ARABI	Arabis sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	6	3	2
ARENA	Arenaria sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	6	3	3
ARAM2	Arnica amplexicaulis	FAC	E	E	M	rhizforbdry	0	0	0	1	0	2	17	4	5
ARCH3	ARNICA CHAMISSONIS	FAC	E	E	M	rhizforbdry	0	0	0	1	0	2	16	4	5
ARCHF	ARNICA CHAMISSONIS	FAC	E	E	M	rhizforbdry	0	0	0	1	0	2	16	4	5
ARLO6	Arnica longifolia	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	12	4	5
ARMO	Arnica mollis	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	9	4	5
ARMO4	Arnica mollis	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	9	4	5
ARMO4	Arnica mollis	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	9	4	5
ARNE3	ARNICA NEVADENSIS	UPL	E	E	E	rhizforbdry	0	0	0	1	0	2	12	4	5
ARSO2	ARNICA SORORIA	UPL	E	E	E	taprootdry									
ARNIC	Arnica sp.	FAC	M	M	M	rhizforbdry	0	0	0	1	0	2	12	4	5
ARTRT	Artemesia tridentata	FACU	E	E	E	taprootdry	0	0	0	1	0	2	5	5	3
ARCA13	Artemisia cana	FAC	E	E	M	rhizforbdry	0	0	0	1	0	2	16	4	5
ARDO3	Artemisia douglasiana	FAC	E	M	M	taprootdry	0	0	0	1	0	2	5	4	3
ARLU	Artemisia ludoviciana	FACU	E	E	E	rhizforbdry	0	0	0	1	0	2	5	4	4
ARTEM	ARTEMISIA SP.	FACU	E	E	E	taprootdry	0	0	0	1	1	2	3	6	3
ARTR2	ARTEMISIA TRIDENTATA	FACU	E	E	E	taprootdry	0	0	0	1	1	2	3	6	3
ARTRV	Artemisia tridentata vaseyana	FACU	E	E	E	taprootdry	0	0	0	1	1	2	1	6	3
ASAL	Aster alpigenus ssp. andersonii	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	12	1	4
ASAL2	Aster alpigenus ssp. andersonii	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	12	1	4
ASALA	Aster alpigenus ssp. andersonii	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	14	4	4
ASALA2	Aster alpigenus ssp. andersonii	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	12	1	4
ASALA3	Aster alpigenus ssp. andersonii	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	12	1	4
ASFO	Aster foliaceous	FAC	E	E	E	rhizforbdry	0	0	0	1	0	2	16	4	4
ASOC	Aster occidentalis	FAC	E	E	E	rhizforbdry	0	0	0	1	0	2	14	4	4
ASTER	ASTER SP.	FAC	E	E	E	rhizforbdry	0	0	0	1	0	2	12	4	4
BOCR	Botrychium crenulatum	FAC	L	L	L	taprootdry	0	0	0	1	0	2	13	2	2
BOPI	Botrychium PINNATUM	FAC	L	L	L	taprootdry	0	0	0	1	0	2	19	2	2
BOSI	Botrychium simplex	FAC	L	L	L	taprootdry	0	0	0	1	0	2	19	2	2
BOTRY	Botrychium SP.	FAC	L	L	L	taprootdry	0	0	0	1	0	2	19	2	2
BRASS	Brassica sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	12	4	2
BRODI	Brodiaea sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	12	4	3
BRCA5	Bromus carinatus	FAC	E	M	L	gramupl	0	1	0	0	0	2	8	5	2
BRDI3	BROMUS DIANDRUS	UPL	E	E	E	annual	0	1	0	0	0	1	0	2	1
BRHO2	BROMUS HORDACEOUS	UPL	E	E	E	annual									
BRIN2	Bromus inermis	FAC	E	E	M	gramupl	0	1	0	0	0	2	6	5	5
BRJA	BROMUS JAPONICUS	FACU	E	E	E	annual	0	1	0	0	0	1	1	1	1
BRMA	BROMUS MADRITENSIS	UPL	E	E	E	annual									
BROMUS	BROMUS SP.	FACU	E	M	L	gramupl									
BRSU2	Bromus suksdorfii	FAC	E	M	L	gramupl	0	1	0	0	0	2	8	5	2
BRTE	Bromus tectorum	UPL	E	E	E	gramupl	0	1	0	0	0	1	1	4	1
CACA4	Calamagrostis canadensis	FACW	L	L	L	gramdeep	0	1	0	0	0	2	15	5	4

SPECIES	SCIENTIFIC NAME	WETLAND	WET	MOIST	DRY	FUNCTION	N FIXER	GRASS	GRASSLIKE	FORB	WOODY	LIFEHIST	ROOT	HT	LATERALS
CAUM2	Calyptridium umbellatum	UPL	E	E	E	taprootdry	0	0	0	1	0	2	2	1	2
CALAM	CAMAGROSTIS SP.	FAC	L	L	L	gramdeep									
CAQU2	Camassia quamash	FACW	L	L	L	taprootwet	0	0	0	1	0	2	22	4	2
CARDU	Carduus sp.	FACU		E	E	taprootdry	0	0	0	1	0	2	3	4	2
CAAB	Carex abrupta	FACW	L	L	L	gramdeep	0	0	1	0	0	2	16	4	3
CAAQ	Carex aquatilis	OBL	L	L	L	gramdeep	0	0	1	0	0	2	25	5	3
CASI3	Carex aquatilis	OBL	L	L	L	gramdeep	0	0	1	0	0	2	25	5	3
CAAT3	Carex athrostachya	FACW	L	L	L	gramdeep	0	0	1	0	0	2	17	4	3
CAAU	Carex aurea	OBL	L	L	L	gramdeep	0	0	1	0	0	2	16	3	4
CAAU3	Carex aurea	OBL	L	L	L	gramdeep	0	0	1	0	0	2	16	3	4
CABO2	Carex bolanderi	FACW	L	L	L	gramshallow	0	0	1	0	0	2	13	4	3
CACA13	Carex capitata	OBL	L	L	L	gramdeep	0	0	1	0	0	2	36	3	3
CADE8	Carex densa	OBL	L	L	L	gramdeep	0	0	1	0	0	2	15	4	3
