Monarch Butterfly Habitat Creation in California

A Technical Field Guide

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Introduction

Current status of the monarch butterfly

One of the most iconic butterfly species in North America, the monarch butterfly *(Danaus plexippus)*, is suffering steep population declines throughout its North American range. The western U.S. monarch population is estimated to have declined by over 95% since the 1980s with estimates of a quasi-extinction risk of 72% in 20 years (Schultz et al. 2017). In addition, the eastern U.S. population has faced significant losses of 80% over the last decade, resulting in a quasi-extinction risk of 11-57% in 20 years (Semmens et al. 2016). Western U.S. breeding habitats and overwintering grounds have shown decreasing acreage trends over time, contributing to the observed dramatic decline in monarch abundance (Schultz et al. 2017; Espeset et al. 2016). This widespread decline across North America has resulted in a petition to list the species as threatened under the Endangered Species Act. The U.S. Fish and Wildlife Service will announce a listing decision by June 2019.

Habitat loss is one of the contributing factors to the widespread decline of monarch butterflies across North America. Restoring habitat in key areas may contribute to species recovery. This technical guide provides hands-on guidance for the planting of habitat to benefit the western monarch butterfly population.

About the monarch butterfly

The Rocky Mountains geographically separate North American monarch butterflies into eastern and western populations. While their eastern counterparts overwinter in central Mexico, the majority of the western monarch population overwinters in wooded groves along coastal California (Schultz et al. 2017). During this overwintering period, monarchs enter a reproductive diapause—not mating or laying eggs—to conserve their energy for survival and spring dispersal (Pelton et al. 2018). From early spring through the end of fall, monarchs breed continuously throughout their western range in California, Nevada, Arizona, and parts of Oregon and Washington. The population will experience several generations during each breeding season, with the final generation of each breeding season making the migration to coastal overwintering grounds.

To support monarchs throughout their breeding and migration, habitat must provide both milkweed and additional nectar sources for the duration of the monarch's breeding season. Milkweed is critical for the monarch's survival because during the breeding season adult female monarchs only lay eggs on milkweed plants, and young caterpillars rely exclusively on milkweed for food. Chemical compounds in milkweed plants are transferred to the caterpillar, which helps deter predators from preying on caterpillars and adult monarchs. After metamorphosis, the new generation of butterflies will typically mate prior to dispersal (Leong et al. 1995). Figure 1 shows approximate migration routes. Flowering milkweed plants and other native nectar plants provide food for adult monarchs through the breeding season and for the return migration to their overwintering sites.

Current threats to monarch populations

Current threats contributing to the decline of monarch populations in the western U.S. include land use change; parasites, disease, and predators; and climate change. Land use change has led to loss of nectar and breeding resources, increased use of herbicide and insecticide, and an increase in invasive species establishment—all of which contribute to the loss of natural monarch habitat. Sparse breeding habitat can lead to prolonged search times by female monarchs, thereby increasing exposure to predation, pesticides, and other threats (Borders and Lee-Mäder 2014). Climate change, including extreme heat, climate variability, and extreme weather (e.g. drought), also increase stress on monarchs and their habitat. Continuing threats to the monarch butterfly population create a need

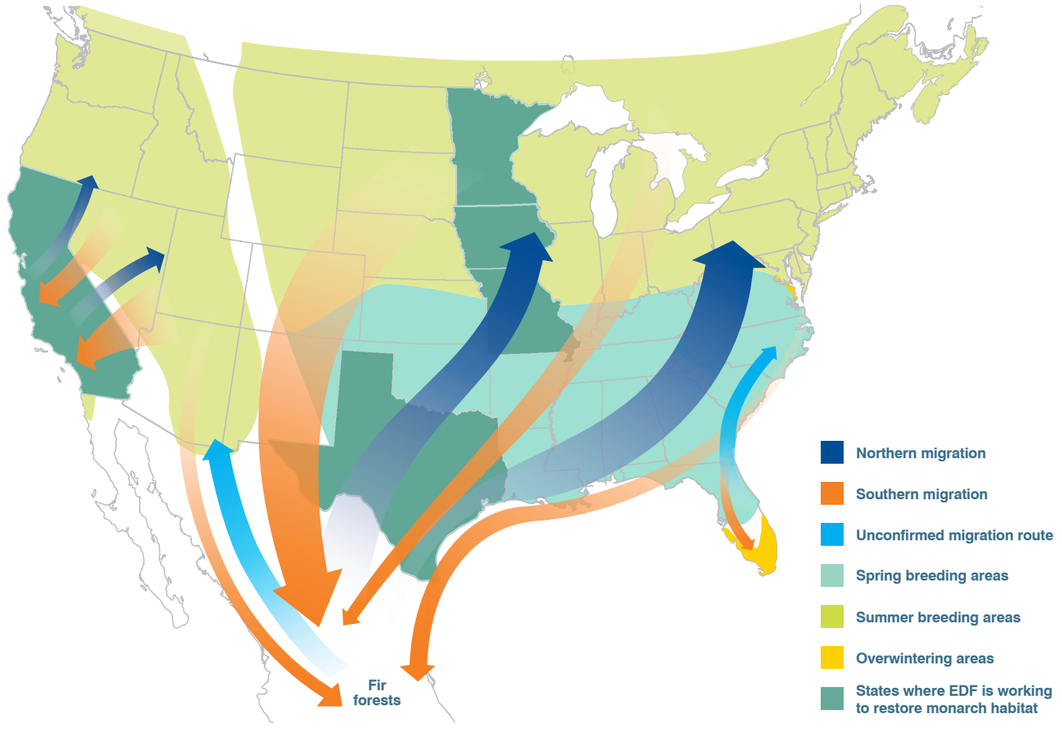
for high quality monarch breeding and migratory habitat that includes native milkweeds and other native forbs, shrubs, and trees that provide nectar.

