Sierra Meadow Planting Palette Tool User Guide

Point Blue Conservation Science

Crimson columbine (Aquilegia formosa)
Cover photo: Leopard lily (Lilium pardalinum)
Photo credit: Marian Vernon

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Willows growing along a beaver dam analog at Childs Meadow. Photo credit: Marian Vernon.

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INTRODUCTION

This document is a companion to the Sierra Meadow Planting Palette Tool, hereafter tool, available here. This document describes how to use the tool, sets the context, and provides supporting information.

The purpose of this tool is to help restoration practitioners plan for climate change in revegetation efforts by identifying plant species that have traits that will increase the likelihood that they will survive, recruit, and continue to provide additional co-benefits under projected future conditions. Our ultimate goal is to increase the resilience of wet meadow restoration projects in the context of climate change while providing additional co-benefits, including wildlife habitat and ecosystem services. We define co-benefit projects as efforts designed to meet societal and/or cultural needs and enhance ecological function and habitat quality for fish and wildlife.

Applying climate-smart restoration principles (Gardali et al. in prep; Vernon et al. 2019) to wet meadow restoration projects can help practitioners increase the likelihood that projects will adapt to a changing climate and continue to provide functions that support wildlife and human communities into the future. Climate-smart restoration encompasses every step in the restoration process (see Vernon et al. 2019); however, this tool was specifically designed to evaluate the ability of plant species to survive, recruit, and provide desired ecosystem services in a changing climate. Many other factors should be considered when designing and implementing a meadow restoration project, such as site hydrology, soil type, seed and propagule sources, land use, existing species assemblages, and more. This tool does not attempt to provide guidance across all important areas of consideration.

This tool is intended to guide revegetation efforts as part of Sierra wet meadow restoration projects in the North Fork Feather River watershed. As such, the majority of the species selected in the tool are those typically found in wet meadows in this particular watershed. However, we do include some mesic and dry meadow species that can be used to revegetate meadow edges and inform more site-specific species selection based on hydrological variability within restored meadows. Practitioners interested in identifying additional dry meadow species and species that occur in the transition zone from wetland to upland can use this palette as a starting point, but should consult other resources to develop a more appropriate list for those types of revegetation projects. Though our target geography is the North Fork Feather River watershed, many of the species included in the tool have ranges that expand beyond our target geography (often throughout the Northern, Central, and Southern High Sierra Nevada Range) and thus the tool is applicable to additional project sites as well. The tool includes details on species distribution to help practitioners assess whether the species is suitable for inclusion in revegetation efforts for your given site.

METHODS

This section describes the methods used to select species and traits for inclusion in the tool. More details on the individual traits and the rationale for their inclusion can be found in Appendix A: Plant Trait Definitions.

Species Selection

The tool is based on an annotated list of native plant species likely to be found in wet and mesic meadows of the North Fork Feather River watershed. All species included in the tool meet the following criteria:

- Wet or mesic meadow species as indicated by Lorenzana et al. 2017 and/or expert opinion. Species found only in dry meadows were excluded, though species that were found in dry meadows plus mesic and/or wet meadows were included.
- Confirmed range and/or confirmed observations within the North Fork Feather River watershed as indicated by the Calflora plant distribution and observation search tools
- Common (e.g., not rare, locally endemic, or state or federally listed)
- Native (e.g., not invasive or non-native introduced species)
- Commercially available in California nurseries as indicated by a search of the California Native Plant Link Exchange and/or Calscape
- Sufficient information available to determine plant trait values

An initial list of species was generated through consultation with local experts and then supplemented through a literature review. For species identified through a literature review, we used criteria in addition to those outlined above (see Table 1). In some rare cases, we included species that are not commercially available in California nurseries but that experts indicated are important components of wet meadow vegetation communities. Plant material from these species (e.g., some *Salix* and *Carex* species) are available from nurseries outside of California and/or could be collected from wild populations for use in restoration projects.

Table 1: Literature sources consulted to identify native Sierra meadow plants for inclusion in the tool, and the parameters used to determine inclusion/exclusion of species for each source.

Source	Inclusion Parameters
Wetlands of Lassen Volcanic National Park: An assessment of vegetation, ecological services, and condition (Adamus 2008)	Dominant species that commonly occur within meadows of Lassen Volcanic National Park
A manual of California vegetation online (California Native Plant Society, n. d.)	Dominant species in wet meadow and mesic meadow vegetation alliances
Bumble bee use of post-fire chaparral in the central Sierra Nevada (Loffland et al. 2017)	Riparian plants that were used by bumble bees significantly more for foraging than expected based on their availability in the central Sierra Nevada, California, USA, 2015-2016.
Monarch nectar plants: California (Fallon et al, n. d.)	Species that are important monarch nectar plants in California that occur within wetlands and riparian areas
Maidu use of native flora and fauna (Hill 1972)	Species found in wetland and riparian areas with recorded ethnobotanical use(s) by the Maidu.
Patterns of floristic diversity in wet meadows and fens of the southern Sierra Nevada, California (Jones 2011).	All species identified in the three plant subgroups classified by the author that characterize Sierra wet meadows and fens. The three groups were obligate wetland species, facultative to obligate wetland species, and drier habitat species.
Plant guide for resource managers: Field reference for common plant species in the Pacific Southwest Region (Lorenzana et al. 2017)	Important sedges, grasses, grasslike plants, and forbs found in wet, mesic, and dry meadows as described in the Vegetation Types section of this plant guide.
Plant community distribution along water table and grazing gradients in montane meadows of the Sierra Nevada Range (California, USA) (McIlroy and Allen-Diaz 2012).	Dominant species for the six plant community types across five wet and mesic meadows in the Sierra Nevada range.
Plant selection by bumble bees (Apidae: Bombus) in montane riparian habitat of California (Cole et al. 2020)	Meadow and riparian plant species that were used more than expected based on availability by 13 bumble bee species. The plant species list is from a survey of meadow and riparian areas within the Moonlight Fire area on the Lassen National Forest.
Riparian and wetland restoration planting guide for the Boise and Payette River Basins, Idaho (Murphy 2012)	Keystone species of wet meadows and mesic meadows that were categorized as high priority for inclusion in restoration projects.
California Wildlife Habitat Relationships System: Wet Meadow Vegetation (Ratliff n. d.).	Important forbs, grasses, and grasslike species associated with the wet meadow habitat type.