CADO	Carex douglasii	FACU	E	M	M	gramupl	0	0	1	0	0	2	12	3	4
CADO2	Carex douglasii	FACU	E	M	M	gramupl	0	0	1	0	0	2	12	3	4
CAEC	Carex echinata	OBL	L	L	L	gramdeep	0	0	1	0	0	2	39	4	3
CAECE	Carex echinata ssp. echinata	OBL	L	L	L	gramdeep	0	0	1	0	0	2	17	4	3
CAEL2	CAREX ELEOCHARIS	OBL	L	L	L	gramdeep	0	0	1	0	0	2	17	4	3
CAFE4	Carex feta	OBL	L	L	L	gramshallow	0	0	1	0	0	2	11	5	3
CAFI	Carex filofolia	FACW	L	L	L	gramshallow	0	0	1	0	0	2	9	4	3
CAFI2	Carex fissuricola	FACW	L	L	L	gramdeep	0	0	1	0	0	2	15	5	3
CAHE8	Carex heteroneura	FACW	L	L	L	gramdeep	0	0	1	0	0	2	15	5	3
CAIL	Carex illota	OBL	L	L	L	gamdeep	0	0	1	0	0	2	15	5	3
CAIN10	Carex integra	FACW	L	L	L	gramdeep	0	0	1	0	0	2	17	4	3
CAJO	Carex jonesii	FACW	L	L	L	gramdeep	0	0	1	0	0	2	17	4	5
CALA30	Carex lanuginosa	OBL	L	L	L	gramdeep	0	0	1	0	0	2	22	5	5
CALE6	CAREX LEAVENWORTHII	FACW	L	L	L	taprootwet	0	0	0	1	0	2	17	4	2
CALE	Carex lemmonii	OBL	L	L	L	gramshallow	0	0	1	0	0	2	13	5	3
CALE7	Carex lemmonii	OBL	L	L	L	gramshallow	0	0	1	0	0	2	13	5	3
CALE8	Carex lenicularis	OBL	L	L	L	gramdeep	0	0	1	0	0	2	27	5	3
CALU6	Carex luzulifolia	OBL	L	L	L	gramdeep	0	0	1	0	0	2	16	5	3
CALU7	Carex luzulina	OBL	L	L	L	gramdeep	0	0	1	0	0	2	22	5	3
CAMA13	Carex mariposana	FACU	L	L	L	gramdeep	0	0	1	0	0	2	15	2	3
CAMI7	Carex microptera	FACW	M	M	L	gramshallow	0	0	1	0	0	2	13	4	3
CAMU6	Carex multicostata	FAC	M	L	L	gramdeep	0	0	1	0	0	2	15	4	3
CANE	Carex nebrascensis	OBL	L	L	L	gramdeep	0	0	1	0	0	2	17	5	5
CANE2	Carex nebrascensis	OBL	L	L	L	gramdeep	0	0	1	0	0	2	17	5	5
CANE5	Carex nervina	FACW	L	L	L	gramdeep	0	0	1	0	0	2	23	5	3
CANU5	CAREX NUDATA	FACW	L	L	L	gramdeep	0	0	1	0	0	2	18	2	4
CAPA14	CAREX PACHYSTACHYA	FACW	L	L	L	gramdeep	0	0	1	0	0	2	16	2	3
CAPR	Carex praegracilis	FACW	L	L	L	gramshallow	0	0	1	0	0	2	13	4	5
CAPR5	Carex praegracilis	FACW	L	L	L	gramshallow	0	0	1	0	0	2	13	4	5
CARA6	Carex raynoldsii	FACW	L	L	L	gramdeep	0	0	1	0	0	2	16	2	3
CASC12	Carex scopulorum	OBL	L	L	L	gramdeep	0	0	1	0	0	2	24	4	5
CASC13	Carex scopulorum	OBL	L	L	L	gramdeep	0	0	1	0	0	2	24	4	5
CASI2	Carex simulata	OBL	L	L	L	gramdeep	0	0	1	0	0	2	19	4	5

SPECIES	SCIENTIFIC NAME	WETLAND	WET	MOIST	DRY	FUNCTION	N FIXER	GRASS	GRASSLIKE	FORB	WOODY	LIFEHIST	ROOT	HT	LATERALS
CAUN3	CAREX UNILATERALIS	FACW	L	L	L	gramdeep									
CAUT	Carex utriculata	OBL	L	L	L	gramdeep	0	0	1	0	0	2	29	5	5
CAVE5	Carex vernacula	FACW	L	L	L	gramshallow	0	0	1	0	0	2	13	5	5
CAVE	Carex vesicaria	OBL	L	L	L	gramdeep	0	0	1	0	0	2	20	5	5
CAVE6	Carex vesicaria	OBL	L	L	L	gramdeep	0	0	1	0	0	2	20	5	5
CALE18	Castilleja lemmonii	FACW	L	L	L	gramdeep	0								
CESO3	Centaura solstitialis	FACU	E	E	E	taprootdry	0	0	0	1	0	1	12	4	1
CEAR4	Cerastium arvense	FACU	E	E	E	taprootdry	0	0	0	1	0	2	12	4	2
CEBE2	Cerastium beeringianum	FACU	E	E	E	taprootdry	0	0	0	1	0	2	20	4	2
CERAS	Cerastium sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	2	17	4	2
CHENO	Chenopodium sp.	UPL	E	E	E	taprootdry									
CHNA2	Chrysothamnus nauseosa	FACU	E	E	E	taprootdry	0	0	0	1	1	2	4	6	3
CIAR4	CIRSIUM ARVENSE	FACU	E	E	E	taprootdry	0	0	0	1	0	2	10	4	2
CIOC	Cirsium occidentale	FACU	E	E	E	taprootdry	0	0	0	1	0	2	6	4	2
CISC2	Cirsium scariosum	FACU	E	E	E	taprootdry	0	0	0	1	0	2	4	4	2
CIRSI	Cirsium sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	2	10	4	2
CLAYT	Clatonia sp.	FACW	M	M	M	taprootwet	0	0	0	1	0	2	12	4	2
CLPE	Claytonia perfoliata	FACW	M	M	M	taprootwet	0	0	0	1	0	2	0	3	2
COPA3	COLLINSIA PARVIFLORA	UPL	E	E	E	annual									
COLLI	Collinsia sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	1	0	3	1
COLI2	Collomia linearis	FACU	E	E	E	taprootdry	0	0	0	1	0	1	7	3	1
COAR4	CONVOLVULUS ARVENSIS	UPL	E	E	E										
CREPI	Crepis sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	2	17	4	2
CYEC	CYNOSURUS ECHINATUS	UPL	E	E	E	annual									
DAGL	Dactylis glomerata	FACU	E	E	M	gramupl	0	1	0	0	0	2	12	5	4
DAUN	Danhtonia unispicata	FAC	M	M	M	gramshallow	0	1	0	0	0	2	7	4	2
DACA	Danthonia californica	FAC	M	M	L	gramshallow	0	1	0	0	0	2	14	4	2