Agricultural involvement in monarch conservation

The amount of land devoted to farming and ranching in California in 2016 was 25.4 million acres (CDFA 2017). There is a significant opportunity to restore and enhance habitat in historical monarch breeding ranges and migratory routes in some of California's vast agricultural regions. The agricultural sector is well suited for monarch conservation—farmers are important stewards of the land and the habitat it provides, and monarch habitat can also provide benefits for agricultural production. Many growers are already supporting monarchs and other pollinators on their land, and are growing habitat for monarchs in hedgerows, on the sides of levees, in buffer strips, in crop margins, and in other out of production areas.

Milkweed and nectar plants on farms not only provide food and shelter for the monarch butterfly, but also support beneficial insects for agriculture such as pollinators and natural predators. Nectar-rich resources help support both native bees and honeybees; healthier honeybees that are more resistant to disease are more reliable for crop pollination (Alaux et al. 2010). Beneficial insects have been shown to be attracted to milkweed species, which can provide support for attacking crop pests through natural biological control and integrated pest management (James et al. 2016). Additional benefits to agricultural landscapes include enhanced weed control, air and water quality protection, and soil erosion control (Long and Anderson 2010).

Figure 1. Map of monarch migration routes.



About this guide

This guide is intended to be a resource for those interested in establishing or increasing habitat for monarchs on farms, ranches, and other working lands. It summarizes the best available scientific and practical information on restoring California native milkweed species and other native plant species important to monarch butterflies as nectar sources. The general guidance it offers can be supplemented with more detailed, location-specific information available from local seed suppliers, local naturalists, native plant societies, and the extensive resources available online. Some suggested resources are imbedded within this document.

The Natural Resource Conservation Service (NRCS) can provide technical assistance on a variety of issues through the Conservation Technical Assistance (CTA) program, including integrated pest management. To find your local NRCS Service Center, please visit: **https://goo.gl/uf9hmQ**

Establishing Monarch Habitat

Monarch habitat requires patches of habitat that consist of a variety of plant species including milkweed to support breeding; woody trees and shrubs to provide shelter that protects adults at night and during bad weather; and a variety of nectar plants to provide food for migrating adults. Ideally, the habitat patch would also have a source of shallow water for monarchs to “puddle”, which is their way of obtaining water and mineral nutrients. While the plant species composition included in these habitat patches may differ regionally, the components listed above must be included to provide high-quality monarch habitat. Providing milkweed and other nectar-rich flowers that bloom where and when monarchs need them is one of the most important contributions we can make to help recover the monarch population. This includes the restoration of patches of habitat on working lands that can serve as migratory corridors for the monarch to get from their wintering sites, across the Central Valley, to the Sierra foothills and north and east into Nevada, Oregon, and beyond.

Part 1: Planning

Where to plant milkweed in California

The Central Valley and foothills of the Sierra Nevada are priority areas for habitat restoration and enhancement because monarchs pass through these regions on their spring and fall migrations (Pelton et al. 2018). Widespread planting of milkweed across California is not a recommended strategy: milkweed shouldn't be planted in plant communities where it would not naturally grow, at extremely high elevations, or within 5-10 miles of the Pacific coast overwintering range in central and northern California (E. Pelton and C. Fallon, Pers. Comm. 11/27/18). However, in coastal areas, it is still highly beneficial to plant nectar resources for monarchs, especially early- and late-blooming species.

Where to plant milkweed at your site

Proper planning is essential when establishing habitat for monarchs and other pollinators—choosing the best possible site helps a project create benefits for monarchs in a way that is compatible with farm or ranch operations. Milkweeds are naturally found in a variety of habitats including grasslands, open woodlands, and riparian habitat. They will also colonize disturbed strips along roadsides, railroad rights of way, and irrigation canals. The best indication of optimal conditions for milkweed establishment at your site may be to find a site close to locations where milkweed is already growing. If you find a patch of milkweed on your property or close to it, make a note of the conditions where plants are currently growing. Noting the soil type, irrigation status, surrounding plant community and management regime could provide invaluable information for establishing your monarch habitat.

The most important factor in planning where to establish milkweed habitat is to find a location that is protected from untimely mowing, disking and chemical (pesticide) application. Since milkweeds and many of the associated nectar plants are perennial species, habitat should be established on a site where long term management and maintenance is feasible. Given proximity of habitat to pesticides used on crop fields, any habitat within 100 feet of target areas for pesticides should be protected from pesticide exposure (USDA-NRCS and Xerces 2014). Provided that exposure pathways are appropriately mitigated, a completely pesticide-free buffer may not be required (more information on pesticides is found in Part 3: Management and Monitoring). Landowners should consult with conservation specialists to develop an integrated pest management plan that adequately protects monarchs and other pollinators from pesticide exposure.

A combination of milkweed, diverse nectar resources, and natural surrounding vegetation are ideal characteristics of monarch habitat. Milkweed tends to grow in patches in open areas with full sun. Some studies have found that smaller areas with dense milkweed plantings are not as beneficial to monarchs as larger areas with a lower density of milkweed (Pitman et al. 2018). Egg-laying females tend to favor lower density milkweed habitat. Lower densities of milkweed also reduce the risk of disease to spread between monarchs. A larger space can also support higher nectar plant diversity, and thus more pollinators (Kasten et al. 2016; Anderson et al. 2017). A target density of between 200 to 2,000 milkweed plants per acre is a realistic suggested density. Kasten et al. (2016) showed that above 2,000 plants per acre, there is no associated increase in monarch eggs laid.

While native milkweeds and other nectar species are generally adapted to drought conditions, the planting may require some irrigation in the first 1-2 years of establishment. Therefore, it is best to choose a site that can be easily irrigated; the proximity of water resources or availability of portable water sources are important considerations.

Milkweed species contain chemicals called cardenolides that can be toxic to many animals including livestock. Milkweed species are common in California's grazing lands, but are typically avoided by grazing animals when sufficient alternate feed is available. Livestock-milkweed interactions are rare unless high-intensity grazing is occurring.