Trait Selection

Our overarching goal was to identify key plant traits that might enable native meadow plant species to cope with projected climate impacts while continuing to provide desired ecosystem services and reach desired meadow conditions. The specific traits selected for the tool were informed by projected climate impacts to Sierra meadows as well as consideration of meadow restoration outcomes typically used by restoration practitioners to guide projects.

Projected climate change impacts that will directly impact Sierra meadows and the wildlife that rely on this habitat include but are not limited to (Garfin et al. 2013; Viers et al. 2013; Reich et al. 2018):

- Decreased April 1 snow water equivalent
- Increased inter-annual variability in precipitation
- Increased maximum daily temperature during the summer months
- Increased minimum daily temperature during the winter months
- Increase in extreme heat days
- Increase in climatic water deficit
- Higher proportion of winter precipitation falling as rain than snow
- A shift in peak snowmelt and surface water runoff to earlier in the year
- Increase in rain-on-snow (high flow) events
- Droughts will be hotter, more severe, and more frequent
- Increased probability of high-severity fire
- Phenological mismatches among hydrology, plants, and animals

In addition to selecting traits that may confer resilience to species given the above climate projections, we also selected traits that could help achieve desired meadow restoration outcomes and additional co-benefits, including provisioning of wildlife habitat, regulating processes and functions, and cultural resource benefits.

We ultimately selected plant traits in five overarching categories that were informed by climate projections and the desire to achieve additional co-benefits informed by desired meadow restoration outcomes. These categories include (1) species persistence traits, (2) disturbance resilience traits, (3) wildlife support traits, (4) ecosystem process traits, and (5) cultural ecosystem services traits . We also collected data on species distribution to help practitioners assess which species are likely to be found in their region and meadow system.

Table 2 includes a general description of the traits included in each category and lists all traits within each category. Appendix B: Plant Traits Definition includes a more detailed description of all traits that fall under each of these categories and the rationale for their inclusion.

Table 2: Trait categories, description, and list of traits included in the tool.

Category	Description	Traits Included
Species persistence traits	Traits that may increase plant survival and species persistence under future climatic conditions.	Drought tolerance Fire tolerance Flood tolerant Tolerates seasonally dry conditions Tolerates wet conditions
Disturbance resilience traits	Traits that might improve the probability of recolonization and recruitment of native vegetation following a disturbance event.	Disturbance tolerance Geophyte Livestock resource value rating Rhizomatous Water dispersed Wind dispersed
Wildlife support traits	Traits that a) support basic food webs and facilitate pollination of native vegetation, which may also assist recruitment and resilience to disturbance, and b) support wildlife.	Cover for wildlife Insectary plant Resource phenology Fruit source Seed source Nectar/pollen
Ecosystem process traits	Traits that help regulate and support ecosystem processes in meadows	Bank stabilization and erosion control Early colonizer/competitive with invasives Stream shading
Cultural ecosystem services traits	Species that provide important cultural ecosystem services through species' form or function	Showy flowers Ethnobotanical species
Species distribution	Details on species distribution to inform inclusion of the species in a planting design for a given site	Bioregion Elevation range Meadow type Wetland indicator status

How to use the tool

The tool can be used to help restoration practitioners plan for climate change in revegetation efforts by identifying plant species that will survive current site conditions while also including species with traits that may increase the likelihood that they will survive, recruit, and continue to provide important ecosystem services under projected future conditions.

General overview

The tool was specifically designed to inform wet meadow restoration projects in the North Fork Feather River Watershed (Figure 1). Most of the species included in the tool are also distributed within additional watersheds in the Sierra Nevada and southern Cascades. The **Plant Selection** tab of the tool workbook specifies the elevation range, Jepson bioregion, meadow type(s), and wetland indicator status for each species. This information can be used to help determine whether the species should be considered for your particular project depending on your project's location and hydrological regime.