DACA3	Danthonia californica	FAC	M	M	L	gramshallow	0	1	0	0	0	2	14	4	2
DAIN	Danthonia intermedia	FACU	M	M	L	gramupl	0	1	0	0	0	2	16	4	2
DANTH	Danthonia intermedia	FACU	M	M	L	gramupl	0	1	0	0	0	2	16	4	2
DACA5	Darlingtonia californica	OBL	L	L	L	taprootwet	0	0	0	1	0	2	21	4	3
DENU2	Delphinium nuttallianum	FACW	M	M	M	taprootwet	0	0	0	1	0	2	14	4	2
DECA	DESCHAMPSIA CESPITOSA	FACW	L	L	L	gramshallow	0	1	0	0	0	2	15	5	2
DECE	DESCHAMPSIA CESPITOSA	FACW	L	L	L	gramshallow	0	1	0	0	0	2	15	5	2
DEDA	Deschampsia danthonioides	FACW	E	E	E	annual	0	1	0	0	0	1	7	4	2
DEEL	Deschampsia elongata	FACW	E	E	L	gramshallow	0	1	0	0	0	2	9	4	2
DESCH	Deschampsia sp.	FACW	L	L	L	gramshallow	0	1	0	0	0	2	15	5	2
DEPI	Descurainia pinnata	FACU	E	E	E	taprootdry	0	0	0	1	0	1	2	4	1
DESO2	Descurainia sophia	FACU	E	E	E	taprootdry	0	0	0	1	0	1	2	4	1
DISP	Distichlis spicata	FAC	M	L	L	gramshallow	0	1	0	0	0	2	3	3	4
DOAL	Dodecatheon alpinum	OBL	L	L	L	taprootwet	0	0	0	1	0	2	21	4	3
DOCO	Dodecatheon conjugens	FAC	M	M	M	taprootdry	0	0	0	1	0	2	21	4	3
DOJE	Dodecatheon jeffreyi	FACW	M	M	M	taprootwet	0	0	0	1	0	2	27	4	3
DRRO	Drosera rotundifolia	OBL	L	L	L	taprootwet	0	0	0	1	0	2	8	2	2
DUHO	Dugaldia hoopsii	FACU	E	E	E	taprootdry	0	0	0	1	0	2	5	4	2
ELAC	Eleocharis acicularis	OBL	M	M	M	annual	0	0	1	0	0	1	12	3	1
ELBE	Eleocharis bella	FACW	E	E	E	annual	0	0	1	0	0	1	2	2	1

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ELPA6	Eleocharis pauciflora	OBL	M	M	M	gramdeep	0	0	1	0	0	2	17	3	4
ELQU2	Eleocharis quinqueflora	FACW	M	M	M	gramshallow	0	0	1	0	0	2	5	3	4
ELEOC	Eleocharis SP.	FACW	M	M	M	gramshallow	0	0	1	0	0	2	12	3	4
ELEL	ELYMUS ELYMOIDES	FACU	E	M	M	gramupl	0	1	0	0	0	2	5	4	3
ELEL5	ELYMUS ELYMOIDES	FACU	E	M	M	gramupl	0	1	0	0	0	2	5	4	3
ELGL	Elymus glaucus	FACU	E	M	M	gramupl	0	1	0	0	0	2	15	5	4
ELTR7	Elymus trachycaulus	FAC	M	M	L	gramshallow	0	1	0	0	0	2	14	5	2
ELTRT	Elymus trachycaulus ssp. trachyc	FAC	M	L	L	gramshallow	0	1	0	0	0	2	14	5	2
AGTR	Elymus trachycaulus ssp. trachyc	FAC	M	L	L	gramshallow	0	1	0	0	0	2	14	5	2
EPBR	EPILOBIUM BRACHYCARPUM	UPL	E	E	E	annual	0	0	0	1	0	1	2	2	1
EPBR3	EPILOBIUM BRACHYCARPUM	UPL	E	E	E	annual	0	0	0	1	0	1	2	2	1
EPCI	Epilobium ciliatum	OBL	M	M	M	taprootwet	0	0	0	1	0	2	20	4	2
EPDE	Epilobium ciliatum	OBL	M	M	M	taprootwet	0	0	0	1	0	2	20	4	2
EPCIC	Epilobium ciliatum ciliatum	OBL	M	M	M	taprootwet	0	0	0	1	0	2	12	4	2
EPCIG	Epilobium ciliatum glandulosum	OBL	M	M	M	taprootwet	0	0	0	1	0	2	19	4	2
EPGL	Epilobium glaberrimum	OBL	M	M	M	taprootwet	0	0	0	1	0	2	13	4	2
EPHA	Epilobium halleanum	FACW	M	M	M	taprootwet	0	0	0	1	0	2	23	4	2
EPMI	Epilobium minutum	FACW	E	E	E	taprootwet	0	0	0	1	0	1	2	3	1
EPOR	Epilobium oreganum	OBL	M	M	E	taprootwet	0	0	0	1	0	2	5	3	2
EPOR2	Epilobium oregonense	OBL	M	E	E	taprootwet	0	0	0	1	0	2	18	3	2
EPILO	Epilobium sp.	FACW	M	M	M	taprootwet	0	0	0	1	0	2	20	4	2
EPILOBIUM	Epilobium sp.	FACW	M	M	M	taprootwet	0	0	0	1	0	2	20	4	2
BOST	Epilobium torreyi	FACW	E	E	E	annual	0	0	0	1	0	1	1	1	1
EPIL	Epliobium sp.	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	9	3	
EQAR	Equisetum arvense	FACW	E	E	E	rhizforbwet	0	0	0	1	0	2	18	4	4
EQUIS	Equisetum sp.	FACW	E	E	E	taprootwet	0	0	0	1	0	2	7	4	2
EQUISETUM	Equisetum sp.	FACW	E	E	E	taprootwet	0	0	0	1	0	2	7	4	2
ERSE	Eragrostis secundiflora	FACU	E	E	E	taprootdry	0	0	0	1	0	1	3	3	1
HAGR6	ERICAMERIA GREENII	UPL	E	E	E	woodydry									
ERIGE	Erigeron sp.	FAC	M	M	M	taprootdry	0	0	0	1	0	2	14	4	2
ERIOG	Eriogonum sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	2	10	4	2
ERCR4	Eriophorum crinigerum	OBL	L	L	L	gramdeep	0	0	1	0	0	2	43	4	4
ERBO	Erodium botrys	FAC	E	E	E	taprootdry	0	0	0	1	0	1	2	3	1
ERCI6	ERODIUM CICUTARIUM	FACU	E	E	E	taprootdry	0	0	0	1	0	1	4	2	1
ERCIC	ERODIUM CICUTARIUM	UPL	E	E	E	annual	0	0	0	1	0	1	1	1	1
ERAR11	Eryngium aristulatum	FAC	E	E	E	taprootdry	0	0	0	1	0	2	2	2	2
ERYSI	Erysimum sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	21	4	2
FEID	Festuca idahoensis	FACU	E	E	L	gramupl	0	1	0	0	0	2	19	5	3