Therefore, planting low densities of milkweed in areas where grazing animals may be present should pose little threat to their health (USDA 2018; Pelton et al. 2018). If high intensity grazing does occur, ranches can plant in areas where cattle are already excluded, such as riparian strips.

Selecting species to plant

Native milkweed species

There are 15 species of milkweed native to California and all are perennial and lose their leaves each year. The milkweed's flowers produce high quality nectar for a variety of pollinators, including the monarch butterfly. Milkweeds are also the only plant that adult monarchs will lay their eggs on, and the only food that monarch caterpillars eat. Milkweeds get their name from the milky sap that they exude when injured. This sap contains the alkaloids and cardenolides that protect monarchs by making the monarch larvae and adult butterfly toxic to predators. Milkweeds typically flower between late spring and the end of summer, producing large seed pods. When the pods are mature, they release a crop of "winged" seeds that have a fluffy top (pappus or floss), which aids in wind dispersal. Following seed dispersal, their aboveground growth dies back to the ground.

Two of the species native to California are widely available commercially:

1. Narrow leaf milkweed (*Asclepias fascicularis*) is geographically widespread and found across most of California. It is found in dry to moist soil in open, sunny areas including grasslands, foothill woodlands, chaparral, wetlands, riparian zones, forest clearings, and roadsides. It flowers from May to October. Narrow leaf milkweed can grow up to 3 feet tall, has flowers with a white corona and pink corolla, 2-5 inch long, narrow leaves that are opposite each other on the stem or in a whorled pattern around the stem. Its fruits are 2-4 inches long, narrow, smooth-textured, and hairless. (Borders and Lee-Mäder 2014).

2. Showy milkweed (*Asclepias speciosa*) is distributed among the hills and mountains of the northern half of California. It is found in dry to moist soil in open, sunny areas including wetlands, meadows, savannah, forest clearings, and along roadsides, railways and waterways. It flowers from May to September. Showy milkweed can grow up to 4 feet tall, can grow in large stands of plants, and has flowers with pink/white corona and pink corolla that can form a 4-pointed star. Its stems are covered in soft hairs that are often matted and has broad leaves 3-7 inches long, that are opposite each other on the stem

and covered in soft hairs and often matted. Its fruits are 2-3 inches long, covered in dense, woolly hairs and some have warty projections (Borders and Lee-Mäder 2014).

In general, milkweeds grown within their native range and preferred soil type are well adapted to non-irrigated conditions. Narrow leaf milkweed is relatively easy to grow in a wide range of soil types, including clay. Showy milkweed is adapted to a range of soil types, but prefers well-drained soils with a pH range of 5.0 to 7.0 (NRCS n.d.).


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Figure 2. Narrow leaf milkweed.


TOM KOERNER,USFWS

Figure 3. Showy milkweed.

California native nectar plants

While monarch larvae are milkweed specialists, adult monarch butterflies are generalists that can feed on nectar from a variety of flowering plants. Nectar provides sustenance for monarch breeding, migration and overwintering. Thus, it is important to have flowering plants from spring to late fall in order to provide a reliable nectar source. Of particular importance are fall and early spring blooming flowers that provide food for migrating monarchs. While it is important to plant native species, non-native plants can also provide nectar resources for monarchs, such as non-native thistles (*Asteraceae* family; Pelton et al. 2018). Many of the species in Table 3 grow naturally along roadsides, riparian habitat, canals, ditches and other ruderal areas. The identification of existing monarch nectar plants on the site can facilitate appropriate management for those areas and help build a list of species that are likely to do well. Other species, not included in Table 3, may also be suitable nectar resources. Consult with a local expert to identify plant species best suited for your area.

Sourcing plant materials

Milkweed and native nectar plant seed and plant material are typically only available from native plant suppliers. Table 2 has a list of California nurseries that have at least one species of native milkweed seed and container stock available. Many of these nurseries also offer services for growing out locally collected seed and roots/rhizomes. If resources are available, this is the best option for sourcing plant material for a project site since the source material is guaranteed to be local.

If existing milkweed plants are locally available and accessible, seed can be collected from them to supplement seed bought from native seed suppliers.

When ordering seed and/or plant material from vendors, try to get seed sourced from a population as close to the site you are planting as possible. This will increase the chances of a successful project since the plant material will be better adapted to local site conditions including precipitation and temperature regime.

Depending on the specifications of the project, it may be suitable to harvest seed from milkweed growing wild nearby. Please be aware that permits are required to collect seed on public lands. Locally-sourced seeds are generally better suited to the site, and can offset costs. If a suitable source of milkweed seed exists at or nearby the site, it can be collected at the end of the flowering season as the plants are producing seed: typically from late spring to early fall, depending on the species and the site. Seeds are ready for collection once the seeds inside the seed pod have turned brown and firm (Borders and Lee-Mäder 2014).

Seed should only be collected when it is mature. Milkweed seed is brown at maturity, and pods will split open when mature. The best time to collect milkweed seed is in fall, after seeds have matured but prior to expansion of floss fibers. It is important not to over-harvest a single strand; the recommended practice is to collect no more than 20% of the seed from a given population on a single day (Borders and Lee-Mäder 2014). Additional information can be found in the Xerces Society's "Milkweed: A Conservation Practitioner's Guide" or from your local seed company.

Locally-collected seed can be sent to a local nursery for propagation, propagated on site if resources are available, or sown directly into the planting site. Most milkweed species must undergo a period of stratification in cold, moist conditions in order to germinate (Borders and Lee-Mäder 2014). If collected seed is planted in the fall, then stratification will occur naturally over the winter.

