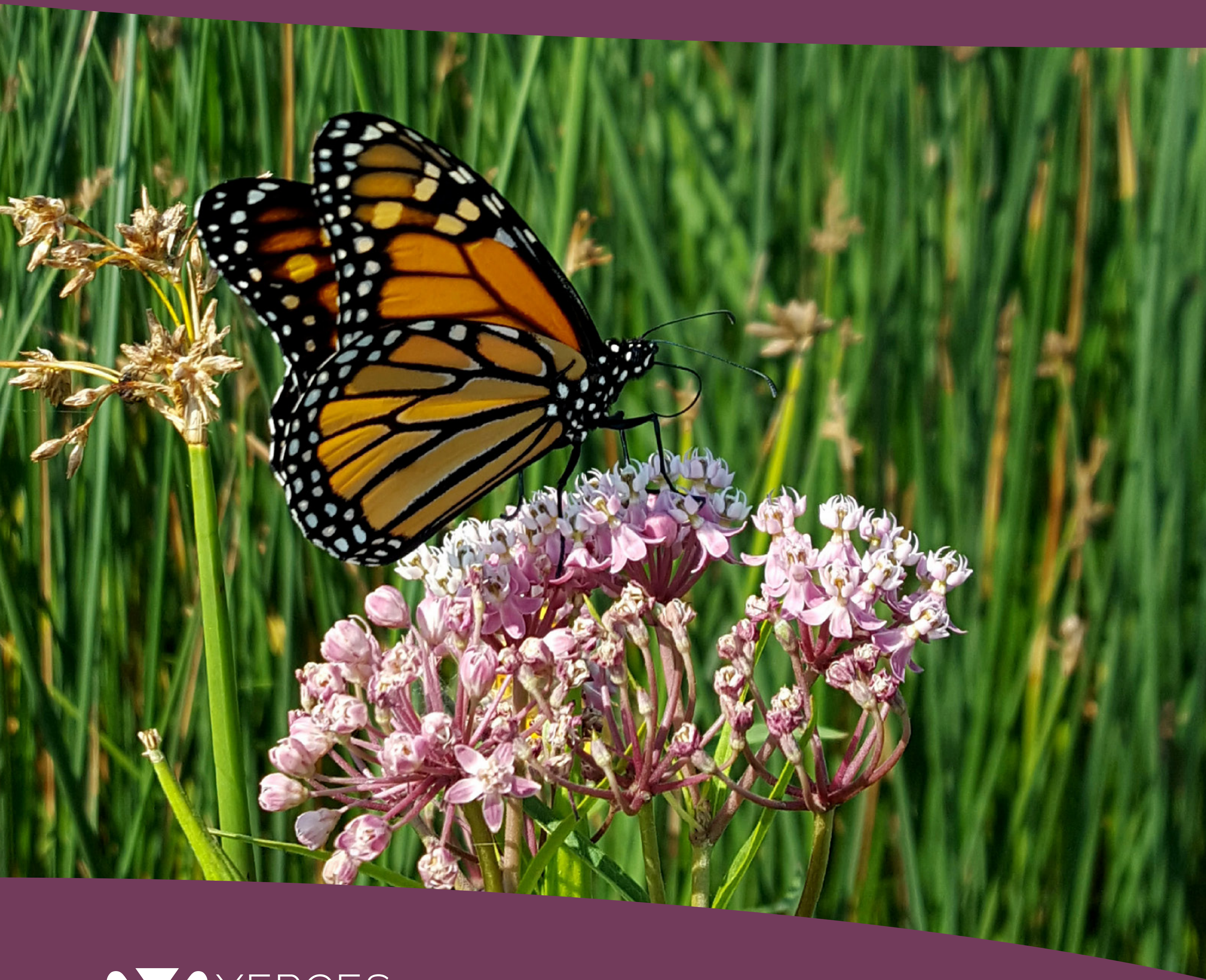
Managing for Monarchs in the West

Best Management Practices for Conserving the Monarch Butterfly and its Habitat



XERCES SOCIETY
for Invertebrate Conservation

MANAGING FOR MONARCHS IN THE WEST

Best Management Practices for Conserving the Monarch Butterfly and its Habitat

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The Xerces Society for Invertebrate Conservation

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XERCES SOCIETY
for Invertebrate Conservation

The Xerces® Society for Invertebrate Conservation is a nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. Established in 1971, the Society is at the forefront of invertebrate protection, harnessing the knowledge of scientists and the enthusiasm of citizens to implement conservation programs worldwide. The Society uses advocacy, education, and applied research to promote invertebrate conservation.

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Cover Photograph

A monarch on swamp milkweed near wetlands by Stephanie McKnight..

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Executive Summary

Western monarchs are in trouble. The number of monarchs overwintering in coastal California has declined by over 95% since the 1980s, with declines also observed in breeding populations during the spring and summer. An increasing number of people are wondering what they can do to save the butterfly and its milkweed host plant. To help them, the Xerces Society for Invertebrate Conservation has developed guidance on how to manage existing monarch breeding and migratory habitat and where and when to restore the butterfly's habitat in the western United States; overwintering habitat is covered in the Xerces Society's publication *Protecting California's Butterfly Groves*: *Management Guidelines for Monarch Butterfly Overwintering Habitat*. These guidelines were informed by a literature review, surveys and interviews with monarch butterfly experts and public land managers, and by field experience. Threats to monarchs are summarized and include habitat loss, insecticides, climate change, and parasites, diseases, and predators.

Consistent with the wide-ranging nature of the monarch butterfly, suitable breeding and migratory habitat is widespread across the West. Habitat suitability modeling shows there are notable concentrations of potentially highly suitable habitat in the Central Valley of California as well as in southern Idaho and eastern Washington; smaller areas are evident across northern Nevada, southern Arizona, parts of Utah, most low-elevation lands in Oregon excluding the coast, and other areas. Widespread planting of milkweed is often the response to help monarchs. However, this is not a recommended strategy across the western US. Instead, the Xerces Society recommends a more holistic and targeted approach to monarch conservation. The three components of this are, in order of importance:

1. Identify, protect, and manage existing habitat to maintain its value for monarchs.
2. Enhance existing habitat (if needed and appropriate) to improve its value for monarchs.
3. Restore habitat in areas where it occurred historically, but has been lost.

High-quality monarch breeding and migratory habitat offers native milkweeds to provide food for caterpillars (and nectar for adults) and other flowers—preferably native—to provide nectar for adults. Habitat should be safe from pesticides and keep butterflies free from high levels of pathogens. Additional factors such as roosting habitat and shade may also be important features of high-quality habitat.

These best management practices (BMPs) provide a brief summary of the known effects of frequently used land management practices on monarchs and their breeding/migratory habitat, followed by recommendations on how to incorporate monarch conservation into management decisions. The BMPs include ecoregion-specific recommendations for management timing and cover the practices of grazing, mowing, prescribed fire, and pesticides. An overview of monarch habitat restoration—including native milkweed and nectar plant species lists as well as native plant sourcing and establishment—provides managers with the necessary technical guidance to incorporate monarchs' needs into projects. Invasive nonnative and noxious plant management, recreation, and climate change impacts are also addressed. Sections on monitoring monarch populations (including major tagging and tracking programs) and resources to learn about western monarch conservation wrap up the document.

To help reverse the western monarchs' population trend, we need to improve protection and management of the butterfly's habitat. These BMPs provides actionable, practical guidance that enables land managers to be part of the solution.

A monarch nectars on narrowleaf milkweed.

A monarch caterpillar foraging on milkweed.

1

Introduction

Butterfly populations are declining across North America. Approximately 19% of the 800 described species in North America have been placed in an extinction risk category (NatureServe 2018). A long-term monitoring program in northern California has revealed species declines across butterfly families (Forister et al. 2011; Casner et al. 2014). Perhaps most alarming is the fact that we are losing not just rare species, but also once-common and widespread species such as the monarch butterfly (*Danaus plexippus plexippus*). Western monarchs which overwinter in coastal California have declined by over 95% since the 1980s and current trends indicate a quasi-extinction risk of 72% in 20 years and 86% in 50 years (Schultz et al. 2017). This is similar to the decline observed in central Mexico where the eastern monarch population (and a subset of the western monarch population) overwinters. That overwintering population has declined by more than 80% since the 1990s and has a quasi-extinction risk of 11–57% in 20 years (Semmens et al. 2016).

Monarchs often evoke strong emotions and hold great personal and cultural significance to many people: childhood memories of chasing butterflies, surprise and delight at finding a green chrysalis streaked with gold, or witnessing the sky filled with butterflies during their annual migration. The bright, orange-and-black wings also make monarchs one of the few butterfly species that many untrained observers can identify. As monarch populations have rapidly declined in the span of a single human generation, it has led many to wonder what they can do to save the butterfly. While guidance to answer this question is in development for the eastern and central areas of the US (see Monarch Joint Venture's *Mowing for Monarchs* and the *Monarch Butterfly Conference Report* developed by the USDA Natural Resources Conservation Service and the US Fish and Wildlife Service), guidance for actions that land managers can take in the western US has been lacking.

To address this gap, the Xerces Society for Invertebrate Conservation has developed guidance on how to manage existing monarch habitat and where and when to restore monarch habitat in the western US, referred to through this document as "the West". Here, the West is defined as areas of the United States west of the Continental Divide. Monarchs may also be found in adjacent areas of Canada and Mexico where milkweed grows and the butterflies breed or migrate, and some of the guidance contained in this document will be relevant for those areas as well.

These guidelines are designed to inform management activities on public lands in the context of managing habitat for multiple other wildlife species and public uses. While the focus is on managing public lands, many of the recommendations are also applicable for private, state, tribal, or non-governmental lands. The document provides best management practices (BMPs) for monarch breeding and migratory habitat; overwintering habitat is covered in the Xerces Society's publication *Protecting California's Butterfly Groves*: *Management Guidelines for Monarch Butterfly Overwintering Habitat*.

The content of this document is directly informed by the results of a review of the peer-reviewed and technical literature, surveys and interviews with monarch butterfly experts and land managers in the western US, and by field experience gained through surveys of monarchs and their habitat in California, Oregon, Washington, Nevada, Idaho, Utah, and Wyoming by Xerces Society staff. Very little peer-reviewed or technical guidance specific to managing for monarchs and their breeding and migratory habitat in the West exists. The authors, thus, relied on the best-available science on monarchs in the eastern US and Canada, as well as Australia and other parts of the world when applicable. In other cases, we relied on general knowledge and studies of how management practices affect plant diversity and pollinators, including other butterflies. As our understanding of monarch biology, phenology, and conservation evolves, some of this guidance may change, but our goal here is to provide actionable, practical guidance based on the current state of knowledge.

To better understand current practices and attitudes towards milkweed as well as the opportunities and obstacles to implement monarch- and pollinator-friendly management practices, a survey was disseminated electronically to biologists and ranchers in the fall of 2017. The forty-three respondents included employees of federal, tribal, state, and local governments, ranchers, and consultants. Respondents came from California, Nevada, Oregon, Idaho, Washington, Colorado, Wyoming, Utah, and New Mexico. Additional responses were received from people in Alaska and South Dakota, but those states fall outside of the geographic scope of this guidance.

Major survey findings related to milkweed and monarchs include:

- Half of respondents said that monarch butterflies are a priority for conservation on the land they manage.
- 90% of respondents reported milkweed occurring on the land they manage; half said that milkweed is considered in management decisions.
- Respondents identified perceived changes (mostly decreases; some reports of increases) in milkweed prevalence on the landscape due to grazing practices, fire exclusion, roadside spraying, targeted eradication on rangelands, agricultural practices, and riparian management as well as climate change impacts such as drought and invasive species encroachment.
- Milkweed and livestock toxicity:
    - Of managers with milkweed on the land they manage, milkweed toxicity to livestock was identified as “somewhat of a concern” for 20% of respondents and “not a concern” for 80%.
    - When asked if milkweed toxicity to livestock is a major concern for other ranchers, grazing permittees, or other land managers they know, three quarters said that the concern has been mentioned on occasion, but was not a major concern.
    - No respondents reported direct knowledge of a livestock poisoning event caused by milkweed.
    - Four respondents reported that they or their agency allow or implement management to control milkweed on public lands to protect livestock using herbicide or mechanical methods.
- 90% of respondents reported feeling at least somewhat confident identifying their area’s native milkweed species.
- Half of the respondents reported planting milkweed in recent years, especially in demonstration or school gardens. A few said they had planted at a larger scale. Others raised concerns about the benefits of milkweed planting initiatives as a “postage stamp solution to a landscape issue.”

While milkweed can be toxic to livestock in some situations, grazing and monarch habitat can coexist when you follow basic precautions.

2

Meet the Butterfly

Monarch Life Cycle

Female monarch butterflies lay eggs on milkweed (*Asclepias* spp.) and related genera which the caterpillars (larvae) rely on for food as they develop through five instars. Milkweed also provides the caterpillars with cardenolides, toxic compounds which make them unpalatable to many predators. Their bright, aposematic coloration warns predators of their toxicity. However, parasitism and predation of caterpillars—especially by fellow invertebrates—can still be high, with less than 10% of eggs typically surviving to adulthood (Nail et al. 2015). Fifth instar caterpillars form a green chrysalis (pupa) with gold trim that may be attached to milkweed, surrounding vegetation, or fences and other structures. A few days later, the adult butterfly emerges and quickly begins searching for a mate and nectar; females also search for milkweed on which to lay their eggs. It takes approximately one month for a monarch to develop from an egg to adult (depending on temperature and other factors). Multiple generations are produced over the spring and summer, with the fall generations migrating to overwintering sites. Spring and summer generations typically live 2–5 weeks as adults while overwintering butterflies may live 6–9 months (see **Figure 1**).

Monarch larvae rely on milkweed plants as their sole food source which is necessary to develop through five instars.