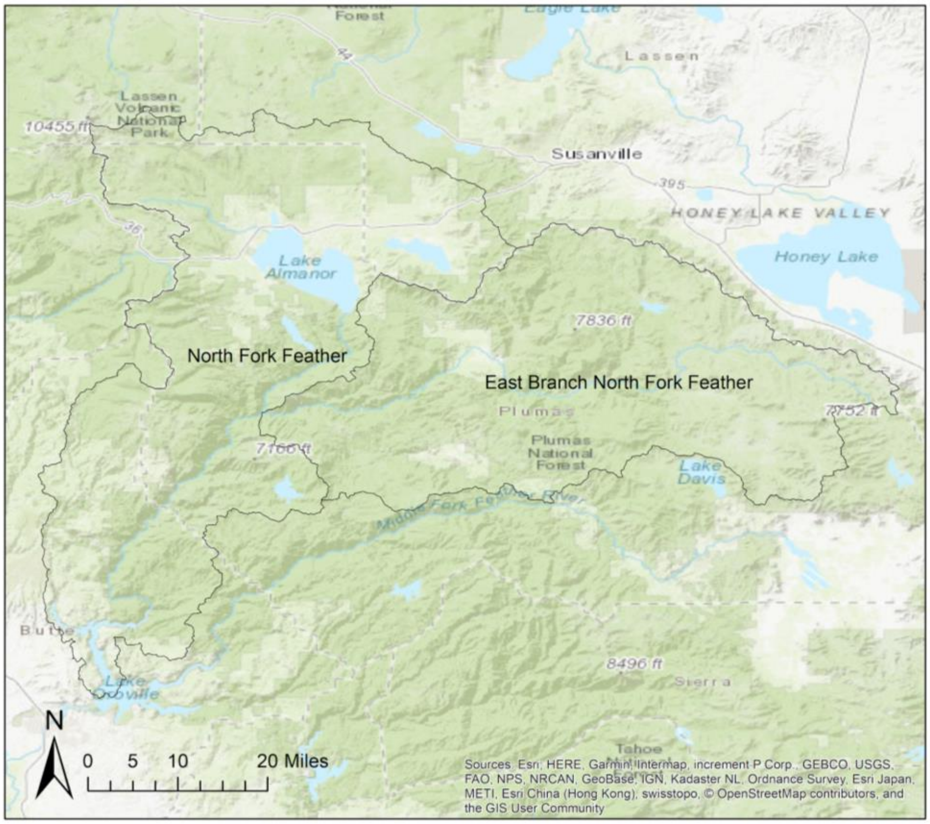

Figure 1. The North Fork Feather River watershed, our geographic region of focus.

To use the tool, we recommend that practitioners first consult an expert to create a site-appropriate planting list for their project based on native plant assemblages of nearby reference sites. The list can then be evaluated with this tool to ensure that it includes species that have traits that enable them to persist, recruit, and function under current and future conditions. It is essential that species are selected that are suited to post-restoration site conditions. Consider hydrological variability and microclimates within the project site and select species likely to do well across this gradient; for example, obligate wetland/wet meadow species can be planted in areas of the meadow likely to be inundated with water year-round, while more mesic meadow species can be placed in areas of the meadow with more hydrological variability. You can also use the **Plant Selection** tab of the tool workbook to inform species selection based on factors such as the bioregion(s), meadow type(s), and wetland indicator status.

The end goal of the user should be to ensure that all traits are represented in a planting list, and ideally, that each trait is represented by multiple plant species; this helps provide ecological redundancy which in turn increases ecosystem resilience (Shigeo and Loreau

1999). If any traits are not well-represented in the species selected, then practitioners can begin a discussion with local experts about which species may need to be added to the restoration design to ensure survival under current site conditions while also anticipating how climate change may impact the site in the future. The **Plant Selection** tab of the tool workbook can also be used to identify additional species for inclusion in your planting design. This tab can help the user evaluate which species are likely to occur in your region based on factors such as elevation range, bioregion, and meadow hydrological type.

Climate change requires dealing with uncertainty. Practitioners should balance inclusion of species well-adapted to current site conditions with inclusion of species that might be adapted to future site conditions. For example, more drought-tolerant species could be planted along drier meadow edges, facilitating the expansion of these species into the meadow during dry years and ensuring resource availability to wildlife during these periods of environmental stress. Adaptive management and monitoring is critical to evaluate how well plants are doing on the site, and practitioners should adjust as needed in response to plant survival and changing site conditions. For example, if climate change is leading to a shift in the meadow from wet to mesic or dry, or if there is an increase in flood events during the winter, practitioners can use the tool to select and plant species that may be better adapted to these changing conditions. Practitioners should be sure to “show their work” by documenting their rationale for why certain species were included or excluded from a planting design.

If users wish to evaluate species not already incorporated in the tool, they can easily add species by following the directions in this user guide. While the tool can be used to identify species with beneficial traits (e.g. drought tolerant), always consult an expert to determine if species are well-suited to a project site and goals before inclusion in a restoration design. Appendix B offers suggested resources for users interested in learning about plant propagation and sourcing of plant material.

Using the climate-smart planting palette workbook

The tool is hosted in an Excel macro-enabled workbook. To use the tool, follow these steps:

1. In the **Plant Selection** tab, under the “Include?” column, place a “1” next to the species that you wish to evaluate, then **save** the workbook to ensure the rest of the workbook will be updated with your selections.
2. Go to the **Climate-Smart Performance** tab. At the top of the Menu bar, click on the Analyze tab, then hit **Refresh -> Refresh All** to update the graphs to reflect your current species selection. This tab will then display a graphical summary of the species persistence traits (e.g., climatic tolerances) of your design.
3. Look through the **Species Traits** tab to see traits results for individual species, including disturbance resilience, wildlife support traits, resource phenology, ecosystem process traits, and cultural ecosystem service traits plus additional notes for each species. You can also use this tab to identify species that will increase climate-smart performance while reaching additional co-benefits.