When propagating seedlings or direct-sowing seed in the spring, artificial stratification in a refrigerator is recommended to enhance germination. To stratify milkweed seed, mix a ratio of one part seed with 2-3 parts moist peat moss or moist vermiculite and place in a sealed container in the refrigerator. Seeds must be kept moist the entire treatment but should not be allowed to mold. Check the seed periodically to make sure the mixture is moist and that there are no visible root tips. If root tips are visible, plant the seed immediately. Milkweed seed needs from 4-6 weeks of cold stratification to break dormancy. See Borders and Lee-Mäder (2014) for additional information on how to stratify milkweed seeds.

Locating seed vendors:
Table 2 and the Xerces Society's Milkweed Seed Finder at **https://xerces.org/milkweed-seed-finder/** can help you locate local seed vendors.

Seed vendors are a valuable resource for information about when and how to plant your seed. Some important questions for seed vendors:

- What species are available? What species are available that are most beneficial for monarchs and other native pollinators?
- What is the origin of the seed? Where do you source it?
- What is the PLS (pure live seed) content of the seed?
- What is the recommended seeding rate?
- What planting methods are most successful for this type of seed?
- Have any of these plant materials been treated with insecticides?

For more information on native plant species, including distribution, please visit **https://plants.sc.egov.usda.gov/**

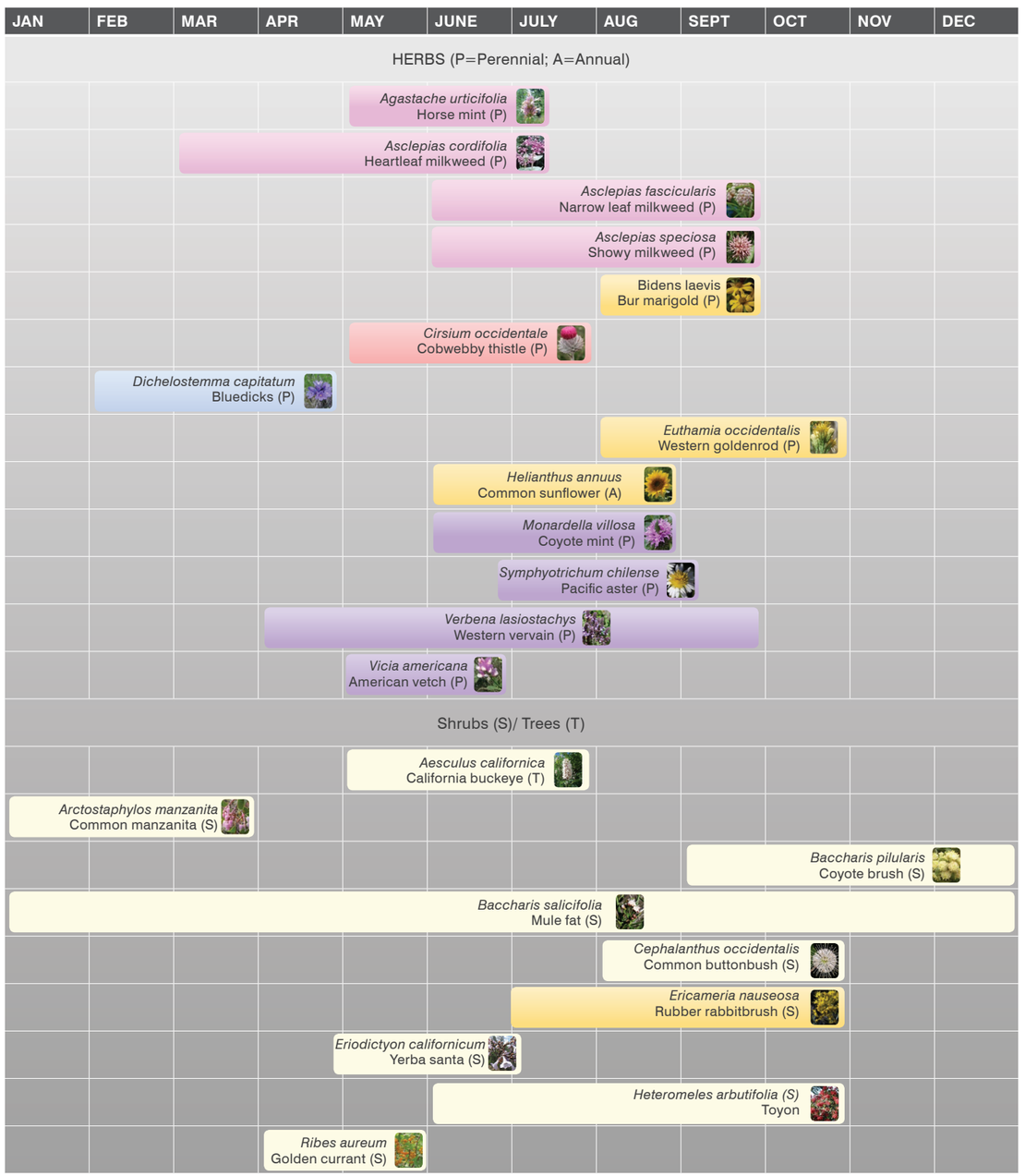
Table 1. Milkweed species common in California (adapted from Pelton et al. 2018).