Migration and Distribution

Monarch butterflies are found throughout North America to southern Canada (up to about 50 degrees North), but can also be found in Hawaii and other Pacific islands, Australia, New Zealand, Spain, and Portugal. In North America, where monarchs are most numerous, they migrate hundreds or thousands of miles from their breeding grounds found across the US and southern Canada to overwintering grounds in both Mexico and California (see **Figure 2**). The eastern monarch population—defined as monarchs which breed east of the Rocky Mountains—migrate to and overwinter in high-elevation oyamel fir forests in the state of Michoacán, central Mexico. The western monarch population—which breeds west of the Rocky Mountains—migrates to and overwinters in forested groves along the Pacific Coast stretching from Mendocino, California, south into western Baja, Mexico. The eastern and western populations are

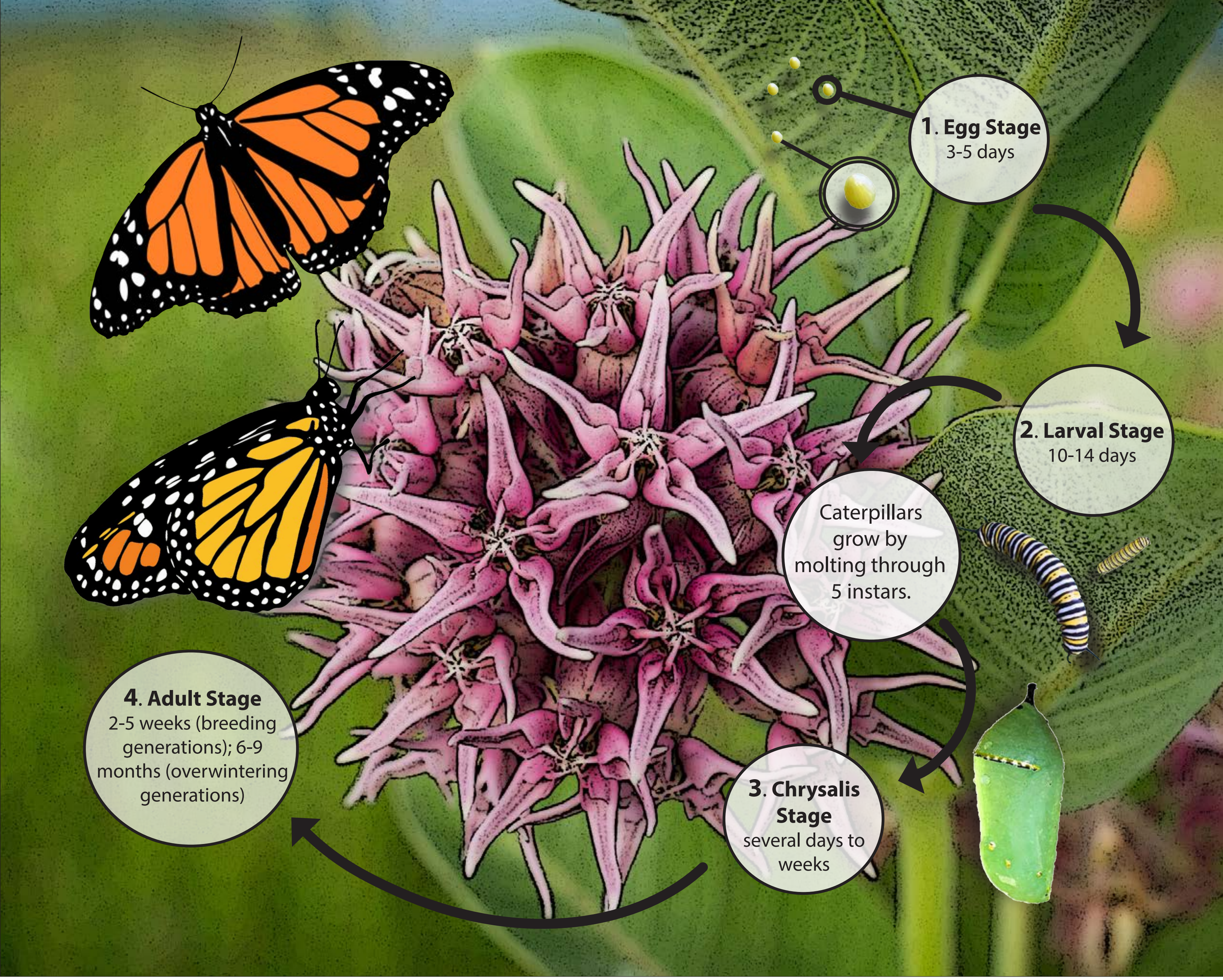


FIGURE 1: Monarch Butterfly Life Cycle.

not genetically distinct (Lyons et al. 2012; Zhan et al. 2014) and tagging studies show at least some portion of monarchs from the West—particularly the Southwest—migrate to central Mexico where they overwinter alongside eastern monarchs (Morris et al. 2015). In addition to these major overwintering sites, small numbers of butterflies (fewer than 100 at any one site) overwinter in the Saline Valley of California (Xerces Society Western Monarch Thanksgiving Count 2018), Sonoran Desert near Phoenix, Arizona (Morris et al. 2015), and the Mojave Desert near Lake Mead, Nevada. There are also smaller, nonmigratory populations in Florida and other parts of the extreme southern United States.

Each spring, monarchs leave their overwintering grounds to seek out milkweed in their spring and summer breeding range, which is broadly distributed across North America as far north as southern Canada. In the West, monarchs are thought to breed continuously from spring through fall in California, Nevada, and Arizona, with later generations traveling north and east into the interior of the continent throughout the summer.

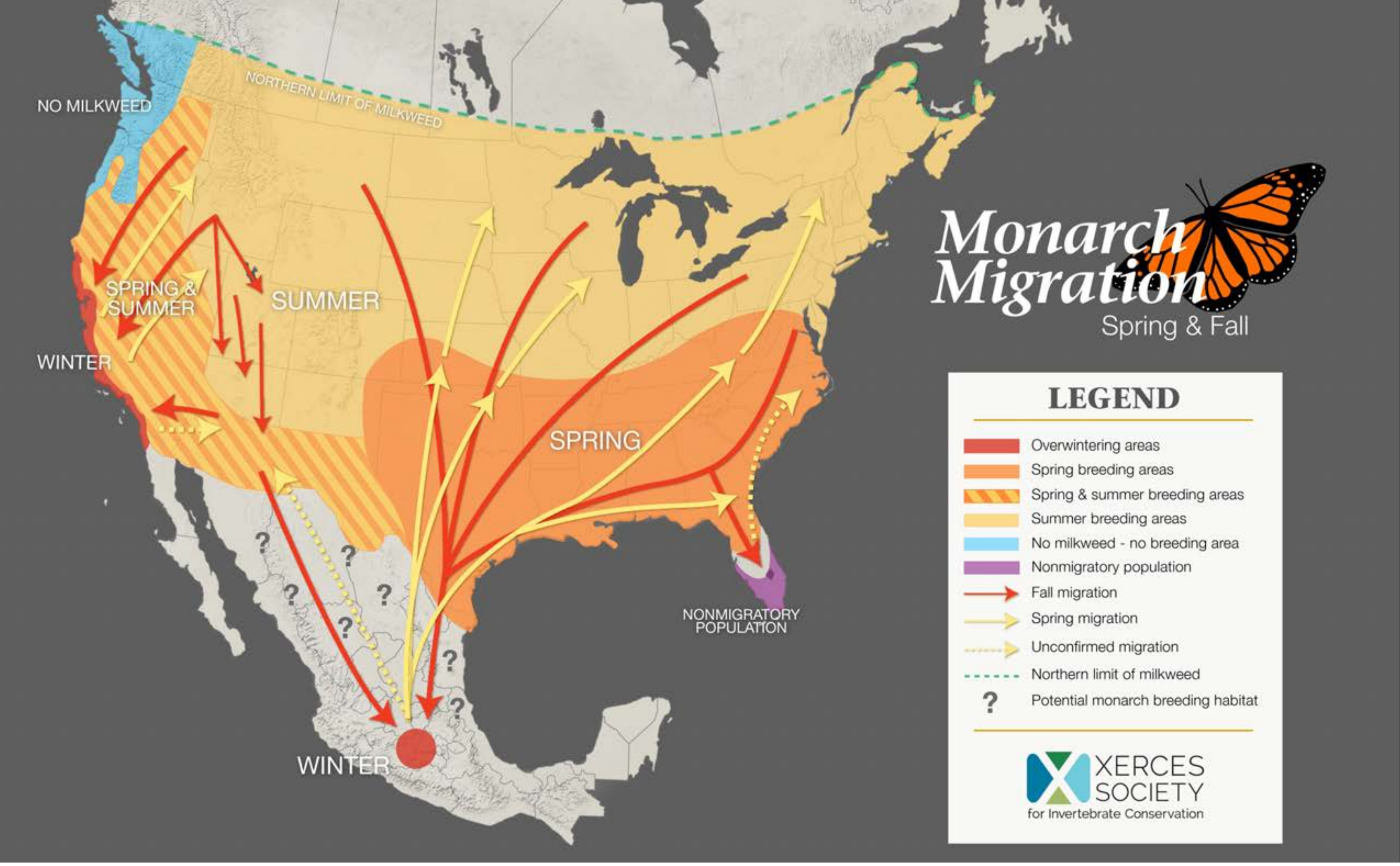


Figure 2: Monarch Migration and Distribution in North America.

As fall approaches, native milkweeds senesce and the last monarchs to reach adulthood focus on finding nectar and starting the journey to the overwintering grounds rather than reproducing. The migratory generation(s) use the earth's magnetic fields, a time-compensated sun compass, and likely other cues to start flying south (Heinze and Reppert 2011). In the West, monarchs generally migrate in a dispersed manner, but sometimes large aggregations are spotted, especially in nectar- and water-rich areas in the arid West. Dingle et al. (2005) found that the location of monarch records had a strong association between the location of monarch collection records and proximity to rivers, and proposed that western monarchs use rivers as major migratory corridors as they provide more reliable sources of water, nectar, and trees to roost in at night. There are anecdotes of fall-migrating monarchs forming temporary aggregations in trees along rivers and in suburbia to spend the night or take shelter from storms. Once the butterflies reach their overwintering grounds—typically in September or October in California; October or November in central Mexico—they form clusters with other butterflies to conserve warmth and settle in for the months ahead. An isotopic study has shown that monarchs at California overwintering sites arrive from all regions of the West, including a large portion coming from interior western states such as Idaho (Yang et al. 2016). Overwintering monarchs are typically in reproductive diapause—not mating or laying eggs—to conserve their fat for survival and spring dispersal in February or March. One exception is the coastal area of southern California (in the greater Los Angeles area and southward) where the widespread planting of nonnative, tropical milkweed (*A. curassavica*) and a mild winter climate has led to year-round breeding and possibly the abandonment of overwintering behavior. Monarchs are also known to breed year-round on native, evergreen milkweeds in parts of Arizona.

Conservation Status

Every fall, thousands of monarchs arrive to overwinter in the forested groves along the Pacific Coast; however, their numbers today are a small fraction of the millions of butterflies which aggregated in the past. A long-term citizen monitoring effort, the Xerces Society Western Monarch Thanksgiving Count, provides annual estimates of the number of monarchs overwintering in coastal California since 1997. Data from this effort and similar historical data show a population decline of 74% since the 1990s (Pelton et al. 2016) and over 95% since the 1980s with a high risk of quasi-extinction (Schultz et al. 2017). In the 1980s, ~10 million monarchs overwintered annually (Schultz et al. 2017); in 2017, fewer than 200,000 monarchs were observed (Xerces Society Western Monarch Thanksgiving Count 2018). Declines have also been documented in their spring and summer migration and breeding season over the past 40 years through butterfly monitoring along a latitudinal transect that spans Northern California (Espeset et al. 2016).

Threats to Monarchs

Monarch butterfly populations in North America face multiple stressors across their range. In the areas where they breed and migrate, the major stressors include habitat loss—both of milkweed and nectar plants—insecticide use, climate change, and parasites, diseases, and predators.

Habitat Loss

The loss of breeding habitat is an important driver of the decline in the monarch population in eastern North America (Pleasants and Oberhauser 2013; Flockhart et al. 2014; Stenoien et al. 2016; Saunders et al. 2017; Thogmartin et al. 2017b; Zaya et al. 2017). Breeding habitat loss in midwestern agricultural fields—especially of common milkweed (*A. syriaca*)—is linked to the adoption of genetically modified, herbicide-resistant crops and the associated increase in use of the herbicide glyphosate since the mid-1990s. The majority of glyphosate use has been on corn and soy fields (Benbrook 2016) and associated milkweed losses have been in midwestern row crop fields (Hartzler 2010; Pleasants and Oberhauser 2013) rather than in natural areas (Zaya et al. 2017). Herbicide use has also been linked to local (Saunders et al. 2017) and population-level declines (Thogmartin et al. 2017b) in the eastern population. The relative importance of milkweed loss, compared with other drivers such as fall nectar or overwintering habitat availability, is an area of active research (e.g., Davis and Dyer 2015; Dyer and Forister 2016; Inamine et al. 2016; Pleasants et al. 2016; Agrawal 2017; Pleasants et al. 2017).

In some of the monarch's key breeding areas of the West, including areas of intensive agriculture—the Central Valley of California, Snake River Plain in Idaho, and Columbia Plateau (also known as the

Industrial agricultural practices often remove milkweed and nectar plants from field edges, reducing the available habitat for monarchs and other wildlife.

Columbia Basin) in southeastern Washington and northeastern Oregon—glyphosate use has also increased dramatically since the 1990s (see **Figure 3**). Agriculture has trended toward replacing tillage, whose soil-disturbing qualities benefit many milkweed species, with herbicide use, resulting in "clean farming" landscapes devoid of the weedy edges or understories that may once have provided monarch habitat. And glyphosate is not the only herbicide which kills milkweed or harms monarch habitat—it is simply the most widely used. Other herbicides can also be used over large swaths of land. Dicamaba and 2,4-D, which some newer genetically modified crops are designed to be resistant to, may be of particular concern because of their potential to move off-site into natural areas.