FEOVV	Festuca ovina	FACU	M	M	M	gramupl	0	1	0	0	0	2	15	5	3
FERU2	Festuca rubra	FACU	M	M	M	gramupl	0	1	0	0	0	2	15	5	4
FESTU	Festuca sp.	FACU	E	E	L	gramupl	0	1	0	0	0	2	3	3	3
FESTUCA	Festuca sp.	FACU	E	E	L	gramupl	0	1	0	0	0	2	3	3	3
FRVI	Fragaria virginiana	FAC	E	E	E	rhizforbdry	0	0	0	1	0	2	5	4	4
FRSP	FRASERA SPECIOSA	UPL	E	E	E	taprootdry	0	0	0	1	0	2	2	4	3
GALIU	Galium sp.	FAC	M	M	M	taprootdry	0	0	0	1	0	1	12	3	2
GATR	Galium trifidum	FACW	M	M	M	taprootwet	0	0	0	1	0	2	15	3	2

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GAYOP	Gayophytum sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	1	11	3	1
GADI2	GAYPHYTUM DIFFUSUM	FAC	E	E	E	taprootdry	0	0	0	1	0	1	3	3	1
GADID	GAYPHYTUM DIFFUSUM	FAC	E	E	E	taprootdry	0	0	0	1	0	1	3	3	1
GADIP	GAYPHYTUM DIFFUSUM	FAC	E	E	E	taprootdry	0	0	0	1	0	1	3	3	1
GENE	Gentiana newberryi	FACW	M	M	M	taprootwet	0	0	0	1	0	2	15	3	3
GENTI	Gentiana sp.	FACW	M	M	M	taprootwet	0	0	0	1	0	2	16	3	3
GEHO3	Gentianopsis holopetala	OBL	M	M	M	taprootwet	0	0	0	1	0	2	11	3	3
GESI3	Gentianopsis simplex	OBL	M	M	M	taprootwet	0	0	0	1	0	1	3	3	1
GERAN	Geranium sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	3	3	3
GEVI2	Geranium viscosissimum	FAC	E	M	M	taprootdry	0	0	0	1	0	1	5	4	3
GEMA4	Geum macrophyllum	FACW	E	M	M	taprootwet	0	0	0	1	0	2	5	4	2
GEUM	Geum sp.	FAC	M	M	M	taprootdry	0	0	0	1	0	2	14	4	2
GETR	Geum triflorum	FAC	M	M	M	rhizforbdry	0	0	0	1	0	2	5	4	4
GLBO	Glyceria borealis	OBL	L	L	L	gramdeep	0	1	0	0	0	2	34	5	4
GLEL	Glyceria elata	OBL	L	L	L	gramdeep	0	1	0	0	0	2	25	5	4
GLYCERIA	Glyceria sp.	OBL	L	L	L	gramdeep									
GNPA	Gnaphalium palustre	FAC	E	E	E	taprootdry	0	0	0	1	0	1	1	3	1
GRIND	Grindelia sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	2	2	4	3
HAFL2	Hackelia floribunda	FAC	E	E	M	taprootdry	0	0	0	1	0	2	6	4	3
HASE2	Hastingia serpentinicola	FAC	E	E	M	taprootdry	0	0	0	1	0	2	14	4	3
HEBI	Helenium bigelovii	FACW	M	M	M	taprootwet	0	0	0	1	0	2	8	4	3
HEHO5	Helenium bigelovii	FACW	M	M	M	taprootwet	0	0	0	1	0	2	8	4	3
HELENIUM	Helenium sp.	FACW	M	M	M	taprootwet	0	0	0	1	0	2	8	4	3
HOLA	Holcus lanatus	FACW	E	E	M	gramshallow	0	1	0	0	0	2	12	4	2
HOBR2	Hordeum brachyantherum	FACW	E	M	M	gramshallow	0	1	0	0	0	2	15	5	2
HOJU	Hordeum jubatum	FAC	E	E	E	gramshallow	0	1	0	0	0	2	7	4	2
HORDE	Hordeum sp.	FACW	E	M	M	gramshallow	0	1	0	0	0	2	14	5	2
HOVU	HORDEUM VULGARE	UPL	E	E	E	annual									
HOCA3	Horkelia californica	FAC	E	E	M	taprootdry	0	0	0	1	0	2	9	4	3
HOCL	Horkelia clevelandii	FAC	E	E	M	taprootdry	0	0	0	1	0	2	3	4	3
HOFU	Horkelia fusca	FAC	E	E	E	taprootdry	0	0	0	1	0	2	13	4	3
HYAN2	Hypericum anagalloides	FACW	E	E	E	taprootwet	0	0	0	1	0	1	2	3	1
HYPE	Hypericum perforatum	FACW	M	M	M	taprootwet	0	0	0	1	0	2	16	3	2
HYFOS	Hypericum scouleri	FACW	M	M	M	taprootwet	0	0	0	1	0	2	12	3	2
IRCH	IRIS CHRYSOPYLLA	FAC	E	E	E	taprootdry	0	0	0	1	0	2	14	3	3
IRMI	Iris missouriensis	FAC	E	E	E	taprootdry	0	0	0	1	0	2	14	3	3
IVAPA	Ivesia aperta	FAC	E	E	M	taprootdry	0	0	0	1	0	2	3	3	2
IVCA2	Ivesia campestris	FACW	E	E	E	taprootwet	0	0	0	1	0	2	12	3	2
IVLY	Ivesia lycopodioides	FACW	M	M	M	taprootwet	0	0	0	1	0	2	13	3	2
IVSE	Ivesia sericoleuca	FAC	M	M	M	taprootdry	0	0	0	1	0	2	3	3	2
IVUN	Ivesia unguiculata	FACW	M	E	E	taprootwet	0	0	0	1	0	2	13	3	2
JUAC	JUNCUS ACUMINATUS	OBL	L	L	L	gramdeep	0	0	1	0	0	2	12	2	3
JUBA	Juncus balticus	OBL	M	M	M	gramdeep	0	0	1	0	0	2	16	4	5
JUBU	Juncus bufonius	OBL	E	E	E	annual	0	0	1	0	0	1	3	2	3
JUCO2	Juncus confusus	FACW	M	M	M	gramshallow	0	0	1	0	0	2	10	3	3

SPECIES	SCIENTIFIC NAME	WETLAND	WET	MOIST	DRY	FUNCTION	N FIXER	GRASS	GRASSLIKE	FORB	WOODY	LIFEHIST	ROOT	HT	LATERALS
JUEN2	Juncus ensifolius	OBL	L	L	L	gramdeep	0	0	1	0	0	2	27	4	5
JULO	Juncus longistylis	FACW	L	L	L	gramshallow	0	0	1	0	0	2	8	4	4
JUME3	Juncus mertensianus	OBL	L	L	L	gramshallow	0	0	1	0	0	2	6	3	4
JUME	Juncus mexicanus	FACW	M	M	M	gramdeep	0	0	1	0	0	2	18	4	4
JUME4	Juncus mexicanus	FACW	M	M	M	gramdeep	0	0	1	0	0	2	18	4	4
JUNE	Juncus nevadensis	FACW	L	L	L	gramdeep	0	0	1	0	0	2	22	4	4