Species	Common Name	Flowering Months	Commercially Available Seed/Plants	Species Distribution in State	Habitat Type
Asclepias albicans	Whitestem milkweed	March–April	No	SE	Dry rock places in deserts, including desert flats, slopes and creosote bush scrub communities
Asclepias californica	California milkweed	April–July	No	W	Flats and grassy or brushy slopes in many plant communities, including valley grassland, foothill woodland, yellow pine forest, pinyon-juniper woodland, and chaparral
Asclepias cordifolia	Heartleaf milkweed	May–July	Yes	N, E	Dry, rocky areas in woodlands, chaparral, and evergreen forest in the North Coast Ranges, the Klamath Ranges, the Modoc Plateau, and the foothills and lower montane zone of the Sierra Nevada and Cascade Range in California. Few records from isolated hills within the Sacramento Valley.
Asclepias eriocarpa	Woollypod milkweed	May–October	Yes	W	Dry, rocky areas in many plant communities, including valley grassland, chaparral, and foothill woodland. It also grows along stream banks and roadsides.
Asclepias erosa	Desert milkweed	April– October	No	SE	Dry washes, gulches, canyons, and roadsides in open deserts; in creosote bush, shadscale, and sometimes sagebrush communities.
Asclepias fascicularis	Narrow leaf milkweed	May–October	Yes	Most counties	Valley grasslands, wetland-riparian areas, foothill woodlands, and chaparral, and clearings within yellow pine, red fir, and lodgepole pine forests. In the Great Basin it grows in pinyon-juniper, sagebrush, and mountain brush communities, and moist to dry places including stream banks, roadsides, the banks of irrigation ditches, and fallowed fields.
Asclepias speciosa	Showy milkweed	May–September	Yes	Most counties	Dry to moist soil in open, sunny areas and occurs in many plant communities including wetlands, meadows, savannah, and forest clearings, as well as disturbed sites along roadsides, railways, and waterways. Widely tolerant of alkaline soils. Can become weedy in cultivated fields, pastures, and along roadsides, railways, and around habitations.
Asclepias vestita	Wooly milkweed	April– July	No	S	Valley grassland, chaparral, and foothill woodland on dry plains and hillsides and in canyons in the South Coast Ranges, the Mojave Desert, the Transverse Ranges, the margins of the San Joaquin Valley, and the foothills of the central Sierra Nevada.

Table 2. California Native Milkweed Seed Suppliers (non-extensive list). Adapted from **http://xerces.org/milkweed-seed-finder**

Name	Contact Information	Available Species	Special Services	Cost (Prices may vary)
Hedgerow Farms	https://www.hedgerowfarms.com 21905 County Road 88 Winters, CA 95694 (530) 662-6847 info@hedgerowfarms.com	Narrow leaf milkweed, heartleaf milkweed, woollypod milkweed, showy milkweed	Seed collection and contract growing for seed increases	$120/0.25 lb seed
Blue Moon Native Garden	https://bluemoonnative.com 38200 Buckeye Road Carmel Valley, CA 93924 (831) 224-7472 info@bluemoonnative.com	Narrow leaf milkweed, showy milkweed, woollypod milkweed		$7/50-75 seeds $20/ 0.25 oz seeds
Larner Seeds	https://www.larnerseeds.com 235 Grove Road Bolinas, CA 94924 (415) 868-9407 Info@larnerseeds.com	Narrow leaf milkweed, woollypod milkweed		$6.50/75-100 seeds
Pacific Coast Seed	http://www.pcseed.com 533 Hawthorne Place Livermore, CA 94550 (925) 373-4417 info@pcseed.com	Narrow leaf milkweed		$15/100 seeds (1/16 oz)
Sierra Seed Supply	http://www.sierraseedsupply.com 358 Williams Valley Rd. Greenville, CA 95947 (530) 284-7926 orders@sierraseedsupply.com	Heartleaf milkweed, narrow leaf milkweed, showy milkweed		$12-$15/gram seed $60/1 oz
Annie's Annuals	http://anniesannuals.com/mailorder-info/ 740 Market Ave. Richmond, CA 94801 (510) 215-3301	Heartleaf milkweed, narrow leaf milkweed, showy milkweed	*Does not sell seeds, only plants	$8.95-$10.95/pot
Las Pilitas Nursery	http://www.laspilitas.com 3232 Las Pilitas Road Santa Margarita, CA 93453 (805) 438-5992 penny@laspilitas.com	Narrow leaf milkweed, showy milkweed, wooly milkweed, California milkweed		$9.99-$12.99/pot

Table 3. California native monarch nectar species by season, life form and color. (Adapted from Pelton et al. 2018 and Fallon et al. 2016; Calflora 2018).



Part 2: Establishing Habitat

Milkweeds should be part of a diverse species mix made up of locally native plants including native grasses, legumes, and other native forbs (Borders and Lee-Mäder 2014). Plots with only milkweed will lack plant diversity, which may encourage weed encroachment and may be more susceptible to damage from milkweed diseases and specialist herbivores like oleander aphids. Also, monarchs typically require a diversity of other adjacent nectar plants in order to forage successfully. It is worthwhile to have a botanist familiar with monarch nectar species evaluate the area where restoration will occur. It is possible that some of the appropriate nectar species already occur on the site in which case more focused restoration of milkweed species may be appropriate. In this case, the emphasis would be placed on managing the existing monarch habitat while establishing milkweed within it, if it is absent.

Establishing native forbs including milkweed takes patience and may require some trial and error to find the best method for establishment at a given site. Based on information gathered from a number of California Central Valley restoration sites, no single method of milkweed establishment appears to work everywhere. One site in Colusa County had limited success seeding narrow leaf milkweed but excellent success planting the species as container plants. Hedgerow Farms in Yolo County had just the opposite experience in a small-scale trial planting of the same species. Establishment from direct sowing of seed versus vegetative propagation was superior at that site in the first year. The bottom line: you may need to experiment with a couple of methods to find the one that works best at your site.

Timing

Milkweed seeds do not germinate naturally immediately after dispersal. Germination is delayed until late winter or spring when the seeds have been exposed to cold, moist conditions (stratification) prior to the spring germination season. In fact, most late-season perennial forbs native to California exhibit this same pattern of seed dormancy during fall and winter. Given this, the best time to plant un-stratified milkweed seeds in California's Central Valley is in the late fall or early winter, prior to the rainy season (typically late October – early January). In addition to allowing for stratification of the seed, the winter rains can also help work seed into the soil (Borders and Lee-Mäder 2014). If seed is already stratified, it may be possible to seed in early spring. An important note is that stratified seed must be kept moist throughout the germination period.