Whether or not milkweed has been lost in the West on a similar scale as in the Midwest, however, is unclear. The predominant land use in the West is grazing, not row crop agriculture. In addition to impacts from agricultural intensification, the quality of monarch habitat can also be affected by water management, urban development, and rangeland and natural area management. In the arid West, highly modified water movement such as dams and irrigation and the associated decline in natural wetlands has altered the availability of mesic habitats in which wetland-dependent milkweed and nectar species grow. Without periodic flooding and scouring, milkweed that would flourish on disturbed river banks is likely outcompeted. Instead, milkweed is often found growing adjacent to the modified water sources—such as in irrigated agricultural fields and along the banks of irrigation ditches and levees. Urban and suburban development continues to convert natural habitat into highly modified landscapes; the loss of milkweed and nectar plants in these natural habitats are likely persistent threats to monarchs. In addition, how we manage remaining natural areas matters and is the focus of the best management practices in this document. Excessive herbicide spraying, mowing, or grazing can decrease nectar plant and milkweed availability. Invasive nonnative and noxious weeds and altered fire regimes also reshape native habitat, often to the detriment of native perennial plant species on which monarchs and other pollinators rely.

Insecticides

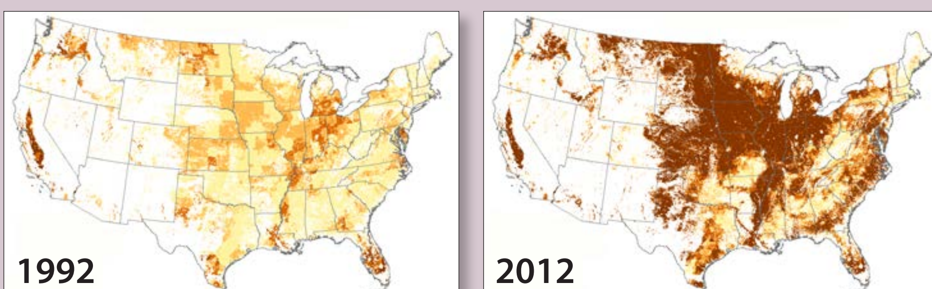
Of the various pesticide groups, insecticides are most likely to directly harm monarchs. Many commonly used insecticides are classified as either moderately or highly toxic to terrestrial insects and are broad spectrum, thus able kill or otherwise harm a variety of beneficial insects, including adult and juvenile butterflies. Because monarchs migrate large distances across a diverse landscape, they can be exposed to insecticides as they move through or visit agricultural, residential, and natural areas.

Systemic insecticides, such as neonicotinoids, are of particular concern due to their persistence in the environment, leading to exposure months to years after a treatment. In addition, because they are taken up by the plant, they can make the pollen, nectar, and leaves toxic to insects that consume these parts of the plant. Neonicotinoids (including imidaclopid and clothiandin) are the most commonly used class of insecticides, and have been shown to have sublethal and lethal effects on developing

Figure 3: Estimated Agricultural Use of Glyphosate; Epest–Low for 1992 (L) and 2012 (R).

No estimated use | <4.52 lb/mi^2 | >88.06 lbs/mi^2

Source: From the USGS Pesticide National Synthesis Project: https://water.usgs.gov



monarchs (Krischik et al. 2015; Pecenka and Lundgren 2015). Monarch larvae fed milkweed treated with imidacloprid following label instructions had significantly lower survival rates than larvae fed untreated milkweed, but adult monarchs who fed on nectar from treated plants were not affected (Krischik et al. 2015). In another study, monarch larvae fed milkweed treated with clothianidin (at levels comparable to those found in the field) suffered both sublethal and lethal effects (Pecenka and Lundgren 2015). A correlative threats analysis for eastern monarchs identified a negative association between neonicotinoid use in the breeding period and monarch population size (Thogmartin et al. 2017b). Neonicotinoids have been used extensively in both agricultural and urban/suburban areas since the early 2000s (see **Figure 4**, page **9**). Data from California's Pesticide Use Reporting system demonstrates the large-scale use of neonicotinoids: imidacloprid, the oldest neonicotinoid, is registered for 140 crop and non-crop uses throughout the state. As in the rest of the country, imidacloprid use in California has increased dramatically over time. In 1994, reported use in California was 5,179 pounds (in 658 applications). In 2015, this had risen to 441,304 pounds (in 70,054 applications). This data is only for commercial applications; household use is excluded from reporting, as is the planting of neonicotinoid treated seed (http://www.cdpr.ca.gov/, accessed March 22, 2018).

Insecticides used for mosquito control can also impact monarchs and other butterflies. Both monarch larvae and adults suffer mortality when directly exposed to the insecticides permethrin and resmethrin residues on host plants (Oberhauser et al. 2006; Oberhauser et al. 2009). Monarch caterpillars raised on milkweeds collected from areas treated with permethrin had low survival rates, even when larvae were not exposed until 21 days after permethrin treatment (Oberhauser et al. 2006). High mortality rates also occurred in monarch caterpillars and adults placed up to 120 m away from a resmethrin spray path (Oberhauser et al. 2009). Larvae that survived exposure to resmethrin produced smaller than normal adults, indicating sublethal effects (Oberhauser et al. 2009). Insecticide applications for mosquito control have also been linked to declines in other butterfly species, especially butterfly populations in Florida (e.g., Eliazar and Emmel 1991; Salvato 2001; Carroll and Loye 2006).

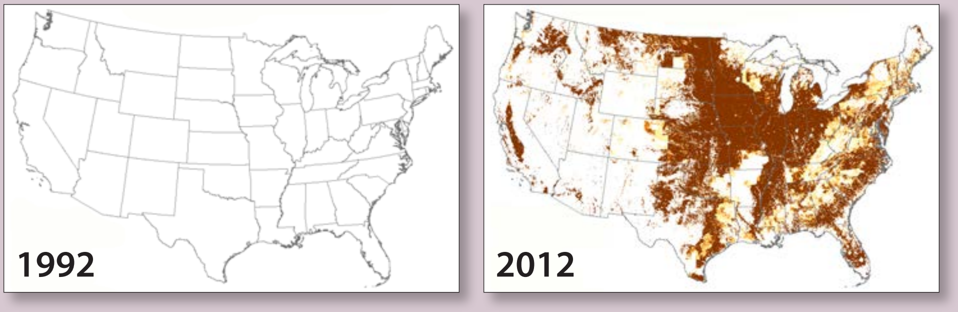
Climate Change

Climate change has been identified as one of the greatest risks to biodiversity worldwide (Maclean and Wilson 2011), due, in part, to the associated changes in seasonal temperatures, altered precipitation patterns, rising sea levels, and higher frequency of extreme weather events such as storms, floods, and droughts (IPCC 2014). Climate change undoubtedly has and will continue to impact monarchs. There have been multiple studies showing shifts and reductions in breeding and overwintering habitat suitability in the eastern US and Mexico under future climate scenarios (e.g., Oberhauser and Peterson 2003; Batalden et al. 2007; Sáenz-Romero et al. 2012). Although relatively little is known about how climate change will impact monarchs in the West, a growing number of studies identify three primary concerns for pollinators in general: (1) phenological divergence of pollinators and the plants they rely

Figure 4: Estimated Agricultural Use of Imidacloprid, Epest–Low for 1992 (L) and 2012 (R).

No estimated use | <0.01 lb/mi^2 | >0.04 lbs/mi^2

Source: https://water.usgs.gov



on, (2) range shifts that lead to spatial mismatches between plants and pollinators, and (3) extreme weather events such as flooding, storms, and drought. Climate change is also expected to be a growing source of stress for species such as monarchs that are already impacted by habitat loss, high pathogen loads, small population sizes, or the many other threats facing pollinators today.

In the West, climate change is expected to lead to earlier spring snowmelt, reduced snowpack, and increases in drought, and extreme events, including storms, floods, large forest fires, and prolonged heat waves, which are projected to become more common (USGCRP 2017). Larger, more frequent wildfires can remove nectar and floral resources from the landscape and may directly kill adult and immature monarchs. Smoke may also impact migrating and overwintering monarchs, although this has not been evaluated. In 2017 alone, more than 10 million acres burned across the US, well above the normal average; the greatest acreage burned was in the Great Basin area, with over 2.1 million acres burned (National Interagency Fire Center 2017). A study by Abatzoglou and Williams (2016) found that anthropogenic climate change is likely responsible for nearly doubling the number of acres burned each year in forest fires in the West from 1979 to 2015. Many regions of the West reported above average fire occurrences in 2017 as well, including the Northern Rockies (141% of average), the Great Basin (122%), and southern California (121%) (National Interagency Fire Center 2017).

Drought and extreme weather events like storms can negatively impact monarchs by influencing host and nectar plant survivability and palatability, or causing mass monarch die-offs, such as those observed after winter storms at monarch overwintering sites in California. Stevens and Frey (2010) examined 10 years of monarch overwintering population data from the Western Monarch Thanksgiving Count and found a correlation between monarch abundance and drought severity in key monarch breeding areas (California, Arizona, Nevada, and Oregon), suggesting that monarch declines may be partially explained by issues in the breeding range. For example, ongoing drought conditions in much of the arid and semi-arid West can cause early milkweed senescence and an increase in the duration of milkweed dormancy. It can also cause reduced palatability of some milkweed species to monarch larvae (Faldyn et al. 2018). Rainfall and soil moisture both affect a plant's ability to produce nectar. Drought can decrease the availability of nectar in the short-term and the availability of nectar plants in the long-term. In areas with nonnative milkweed, changes in temperatures combined with altered milkweed phenologies may also affect the physiology and dynamics of monarch migration (see review in Malcolm 2018). In the eastern US, milkweed distributions are expected to shift northward under both moderate (1–3° Celsius increase) and severe (2–6° Celsius increase) climate warming scenarios, potentially leaving large milkweed-less areas that monarchs will need to cross as they leave overwintering sites in the spring (Lemoine 2015); similar scenarios are possible for the West.

Monarch on narrowleaf milkweed in California after a fire swept through the area earlier in the season.

Other threats to monarchs that relate to climate change may include air pollution, changes to abiotic and biotic cues used by monarchs for migration, and elevated carbon dioxide levels (Malcolm 2018 and references therein), as well as increased pesticide use in agricultural areas (Chiu et al. 2017; Taylor et al. 2018). As with all threats to monarchs, climate change impacts should be viewed within the context of multiple drivers of decline interacting over large spatial and temporal scales. And not all climate change impacts are necessarily negative. In a field-based insect metacommunity experiment in southern Ontario, warming treatments (average of 2.7° Celsius warming during the day) increased monarch survival (Grainger and Gilbert 2017). This may be due to warmer temperatures speeding up development time, decreasing the window caterpillars are exposed to predation, or other factors such as desiccation.

Mantid preying on a fifth instar monarch caterpillar.

Parasites, Diseases, and Predators

Like other insects, monarchs are susceptible to a wide range of parasites, diseases, and predators. The impacts of natural and introduced enemies on monarch populations in the West are poorly understood, but are thought to be an increasing problem with the spread of introduced species and widespread planting of nonnative milkweed associated with the protozoan parasite *Ophryocystis elektroscirrha* (OE).

Monarchs are most vulnerable in their egg and larval stages, and although the overlap of monarchs with predators and parasitoids varies over time and space, relatively few individuals make it to the adult stage. Studying monarchs in the eastern US, Nail et al. (2015) found that less than 10% of eggs laid result in adults. Although larval and adult monarchs use warning coloration and unpalatable sequestered cardenolides to deter predators, a number of species have learned how to avoid or minimize the effects of these toxic chemicals. Numerous invertebrate species prey on immature and adult monarchs throughout their range, including spiders, lacewings, mantids, yellow jackets, and assassin bugs. Birds and mammals documented feeding on monarchs at the California overwintering sites include crows, Stellar's jays, western scrub jays, spotted towhees, chestnut-backed chickadees, hermit thrushes, starlings, and eastern fox squirrels (Xerces Society, unpublished data).

Across the monarch's breeding range, introduced insect species are becoming more of a concern. The red imported fire ant (*Solenopsis invicta*) has been documented throughout the Southeast and Texas and continues to spread north and west; it is now known from southern California, Arizona, and New Mexico (Korzukhin et al. 2001). Although this species appears to be limited by cold temperatures and dry conditions (Allen et al. 1995; Vinson 1997), it has the potential to spread as far north as Washington state (Korzukhin et al. 2001). Fire ants in Texas have reached upwards of 2,000 mounds per hectare and are voracious predators of arthropods. They have been documented to cause 100% mortality of monarch eggs and larvae (Calvert 1996). In another study, Calvert (2004) used exclosures to measure mortality of predators with and without fire ants to compare natural rates of predation in other areas of the Midwest; he found that fire ants have likely displaced other natural predators of the monarch butterfly and have the ability to locally decimate monarch immature stages (eggs, larvae). The European paper wasp (*Polistes dominulus*), another introduced species, feeds primarily on Lepidoptera caterpillars (Liebert et al. 2006). Some evidence suggests that these nonnative wasps may consume some sensitive butterfly larvae such as the monarch butterfly (De Anda and Oberhauser 2015). Invasive multicolored

A newly emerged monarch accompanied by a wasp likely taking advantage of this vulnerable stage.

Asian lady beetle (*Harmonia axyridis*) larvae also feed on monarch eggs and larvae (Koch et al. 2005), and introduced biocontrols such as Chinese mantids (*Tenodera sinensis*) have been documented feeding on monarch larvae in the East (Rafter et al. 2013). Limited occurrence data reported by observers using the BugGuide website (www.bugguide.net) suggest that this species may now be found in the West.