JUOR	Juncus orthophyllus	FACW	M	M	L	gramdeep	0	0	1	0	0	2	17	4	3
JUOX	Juncus oxymeris	FACW	L	L	L	gramdeep	0	0	1	0	0	2	19	4	3
JUPA	Juncus parryi	FACU	E	E	M	gramdry	0	0	1	0	0	2	4	4	3
JUPA2	Juncus patens	FACW	M	M	L	gramshallow	0	0	1	0	0	2	11	4	3
JUPH	Juncus phaeocephalus	FACW	L	L	L	gramdeep	0	0	1	0	0	2	15	4	5
JUNCU	JUNCUS SP.	FACW	L	L	L	gramdeep	0	0	1	0	0	2	15	3	4
JUNCUS	JUNCUS SP.	FACW	L	L	L	gramdeep	0	0	1	0	0	2	15	3	4
JUTE	JUNUS TENUIS	FACW	M	M	M	gramshallow	0	0	1	0	0	2	2	1	
KAPO	KALMIA POLIFOLIA	FACW	L	L	L	rhizforbwet	0	0	0	1	1	2	17	3	4
KAPOM3	KALMIA POLIFOLIA	FACW	L	L	L	rhizforbwet	0	0	0	1	1	2	17	3	4
LASE	Lactuca serriola	FACU	E	E	E	taprootdry	0	0	0	1	0	1	2	3	1
LEPID	Lepidium sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	1	10	3	1
LESSI	LESSINGIA SP.	FAC	E	E	M										
LENE5	Lewisia nevadensis	FACU	L	L	L	taprootdry	0	0	0	1	0	2	7	3	3
ELTR3	Leymus triticoides	FAC	M	M	L	gramshallow	0	1	0	0	0	2	8	5	5
LETR5	LEYMUS TRITICOIDES	FAC	M	M	L	gramshallow	0	1	0	0	0	2	14	5	2
LIHA	Linanthus harknessii	FACU	E	E	E	taprootdry	0	0	0	1	0	1	4	2	1
LICI	Linathus ciliatus	FACU	E	E	E	taprootdry	0	0	0	1	0	1	5	2	1
LINAN	Linathus sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	1	2	3	1
LILE3	Linum lewisii	FACU	E	E	E	taprootdry	0	0	0	1	0	2	12	3	3
LOMU	LOLIUM PERENNE	UPL	E	E	E	annual									
LOMAT	Lomatium sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	2	1	3	3
LOCO6	Lotus corniculatus	FAC	E	E	M	taprootdry	0	0	0	1	0	2	7	3	2
LOOB	Lotus oblongifolius	FACW	E	E	M	taprootwet	0	0	0	1	0	2	3	3	2
LOOB2	Lotus oblongifolius	FACW	E	E	M	taprootwet	0	0	0	1	0	2	3	3	2
LOPI2	Lotus pinnatus	FACW	E	E	M	taprootwet	0	0	0	1	0	2	4	3	2
LOPU3	Lotus purshianus	FAC	E	E	E	taprootdry	0	0	0	1	0	1	10	3	1
LOTUS	Lotus sp.	FAC	E	E	E	taprootdry	0	0	0	1	0	1	13	3	1
LOST4	Lotus strigosus	FAC	E	E	E	taprootdry	0	0	0	1	0	1	1	3	1
LUAR3	Lupinus argenteus	FACU	E	E	E	taprootdry	0	0	0	1	0	2	6	3	3
LUBI	Lupinus bicolor	FACU	E	E	E	taprootdry	0	0	0	1	0	1	3	3	1
LUCA	LUPINUS CAUDATUS	UPL	E	E	E	taprootdry	0	0	0	1	0	2	2	2	3
LULES2	Lupinus lepidus var. sellulus	UPL	E	E	M	taprootdry	0	0	0	1	0	2	4	1	3
LUPO2	Lupinus polyphyllus	FACW	M	M	M	taprootwet	0	0	0	1	0	2	4	5	3
LUPIN	Lupinus sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	2	9	3	3
LUCO6	Luzula comosa	FACW	L	L	L	gramshallow	0	0	1	0	0	2	10	4	4
LUOR4	Luzula orestera	OBL	L	L	L	gramshallow	0	0	1	0	0	2	7	4	4
LUPA4	Luzula parviflora	FAC	E	E	M	gramshallow	0	0	1	0	0	2	15	4	4
LUZUL	Luzula sp.	FAC	L	L	L	gramshallow	0	0	1	0	0	2	16	4	4

SPECIES	SCIENTIFIC NAME	WETLAND	WET	MOIST	DRY	FUNCTION	N FIXER	GRASS	GRASSLIKE	FORB	WOODY	LIFEHIST	ROOT	HT	LATERALS
MELU	Medicago lupulina	FAC	E	E	E	taprootdry	0	0	0	1	0	1	2	3	2
MEDIC	Medicago sp.	FAC	E	E	E	taprootdry	0	0	0	1	0	1	3	3	1
MEBU	Melica bulbosa	UPL	E	E	E	gramupl	0	1	0	0	0	2	14	4	3
MEAR4	Mentha arvensis	FACW	E	E		taprootwet	0	0	0	1	0	2	7	3	2
MECI3	Mertensia ciliata	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	3	3	4
MIGU	Mimulus guttatus	OBL	M	M	M	rhizforbwet	0	0	0	1	0	2	12	3	4
MIMO3	Mimulus moschatus	OBL	M	M	M	taprootwet	0	0	0	1	0	2	5	3	2
MIPR	Mimulus primuloides	OBL	M	M	M	rhizforbwet	0	0	0	1	0	2	19	3	4
MIPRL	Mimulus primuloides	OBL	M	M	M	rhizforbwet	0	0	0	1	0	2	19	3	4
MOOD	Monardella odoratissima	FACW	M	M	M	taprootwet	0	0	0	1	0	2	8	3	2
MOCH	Montia chamissoi	OBL	M	M	M	rhizforbwet	0	0	0	1	0	2	15	3	4
MOLI4	Montia linearis	OBL	E	E	E	taprootwet	0	0	0	1	0	1	14	3	1
MUAS	Muhlenbergia asperifolia	FACW	M	E	M	gramshallow	0	1	0	0	0	2	18	4	4
MUFI	Muhlenbergia filiformis	OBL	M	M	M	annual	0	1	0	0	0	1	18	3	1
MUFI2	Muhlenbergia filiformis	OBL	M	M	M	annual	0	1	0	0	0	1	18	3	1
MURI	Muhlenbergia richardsonis	FAC	E	M	M	gramshallow	0	1	0	0	0	2	14	3	4
MURI2	Muhlenbergia rigens	FAC	E	M	L	gamshallow	0	1	0	0	0	2	10	5	3
NABR	Navarretia breweri	FACU	E	E	E	taprootdry	0	0	0	1	0	1	2	3	1
NAIN2	Navarretia intertexta	FACU	E	E	E	taprootdry	0	0	0	1	0	1	7	3	1
NALE	Navarretia leucocephala	OBL	E	E	E	taprootwet	0	0	0	1	0	1	10	3	1