Container plants can be planted later in the season (late winter/early spring) as long as soil moisture is available. Transplanting should only be done after the threat of frost has passed and should also be timed to avoid prolonged periods of hot, dry, or windy weather. Seedlings may be ready to transplant within as little as eight weeks and up to five months. A general guideline for timing transplant starts is to sow seed in a greenhouse two months before the last frost date. Given that, the stratification process should be started approximately three months prior to the target transplanting date. This is a conservative timeline, since seedling propagation may take longer than eight weeks. More detailed information on both growing and installing transplants can be found in the Xerces Society's Milkweeds: A Conservation Practitioner's Guide (Borders and Lee-Mäder 2014).

Seeding/Planting rates

Determining the configuration of the milkweed planting is important for determining how much seed and/or plant material is needed. The term "live seed" or "pure live seed" (PLS) is important when determining how much seed is needed for a project. It translates to the amount of seed in the lot that is capable of developing into a seedling. Be sure to ask your seed supplier for the PLS content of the seed you purchase.

In a mature restoration site, milkweed stem density should range between 200-2000 stems per acre. To achieve this

density, 0.5 to 1 lb PLS per acre should typically be used (EDF unpub. data). If seed supplies are not limited, or if seed lot viability is low or unknown, it can be advantageous to seed at a higher rate to promote vigorous germination and establishment. This may result in the need to hand-thin seedlings if high germination rates result in milkweed density above the recommended range—project implementers could also try transplanting any excess milkweed plants to other habitat sites.

If establishing milkweed seeds for seed production rather than habitat restoration, higher seeding rates are recommended.

Seeding rates for milkweed production fields: Seeding rates for establishing dense milkweed stands, such as in production fields rather than in restoration sites, typically range from 2–20 live seeds per linear foot. When single rows are spaced 40 inches apart, there are an estimated 13,800 linear feet in a 1-acre field. Given this row spacing, to seed a 1-acre field at a rate of 12 live seeds per linear foot, approximately 165,600 live seeds would be needed. Although variable with the milkweed species being planted; this translates to roughly 2–4 PLS pounds per acre.

Site preparation

Successful establishment of native plantings requires proper site preparation. The first step in site preparation is to assess the site for existing weeds and understand any restrictions on weed control methods at the site (e.g. certified organic crops). Eliminating or substantially reducing existing weed seed in the soil should be the main goal prior to planting and should start well before planting. Weeds can be eliminated with herbicides, solarization (using plastic sheets to heat the soil and kill seeds), burning, grazing or a combination of those methods. Depending on the abundance of weeds or weed seed at the planting site, one to two full years of weed control may be necessary to deplete the weed seed bank and effectively reduce competition from weeds.

Planting methods

There are three primary methods recommended for establishing your monarch habitat: drill seeding, hand sowing and container planting (Borders and Lee-Mäder 2014). A fourth option is to use a more targeted method of seeding using seed balls. The choice of planting method will be based on several factors including cost, plant availability, site conditions, desired habitat configuration and equipment availability.

Drill seeding

When the proper equipment is available, drill seeding may be the best method for establishing milkweed and other native forbs at sites larger than ¼ acre in size. Proper equipment includes a drill seed attachment that can handle the shape and size of the species being planted. Specialty native seed or wildflower drills are available, or a vegetable seeder can be used if it has a setting that can handle the shape and size of the native plant seeds (Borders and Lee-Mäder 2014). When drill seeding is used, milkweed should be seeded to a maximum depth of ½ inch. A light covering of clean, weed-free straw will help keep the seed moist and hide the seed and seedlings from birds.

Broadcast seeding

Hand-sowing native milkweed and other forb species may be a cost-effective method for small restoration projects or at sites where low-cost labor (e.g. volunteers) is readily available. Hand-sowing consists of spreading seed by hand or using a belly grinder to broadcast seeds directly into the prepared site. It is critical that the seeded area is covered with a thin layer of soil after seeding is complete to ensure proper soil-to-seed contact. This can be done with a rake or a harrow pulled by a tractor. A light covering of clean, weed-free straw will help keep the seed moist and hide the seed and seedlings from birds.

Seed balls

With the above seeding methods, controlling specific plant locations or plant densities is very difficult. Planting seed balls allows you to place seeds in specific locations and at a desired spacing. Seed balls have the added benefit of protecting seeds from weather and animal predation. The seed-humus mixture also maintains seed dormancy until enough precipitation occurs to allow prompt germination and survival. By placing seed balls out in the late fall or winter, seeds are stratified naturally and dormancy is broken (Landis 2014). Planting seed balls can also be a great activity for kids or volunteers who want to help with monarch habitat restoration.

A seed ball is a mixture of clay and compost that contains seeds of the desired plants. Seed-balls.com (**https://goo.gl/WzCps7)** recommends using anywhere from one to four parts compost to one part clay. For milkweed species, 4 to 5 seeds per seed ball should be used to ensure that at least one seed will germinate. Other seed balls can be made with mixtures of various nectar species, but each seed ball shouldn't contain more than 4-5 seeds. Adding a tablespoon (15 ml = ½ oz.) of powdered mycorrhizal inoculant to the dry mixture protects the germinating seeds from pathogens and then aids in moisture and nutrient uptake once the seedling is established. A highly plastic clay, such as pottery clay, holds the ball together. Five pounds of clay will make more than 300 seed balls of about ¾ inch in diameter.

To create seed balls, start with moistened clay and mix in a 1:1 ratio of clay to compost by volume. Add water to this mixture until it is workable and the ball holds together. Mix in more compost if it is too sticky—a cookie dough consistency is ideal. A pinch of the mixture can then be rolled into a ball by hand with the seeds added. The ball is then dried and stored until needed. The website **http://seed-balls.com**/ provides good information on seed balls, and also sells seed ball ingredients.