A number of parasites and parasitoids of monarchs have been identified, including wasps, flies, and the protozoan parasite OE. Tachinid flies may be the most prevalent monarch parasitoid. Oberhauser et al. (2017) found that parasitism by tachinid flies was 10% across all monarch life stages, based on rearing observations of over 20,000 monarchs. High levels of OE can decrease larval survivorship, affect wing size, cause wing deformities and difficulties during eclosion, shorten monarch life spans, decrease lifetime fecundity, or even result in direct mortality (Altizer and Oberhauser 1999; Bradley and Altizer 2005; De Roode et al. 2009). OE spreads via spores deposited by infected females on milkweed host plants and monarch eggs. Newly hatched larvae then ingest the spores, which move into the caterpillar's gut and release the parasite. While low levels of parasitism are normal in wild monarch populations, much higher OE loads have been associated with nonmigratory monarch populations (such as those in Florida or southern California). Western monarchs have historically had higher OE levels than their eastern counterparts (Satterfield et al. 2015), possibly because the average migration distance is shorter and affected butterflies are not as strongly selected against as butterflies that have to make it to Mexico and back. Research in the eastern population has shown that OE impairs adult flight ability and migration success (Bradley and Altizer 2005; Bartel et al. 2011). OE is of particular concern when nonnative tropical milkweed is planted near overwintering sites in coastal California, since it does not die back in the winter and may lead to interruption of the monarchs' winter diapause. Satterfield et al. (2016) found OE levels were nine times higher in winter breeding monarchs on nonnative tropical milkweed (*A. curassavica*) than those in reproductive diapause in California. See Recommendation Against Planting Nonnative Milkweeds on page **50** for more detail.

3

What is High-Quality Monarch Habitat?

Breeding habitat consists, at a minimum, of milkweed, but often includes other flowers for nectar and trees or shrubs for shade and perching (if appropriate for the habitat).

Migrating habitat includes flowers, which provide nectar for adults during the spring and/or fall migration period, as well as roosting habitat, which is thought to be particularly important during the fall migration; monarchs are sometimes observed using trees to spend the night or wait out a storm. Milkweed is not necessary during fall migration as adult butterflies are typically in reproductive diapause.

Monarch breeding and migration habitat are often synonymous—a field with milkweed and flowers provides both places to lay eggs and nectar for migrating adults. For this reason, breeding and migratory habitat are frequently undifferentiated in this document and in other resources (often called "breeding habitat"). However, there are some important exceptions. For example, monarchs may nectar on abundant blooms of late season rabbitbrush (*Ericameria* spp. and *Chrysothamnus* spp.) or sunflowers (*Helianthus* spp.) in areas lacking milkweed; or river corridors may be used more extensively during fall migration when plants far from water may have senesced. Recognizing that differences exist in some areas, the management and restoration recommendations for both breeding and migratory habitat are generally quite similar and are grouped together in this document.

The Principal Features of High Quality Monarch Habitat

1. Native milkweeds to provide food for monarch caterpillars and nectar for adults.
2. Flowers, ideally a diversity of native species with overlapping flowering phenologies, to provide nectar for adults.
3. Protection from pesticides. (See Pesticides on page **42** for more information.)
4. Places that are safe from high levels of pathogens. (See Recommendation Against Planting Nonnative Milkweeds, on page **50**, and Issues With Planting Milkweed Outside of Its Historic Range, on page **21**, for more information.)
5. Other features such as trees, shrubs, and structures for shade, perching, or roosting may also be key components of monarch habitat, but they will vary in importance throughout the butterfly's life cycle and are not well studied.

A good example of monarch habitat: showy milkweed in a grassland with shade from willows.

Milkweed Species

Milkweed Diversity and Distribution

There are approximately 44 species of milkweed (*Asclepias* spp.; family Asclepiadaceae), excluding subspecies, native to western North America of which 20 have been documented as larval hosts for the monarch (see **Appendix 1**). Milkweeds occur in every Western state, though not equally. Diversity is highest in Arizona, which has 32 species, and lowest in Washington where only three species occur.

Milkweeds grow in a variety of habitat types from barren desert slopes to wet meadows in both disturbed and undisturbed areas (Appendix **1**). Some milkweed species are adapted to natural disturbances, and are commonly found on roadsides, along irrigation ditches or canals, in or adjacent to irrigated agricultural fields, in burned areas, or along stream or river banks (e.g., *A. speciosa* and *A. fascicularis*), while others may be more sensitive to disturbance and have more specific habitat associations (e.g., *A. cryptoceraus*).

Milkweed grows throughout the West (see **Figure 5**). The primary limits to milkweed distribution are elevation and proximity to the Pacific Coast. Milkweeds generally do not occur above 9,000 feet, though there are two exceptions. Hall's milkweed (*A. hallii*), which occurs in Nevada, Utah, Colorado, and Arizona, and mahogany milkweed (*A. hypoleuca*), which can be found in southern Arizona and New Mexico, both grow above that elevation. At this time, we lack data on whether these two high elevation milkweed species are used by monarchs as larval hosts.

Showy milkweed is a species that is adapted to natural disturbances and sometimes found along roadsides, such as this stand in northern Utah.

Near the Pacific coast, milkweed is largely confined to southern California. Historically, milkweeds occurred along the coast very rarely north of Santa Barbara and more commonly along the coast south to San Diego and into Baja, Mexico. There are three species of native milkweed that historically and currently occur on the California coast south of the Santa Barbara area: woollypod milkweed (*A. eriocarpa*), California milkweed (*A. californica*), and narrowleaf milkweed (*A. fascicularis*). In Oregon, the only records of milkweed on the coast are in the south of the state, a handful of occurrences of showy milkweed (*A. speciosa*) at the mouth of the Rogue River. There are even fewer records from coastal Washington, a single historical record from the 1920s of narrowleaf milkweed for the mouth of the Columbia River. There are no other reports of native milkweeds west of the Cascade Crest in Washington, except a few (likely planted) milkweeds in the Seattle area.

The family Apocynaceae has several native species that are closely related to milkweed and that look similar. Some butterflies may even lay eggs on them, but these plants are not documented as being able to support monarch larvae for their entire development. Some of these species include native dogbanes (*Apocynum* spp.) which are native to all western states, and twinevines (*Funastrum* spp.) which are native to the Southwest.

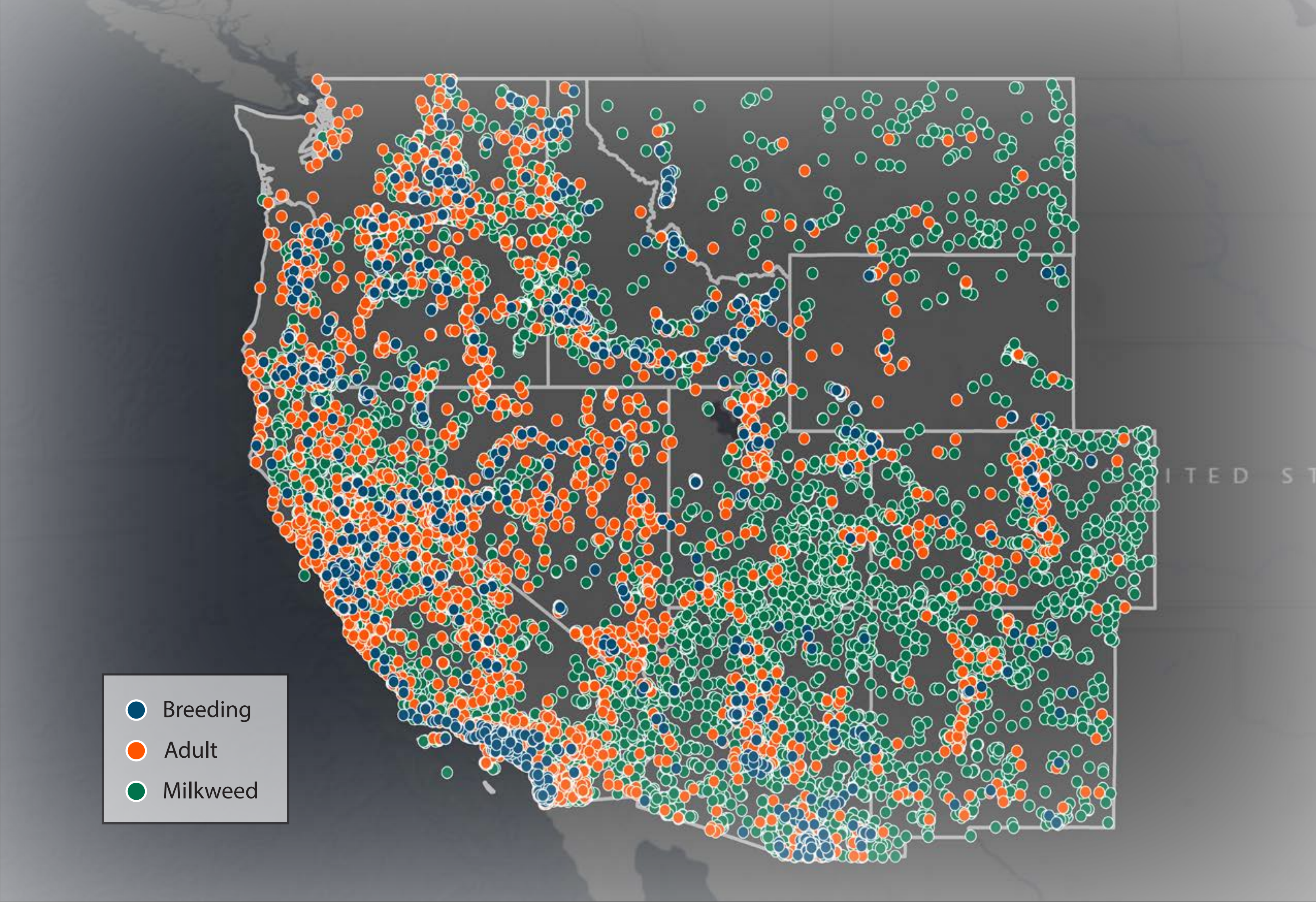


FIGURE 5. Records of Milkweed, Adult Monarchs, and Monarch Breeding in the West from the Western Monarch Milkweed Mapper.

Milkweed Phenology

Milkweed species have differing phenologies, including evergreen perennials and short-lived deciduous perennials. Most native milkweeds are the latter, typically growing in the spring and summer, and then senescing and remaining dormant for the winter. They reemerge the next spring. However, in the Desert Southwest, there are several milkweed species that grow and flower year-round, such as rush milkweed (*A. subulata*) and whitestem milkweed (*A. albicans*). Nonnative species such as tropical milkweed (*A. curassavica*) and balloon plant (*Gomphocarpus* spp.) can also grow and flower year-round in areas with mild winters (see Recommendation Against Planting Nonnative Milkweeds on page **50**). Across the West, native milkweeds may emerge as early as March and some species continue to grow into November, depending on the species, habitat, water availability, and elevation. Some research suggests that monarch adults may be selecting milkweed plants to lay eggs on based on the plant's phenology; more eggs being laid on young plants and those that are flowering versus those that are fruiting or beginning to senesce (e.g., Zalucki and Kitching 1982b).

Milkweeds support a diverse insect community; this showy milkweed's flower is providing nectar for three native bees.

Milkweed Identification

Milkweeds vary widely in flower color, growth form, leaf structure, and phenology, but the flower and fruit structure are similar among all species. The flowers have five nectar storing structures called hoods and horns, subtended by five petals which are generally recurved or bent backwards. The fruits are fleshy pods or follicles that split at maturity to release wind-borne seeds equipped with fluffy white hairs (floss, pappus, coma, or silk) to catch the wind and aid in dispersal. Another similarity among all milkweed plants is that they all secrete a white or clear latex when plant tissue is damaged. The flower, fruit structure, and latex are all important features used to identify a species of milkweed. To learn to identify milkweed species in your region, you can use resources such as:

- **Appendix 1** includes state-specific milkweed lists and other information.
- State-specific milkweed species lists, species profiles, an interactive identification tool, and occurrence records are available through the Western Monarch Milkweed Mapper website for eleven Western states (www.monarchmilkweedmapper.org).
- Region-specific milkweed species lists and profiles developed by Xerces, NRCS, and Monarch Joint Venture are available for California, Oregon, Washington, Nevada, Great Basin, and Desert Southwest through the Xerces Society's website.

Nectar Species

Unlike monarch caterpillars which are highly host specific, adult monarchs are generalists that feed on nectar from a wide variety of blooming plants. Flower nectar is important for fueling all adult monarch activities (including breeding, migration, and overwintering), and the quality and quantity of available nectar sources in the landscape are thought to have a population-level impact on monarchs. Late-blooming floral resources such as rabbitbrush (*Chrysothamnus* spp. and *Ericameria* spp.), mule fat (*Baccharis* spp.), and sunflowers (*Helianthus* spp.) can be especially important to late-fall generations, which need large quantities of nectar to generate the lipids (fats) that will fuel their migration journeys and sustain them until the breeding season begins the following spring.

Monarchs have a broad visual spectrum and true color vision (Blackiston et al. 2011), which they use to find nectar plants in the landscape. They also have specific color preferences, but can quickly learn to switch to a different color if it proves more rewarding. In laboratory experiments with colored paper models, Blackiston et al. (2011) found that monarchs have strong innate preferences for orange, yellow, or red (out of six colors, including green, purple, and blue). These color preferences are often reflected in the types of flowers monarch are attracted to, including goldenrod, sunflowers, and marigolds. However, monarchs will also readily nectar at blue, pink, purple, and white flowers, among others (Xerces Society, unpublished data), and Blackiston et al. (2011) found that monarchs will switch allegiances to a particular flower color if a less preferred color provides a better nectar reward. Also conducting laboratory experiments, Cepero et al. (2015) found that monarchs were also able to associate floral shape with a sugar reward, suggesting that monarchs may use these cues in the landscape as well.