Depending on how well different traits are represented among your selected species, you may decide to include additional species in your palette. Always be sure to save the workbook and refresh the Climate-Smart Performance charts whenever you make a change to the species selection.

APPENDIX A: Plant Trait Definitions

Species Persistence Traits

The following traits were selected to increase plant survival and species persistence under future climatic conditions.

Drought Tolerance

Rationale: Climate models for the Sierra Nevada and southern Cascades project increased temperatures and increased likelihood of drought events (Garfin et al. 2013; Viers et al. 2013). Warming increases the probability that years with low precipitation will coincide with high temperatures, increasing the frequency, intensity, and severity of drought events (Diffenbaugh et al. 2015). Considering these projections, restoration projects that include drought tolerant plants may have better survival during periods of high moisture deficit as well as in a warmer climate with more variable precipitation.

Definition: Based on USDA's Conservation Plant Characteristics Data Definitions, drought tolerant species were defined as those typically found in coarse, well-drained soils with low soil-moisture relative to species of the same growth form that occur in the same geographic area. Drought tolerance of each species was based on USDA Conservation Plant Characteristics Data. Wetland Indicator Status and/or expert opinion were used when USDA data were not available. A comparison of USDA Conservation Plant Characteristics Data and Wetland Indicator Status found parallels used to classify plant species as:

- High – Plant reported to have high drought tolerance or Wetland Indicator Status of Obligate Upland
- Medium – Plant reported to have medium drought tolerance or Wetland Indicator Statuses of Facultative or Facultative Upland
- Low – Plant reported to have low drought tolerance or Wetland Indicator Status of Facultative Wetland
- None – Plant reported to have no drought tolerance or Wetland Indicator Status of Obligate Wetland

Fire Tolerance

Rationale: Climate projections indicate increased frequency, severity, and extent of wildfire in response to rising temperatures and increased summer dryness (Miller et al. 2009; Garfin et al. 2013) in addition to human factors such as past land management and fire suppression. Because many of our California native plants have evolved in concert with natural wildfire regimes, including these species in restoration designs can increase the ability of vegetation to persist after fire. Potential fire adaptations include the ability to resprout from the roots, tubers, or rhizomes, and the tolerance of the seed to fire including serotinous seeds, bark thickness, tall crowns, and bud protection.

Definition: Based on USDA's Conservation Plant Characteristics Data Definitions, fire tolerance was defined as the relative ability (high, medium, low, none) to resprout, regrow, or reestablish from residual seed after a fire. When data from USDA is unavailable, published literature was used to determine whether the species does or does not have adaptations that allow it to resprout, regrow, or reestablish from residual seed after fire (yes/no).

- High: Species has high relative ability to resprout, regrow, or reestablish from residual seed after a fire
- Medium: Species has medium relative ability to resprout, regrow, or reestablish from residual seed after a fire
- Low: Species has low relative ability to resprout, regrow, or reestablish from residual seed after a fire
- None/No: Species has no adaptations that allow it to resprout, regrow, or reestablish from residual seed after a fire and/or is maladapted to fire.
- Yes: Species have adaptations that allow it to resprout, regrow, or reestablish from residual seed after a fire, but relative ability is unknown.
- ? - Information unavailable, inconclusive, or of inadequate quality

Flood Tolerant

Rationale: Climate projections for the Sierra Nevada indicate potential increases in rain-on-snow events leading to high winter flows and extreme flood events (Garfin et al. 2013; Viers et al. 2013). In addition, a common goal of riparian meadow restoration projects is to reconnect stream channels to the floodplain to help dissipate the energy of high flow events onto the floodplain. Thus, species that tolerate seasonal flooding and/or periodic inundation may therefore be well adapted to future climate and post-restoration conditions.

Definition: Species in this category can tolerate seasonal flooding and/or periodic inundation as indicated by published information and expert opinion.

- Yes - Plant can tolerate seasonal or periodic flooding.
- No - Plant cannot tolerate seasonal or periodic flooding.
- ? - Information unavailable, inconclusive, or of inadequate quality

Tolerates Seasonally Dry Conditions

Rationale: Overall temperatures are expected to increase through the end of this century. Warming temperatures will result in widespread hydrological changes throughout the Sierra Nevada and southern Cascades, driven primarily by loss of snowpack and climatic water deficit (Stephenson 2007; Viers et al. 2013; Reich et al. 2018; Rhoades et al. 2018). Though there is disagreement among models as to the direction and magnitude of projected change in precipitation, there is agreement that more precipitation will be falling as rain instead of snow, which in turn will shift stream runoff timing to earlier in the year; this will lead to drier late-season conditions and increased climatic water deficit (Viers et al. 2013; Garfin et al. 2013; Reich et al. 2018; Rhoades et al. 2018). We need to plan for projects to annually experience extended warmer periods with less moisture and surface water availability.

Definition: Tolerance to seasonally dry conditions was qualitatively ranked into three categories of low, medium, and high based on the montane meadow habitat type in which the species is known to occur, using definitions from Lorenzana et al. 2017. When details on the montane meadow habitat type was not available, expert opinion was used to assign species to the following categories:

- High - Species known to occur in dry meadows, where soil moisture is generally below the rooting zone for the entire growing season. These species generally have a wetland rating of facultative or facultative upland.
- Medium - Species known to occur in mesic meadows, where soils are saturated within the rooting zone early in the growing season but then drops below the rooting zone in the latter half of the growing season. These species could have a wetland rating of facultative, facultative wetland, or obligate wetland.
- Low - Species known to occur in wet meadows, where the water table is generally within the rooting zone for most of the growing season. These species generally have a wetland rating of obligate or facultative wetland.