Transplanting

Container-grown milkweed can be purchased from some seed vendors and directly planted into the ground after rainfall has created suitable moist soil conditions at the restoration site. This is typically done with a dibble tool that creates a hole in the moist soil where the transplant is placed. The soil is then squeezed together by hand to ensure the surrounding soil makes complete contact with the roots of the transplant. This method is an advantage if limited seed is available, as it is easier to ensure that a greater number of plants survive (Borders and Lee-Mäder 2014). Because this method bypasses the germination stage, these seedlings have a head start and are better able to compete with weeds and other plants.

To determine how large of an area you need for a given number of transplants for a site where evenly spaced planting is desirable, you need only know the desired spacing between plants. As an example, if you have 500 transplants and would like to plant them at a density of 2,000 plants per acre, you will need to prepare an area of 10,890 square feet (0.25 acre), if you plant them on 4.5 foot centers. Plant spacing will vary based on the species planted and whether regular spacing is used versus a patchy planting configuration. You can also work backward from the acreage available for planting to determine how many transplants will be needed given the density desired. These calculations assume even spacing between plants.

Depending on site layout and restoration design, it may be more advantageous to install patches of milkweed within a restoration site instead of evenly spacing plants. In that case, you would use the patch size and planting density desired to calculate the number of transplants needed.

Part 3: Management and Monitoring

Site management

Timing

Survey your milkweed plants for signs of immature stages of monarchs prior to implementing management treatments such as mowing, fire, or herbicide application.
In the central California and the Coast ranges, timing of management treatments is recommended between early November to mid-March and/or after October. This avoids the typical breeding season for monarchs.

Irrigation

To enhance survival, milkweed seedlings should be irrigated in the first year or two of establishment, especially in years with inadequate rainfall. The first irrigation should occur after the seeds or transplants are planted. The planting should then be checked once or twice per week during the first 2 to 3 months post-planting to ensure adequate soil moisture exists. Only water seedlings if soil is dry, but avoid overwatering. If an irrigation system is installed, it can be removed after establishment, which is typically by the end of the first year, but possibly the second year if plants are slow to establish. Once established, milkweed plants are fairly drought-resistant. However, after removal of irrigation, milkweed should be monitored for any changes to plant health—in particularly dry regions, additional irrigation may be needed to keep plants healthy.

Pest control

Herbicide treatment can be an important tool for promoting desirable native forbs in pollinator habitat. It can be used in habitat establishment and management to reduce weed pressure. However, it is still important to be cautious in the use of herbicides, especially during management, to ensure that milkweed and other nectar resources are not impacted.

While insecticides may be used on crop fields, it is important not to apply them in habitat areas to protect monarchs and other pollinators. To minimize risks to monarchs, a 100-foot pesticide-free buffer zone is ideal, but when that is not possible, a buffer of 100 feet in which exposure pathways are mitigated is recommended. If pest or weed issues arise that are impacting the habitat site, alternative pest control methods, such as hand weeding, spot treatments or mulching can be used.

Habitat should be either (a) located where it is not downwind of areas treated with insecticides based on prevailing wind direction during the growing season or
(b) pesticides are not applied when wind is blowing towards the habitat, including situations when seeds treated with insecticide are being planted.

Integrated Pest Management (IPM) is advised to mitigate potential impacts to the monarch. IPM prioritizes the least hazardous pest management options, for use only when there is a demonstrated need. The IPM strategy involves reducing conditions that may favor pest populations, establishing an economic threshold of pest damage above which pest control must occur, monitoring pest populations, and controlling pests with specific methods that minimize unintentional harm to beneficial insects when the threshold is reached (USDA-NRCS and Xerces 2014). For more information on IPM as well as pesticide toxicity, potential exposure pathways, and mitigation techniques, please see USDA Agronomy Technical Note No. 9 at **https://goo.gl/y7dQsh**.

For more information on IPM:
Please visit University of California Agriculture and Natural Resources (UCANR) Statewide Integrated Pest Management Program's website:

https://www2.ipm.ucanr.edu/What-is-IPM/.

For UC ANR IPM events and workshops:
http://ipm.ucanr.edu/IPMPROJECT/workshops.html

Take measures to limit the risk of pesticide drift when applying pesticide to crop fields: only apply when wind is very low but not still (<2 mph), create a windbreak when possible, and use direct application instead of aerial applications or mist blowers (USDA-NRCS and Xerces 2014).

Aside from direct contact, other pesticide exposure pathways for pollinators may include: residue contact, pollen and nectar contaminated by systemic insecticides, contaminated water, contaminated nesting material, dust released from pesticide seed coatings, pollen-like formulations, contaminated nesting areas, guttation fluid, and aphid honeydew. Pesticide exposure may also come from a neighbor's field; when this is the case, it is best to assume that the pesticides will have some level of toxicity and to try to mitigate exposure pathways. It is important to consider if any of these pathways are potential exposure pathways for monarchs and pollinators at your site (USDA-NRCS and Xerces 2014).

Some best practices for protecting monarchs and their habitat include:

- Spot spray using backpack sprayers to help reduce overspray and drift (USDA and DOI 2015, Tallgrass Prairie Center 2015)
- Minimize or eliminate broadcast herbicide applications when flowers in the habitat are in bloom (USDA and DOI 2015)
- After planting, herbicides may be spot sprayed to remove broadleaf weeds, or grass-selective herbicides may be applied to larger areas to eliminate persistent weedy grasses (USDA-NRCS 2015a). Spray only the persistent perennial weeds and woody plants. If possible, spray when the natives are dormant (Tallgrass Prairie Center 2015)
- Avoid aerial spraying whenever possible. Limit spray applications to times when wind speed is low (i.e. less than 10 miles per hour), but not still (<2 mph). (USDA and DOI 2015)
- Reduce the risk of drift by operating standard boom sprayers at the lowest effective pressure and with nozzles set as low as possible and/or by using nozzles that are capable of operating at low pressures (15-30 pounds per square inch). Operate spray equipment with nozzles set just above plant height (USDA and DOI 2015)
- Minimize or avoid pesticide applications when dew is present or forecasted to be present on vegetation

Habitat management

Management of monarch habitat, including grazing, mowing, and burning, should leave some habitat undisturbed each year (Vaughan et al. 2015). This is to ensure sufficient protected and undisturbed habitat exists at any given time. The best time to implement management actions in the Central Valley Region is from early November through mid-March. This timing is typically outside the monarch breeding and migration season and will reduce the risk of direct mortality. Workers should be trained to identify milkweed species and important nectar plants to limit the risk of unintentional habitat disturbance/degradation.