Late-blooming sunflowers (*Helianthus* spp.) are an important nectar source for fall-migrating monarchs.

Over 150 different nectar plant species have been reported as being used by monarchs in the West (Xerces Society, unpublished data). Milkweeds (*Asclepias* spp.) make up about a third of all nectaring observations reported, highlighting their importance not only as caterpillar hosts but also as nectar sources for adults. **Appendix 2** provides a list of native species that appear to be of high value to monarchs as nectar plants in the West. Nonnative plants can also provide monarchs with nectar, and can be especially valuable for monarchs in areas with few native nectar resources. For example, monarchs are often found nectaring on nonnative thistles (Asteraceae family) on rangelands and ornamental plants in gardens. James et al. (2016) found purple loosestrife (*Lythrum salicaria*) to be a good nectar source for late season monarchs at a site in eastern Washington because it blooms after the resident milkweed plants (*A. speciosa*) have senesced. While removing invasive weeds such as purple loosestrife is strongly recommended, replacing nonnatives with native nectar sources is important in restoration projects to ensure adequate nectar resources are still available for monarchs. See the Invasive Nonnative and Noxious Plant Management on page **60** for more details.

While milkweeds make up about a third of all reported nectaring observations (top), monarchs may utilize a diversity of nectar plants to fuel their migration, including goldenrod (*Euthamia occidentalis*; bottom left) and mountain monardella (*Monardella odoratissima*; bottom right).

4

Approach to Monarch Habitat Conservation

Overall, monarch habitat conservation in the West should be primarily to manage for existing monarch habitat and, secondarily, to enhance or create new habitat where appropriate. Native, diverse wildflower and blooming shrub plantings—including milkweed—that support wildlife, including monarchs and other pollinators, should be an integral component of restoration efforts and ideally, part of larger ecosystem restoration efforts.

Priority Areas for Habitat Conservation and Restoration

Planting milkweed across the West is not a recommended monarch conservation strategy. Many areas of the West have native milkweed, and in many cases, the milkweed stands are used by monarchs at low rates or not at all. In the absence of knowledge that milkweed across the landscape is limiting monarch populations, we recommend a more holistic and targeted approach to monarch conservation. The Xerces Society's approach to monarch habitat conservation can be summarized by the following priorities, in order of importance:

1. Identify, protect, and manage existing habitat to maintain its value for monarchs.
2. Enhance existing habitat (if needed and appropriate) to improve its value for monarchs.
3. Restore habitat in areas where it occurred historically, but has been lost.

We should also consider how climate change may impact monarch habitat and prioritize the conservation and restoration of areas which are most likely to be resistant and resilient as well as important to monarchs under climate change. Northern latitudes (e.g., Washington, Idaho, Montana, and southern British Columbia) and higher-elevation areas, for example, may become more important as the climate warms.

In many cases, more milkweed does not need to be planted, but rather, monarch breeding sites should be identified, protected, and managed in a way that benefits monarchs. However, in some of the key breeding areas of the West, restoring and re-creating monarch habitat may be an appropriate strategy, depending upon the history of the particular site and

Habitat conservation for monarchs should first focus on protecting current habitat.

the current land use. For example, planting milkweed may be recommended in agricultural landscapes that have been converted from native grassland or rangeland use, where milkweed historically occurred.

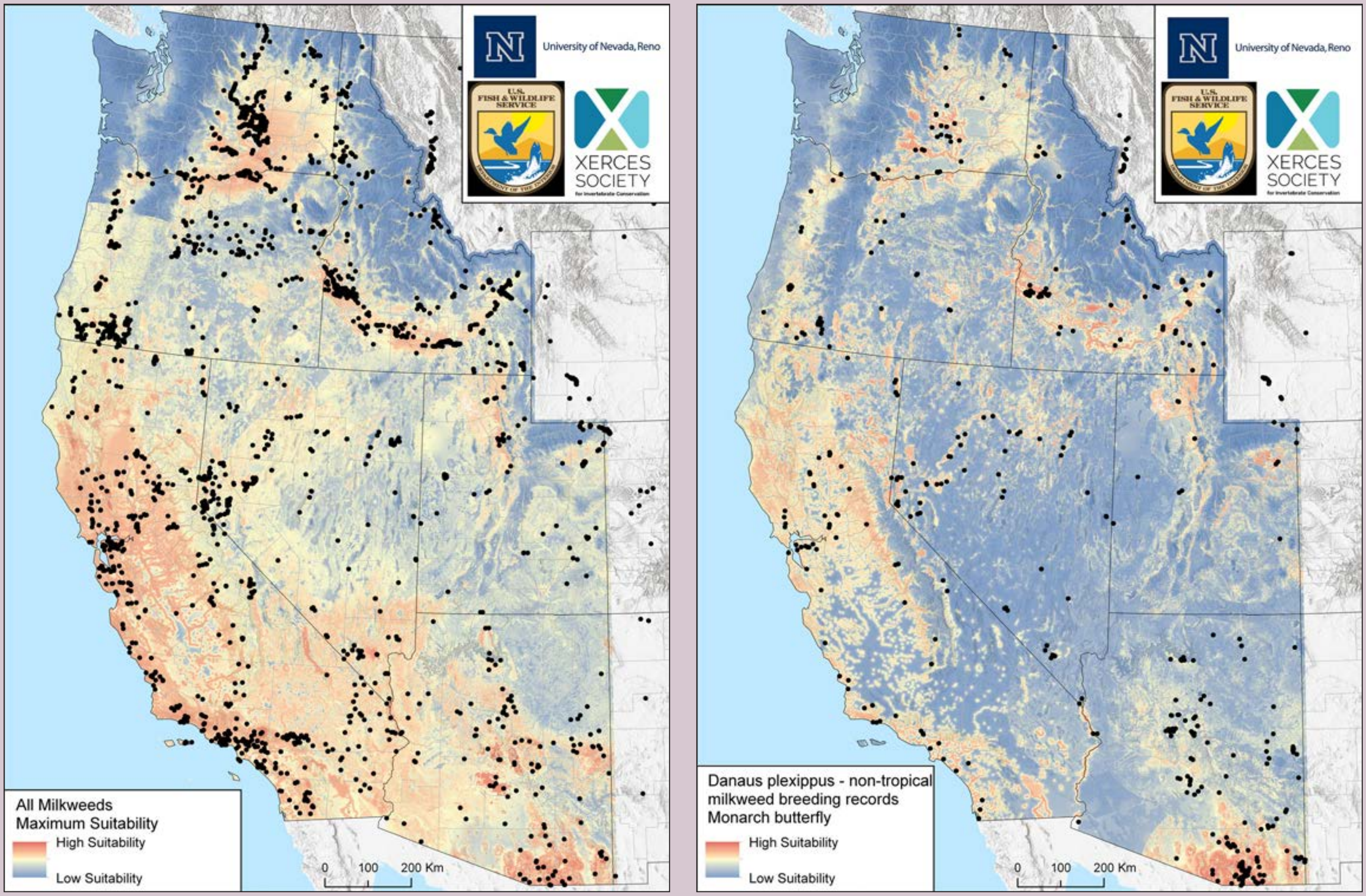
Our understanding of priority areas for monarch habitat conservation and restoration are based on a habitat suitability modeling effort between the US Fish and Wildlife Service, the Xerces Society, and the University of Nevada–Reno. The data used in the modeling was compiled as part of a multi-year effort to collect western milkweed and monarch occurrence records via crowd-sourcing (e.g., online surveys, Flickr), existing herbaria and biodiversity datasets (e.g., BISON), and extensive on-the-ground surveys by the US Fish and Wildlife Service, the Xerces Society, Idaho Department of Fish and Game, Washington Department of Fish and Wildlife, and others.

Consistent with the wide-ranging nature of the monarch butterfly, suitable breeding and migratory habitat is widespread across the West. The modeling results show there are notable concentrations of potentially highly suitable habitat in the Central Valley of California as well as in southern Idaho and eastern Washington; smaller areas are evident across northern Nevada, southern Arizona, parts of Utah, most low-elevation lands in Oregon excluding the coast, and other areas (see **Figure 6**). The Central Valley and adjacent foothills of the Sierra Nevada of California are particularly important because monarchs likely pass through these areas on both their spring and fall migrations to and from interior and northern western states. These areas can be prioritized for monarch habitat protection and management. In some areas, and within habitat types that are suitable, restoration or enhancement may be appropriate.

We recommend using a combination of the milkweed and monarch breeding models to prioritize areas for monarch habitat protection, management, and restoration. The milkweed models—both species-specific and the combined "all milkweed" model in **Figure 6**—represent areas which are potentially suitable for milkweed based on environmental covariates. The monarch breeding model (excluding tropical milkweed) is a more restricted model, based upon where we know monarchs use milkweed across the West. This is very useful in helping us understand not just where milkweed grows, but where monarchs are actually using milkweed. This model, however, should be used with caution. Because we have many fewer breeding records compared with milkweed records, and the breeding records are strongly biased towards areas with high human populations (more observers equals more observations), the model is likely under-valuing some of the areas currently shown as "low suitability." Thus, we recommend considering both milkweed and monarch breeding models when making decisions about which areas are the highest priority for monarchs in your region, ideally by comparing the models of milkweed species you are considering including in your restoration efforts. In addition, you should consider the historical occurrence of milkweed in your area. Not every area which appears as highly suitable for milkweed is appropriate for monarch habitat restoration (such as the coastal areas of central and northern California). See Issues with Planting Milkweed Outside Its Historic Range on page **21**.

Because habitat suitability modeling is, in part, influenced by survey effort and requires a minimum number of records which are of high-geographic accuracy, we had to exclude the interior western states of Montana, Wyoming, Colorado, and New Mexico due to a paucity of data. However, we know from limited survey work that all four states support suitable habitat and breeding, and increased survey and tagging efforts in these states would greatly improve our understanding of monarch distribution and habitat use in this region. Visit the Western Monarch Milkweed Mapper website (www.monarchmilkweedmapper.org) to read more information about this modeling project, see the results from two phases of modeling, and contribute data.

FIGURE 6: Maximum Milkweed Suitability (L) and Monarch Breeding Without Tropical Milkweed (R) (Dilts et al. 2018).



Black dots indicate geographically high-accuracy occurrences used in habitat suitability modeling of milkweed (L) and monarch eggs, larvae, or pupae (R).

Issues with Planting Milkweed Outside its Historic Range

According to the best available records, native species of milkweed did not historically grow along most central and northern parts of the California coast or west of the Cascade Crest in Washington and parts of western Oregon. But many people ask, is planting milkweed in these areas still helpful for monarchs?

In areas west of the Cascade Crest in Washington and parts of western Oregon, monarchs only pass through in relatively small numbers or in some years. For this reason, planting milkweed in these areas is not a recommended monarch conservation strategy—but is also not a major conservation concern and may become more valuable under climate change if the monarchs' range expands to higher latitudes and elevations. Monarchs may find and use it in the years in which they reach the area during their migration. In addition, native milkweeds provide valuable resources for other native invertebrates including native bees and parasitic wasps (James et al. 2016).

In coastal California, however, there is stronger evidence that planting milkweed near the coast could negatively impact monarchs. Because of the mild winter temperatures in most parts of coastal California, milkweed planted close to the ocean can escape hard frosts, delaying or preventing these species from going dormant in the fall. This may disrupt the monarch's natural cycle of going into reproductive diapause while they overwinter at the coast. If there is available milkweed, monarchs may continue to mate and lay eggs into the winter. This phenomenon is well-documented in nonnative, tropical milkweed (*A. curassavica*) which stays evergreen and is associated with winter breeding and high OE loads (see Recommendation Against Planting Nonnative Milkweeds on page **50)**. But in coastal California, even native species may stay green through much of the fall and winter, and cause similar issues. For these reasons, the Xerces Society does not recommend planting milkweed, whether nonnative or native, close to overwintering sites (within 5–10 miles of the coast) in central and northern coastal California, where it did not occur historically (see Pelton et al. 2016 for additional information). Instead of planting milkweed in these regions, plant fall-, winter-, and spring-blooming native flowering plants which provide nectar resources for monarchs and other pollinators.

Antelope horn milkweed can tolerate drier conditions than showy milkweed. In this picture, it is growing on a rangeland in Nevada.

5

Best Management Practices for Monarch Habitat

The best management practices (BMPs) below provide a brief summary of the known effect of each land use/management practice on monarchs and their breeding/migratory habitat, followed by recommendations on how to incorporate monarch conservation into management decisions. This guidance does not require that land managers manage habitat exclusively for monarchs, but instead is provided to help land managers include this species when considering broader goals for land management such as managing to promote biodiversity, native plant communities, and ecosystem function.