NAVAR	Navarretia sp.	FACU	E	E	E	taprootdry	0	0	0	1	0	1	17	3	1
NEPE	Nemophila pedunculata	FAC	E	E	E	taprootdry	0	0	0	1	0	1	14	3	1
NEMOP	Nemophila sp.	FACW	E	E	E	taprootwet	0	0	0	1	0	1	11	3	1
ORLU2	Orthocarpus luteus	FACU	E	E	E	taprootdry	0	0	0	1	0	1	0	3	2
ORTHO	Orthocarpus sp.	FAC	E	E	E	taprootdry	0	0	0	1	0	1	13	3	1
OXOC	Oxypolis occidentalis	FACW	L	L	L	taprootwet	0	0	0	1	0	2	15	3	2
PANIC	Panicum sp.	FAC	M	M	M	taprootdry	0	0	0	1	0	2	14	3	2
PEAT	Pedicularis attollens	OBL	L	L	L	taprootwet	0	0	0	1	0	2	15	4	3
PEGR2	Pedicularis groenlandica	OBL	L	L	L	taprootwet	0	0	0	1	0	2	8	4	2
PEDIC	Pedicularis sp.	FACW	L	L	L	taprootwet	0	0	0	1	0	2	12	4	3
PEHE2	Penstemon herterodoxus	FAC	E	E	M	taprootdry	0	0	0	1	0	2	22	3	2
PELA7	Penstemon laetus	FAC	E	E	M	taprootdry	0	0	0	1	0	2	10	3	2
PEPR2	Penstemon procerus	FAC	E	E	M	taprootdry	0	0	0	1	0	2	7	3	2
PERY	Penstemon rydbergii	FAC	M	M	M	taprootdry	0	0	0	1	0	2	16	3	2
PERYO	Penstemon rydbergii	FAC	M	M	M	taprootdry	0	0	0	1	0	2	10	3	2
PENST	Penstemon sp.	FAC	M	M	M	taprootdry	0	0	0	1	0	2	25	3	2
PERID	Perderidia sp.	FAC	M	M	M	taprootdry	0	0	0	1	0	2	14	4	2
PELE5	Perideridia lemmonii	FAC	E	E	M	taprootdry	0	0	0	1	0	2	26	4	2
PEPA21	Perideridia parishii	FACW	E	E	M	taprootwet	0	0	0	1	0	2	15	4	2
PEPAL	Perideridia parishii	UPL	E	E	M	taprootdry	0	0	0	1	0	2	10	2	2
PHBO	Phalacroseris bolanderi	FACW	M	M	M	taprootwet	0	0	0	1	0	2	16	3	3
PHBO2	Phalacroseris bolanderi	FACW	M	M	M	taprootwet	0	0	0	1	0	2	16	3	3
PHAQ	Phalaris aquatica	FACW	E	E	E	gramshallow	0	1	0	0	0	2	15	5	4
PHAL2	Phleum alpinum	FACW	L	L	L	gramshallow	0	1	0	0	0	2	20	4	3
PHPR3	Phleum pratense	FAC	E	E	M	gramshallow	0	1	0	0	0	2	18	5	3

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PICOM4	PINUS CONTORTA	FAC	M	M	L	woodymesic	0	0	0	1	1	2	24	6	3
PIJE	Pinus jeffreyi	FACU	E	E	E	woodydry	0	0	0	1	1	2	10	6	3
PLAGI	PLAGIOBOTHRYS SP.	FACU	E	E	M	gramdry									
PLMA2	Plantago major	FACU	E	E	E	taprootdry	0	0	0	1	0	2	8	3	2
PLLE5	Plantanthera dilatata	FAC	E	E	M	taprootdry	0	0	0	1	0	2	28	4	3
PLANT	Plantanthera sp.	FACW	E	E	E	taprootwet	0	0	0	1	0	2	0	3	3
PLHY2	Platanthera hyperborea	FACW	L	L	L	taprootwet	0	0	0	1	0	2	12	4	3
POA	POA	FACU	E	E	M	gramupl									
POAN	Poa annua	FAC	E	E	E	gramshallow	0	1	0	0	0	2	1	2	3
POBU	Poa bulbosa	FACU	E	E	E	gramupl	0	1	0	0	0	2	6	3	3
POCO	Poa compressa	FAC	E	E	M	gramshallow	0	1	0	0	0	2	3	3	4
POCU3	Poa cusickii	FACW	L	L	L	gramshallow	0	1	0	0	0	2	4	3	3
POCUE2	Poa cusickii eplis	FACW	L	L	L	gramshallow	0	1	0	0	0	2	10	3	3
POPR	Poa pratensis	FACU	E	M	L	gramupl	0	1	0	0	0	2	16	4	4
PONE3	Poa secunda	FACU	M	L	L	gramupl	0	1	0	0	0	2	12	4	3
POSE	Poa secunda	FACU	M	L	L	gramupl	0	1	0	0	0	2	12	4	3
POSEJ	Poa secunda juncifolia	FACU	M	L	L	gramupl	0	1	0	0	0	2	15	4	3
POSES	Poa secunda secunda	FACU	M	L	L	gramupl	0	1	0	0	0	2	12	4	3
POST11	Poa stebbinsii	FACW	M	L	L	gramshallow	0	1	0	0	0	2	11	4	3
POWH2	Poa wheeleri	FACU	E	E	L	gramupl	0	1	0	0	0	2	19	5	4
POBI	Polygonum bistortoides	OBL	M	M	M	rhizforbwet	0	0	0	1	0	2	12	2	4
POBI6	Polygonum bistortoides	OBL	M	M	M	rhizforbwet	0	0	0	1	0	2	15	4	4
PODA	Polygonum davisiae	UPL	E	E	E	taprootdry									
PODO	Polygonum douglasii	FACU	E	E	E	taprootdry	0	0	0	1	0	1	8	3	1
PODO4	Polygonum douglasii	FACU	E	E	E	taprootdry	0	0	0	1	0	1	8	3	1
POMI2	Polygonum minimum	FAC	E	E	E	taprootdry	0	0	0	1	0	1	14	3	1
POPO4	Polygonum polygaloides ssp. kell	FAC	E	E	E	taprootdry	0	0	0	1	0	1	4	2	1
POPOK	Polygonum polygaloides ssp. kell	FAC	E	E	E	taprootdry	0	0	0	1	0	1	4	2	1
POLYG	Polygonum sp.	FACU	E	E	E	rhizforbdry	0	0	0	1	0	2	8	3	4
POAN5	Potentilla anserina	FACW	E	E	E	rhizforbwet	0	0	0	1	0	2	17	2	4
POBI7	Potentilla biennis	FACW	E	E	E	taprootwet	0	0	0	1	0	1	4	2	1
PODR	Potentilla drummondii	FACW	M	M	M	taprootwet	0	0	0	1	0	2	16	3	3
POFL	Potentilla floribunda	FAC	E	E	M	taprootdry	0	0	0	1	0	2	13	3	3
POFL3	Potentilla floribunda	FAC	E	M	M	taprootdry	0	0	0	1	0	2	13	3	3
POGL9	Potentilla glandulosa	FAC	E	E	E	taprootdry	0	0	0	1	0	2	17	3	3