Tolerates Wet Conditions

Rationale: Although most climate models project increased air temperatures and overall drier soil conditions in the summer, models also project an increase in the frequency and severity of extreme winter precipitation events, floods, and summer storms (Garfin et al. 2013; Viers et al. 2013). While climate models disagree about whether there may be an overall increase or decrease in precipitation throughout the century, it is likely that there will continue to be inter-annual variability in precipitation. By incorporating species that tolerate or thrive in wet conditions into planting designs with species that tolerate dry conditions, practitioners can address the uncertainty in the future precipitation patterns.

Definition: Species in this category can persist in high moisture conditions throughout the calendar year. These species generally occur in wet meadows and/or have a wetland rating of obligate or facultative wetland. Published literature and/or expert opinion indicate that:

- Yes - Plant is known to occur and thrive in wet conditions year round.
- No - Plant is not known to occur and survive in wet conditions year round.
- ? - Information unavailable, inconclusive, or of inadequate quality.

Disturbance Resilience Traits

The following traits were selected because they might improve the probability of recolonization and recruitment of native vegetation following a disturbance event.

Disturbance Tolerance

Rationale: Climate change will lead to increases in disturbances such as floods, fire, and drought. Species that are tolerant of moderate or high intensity disturbance and moderate to high levels of stress may be better adapted to these future conditions. Additionally, species adapted to disturbance may be useful for immediate revegetation post-restoration activities on disturbed soil.

Definition: The species' ecological status code of ruderal, intermediate, or competitor is used to determine whether the species has low, moderate, or high tolerance to disturbance; when this information was unavailable, expert opinion was used. The ecological status code rating describes how a plant generally responds to disturbance and are presented based on general group characteristics (Lorenzana et al. 2017). Competitor species typically occupy sites with low to moderate amounts of disturbance and are generally more competitive in later successional stands. Intermediate species typically occupy sites of moderate intensity disturbance and are able to adapt to moderate to high levels of stress imposed by the environment. Ruderal species typically occupy sites with high intensity disturbance and usually low intensity environmental stress.

- High - The species has a high tolerance to disturbance (ruderal species).
- Moderate - The species has a moderate tolerance to disturbance (intermediate species).
- Low - The species has a low tolerance to disturbance (competitor species).
- ? - Information is not available.

Geophyte

Rationale: Geophytes are perennial plants with an underground food storage organ, such as a bulb, tuber, corm, or rhizome. These species may be able to persist after a disturbance.

Definition: Plants in this category are geophytes. Published information from sources such as Jepson eFlora and USDA's Conservation Plant Characteristics (Growth Form) were used to classify plant species as:

- Yes – Plant has an underground food storage organ.
- No – Plant does not have an underground food storage organ.
- ? - Information unavailable, inconclusive, or of inadequate quality.

Livestock Resource Value Rating

Rationale: Livestock grazing can be a source of disturbance to meadow vegetation. If livestock grazing is to occur post-restoration, managers may want to select species for revegetation that have low, moderate, or high resource value for livestock depending on goals.

Definition: Species are assigned to one of the following categories for livestock resource value ratings from Lorenzana et al. 2017:

- High - Plant is highly relished and consumed to a high degree.
- Moderate - Plant is moderately relished and consumed to a moderate degree.
- Low - Plant is not relished and normally consumed only to a small degree or not at all.
- ? - Information unavailable, inconclusive, or of inadequate quality.

Rhizomatous

Rationale: Plants with rhizomes or underground stems have the ability to reproduce vegetatively (without flowering or producing seeds), and can spread from a single individual to colonize a larger area. Newly restored sites may be vulnerable to colonization by invasive plants and weeds that out-compete native species. Incorporating rhizomatous plants into a restoration design helps ensure that the restoration site will be quickly colonized by native plants, may help reduce openings where invasive plants can establish, and may help reduce erosion by stabilizing soil and streambanks.

Definition: Plants in this category have rhizomes, and reproduce vegetatively. Published information from sources such as Jepson eFlora and USDA's Conservation Plant Characteristics (Growth Form) were used to classify plant species as:

- Yes – Plant spreads and reproduces via rhizomes, or underground stems.
- No – Plant does not have rhizomes.
- ? - Information unavailable, inconclusive, or of inadequate quality.

Water Dispersed

Rationale: Climate projections for the Sierra Nevada indicate potential increases in rain-on-snow events leading to high winter flows and extreme flood events (Garfin et al. 2013; Viers et al. 2013). In addition, a common goal of riparian meadow restoration projects is to reconnect stream channels to the floodplain, increasing seasonal inundation and recharging groundwater tables. Species that have seeds or propagules that disperse via water movements and/or flood disturbance may be better able to survive and recolonize sites post-restoration and in response to flood disturbances.

Definition: Species in this category have seeds or propagules that disperse via flood disturbance and/or water movements. Information from the California Native Plant Society's Manual of California Vegetation and other published sources of information was used to classify species as:

- Yes - Plant seeds or propagules can be dispersed by floods or water.
- No - Plant seeds or propagules are not dispersed by floods or water.
- ? - Information is unavailable, inconclusive, or of inadequate quality.