Management Timing

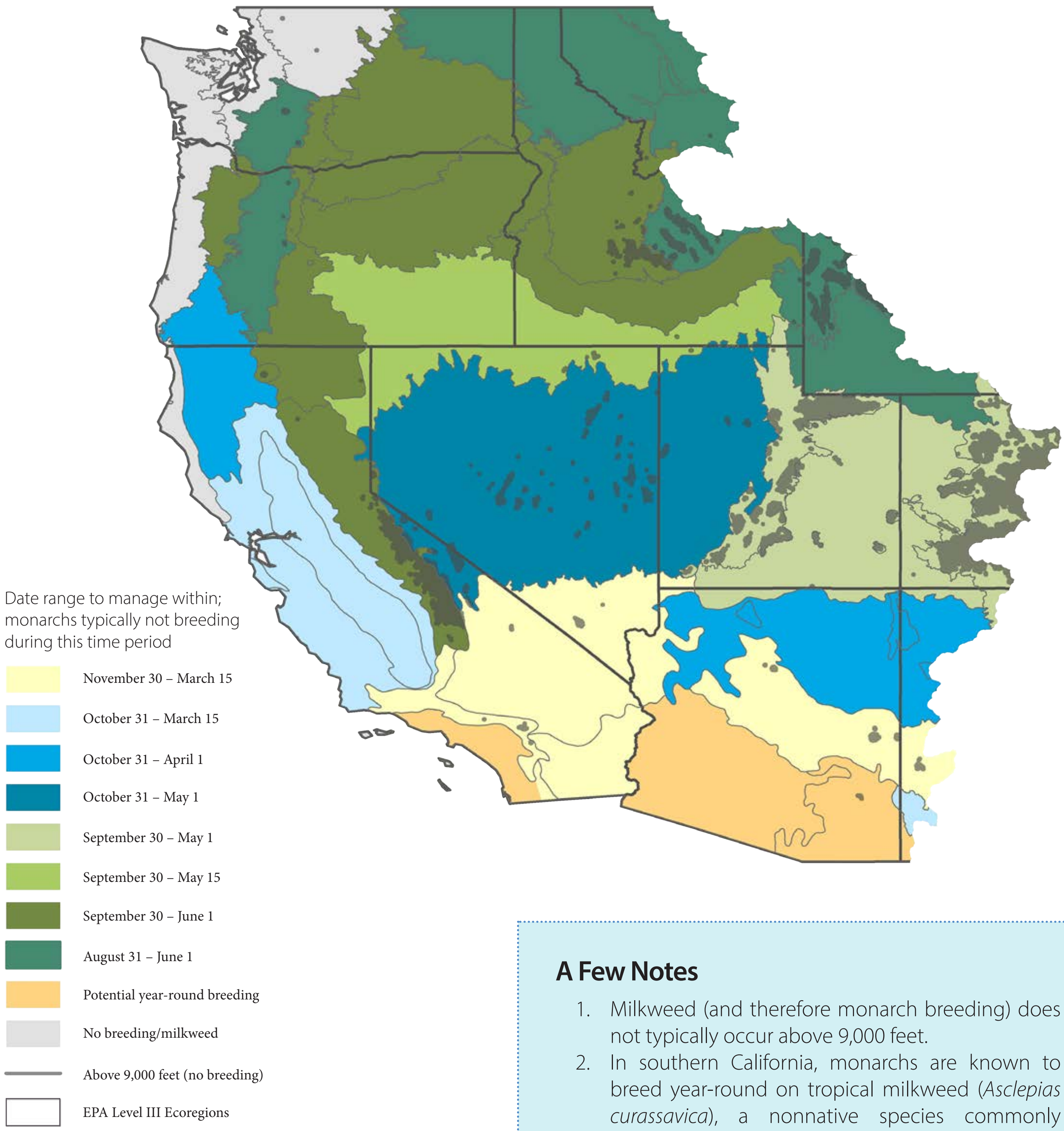
Each spring, monarchs disperse from overwintering grounds on the California coast and Mexico to spread across the United States and southern Canada in search of milkweed plants (*Asclepias* spp.) on which to lay their eggs. In the West, monarchs breed and lay eggs continuously from spring to fall, ending when the final breeding generation(s) of adults migrates back to their overwintering grounds. However, the timing of when breeding begins and ends varies across the West. Understanding when monarchs are present and breeding in a region allows land managers to avoid using management practices such as mowing or burning during times when monarch immature stages (eggs, larvae, pupae) are present.

Based on the best available data for when and where monarchs breed in the West, we have developed regionally appropriate monarch breeding habitat management windows. These windows are periods when management activities are least likely to have negative effects on monarchs. Data used includes breeding data and adult records from Journey North (www.learner.org/jnorth/monarchs) and the Western Monarch Milkweed Mapper, as well as expert opinion by field biologists and scientists. Management windows were customized by EPA Level III ecoregion. Based on the availability of data, some ecoregions were combined into the same window and one ecoregion in southern California (the Sonoran Desert 10.2.2) was split into two management windows.

We are still learning about the phenology of monarch breeding—when the earliest breeding begins and the latest breeding ends—in different regions of the West. As such, these management windows should be viewed as approximate recommendations. The exact timing of monarch breeding may vary from year to year and site to site—and these windows may

Managing monarch outside of the butterfly's breeding season is important to avoid mortality of immatures such as this caterpillar on pallid milkweed.

FIGURE 7: Recommended Management Timing for Monarch Breeding Habitat.



Data source: EPA Level III Ecoregions, Western Milkweed Mapper, Journey North, Southwset Monarch Study, Department of Defense Legacy Fund Research, Dingle et al. 2005.

A Few Notes

1. Milkweed (and therefore monarch breeding) does not typically occur above 9,000 feet.
2. In southern California, monarchs are known to breed year-round on tropical milkweed (*Asclepias curassavica*), a nonnative species commonly planted in gardens.
3. In southern Arizona, monarchs have been documented breeding year-round on native milkweed species such as rush milkweed (*A. subulata*).

be revised in the future as we learn more. This is especially true for areas where little data is currently available on the timing of monarch breeding, such as in Montana and Wyoming.

As every year and site are slightly different, consider surveying milkweed plants for immature stages of monarchs prior to mowing, burning, grazing, or using pesticides. This is especially helpful if the management timing falls on the cusp of the recommended window for your region or if it has been an early spring/late fall year. If management must take place while immature monarchs are present, spot-apply management to avoid milkweed plants when possible or try to leave at least some milkweed unaffected to act as a refugia. Generally milkweeds are easy to identify, and training staff or volunteers to recognize milkweed and avoid mowing, spraying, or otherwise disturbing plants during the breeding season can be an effective solution.

Grazing

In the West, approximately 70% of all land (public and private) is grazed by livestock (Fleischner 1994). With grazing as a major land use, there is a need for rangeland management strategies which minimize negative impacts to monarchs and other pollinators. However, there is very little research directly assessing the effects of grazing on monarchs or milkweed, so generalizations must be drawn from research focused on other pollinators. Further, the research that does exist rarely reports the grazing stocking rates or timing that would be needed to develop specific grazing recommendations. However, grazing management practices that are already in place which aim to increase or maintain a diversity of flowering plants, including milkweed, for federally listed or sensitive gallinaceous birds, upland game and birds, and fish will generally also benefit monarch butterflies and other pollinators (Gilgert and Vaughan 2011; Bates et al. 2016; Dumroese et al. 2016).

Livestock grazing can greatly alter the structure and composition of plant communities, hydrology of mesic habitats, and soil structure, and introduce or spread invasive plants (e.g., Belsky et al. 1999; Hayes and Holl 2003; Swanson et al. 2015). Grazing has been documented to cause plant community shifts towards invasive plants that are both less palatable to ungulates and less suitable habitat for native pollinator communities (e.g., Hanula et al. 2016; Vavra et al. 2007; Kobernus 2011; Veblen et al. 2015a). Grazing-induced changes to the plant community can reduce the availability of nectar and host plants for all life stages of butterflies (Hayes and Holl 2003; Cushman 2009). In some studies, the abundance and richness of flowering plants is directly correlated with the abundance of butterflies (Erhardt 1985; Marini et al. 2009), and therefore management should strive to maintain diverse floral resource availability for butterflies such as the monarch. However, this is complicated as the response of herbaceous flowering vegetation to grazing is generally species-specific and often based on plant life-history traits. Plant responses vary with some studies reporting no response (Sjödin 2007; Batáry et al. 2010), a positive response (Willms et al. 1985; Carvell 2002; Hayes and Holl 2003; Marty 2005; Vulliamy et al. 2006), or a negative response (Damhoureyeh and Hartnett 1997; Hickman and Hartnett 2002; Yoshihara et al. 2008; Xie et al. 2008).

Despite the toxicity of milkweed plants—abundant milkweed can be a sign of overgrazing in some cases—livestock sometimes do consume milkweed even when other forage is available. Livestock eating milkweed can be both a toxicity concern as it reduces available host plants for monarchs, and by causing direct mortality to immature stages of the butterfly that may be on the plants. For this reason, high intensity grazing or overgrazing during the milkweed growing season is considered a threat to monarchs and some milkweed species, including the federally threatened Mead's milkweed (*A. meadii*) (USFWS 2003). See **Box 1** on page **26** for more information.

The response of pollinator communities to grazing also varies widely in the literature (Kruess

Box 1: Toxicity of Milkweed to Livestock

Many plants are classified as toxic to livestock, and have been assigned a name with "weed" in it, including milkweed. Milkweed contains plant chemical compounds called cardenolides which are toxic to many animals. But cardenolide levels vary by milkweed species and local conditions, causing plants to vary from relatively nontoxic to very toxic to livestock, including sheep, cattle, horses, goats, turkeys, and chickens (FDA Poisonous Plant Database; Panter et al. 2011). Despite their "weed" status, these plants play an important role in the ecosystem, providing nectar for butterflies and bees and supporting a wide range of specialist and generalist beetles, true bugs, flies, and aphids. A large percentage of milkweed species native to North America have also been documented as host plants of the monarch butterfly, which the caterpillars need to complete their life cycle.

While there have been instances of livestock poisoning from milkweed, the record is sparse and mostly associated with hungry animals being released into milkweed patches (Fleming 1920) or confined to an area without sufficient alternate forage. Milkweed plants are toxic to livestock year-round during all growth stages, but can be of particular concern when dried—such as in hay—because palatability to livestock increases (Fleming 1920; DiTomaso and Healy 2007; Schultz 2003). While toxicity varies, all milkweed plants should be considered toxic to livestock (Malcolm 1991; Agrawal et al. 2015). However, two species, western whorled milkweed (Asclepias subverticillata) and narrowleaf milkweed (A. fascicularis), have been reported as especially problematic species for cattle and sheep, likely because of their growth forms. Their thin stems and leaves are easily tangled in grasses and difficult for grazing animals to separate out.

Livestock graze in areas with milkweed all over North America and there are anecdotal reports of cattle and sheep eating milkweed even when other forage is available (Stephanie McKnight, personal observation). Despite this, poisoning events are rare, possibly because livestock must consume a large amount of milkweed to become sick or die. An average cow weighing roughly 1,200 lbs will need to eat 12 lbs or more (or 1–2% of their body weight) of dried milkweed on average to die of poisoning (Kingsbury 1964; Burrows and Tyrl 2007). In a recent survey of forty-three land managers and ranchers (see Introduction on page **1**), poisoning events from milkweed were not reported as a major concern, and no one reported first-hand knowledge of a poisoning event.

Milkweed growing along a fence line on rangeland in Nevada.

So is conserving milkweed compatible with livestock grazing? The answer is yes, if you take some basic precautions:

1. Maintain an appropriate stocking rate and ensure livestock have sufficient forage.
2. Keep livestock driveways and small paddocks free from milkweed because confined animals may be more likely to eat it.
3. Closely monitor animals that are new to an area where milkweed occurs.
4. Avoid planting western whorled milkweed and narrowleaf milkweed in grazing allotments; these species may cause greater problems for livestock.
5. Keep fields that will be used for hay free from milkweed.

and Tscharntke 2002; Vulliamy et al. 2006; Sjödin 2007; Kimoto et al. 2012; Minckley 2014b; Elwell et al. 2016). Pollinators may exhibit species-specific responses to grazing dependent on their diet, foraging behavior, and nesting requirements or overwintering behavior (Cushman 2009; Roulston and Goodell 2011; Yamhill Soil and Water Conservation District 2014). In general, research done in western North America shows that as percent utilization or grazing intensity increases, pollinators generally decrease in abundance (DeBano 2006; Cushman 2009; Kimoto et al. 2012; Minckley 2014a). If monarchs respond similarly to other pollinators, then grazing management that reduces nectar or milkweed plants likely have negative consequences for monarchs.

Livestock do occasionally eat milkweed, even reaching through the fence in this case.

Livestock grazing can also cause direct mortality to adult butterflies and immature stages, and some butterflies are sensitive to livestock grazing, such that they will not lay eggs in grazed habitat when ungrazed habitat is available (Stoner and Joern 2004; Yamhill Soil and Water Conservation District 2014). It is not known if monarchs exhibit this behavior. Livestock can also trample or consume butterfly larval host plants resulting in mortality to the eggs, larvae, pupae, and even immobile adults (Warren 1993; Smallidge and Leopold 1997; Stephanie McKnight, personal observation).

However, when carefully managed, grazing can be an important management tool for maintaining the open herbaceous- or shrub-dominated and heterogenous plant communities such as grasslands, meadows, prairies, and shrublands which are often important to monarchs (e.g., Pöyry et al. 2005; Weiss 1999; WallisDeVries and Raemakers 2001; Konvicka et al. 2008; Potts et al. 2009; Kobernus 2011; Vanbergen et al. 2014). Carefully timed and implemented grazing can also be used to suppress nonnative plants such as invasive grasses that can significantly affect butterfly habitat (Olson 1999; Weiss 1999; Schmelzer et al. 2014; Stonecipher et al. 2016). In these cases, the short-term costs to monarch habitat are likely outweighed by the long-term benefits of restoring an area to better ecosystem function and its value to monarchs in years to come.

Habitats such as mesic aspen (*Populus tremuloides*) stands, spring-fed wetlands, wet meadows, emergent wetlands, and riparian areas are especially vulnerable to livestock grazing (Dockrill et al. 2004; Gonzalez et al. 2013; Sada and Lutz 2016). Mesic habitats in rangelands comprise a small fraction of the landscape (1% in the Great Basin; Chambers and Miller 2004), and yet they often support a high diversity of butterflies, including many endemic species and monarch butterflies (Austin 1992; Fleishman et al. 2005; Sanford 2011), and may support a higher abundance of pollinators compared to more xeric habitats (Griswold et al. 2003; Pendleton et al. 2011). There are many endemic or declining butterflies associated with isolated spring-fed mesic wetlands in arid regions, especially in the Great Basin, and many are threatened by livestock grazing (Sanford 2011). While milkweed plants occur in a variety of habitat types across the West, some of the more common species—showy (*A. speciosa*), swamp (*A. incarnata*) and narrowleaf (*A. fascicularis*)—often occur in great abundance in mesic habitats, providing important breeding grounds for the monarch. A survey of monarch breeding habitat in Arizona, found that breeding areas were most numerous in riparian zones (Morris et al. 2015). Further, mesic habitats often provide critical resources including nectar, shade, water, roosting sites, and migratory corridors for adult monarchs (Dingle et al. 2005; Morris et al. 2015).