Grazing

If habitat is in an area subject to grazing, rotational grazing of light to moderate intensity or short grazing periods with subsequent recovery time is recommended (Swengel 2001). A mosaic of grazed and ungrazed grassland can be important for maintaining some undisturbed habitat refuges (Kruess and Tscharntke 2002) and for enhancing plant community diversity. Avoid grazing or keep intensity low when monarch larvae or adults may be present. Milkweed is toxic to livestock; however, they typically avoid contact with milkweed when there is sufficient forage available (Forero et al. 2010; Schultz 2003). Precautions to minimize the risk of livestock consumption include ensuring there is sufficient forage available in areas when milkweed is

present, and not confining livestock to small areas when milkweed is present.

Mowing

Mowing up to two times per year can help support plant species diversity in grassland habitats and promote milkweed regeneration (Noordijk et al. 2009). Mowing on a rotational basis, leaving some patches undisturbed each season, may provide important habitat refuges. The timing of the mowing application is important because it influences the availability of floral resources to pollinators. Mowing should be limited during times of monarch breeding and migration (spring and summer) to decrease the risk of direct mortality (Johst et al. 2006). Mowing or any other disturbance should be avoided when monarchs are present, especially during the egg, caterpillar, and chrysalis stages of the life cycle, when monarchs are less mobile. Cutting as high as possible (a minimum of 10-12 inches) helps effectively remove seed producing parts of most invasive plants and minimize impacts on native plants.

Burning

Ideally, burning should be conducted outside of the monarch breeding season and ideally on less than 1/3 of the acreage during any given year (USDA-NRCS 2015a, USDA and DOI 2015). However, in Central Valley grasslands, burning is typically conducted in late spring because that is the timing found to be most effective for controlling a number of particularly invasive late-season non-native annual grasses (Marty et al. 2015; Kyser et al. 2014). Ultimately, these management burns will improve the milkweed stands by reducing competition from the annual grasses and by stimulating growth of the milkweed and other nectar species (Pelton et al. 2018). If burns are conducted during the monarch breeding season when eggs, chrysalises, or caterpillars are present, if possible, leave small unburned patches of milkweed within the burned areas (USDA and DOI 2015; Gilgert and Vaughan 2011; Black et al. 2007). Milkweed will often reemerge in the same year after a late spring burn and will provide habitat for monarchs as they come back through the Valley on their journey to the coast.

Depending on how the restoration site is managed, there may not be enough fuel to carry a fire in a one or two-year old restoration site. If fire is a tool that can be used at the restoration site, then leaving the site unmowed for a year may help it develop enough dry matter (approx. 2000 lbs/acre) to produce an adequate management burn.

For more information on monarchs and management guidelines please visit: **https://xerces.org/monarchs/**

Monitoring

Approximately two to three years after planting, milkweed should be fully established and site maintenance and management should be minimal. However, monitoring is important to assess any changes in habitat condition over time and to inform adaptive management. Restoration plantings should be monitored for overall health of milkweed and nectar plants. Look for signs of damage, such as strange coloring, spots, etc.

The Monarch Butterfly Habitat Quantification Tool (HQT) measures habitat quality based on the specific needs of the monarch. It can be a useful tool to inform site selection, measure changes in habitat condition resulting from management actions, and monitor project success. The Monarch HQT incorporates information including site capacity (density and diversity of milkweed and other forb species) and threats (risk of pesticide exposure) (Anderson et al. 2017). The best time to conduct an HQT assessment is when monarchs are present in the region and when the abundance of blooming forbs (including milkweed) is highest. In the western region, this window is typically from May 20 to October 1.

For more information on HQT, please visit
http://www.monarchhabitatexchange.org/tools

Useful documents include: Monarch Habitat Quantification Tool Explained and Monarch HQT Specifications.

Monarch sighting

If you observe monarch eggs, caterpillars or adults, we encourage you to share your sighting with the Western Monarch Milkweed Mapper (**https://www.monarchmilkweedmapper.org**). This website accepts citizen submissions of monarch sightings to help improve knowledge and efforts to protect the monarch butterfly.

Other milkweed visitors and potential pests

The oleander aphid (*Aphis nerii*) is a non-native, bright yellow-orange aphid with black limbs, and feeds on milkweed plant sap. Aphid infestations are sometimes associated with sooty mold (fungus) and can be a potential vector of viruses and phytoplasmas. Milkweed can typically tolerate a low abundance of aphids; when 50 or more aphids are present per terminal growth point, control is advised. Monitoring of milkweed plants can help with early detection of aphid infestations. Avoid planting other oleander aphid host plants in the habitat area, which include: oleander (*Nerium oleander*), periwinkle (*Vinca* spp.), and wax plant (*Hoya carnosa*). Plants that support beneficial insects (e.g. phacelia) can promote aphid predation by natural predators (e.g. ladybird species). For large infestations, non-chemical controls are recommended, such as a forceful water stream or 10% milk solution applied directly onto aphids. As a last result for extreme cases, chemical control may be used, such as insecticidal soaps and oils (Heidel-Baker et al. 2017).

The large milkweed bug *(Oncopeltus fasciatus)*, small milkweed bug *(Lygaeus kalmii*), red milkweed beetle (*Tetraopes* spp.), and blue milkweed beetle (*Chrysochus cobaltinus*) are common milkweed visitors. These native bugs do not pose threats to milkweed, monarchs, or nearby crops, and therefore should not be controlled (Heidel-Baker et al. 2017).

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Notes

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