Wind Dispersed

Rationale: Climate change will lead to an increase in disturbances such as fire and drought. Species that are wind-dispersed may be more likely to colonize or recolonize a site after disturbance.

Definition: Species in this category have seeds or propagules that disperse via wind. Information from the California Native Plant Society's Manual of California Vegetation and other published sources of information was used to classify species as:

- Yes - Plant seeds or propagules can be dispersed by wind.
- No - Plant seeds or propagules are not dispersed by wind.
- ? - Information is unavailable, inconclusive, or of inadequate quality.

Wildlife Support Traits

The following traits were selected to 1) support basic food webs and facilitate pollination of native vegetation, which may also assist recruitment and resilience to disturbance, and 2) support wildlife by providing cover.

Cover for Wildlife

Rationale: Target wildlife species (e.g., amphibians, birds, fish, mammals) may be vulnerable to novel temperature and precipitation conditions, including increasing spring and summer temperatures as well as extreme summer precipitation and heat events. This may lead to increased competition among species for thermal refugia, and may result in mortality to individuals through direct exposure to extreme conditions (Vernon et al. 2019). Restoration projects can address these vulnerabilities by selecting plant species known to provide cover for wildlife, including cover from predators, cover for nesting and resting, and/or cover from climatic extremes.

Definition: Published information from sources such as the USDA Fire Effects Information System and USDA Plants Database, and/or expert opinion indicates that the species provides cover for wildlife, which includes concealment from predators and for nesting/resting, and also cover in the form of shade from extreme heat events.[1]

- Yes – Plant known to provide cover for wildlife.
- No – Plant not known to provide cover for wildlife.
- ? – Information unavailable, inconclusive, or of inadequate quality.

Insectary Plant

Rationale: Insects provide many ecosystem functions. They are critical for pollination and also provide food for other organisms, and are a critical source of protein during nesting season for birds (Parodi et al. 2016). Including plant species that provide resources for insects under a range of climate conditions in restoration projects can help promote a large and diverse population of insects that will enhance ecological benefits.

Definition: Plants in this category are known to play a role in an insect's life cycle by serving as a host plant, providing valuable resources such as nesting material, and/or being especially valuable to native bees as a source of nectar/pollen.[2] The "Associated Organisms" section on Calflora, the "Wildlife Supported" section on Calscape, and other published information was used to classify species as:

- Yes - Plants in this category are known to play a role in an insect's life cycle as a host plant, and/or benefit insects by providing resources such as pollen, nectar, or nesting material.
- No - Plant is not known to be used by or beneficial to insects.
- ? - Information unavailable, inconclusive, or of inadequate quality.

Resource Phenology

Rationale: Changing hydrological conditions driven by warming winter temperatures and declining snowpack may result in phenological mismatches among hydrology, plants, and animals. A shift in the hydrograph toward earlier in the year may cause flowers to be

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[1] Species that provide stream shading and bank stabilization also provide cover to fish by creating thermal refugia and creating habitat from undercut banks and root-wads. These traits are included under Ecosystem Process traits.

[2] This definition differs slightly from the nectar/pollen definition of food for wildlife and insects, in that there may be plants categorized as providing nectar/pollen as food for wildlife and insects that are not listed as insectary plants under this definition, which restricts insectary plants that provide nectar/pollen to those that have special value to native bees.

unavailable when birds are migrating, fruit to be unavailable for birds in late summer, and a mismatch between when flood waters recede and riparian shrub seeds set. Similarly, changing temperature and precipitation patterns may change the timing of invertebrate emergence, with implications for species that rely on invertebrates as a food source as well as for plant pollination. Considering that ecological patterns such as migration and plant phenology are subject to unpredictable changes, long-term project success may be enhanced by providing food resources for wildlife regardless of future scenarios. One way to maximize the potential for success is to ensure that the plants provide resources over most or all of the growing season in the Sierra, which we define as March-November. Doing so will help ensure that there are resources available that may buffer species from phenological mismatches in riparian systems.

Definition: Published information indicates that the species is known to provide resources (flowers, seeds) in the months outlined in the accompanying table. Species phenology can vary across populations depending on the elevation and region in which the species occurs, with some populations known to bloom earlier in the year than others. For the purposes of this tool, we restrict phenology to the months of March through November, which captures the growing season in the Sierra.

- F - Plant is known to flower during the indicated month(s).
- S - Plant is known to produce seed during the indicated month(s).
- F/S - Plant is known to flower and produce seed during the indicated month(s).

Food for Wildlife and Insects

Rationale: Restoration projects with goals related to target wildlife species should consider planting species known to provide abundant resources under various climatic conditions (Parodi et al. 2016). In addition, climate change has the potential to create new “novel” assemblages of wildlife that might use a project in ways that have not been observed (Ko 2014). Restoration projects can address this by including multiple sources of forage resources that fill as many niches as possible while considering resource phenology (see below).

Definition: Species in this category provide a food resource (fruit, seeds, nectar/pollen) known to be important for use by wildlife (including insects). Published information from Calflora’s “Associated Organisms” section, Calscape’s “Wildlife Supported” section, USDA Fire Effects System, USDA PLANTS Database, and expert opinion indicate that:

- Yes - Plant produces fruit, seeds, and/or nectar/pollen documented as used by wildlife and/or insects.
- No - Plant does not produce fruit, seeds, and/or nectar/pollen documented as used by wildlife and/or insects.
- ? - Information unavailable, inconclusive, or of inadequate quality.