Mesic habitats are also attractive to livestock due to greater forage and water availability—especially in the hot, dry summer months—and livestock often concentrate for long periods of time in these areas (Belsky et al. 1999; Swanson et al. 2015). Grazing of mesic habitats can greatly alter the hydrology, plant community, and plant structure, reducing available habitat for butterflies, including the monarch (Belsky et al. 1999; Swanson et al. 2015). Alterations of the physical structure of riparian channels, springs, or meadows can increase erosion and evaporation through incision, gullies, or rills, which over time can cause plant communities to shift towards more xeric species, or alter the palatability of host plants to caterpillars (Belsky et al. 1999; Sarr 2002). Deterring concentrated livestock utilization in mesic habitats can be accomplished by a variety of means including fencing, herding, supplements, geography, and release location of livestock on the landscape (Swanson et al. 2015; Stonecipher et al. 2016; Stephenson et al. 2017). Careful grazing management is needed in mesic habitats in the summer months to maintain nectar and host plant availability for monarchs, and maintain habitat for wildlife such as the greater sage-grouse (*Centrocercus urophasianus*). Ideally, the timing of grazing would be adjusted to avoid the period when monarchs are present or to keep the intensity and duration of grazing low. Water developments for livestock can also eliminate or severely degrade spring and riparian habitats in rangelands and reduce habitat for butterflies (Sada 2008; Sanford 2011). In an inventory of 2,256 springs in the Great Basin and the Mojave, livestock grazing and water diversion were reported as the most common disturbances to these biodiversity hotspots (Sada and Lutz 2016).

However, not all milkweed species occur in mesic habitats, with many—such as pallid milkweed (*A. cryptoceras*)—occurring in xeric habitats, including barren slopes sensitive to livestock trampling. Loose soils on barren desert slopes are especially vulnerable to disturbance by livestock, and milkweed can be uprooted and killed by livestock trampling (Stephanie McKnight, personal observation). It is important to recognize that milkweed occurs in a variety of habitat types in rangelands, and monarchs have been documented using these plants as larval hosts, even in areas where water or mesic habitats are far away.

While some milkweed species are adapted to more arid habitats, others may be very sensitive to drought conditions. With increasing drought in the West—particularly in the Desert Southwest and southern California—grazing may further exacerbate already drought-stressed milkweed plants and nectar resources. During drought years, livestock may be more likely to consume milkweed or monarch nectar plants if there is limited alternative forage (Stephanie McKnight, personal observation). As such, reducing stocking rates during drought may be necessary to maintain habitat for monarchs and other pollinators. Overgrazing during drought has been documented as the cause of extirpation for three populations of the bay checkerspot butterfly (*Euphydryas editha bayensis*) in northern California (Murphy and Weiss 1988).

Generally, light- to moderate-intensity rotational grazing or short grazing periods followed by a long recovery has been found to be most beneficial to butterflies (Elmer et al. 2012; Hatfield et al. 2015). Due to the variation in responses of both plant communities and butterflies and other pollinators to grazing, careful adaptive management with regular monitoring is advised to ensure that habitat for butterflies such as the monarch are conserved under grazing management plans.

Overgrazing near streams degrades riparian vegetation.

Grazing Best Management Practices

Overall, grazing management should aim to conserve existing milkweed and major nectar plants important for monarchs in their breeding range, as well as conserve mesic habitats that are often important breeding and foraging habitat for monarchs. Generally, grazing that is of short intensity and duration in the fall or winter is best.

With the large variety of habitat types and elevations that support milkweed species in the West, it is recommended that regional milkweed species be included in management objectives of grazing management plans to ensure they are identified and protected from livestock grazing. Examples of specific objectives could be to document milkweed populations and maintain them, or to limit livestock use of mesic habitats where the majority of milkweed plants occur in an allotment. Site-specific objectives will need to be developed for the habitat type and species of milkweed in a grazing allotment or pasture. This will allow grazing to be adjusted to conserve existing milkweed populations and habitat for monarchs.

Since milkweed contains toxic secondary compounds known as cardenolides, ranchers may have concerns about keeping milkweed in rangelands. Education and outreach about how to minimize the risk of livestock poisoning may help managers find how conserving milkweed and protecting livestock can be compatible. See **Box 1** on page **26** for more information on this topic.

Intensity and Duration

Strive to achieve heterogenous grazing intensities with ungrazed refugia across the landscape. Stocking rates should be appropriate for the characteristics of the site, livestock species, and management objectives.

- Keep grazing intensity low (low Animal Unit Months [AUM] for site or allotment) for season-long grazing or use High Density Short Duration (HDSD), and/or rest-rotation grazing schemes.
- Use rotational grazing. In public land management allotments where continuous season-long grazing is the norm, rotational grazing is possible with some ingenuity, including close collaboration with grazing permittees. Rotational grazing could be achieved by using natural barriers (topography inaccessible to livestock), herders, water, or fencing to keep livestock in desired areas and out of an area designated to be rested or excluded from livestock for the year.
    - In a rotational grazing scheme, the excluded area would change every year to maintain habitat heterogeneity, provide periods of rest for excluded areas adequate for the habitat type and that allow vegetation to recover to avoid overutilization of any given area, and to maintain floral resources for pollinators (Scohier et al. 2012).

Utilization Recommendations

- Aim to graze only ⅓ of an area per year. The ungrazed or minimally grazed refugia within each allotment will serve as reservoirs of pollinators to recolonize grazed areas.
- Managers should aim for utilization rates up to but not exceeding 40% of the current season's growth (Kimoto et al. 2012).
- Utilization rates should be lower in mesic meadows, springs, and riparian areas, to protect milkweed and nectar plants. Because drought, grazing history, and native ungulate use all affect utilization rates, determinations should be made on an annual basis.
- Land managers should work closely with local wildlife biologists and botanists to determine regionally appropriate and habitat-specific percent utilization of current year's growth, and stubble height limits that will maintain forb diversity and abundance and milkweed for monarchs

during the breeding season.

- In times of drought, follow AUMs or stocking rates recommended for your region in drought conditions.
- In sagebrush-steppe habitats, aim for short-duration spring cattle grazing of less than 1 AUM/ha (Elwell et al. 2016) and use the current grazing utilization rates or stubble height recommendations for greater sage-grouse. See **Box 2** on page **32.**

Timing

- If feasible, and soils can withstand it, adjust grazing time to fall or winter grazing when milkweed is dormant and monarchs are not breeding, which is generally between first frost and spring (see **Figure 6,** page **21**).
- Keep grazing periods short, with recovery periods relatively long (e.g., high density, short duration grazing; short duration grazing; or Santa Rita grazing management regimes [Howery et al. 2000]). Rest periods will vary (3 months to years) for different habitat types, but should ideally allow vegetation to adequately recover (plants are flowering, setting seed, etc.) before allowing livestock to return.
- Avoid grazing the same location at the same time every year.
- Sheep are particularly prone to eating milkweed. If sheep grazing must occur in an area with milkweed when monarchs are present (see **Figure 7** on page **24**), then animals should be introduced at low stocking rates and the animals should be continuously moved to avoid depleting resources in any single location.
- In arid regions such as the Desert Southwest, there may be a large flush of annual flowers after a high precipitation event or flood. Similar concentrated bloom events can occur after spring snowmelt in high elevation meadows. In both habitats, adjusting the timing of grazing can ensure ephemeral flowering plants have time to set seed and monarchs can use the plants as nectar resources if they are present in the area.

Adaptive Management

This is key to ensuring long-term habitat quality for grazing animals and for wildlife, including monarchs. Good adaptive management hinges on documenting the what, where, and why you took certain actions—a photo, paper, or electronic trail to learn from and draw on in years to come. Grazing management plans should be site-specific, and flexible in order to adapt grazing stocking rates, timing, and duration to changing environmental conditions including but not limited to drought, fire, and invasive species.

- Include milkweed plants and monarch nectar resources as management objectives in grazing management plans. Aim for a goal of maintaining the presence of milkweed, plus a minimum of 3 nectar plant species in bloom in an allotment or pasture throughout the season. This is especially important when a grazing allotment contains milkweed plants.

Livestock Movement

Keep livestock on the move within an allotment to prevent concentrated hoof damage to soils, trampling of milkweed and immature stages (eggs, larvae, pupae) of monarchs, and excess utilization of nectar plants, especially in mesic habitats, areas with large milkweed populations, or areas with documented monarch breeding.

- Establish exclosures or moveable fencing so that livestock can be rotated through grazing allotments to allow recovery of vegetation. If fencing is not an option, then geography, water structures, or nutritional supplements might be useful in keeping livestock within a specified area (Stephenson et al. 2017).

- Sheep should be herded regularly and through different routes each year with a 3–5 year rotation of routes used. Sheep should not be allowed to graze one location longer than one to two days, and floral resources should be closely monitored to avoid depleting an area of flowering plants during peak summer months (June-September).

Sheep are particularly prone to eating milkweed and other forbs, with potentially greater impacts on monarch habitat.

Landscape-scale Considerations

Incorporate resilience and resistance concepts into grazing management plans. This approach is being used for greater sage-grouse conservation and is widely applicable to pollinator conservation (Chambers et al. 2017), including for monarchs. See **Box 2** on page **32** for more information on the overlap between restoration for monarchs, other pollinators, and greater sage-grouse.

- Existing conditions should be maintained in areas identified as high priority, resilient, and resistant to habitat stressors such as fire, invasive species, and drought.
    - This is especially important in shrublands in the West that are under threat of invasion by cheatgrass (*Bromus tectorum*).
    - More information about resilience and resistance can be found in other resources including the US Forest Service (www.fs.fed.us) and US Fish and Wildlife Service (www.fws.gov) websites.

Special Circumstances

- **Sensitive habitats.** Avoiding high intensity or long duration grazing is particularly important in sensitive habitats such as riparian areas, springs, seeps, and meadows. These areas support a high diversity of pollinators, and provide important breeding and migratory habitat for monarchs. These sources of water are also essential for maintaining the long-term integrity of meadow and grassland ecosystems; disturbing them can have long-term and lasting impacts. Where possible, we recommend fencing sensitive habitats to prevent overutilization. If exclusions are not possible, we recommend the following best management practices.
    - To avoid overutilization of riparian areas, Swanson et al. (2015) recommend:
        - High density, short duration grazing management followed by rest periods long enough for the vegetation to recover are recommended for areas with sensitive hydrology such as riparian, spring, meadow, and wetland habitats.
        - Encourage water structures for livestock to be built away from sensitive spring, riparian, or meadow habitats.
        - Use geographic features to keep livestock away from sensitive habitats.
        - Use portable water troughs as a way to move livestock.

Box 2: Restoring Habitat for Monarchs Benefits Other Pollinators, Greater Sage-Grouse, and Other Wildlife

Restoring habitat for monarchs is really about restoring healthy diverse native plant communities for all wildlife species. Milkweed plants provide habitat for a wide variety of butterflies, moths, and native bees including the western bumble bee (*Bombus occidentalis*; a species of conservation concern in the West), an assemblage of other insects including milkweed specialists, and birds (Borders and Lee-Mäder 2014). In arid regions of the West, milkweed species are sometimes the only plants blooming in the hot summer months, and a plethora of native pollinators and insects forage nectar and pollen from their flowers. In addition, songbirds, including the vermillion flycatcher (*Pyrocephalus rubinus*) and black-capped chickadee (*Poecile atricapillus*), have been observed using the fibers from the seed pods and plants to construct their nests (Borders and Lee-Mäder 2014). Conserving or restoring habitat for monarchs by planting milkweed (*Asclepias* spp.) should not be viewed as an insular endeavor—it should be viewed as part of a larger landscape level effort to conserve or restore habitat for a wide variety of pollinators, insects, birds, and other wildlife. Overlap in conservation targets for multiple species allows resource-limited land managers to simultaneously achieve multiple conservation objectives.

Restoring habitat for monarchs not only supports their populations, but other at-risk species like the Morrison's bumble bee (*Bombus morrisoni*), which is a Species of Greatest Conservation Concern in several western states.

In the past decade, the sagebrush biome of the West has become a central focus of landscape-level conservation and restoration efforts for the declining greater sage-grouse (*Centrocercus urophasianus*). Greater sage-grouse chicks are highly reliant on forbs and insects, consuming species from 34 genera of forbs and 41 families of invertebrates (Drut et al. 1994; Gregg and Crawford 2009), and high-quality greater sage-grouse habitat contains native forbs from at least 10 genera. Conservation plans that have already been developed with goals to maintain high-quality sage-grouse habitat will also improve habitat for monarchs and other pollinators by increasing the cover and diversity of forbs that provide nectar resources for adult butterflies and other pollinators, and larval hosts for some butterflies (Gilgert and Vaughan 2011; Dumroese et al. 2016). Dumroese et al. (2016) determined the forbs that are most likely preferred and consumed by greater sage-grouse and are also recommended for pollinators including monarchs. By leveraging available resources, land managers can achieve conservation targets for both greater sage-grouse and other birds, native insects, and pollinators—including the monarch butterfly.

The plants in the following table (Table 1) proffer high-quality forage for both pollinators and the greater sage-grouse (Dumroese et al. 2016; Drut et al. 1994; Gregg and Crawford 2009; Cane and Love 2016; Stettler et al. 2017). Rabbitbrush communities (*Ericameria* spp. and *Chrysothamnus* spp.) in particular are important as they host more Lepidoptera larvae as potential sage-grouse forage, compared to sagebrush (*Artemesia* spp.) communities. They also provide crucial late-season nectar for migrating butterflies and native bees (Ersch 2009; Griswold and Messinger 2009).