POGR9	Potentilla gracilis	FACW	E	E	E	rhizforbwet	0	0	0	1	0	2	14	3	4
POTEN	Potentilla sp.	FAC	E	E	E	taprootdry	0	0	0	1	1	2	22	6	3
LOPUP	Potus purshianus	FAC	E	E	E	taprootdry	0	0	0	1	0	1	8	3	1
PRVU	Prunella vulgaris	FACW	M	M	M	taprootwet	0	0	0	1	0	2	4	3	2
PSJA2	Pseudostellaria jamesiana	FACU	M	L	E	taprootdry	0	0	0	1	0	2	10	3	2
PEBOB	Pteridia bolanderi	FACW	L	L	L	taprootwet	0	0	0	1	0	2	10	4	2
PTKI	PTILIGROSTIS KINII	FACU	L	L	L	gramupl									
PUCCI	Puccinellia sp.	OBL	L	L	L	gramshallow	0	1	0	0	0	2	12	4	4
PYAP2	Pyrrocoma apargioides	FACW	E	E	E	taprootwet	0	0	0	1	0	2	11	3	2

SPECIES	SCIENTIFIC NAME	WETLAND	WET	MOIST	DRY	FUNCTION	N FIXER	GRASS	GRASSLIKE	FORB	WOODY	LIFEHIST	ROOT	HT	LATERALS
RAOC	Ranunculus occidentalis	FACW	E	E	E	taprootwet	0	0	0	1	0	2	11	3	2
RAOR3	Ranunculus orthorhynchus	FACW	E	E	E	taprootwet	0	0	0	1	0	2	16	3	2
RANUN	Ranunculus sp.	FACW	E	E	M	taprootwet	0	0	0	1	0	2	20	3	2
RIAU	Ribes aureum	FACW	L	L	L	rhizforbwet	0	0	0	1	1	2	3	6	4
RICE	Ribes cereum	FACU	E	E	E	taprootdry	0	0	0	1	1	2	1	6	3
RIIN2	Ribes inerme	FACW	L	L	L	taprootwet	0	0	0	1	1	2	2	6	3
RIMO2	Ribes montigenum	FACW	L	L	L	taprootwet	0	0	0	1	1	2	2	6	3
ROCU	Rorippa curvisiliqua	OBL	E	E	E	taprootwet	0	0	0	1	0	1	1	3	1
RONA2	Rorippa nasturtium-aquaticum	OBL	E	E	E	taprootwet	0	0	0	1	0	2	13	3	2
RORIPPA	Rorippa sp.	OBL	M	M	M	taprootwet	0	0	0	1	0	2	13	3	2
ROWOU	Rosa woodsii	FAC	M	L	L	woodymesic	0	0	0	1	1	2	2	6	4
RUFU5	RUBUS WHEELERI	UPL	E	E	E	woodydry									
RUDBE	Rudbeckia sp.	FACU	E	E	E	rhizforbdry	0	0	0	1	0	2	4	3	4
RUAC3	Rumex acetosella	FACW	E	E	M	taprootwet	0	0	0	1	0	2	12	3	3
RUCR	Rumex crispus	FACW	E	E	E	taprootwet	0	0	0	1	0	2	12	3	3
RUPA6	Rumex paucifolius	OBL	E	E	E	taprootwet	0	0	0	1	0	2	7	3	3
RUMEX	Rumex sp.	FACW	E	E	E	taprootwet	0	0	0	1	0	2	3	3	3
SASA	Sagina saginoides	FACW	E	E	E	taprootwet	0	0	0	1	0	2	0	2	2
SAGE2	Salix geyeriana	FACW	L	L	L	woodywet	0	0	0	1	1	2	10	6	3
SALE	Salix lemmonii	FACW	L	L	L	woodywet	0	0	0	1	1	2	15	6	3
SAOR	Salix orestera	FACW	L	L	L	woodywet	0	0	0	1	1	2	15	6	3
SAPL	Salix planifolia	FACW	L	L	L	wodywet	0	0	0	1	1	2	2	6	3
SAOR2	Saxifraga oregana	OBL	M	M	M	taprootwet	0	0	0	1	0	2	12	4	2
SAXIF	Saxifraga sp.	FACW	M	M	M	taprootwet	0	0	0	1	0	2	12	3	2
SCCL	Scirpus clemantis	FACW	L	L	L	gramshallow	0	0	1	0	0	2	10	2	4
SCCO	Scirpus congdonii	OBL	L	L	L	gramdeep	0	0	1	0	0	2	22	4	4
SCMI	Scirpus microcarpus	OBL	L	L	L	gramdeep	0	0	1	0	0	2	20	4	5
SCMI2	Scirpus microcarpus	OBL	L	L	L	gramdeep	0	0	1	0	0	2	20	4	5
SCIRP	Scirpus sp.	OBL	L	L	L	gramdeep	0	0	1	0	0	2	15	4	5
SCIRPUS	Scirpus SP.	OBL	L	L	L	gramdeep	0	0	1	0	0	2	20	4	5
SESES	Senecia serra	OBL	M	E	M	taprootwet	0	0	0	1	0	2	12	5	2
SEHY2	Senecio hydrophilus	OBL	M	M	M	taprootwet	0	0	0	1	0	2	14	5	2
SECA2	Senecio serra	FACW	M	M	M	taprootwet	0	0	0	1	0	2	2	4	2
SETR	Senecio triangularis	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	18	5	4
SIPR	Sibbaldia procumbens	FAC	E	L	L	taprootdry	0	0	0	1	0	2	11	2	2
SIMA2	Sidalcea malviflora	FAC	E	E	M	taprootdry	0	0	0	1	0	2	5	3	2
SIOR	Sidalcea oregana	OBL	E	E	E	taprootwet	0	0	0	1	0	2	5	4	2
SIRA	Sidalcea ranunculacea	OBL	E	E	E	taprootwet	0	0	0	1	0	2	3	4	2
SIRE	Sidalcea reptans	OBL	E	E	E	taprootwet	0	0	0	1	0	2	15	4	2
SIDAL	Sidalcea sp.	FACW	E	E	E	taprootwet	0	0	0	1	0	2	5	3	2
SILEN	Silene sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	22	4	2
SISYM	Sisymbrium sp.	FACW	M	M	M	taprootwet	0	0	0	1	0	2	1	4	2
SIID	Sisyrinchium idahoense	FACW	M	M	M	taprootwet	0	0	0	1	0	2	10	4	2
SISYR	Sisyrinchium sp.	FAC	E	E	M	taprootdry	0	0	0	1	0	2	15	4	2
SOCA5	Solidaga canadensis	FAC	E	E	M	taprootdry	0	0	0	1	0	2	10	4	3

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SPRU	Spergularia rubra	FAC	E	E	E	taprootdry	0	0	0	1	0	1	10	3	1
SPCA5	Sphenosciadium capitellatum	OBL	L	L	L	taprootwet	0	0	0	1	0	2	12	4	2
SPRO	Spiranthes romanzoffiana	OBL	L	L	L	taprootwet	0	0	0	1	0	2	21	4	2
STBU	Stachys bullata	FAC	E	E	M	taprootdry	0	0	0	1	0	2	27	4	2