Ecosystem Process Traits

The following traits were selected because they help regulate and support ecosystem processes in meadows that are often targeted in meadow restoration projects, such as streambank stabilization.

Bank Stabilization and Erosion Control

Rationale: Climate change will lead to increases in disturbances such as floods, fires, and drought that may lead to streambank erosion. Cattle grazing in meadows post-restoration might also lead to unstable streambanks and contribute to erosion. Restoration projects can help address these vulnerabilities by planting species with rooting systems that can help stabilize soils, buffer the forces of moving water, and provide cover for fish and aquatic organisms in exposed root-wads.

Definition: Published literature and expert opinion indicate that the species has rhizomes or other characteristics that might help stabilize banks and/or reduce erosion. The greenline stability rating (channel bank stability rating on a scale of 1-10) was also used in place of or in supplementation to published information (Lorenzana et al. 2017). This rating is based on the type of rooting system, the strength of the roots, and the below-ground coverage of the root system and is on a scale of 1 (least) to 10 (greatest), rating the rooting system's ability to buffer the forces of moving water. Published literature, expert opinion, and/or greenline stability rating indicate that:

- Yes - The species can be used to help stabilize stream banks and/or help reduce erosion.
- No - The species cannot be used to help stabilize stream banks and.or help reduce erosion.
- ? - Information unavailable, inconclusive, or of inadequate quality.

Early Colonizer and/or Competitive with Invasives

Rationale: Climate change will lead to increases in disturbances such as floods, fire, and drought. Species that are early colonizers of disturbed sites may be able to more quickly recover after disturbances and outcompete invasive species.

Definition: Published literature and expert opinion indicate that the species is an early colonizer and/or competitive with invasives.

- Yes - Species is an early colonizer of disturbed sites and/or has traits that make it competitive with invasives.
- No - Species is not known to be an early colonizer and/or have traits that make it competitive with invasives.

Stream Shading

Rationale: Increasing air temperatures and reduced late-season water availability may lead to water temperatures outside the thermal tolerance of some fish and amphibians as well as a lack of instream habitat, especially during the late summer months when there is reduced runoff (Vernon et al. 2019). Restoration projects can address this vulnerability by planting riparian vegetative cover along stream channels to provide shade, decrease the potential for rising stream temperatures and associated negative impacts, reduce exposure by providing cover for fish and wildlife, stabilize stream banks, and capture sediment (Addington et al. 2018).

Definition: Published literature and expert opinion indicate that the species can provide shade to streams.

- Yes - Species known to shade streams.

- No - Species not known to shade streams.
- ? - Information unavailable, inconclusive, or of inadequate quality.

Cultural Ecosystem Services Traits

The following traits were selected to indicate whether the species provides important cultural ecosystem services through species' form (e.g., aesthetically pleasing flowers) or function (e.g., used for food, fiber, etc.).

Showy Flowers

Rationale: One of the goals of restoration may be to provide recreational opportunities and/or revegetate with plants that are aesthetically pleasing.

Definition: Species in this category have conspicuous, showy flowers either individually or in mass that may provide aesthetic value to a restoration site.

- Yes - Species has conspicuous, showy flowers.
- No - Species does not have conspicuous, showy flowers.

Ethnobotanical Species

Rationale: One of the goals of a restoration project may be to include ethnobotanical species that are especially culturally important to native peoples. This planting palette includes wetland-riparian species identified by Hill (1972) as those with recorded uses by the Maidu, who historically occupied the Feather River watershed.

Definition: Whether published information, traditional ecological knowledge, and/or expert opinion indicate that the species is ethnobotanical, defined as a species that has been used for medicinal, functional, or ceremonial purposes or used as a food source for human consumption.

- Yes - Species known to be used for medicinal, functional, ceremonial, or food purposes.
- No - Species not known to be used for medicinal, functional, ceremonial, or food purposes.

Species Distribution

The following categories were selected to provide details on species distribution and range to inform inclusion of the species in a planting design for a given site.