STAJR	Stachys rigida	FAC	E	E	M	taprootdry	0	0	0	1	0	2	10	4	2
STLO	Stellaria longipes	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	17	4	4
STLO2	Stellaria longipes	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	17	4	4
STLOL5	Stellaria longipes	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	17	4	4
STELL	Stellaria sp.	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	27	4	4
ASAD6	Symphyotrichum ascendens	FAC	E	E	E	rhizforbdry	0	0	0	1	0	2	12	4	4
TACA8	TAENIATHERUM CAPUT-MEDU	UPL	E	E	E	annual									
TAOF	Taraxacum officinale	FACW	E	E	E	taprootwet	0	0	0	1	0	2	4	3	2
TARAX	Taraxacum sp.	FACW	E	E	E	taprootwet	0	0	0	1	0	2	4	3	2
THFE	THALICTRUM FENDERLIANA	FACU	E	E	E	taprootdry	0	0	0	1	0	2	2	3	3
TOGLO2	TOFIELDIA	OBL	L	L	L	taprootwet									
TRAL5	Triantha occidentalis	FAC	E	E	E	taprootdry	0	0	0	1	0	1	1	3	1
TROB	Trichostema oblongum	FACW	E	E	E	Nfix		0	0	1	0	1	2	4	1
TRHI4	Tridolium hirtum	FACU	E	E	E	taprootdry	1	0	0	1	0	1	2	3	2
TRBO	Trifolium bolanderi	OBL	M	M	M	Nfix	1	0	0	1	0	1	3	1	1
TRBO3	Trifolium bolanderi	OBL	E	E	E	Nfix	1	0	0	1	0	1	12	3	2
TRCY	Trifolium cyathiferum	FACW	E	E	E	Nfix	1	0	0	1	0	1	2	3	1
TRER2	TRIFOLIUM ERIOCEPHALUM	FAC	M	M	M	Nfix									
TRLE2	Trifolium lemmonii	FACW	M	M	M	Nfix	1	0	0	1	0	2	6	3	2
TRLO	Trifolium longipes	FACW	M	M	M	Nfix	1	0	0	1	0	2	12	3	4
TRMI4	Trifolium microcephalum	FACW	E	E	E	Nfix	1	0	0	1	0	1	9	3	1
TRMI5	TRIFOLIUM MOICRODON	UPL	E	E	E	Nfix									
TRMO	Trifolium monanthum	FACW	M	M	M	Nfix	1	0	0	1	0	2	12	3	2
TRMO2	Trifolium monanthum	FACW	M	M	M	Nfix	1	0	0	1	0	2	12	3	2
TRRE	Trifolium repens	FAC	E	E	E	Nfix	1	0	0	1	0	2	3	3	4
TRRE3	Trifolium repens	FAC	E	E	E	Nfix	1	0	0	1	0	2	3	3	4
TRIFO	Trifolium TRIFOLIUM	FACW	M	M	M	Nfix	1	0	0	1	0	2	2	5	2
TRVA	Trifolium variegatum	FACW	M	M	M	taprootwet	1	0	0	1	0	1	8	3	1
TRWI3	Trifolium wildenovii	FACW	E	E	E	taprootwet	1	0	0	1	0	1	1	3	1
TRWO	Trifolium wormskioldii	OBL	M	M	M	Nfix	1	0	0	1	0	2	16	3	4
TRSP2	Trisetum spicatum	FACW	L	L	L	gramshallow	0	1	0	0	0	2	11	4	3
TRWO3	Trisetum wolfii	FACW	L	L	L	gramshallow	0	1	0	0	0	2	12	4	3
TRHY3	Triteleia hyacinthina	FACW	E	M	M	taprootwet	1	0	0	1	0	2	10	3	3
2GRAM	UNK graminoid	FAC	E	M	L	gramupl									
URDI	Urtica dioica	FACW	E	E	E	taprootwet	0	0	0	1	0	2	2	4	1
URTIC	Urtica sp.	FACW	E	E	E	rhizforbwet	0	0	0	1	0	2	13	4	4
VACA	VACCINIUM CESPITOSUM	FACW	L	L	L	taprootwet	0	0	0	1	1	2	12	5	3
VACE	VACCINIUM CESPITOSUM	FACW	L	L	L	taprootwet	0	0	0	1	1	2	12	5	3
VACCI	VACCINIUM SP.	FACW	L	L	L	taprootwet	0	0	0	1	1	2	12	5	3
VAUL	VACCINIUM ULIGINOSUM	FACW	L	L	L	taprootwet	0	0	0	1	1	2	12	5	3
VAULO	VACCINIUM ULIGINOSUM	FACW	L	L	L	taprootwet	0	0	0	1	1	2	12	5	3

SPECIES	SCIENTIFIC NAME	WETLAND	WET	MOIST	DRY	FUNCTION	N FIXER	GRASS	GRASSLIKE	FORB	WOODY	LIFEHIST	ROOT	HT	LATERALS
VELA	Verbena lasiostachys	FAC	E	E	E	taprootdry	0	0	0	1	0	2	16	4	2
VEAM2	Veronica americana	OBL	M	M	M	rhizforbwet	0	0	0	1	0	2	20	3	4
VEAR	Veronica arvensis*	FAC	E	E	M	taprootdry	0	0	0	1	0	1	7	1	3
VECH	VERONICA CHAMAEDRYS	UPL	E	E	E	taprootdry									
VESC2	Veronica scutellata	OBL	M	M	M	taprootwet	0	0	0	1	0	2	17	3	2
VERON	Veronica sp.	FAC	M	M	M	taprootdry	0	0	0	1	0	1	14	3	2
VEWO2	Veronica wormskjoldii	FACW	M	M	M	rhizforbwet	0	0	0	1	0	2	4	1	4
VIAM	Vicia americana	FAC	E	E	M	rhizforbdry	0	0	0	1	0	2	6	4	4
VICIA	Vicia sp.	FAC	E	E	E	taprootdry	0	0	0	1	0	2	2	3	2
VIAD	Viola adunca	FAC	M	M	M	taprootdry	0	0	0	1	0	2	5	3	2
VIGL	Viola glabella	FACW	M	M	M	taprootwet	0	0	0	1	0	2	22	3	2
VIMA	Viola macloskeyi	OBL	M	M	M	taprootwet	0	0	0	1	0	2	17	3	2
VIMA2	Viola macloskeyi	OBL	M	M	M	taprootwet	0	0	0	1	0	2	17	3	2
VIOLA	Viola sp.	FACW	M	M	M	taprootwet	0	0	0	1	0	2	21	3	2
VUMY	VUPLIA MYUROS	UPL	E	E	E	annual	0	0	0	1	0	1	1	1	1
VUOC	VUPLIA OCTOFLORA	UPL	E	E	E	annual	0	0	0	1	0	1	1	1	1
VULPIA	VUPLIA SP.	UPL	E	E	E	annual	0	0	0	1	0	1	1	1	1
WYOV	Wyethia ovina	FACU	E	E	E	taprootdry	0	0	0	1	0	2	2	3	2
WYETH	Wyethis ap.	FACU	E	E	E	taprootdry	0	0	0	1	0	2	2	4	3
DODEC		FACW	M	M	M	taprootwet	0	0	0	1	0	2	11	4	3