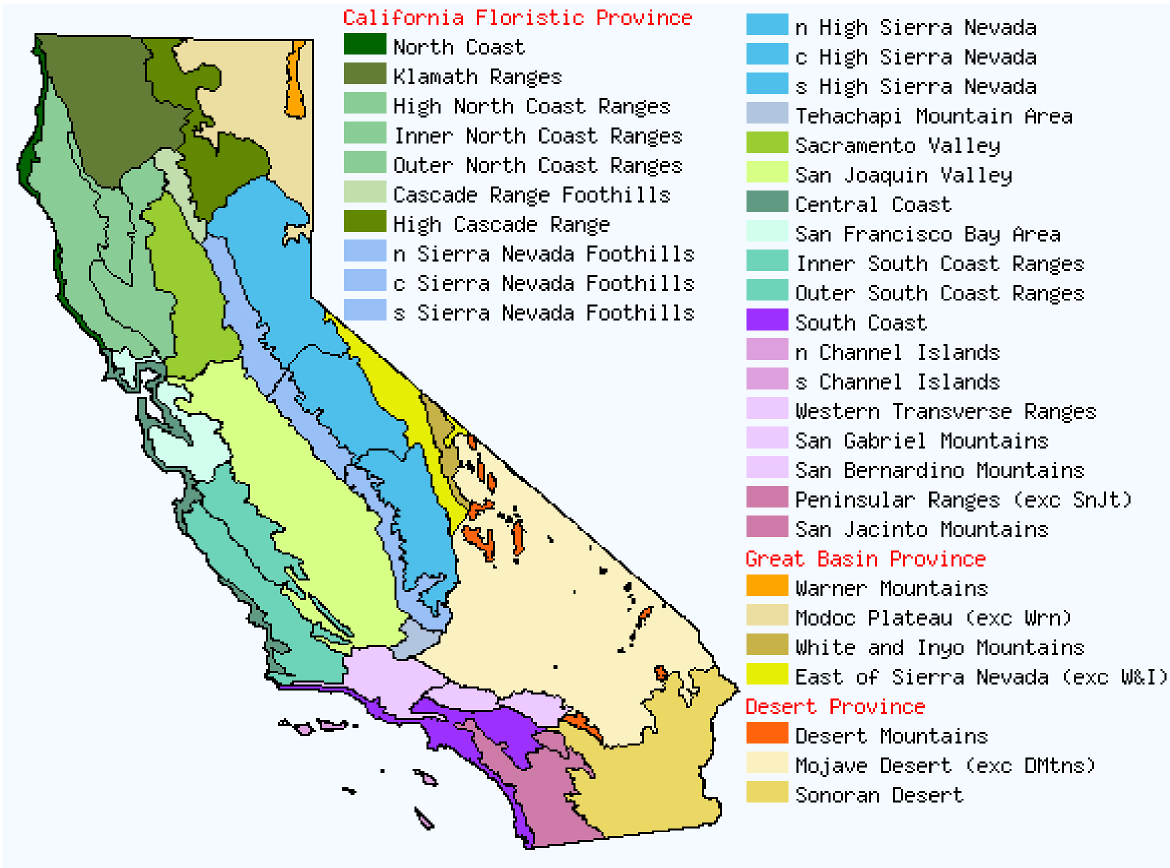

Figure 2: California Floristic Provinces, aka Bioregions, based on natural landscape features and biota and reflect broad patterns of natural vegetation, geology, topography, and climate. Image from Jepson eFlora, https://ucjeps.berkeley.edu/eflora/geography.html.

Bioregion: The California Floristic Province (aka bioregion or geographic subdivision) in which the species grows (from Jepson eFlora). These provinces are based on natural landscape features and biota and reflect broad patterns of natural vegetation, geology, topography, and climate (Figure 2). For the purposes of this tool, bioregion data are restricted to the High Cascade Range, Northern High Sierra Nevada Range, Central High Sierra Nevada Range, Southern Sierra Nevada Range, Modoc Plateau, and Warner Mountains.

Elevation range: The elevation range at which this species is found, in meters (from Calflora).

Habitat type: The habitat type(s) in which the species is usually found (from Lorenzana et al. 2017 and expert opinion.). This information can help practitioners determine which plants are suitable for different parts of the meadow.

- **Wet meadows:** Meadows where the water table is near the surface for most of the growing season and generally supports obligate wetland or facultative wetland species.

- **Mesic meadows:** Meadows where soils are saturated within the plant rooting zone early in the growing season, with the water table dropping below the rooting zone in the latter half of the growing season. Commonly adjacent to wet meadows within the same meadow complex. Generally support obligate wetland, facultative wetland, and facultative species.
- **Dry meadows:** Meadows where soil moisture is adequately available during the first half or so of the summer and the water table is generally below the rooting zone for the entire growing season. Generally supports facultative or facultative upland species.
- **Riparian zone:** Areas at the interface of a stream/river channel and land.

Wetland indicator status: These indicator statuses are used to designate a species' preference for occurrence in a wetland or upland and are as follows:

- **Obligate wetland (OBL):** Hydrophyte, almost always occurs in wetlands.
- **Facultative wetland (FACW):** Hydrophyte, usually occurs in wetlands, but may also occur in non-wetlands.
- **Facultative (FAC):** Hydrophyte, occurs in both wetlands and non-wetlands.
- **Facultative upland (FACU):** Non-hydrophyte, usually occurs in non-wetlands, but may occur in wetlands.
- **Obligate upland (UPL):** Non-hydrophyte, almost never occurs in wetlands.

APPENDIX B: Plant Propagation and Materials Sourcing

It is outside the scope of this tool to provide detailed information on plant propagation and materials sourcing for each species. However, there are several resources available that can assist with these needs. The California Native Plant Link Exchange and Calscape both include information about commercial availability of species in nurseries. Native plant nurseries located in the Sierra Nevada and southern Cascades regions include:

- Sierra Seed Supply, Greenville, CA
- Comstock Seed, Gardnerville, CA
- Shilling Seed, Auburn, CA
- Washoe State Nursery, Carson City, NV
- Native Grounds Nursery, Shasta, CA
- Villager Nursery, Truckee, CA
- Floral Native Nursery, Chico, CA
- High Ranch Nursery, Loomis, CA

Information on plant propagation and materials sourcing can be found online through the following databases:

- USDA Natural Resource Conservation Service PLANTS Database
- Lady Bird Johnson Wildflower Center
- Germplasm Resources Information Network (GRIN)
- Native Plant Network - Propagation Protocol Database
- Seed Information Database

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