- ➢ Move livestock using supplements.
- ➢ Consider releasing livestock from points that will limit or postpone their access to sensitive habitats.

- The following riparian grazing standards may increase flowering plant abundance which may benefit monarchs and other pollinators (Oles et al. 2017):
  - ➢ Limit herbaceous vegetation biomass consumption (e.g., <30% utilization of annual production)
  - ➢ Aim for a minimum residual herbaceous vegetation height (e.g. >10 cm)
  - ➢ Limit browsing of recruiting riparian woody species (e.g., <20% of annual leader growth)
  - ➢ Limit livestock hoof damage to soil and streambanks (e.g., <10% soil shearing by hooves).

Native or feral ungulates. In areas with large populations of native ungulates such as elk or deer or feral ungulates such as horses, it may be necessary to adjust the timing, intensity, and duration of

Table 1: Plant List: Forage for Native Bees, the Monarch, and Greater Sage-grouse.

Family	Genus/Species	Common Name	Native Bees	Greater Sage-grouse	Monarch
Apiaceae	*Lomatium* spp.	desert parsley	x	x	
Asteraceae	*Balsamorhiza* spp.	balsamroot	x	x	
Asteraceae	*Chrysothamnus* spp.	rabbitbrush	x	x	x
Asteraceae	*Crepis* spp.	hawksbeard	x	x	
Asteraceae	*Ericameria* spp.	rabbitbrush	x	x	x
Asteraceae	*Erigeron* spp.	fleabane	x	x	
Asteraceae	*Symphyotrichum* spp.	asters	x	x	x
Boragniaceae	*Mertensia* spp.	bluebells	x	x	x
Fabaceae	*Astragalus* spp.	milkvetch	x	x	
Fabaceae	*Dalea* spp.	prairie clover	x	x	
Fabaceae	*Hedysarum* spp.	sweet vetch	x	x	
Fabaceae	*Lotus utahensis*	Utah lotus	x	x	
Fabaceae	*Trifolium* spp.	clover	x	x	x
Fabaceae	*Vicia* spp.	vetch	x	x	
Liliacea	*Calochortus* spp.	mariposa lily	x	x	
Polemoniaceae	*Microsteris gracilis*	slender phlox	x	x	
Polygonaceae	*Eriogonum* spp.	buckwheat	x	x	x
Rosaceae	*Geum* spp.	avens	x	x	

*Plants highlighted provide forage for native bees, the monarch butterfly, and Greater sage-grouse.

domestic livestock grazing. There is overlap in forage preferences and potentially competition for forage (floral resources for monarchs) between native pollinators, livestock, and native ungulates (DeBano et al. 2016). Avoiding overlap between livestock and native or feral ungulates may help to maintain important floral resources for monarchs.

- **Grazing post-fire.** Allow 2–3 years of rest after a fire before resuming grazing to give the plant community sufficient time to recover from the disturbance. This interval will vary depending on ecoregion and site conditions. Generally, perennial grasses need to resume reproduction, and the cover of perennial and annual flowering plants, biological soil crusts, and accumulation of litter need to be sufficient to stabilize soils (Veblen et al. 2015b).
- **Overutilization.** After heavy use or overutilization occurs, livestock should be excluded from the area until it has sufficiently recovered and has the minimum number of flowering resources recommended above (at least three nectar sources, plus milkweed). The length of rest needed will vary by region and site conditions, but we recommend at least one year.
- **Drought.** Reduce grazing intensity and duration to account for drought conditions, and avoid depleting already scarce floral resources. Livestock are also more likely to consume toxic plants such as milkweed during times of drought (McDougald et al. 2001). Grazing during times of drought has the potential to locally extirpate butterfly populations (Murphy and Weiss 1988).

Mowing

Relatively little research has been conducted to determine the specific effects of mowing on pollinators in the West, and even less so on monarchs. Many of the existing pollinator studies have taken place in European grasslands and shrublands, and while their results have some bearing on western landscapes, more research is needed to develop region-specific mowing guidance to benefit monarchs and their habitat.

In general, when done carefully, mowing can be an effective management tool for increasing or maintaining plant diversity, controlling invasive weeds, and eliminating encroaching woody plants. In the West, early spring mowing is key to removing cool-season weedy annual grasses, and fall mowing can remove thatch and aid wildflower seed dispersal. Mowing may also be used to reduce fire fuel loads in the landscape. If done inappropriately—such as too frequently or at the wrong times of year—

Mowing can be an important management tool, but, if excessive, can remove floral resources for pollinators.

mowing can have detrimental effects on monarchs and other pollinators. Mowing during the growing season affects pollinators by altering vegetation structure, reducing habitat diversity, and removing floral resources (Morris 2000; Johst et al. 2006; Noordijk et al. 2009; Kayser 2014), and can result in direct mortality of butterfly eggs, larvae, and adults, and destroy topographical features important for shelter (Thomas 1984; Wynhoff 1998; Humbert et al. 2010; Kayser 2014). For these reasons, mowing can cause temporary declines in the local diversity and abundance of butterflies (Munguira and Thomas 1992; Feber et al. 1996). Weber et al. (2008) found that field mowing every four years resulted in significant decreases in adult butterflies immediately following mowing, but in the years following, rebound was generally robust, especially in large fields in which not all areas were mown in the same year. In southwest Germany, Weiner et al. (2011) examined pollinator and flower diversity in 40 grasslands and found that diversity and abundance of bees and butterflies decreased with increasing land use intensity (including mowing), likely reflecting lower diversity and altered composition of floral resources. Dover et al. (2010) found that species in the moth family Satyridae had significantly reduced abundance in hay fields immediately after cutting, likely due to direct mortality.

Maintain a regularly mown clear zone for safety, but limit mowing beyond this zone during the monarch breeding season to allow milkweeds and other native plants to flower.

The time of mowing influences which floral resources are available for pollinators (Johansen et al. 2017). Frequent mowing can reduce native plant species diversity and abundance and may also favor the development of grasses over herbaceous plant species (Parr and Way 1988; Williams et al. 2007; Mader et al. 2011), which can indirectly affect monarchs and other pollinators. However, moderate mowing levels—such as twice per season—have been shown by multiple studies to increase plant species diversity in grassland habitats (Parr and Way 1988; Forman et al. 2003; Noordijk et al. 2009). Other studies suggest that a single mowing during the growing season (Valtonen et al. 2007) or in the fall (Entsminger et al. 2017) is more beneficial compared to two or more mowings in a year. It should be cautioned that spring or summer mowing, while potentially beneficial to plant diversity, can lead to direct mortality of some pollinators.

Limited research in eastern North America has shown that spring or summer mowing can be used to extend the availability of milkweed plants for monarch breeding. Alcock et al. (2016) found that mowed milkweed had a slightly higher numbers of eggs and larvae compared to unmown and senescing milkweed. In another study, significantly more eggs were laid on newly sprouted milkweeds than on older control plants (Fischer et al. 2015). Summer (July) mowing and burning can increase green antelopehorn milkweed (*Asclepias virdis*) availability in the fall in the southern Great Plains, whereas in areas without mowing, the milkweed has senesced by August (Baum and Mueller 2015). Bhowick (1994) notes that mowing or clipping of common milkweed (*A. syriaca*) can cause lateral root buds to sprout, increasing milkweed patch size in the long term unless mowing is repeated frequently enough to deplete the plant's energy stores. In the West, showy milkweed (*A. speciosa*) will regrow after summer mowing and continue to support monarch breeding (Stephanie McKnight, personal observation). However, more research is needed in western ecoregions to determine the optimal timing and frequency of mowing that promotes not only milkweed but also nectar plants. It is also unknown if the benefit of additional milkweed availability in the fall outweighs the costs of the larval mortality caused by summer mowing.

In the absence of more species-specific research, land managers should focus on achieving a diverse mosaic of habitat types across the landscape in order to sustain healthy monarch populations.

This tactic is supported by numerous studies examining the effects of mowing and other intensive management strategies on pollinators and other invertebrates. For example, leaving unmown strips as refugia, delaying mowing until late summer or fall, and increasing heterogeneity of mowing (e.g., mowing in patches or at different heights) can all help increase abundance and diversity of native bees and butterflies on managed meadows (Bruppacher et al. 2016; Unternährer 2014; Buri et al. 2014; Kühne et al. 2015; Meyer et al. 2017).

Mowing Best Management Practices

Timing and Frequency

In general, reducing mowing frequency and delaying mowing until fall is beneficial to monarchs.

- Limit mowing to no more than twice per year. Ideally, sites would be mowed only once each year or every few years on rotation.
- Avoid mowing milkweed during the monarch breeding season in your area. (See **Figure 6** on page **21** for region-specific guidance on mowing windows for monarchs.)
  - Generally, fall mowing after the first frost is ideal to avoid mowing floral resources and host plants for breeding and migrating monarchs.
- If mowing must occur during monarch breeding season,
  - Delay mowing to as late as possible (late summer or early fall) to provide a longer period for monarch caterpillars to develop and extend availability of nectar plants to monarchs and other pollinators into the late summer.
  - Flag existing milkweed patches, when feasible, and avoid mowing them to conserve milkweed plants and avoid causing direct mortality to immature stages of monarchs.
  - Train people operating mowers to recognize milkweed plants and important native nectar plants so they can be spared during mowing.
  - Adjust mowing height and do not mow vegetation all the way to the ground. Mow at a minimum height of 10–12 inches to avoid cutting newly emerged milkweed plants in the spring (March–early June).
  - Mow during the middle of the day. Monarch adults are typically most active during the warmer parts of the day, which means they are better suited to escaping a mower.
  - Experiment with mowing at a time that could promote milkweed growth. For example, summer mowing in the southern Great Plains can lead to a fall resurgence of milkweed (Baum and Mueller 2014), which may extend the availability of milkweed plants for monarch breeding. However, because information on efficacy of mowing to promote late season milkweed growth is largely unstudied in the West, land managers are encouraged to document milkweed response and adapt future mowing practices accordingly.

If invasive nonnative and/or noxious weeds are present:

- Clean mowing equipment after use and between sites to limit the spread of these weeds.
- Become familiar with the life-history traits of your target invasive weeds. Some species are stimulated by mowing, so alternative control methods may be preferable when they are present.

- Time mowing for periods before weeds flower. Avoiding mowing when invasive weeds have seed heads will help to reduce the spread of weeds at the site by limiting the number of weed seeds that attach to mowing equipment and potentially get moved to a different site.
- Control of invasive weeds generally takes precedence over protecting milkweed. See Invasive Nonnative and Noxious Plant Management on page **60** for more information.

General Considerations

- Use spot mowing. Focus on areas with weeds and other target vegetation.
- Avoid mowing of an entire habitat patch. Aim to mow no more than ⅓ of an area in one year.
- Create a mosaic of patches with structurally different vegetation.
    - Leave one or more patches—as large as possible—of habitat unmown for the entire year. These patches can provide important refugia for pollinators.
    - Where possible, vary mowing times every few years to increase plant diversity.

Roadsides and Other Rights-of-Way

Roadsides and other rights-of-way frequently offer good opportunities for monarch habitat because they offer linear, continuous habitat across the landscape. Milkweed often thrives in these areas, especially roadsides, partially due to the periodic disturbance such as mowing. This is especially true in the Upper Midwest (Kasten et al. 2016) and southern Great Plains (Mueller and Baum 2014; Baum and Mueller 2015), and anecdotally in the Pacific Northwest. In the Great Basin, roadsides infrequently support milkweed, but there are important monarch nectar plants such as rabbitbrush and sunflowers blooming along roadsides in the fall (Emma Pelton and Stephanie McKnight, personal observations). However, roadsides and other rights-of-ways are also mainly managed for non-wildlife reasons, such as driver safety and equipment access. Mowing or other management which reduces vegetation can have very detrimental effects during the breeding season and, over time, lead to a reduction in plant diversity. To incorporate monarchs into mowing (or other) management plans for roadsides and other rights-of-ways, consider the following:

- Along roadsides, maintain a regularly mown clear zone as needed for sight distance and safety, but limit mowing of vegetation beyond this zone when possible. Keep in mind that some roadside plant communities will need regular disturbance or management to promote high vegetation quality and reduce weeds.

Some milkweed species flourish along roadsides, benefiting from periodic disturbances. However, mowing and other types of management during the breeding season can cause immature monarch mortality.

- Conduct mowing or other vegetation management practices within the context of an integrated roadside vegetation management (IRVM) plan that takes into account the needs of monarchs and milkweeds. See **Box 3** for a case study on using IRVM in Washington.
- Consult the Xerces Society's *Roadside Best Management Practices that Benefit Pollinators* handbook and other guidelines for more detailed information on best management practices for monarchs and other pollinators along rights-of-way.
- Consult the Ecoregional Revegetation Assistant Tool, an online map-based tool to help practitioners to select native plants suitable for revegetation of a site by using filters for needed plant attributes, including value to pollinators. This is part of a collaboration between the Federal Highway Administration, US Forest Service, WSP, and Xerces Society. Links are available on the Xerces website.
- Collaborate with other land managers to create continuous habitat across a larger landscape. The I-35 "Monarch Highway", for example, aims to create habitat across six states.

CASE STUDY

Box 3: Using Integrated Vegetation Management Strategies to Benefit Monarchs and other Pollinators along Washington Roadways

State departments of transportation manage millions of acres of roadsides in the United States. Because roads bisect numerous types of habitats and often include larger tracts of land, roadsides present significant conservation opportunities for monarch conservation. The Washington State Department of Transportation (WSDOT) maintains about 100,000 acres of roadside along more than 7,000 miles of roads. Since 1993, when an environmental impact study was completed, WSDOT has been implementing integrated vegetation management (IVM) with the overarching goals of reducing undesirable vegetation and encouraging desirable vegetation. Many of the practices and policies used to manage roadside vegetation focus on benefits to pollinators and other wildlife, including using native plants in revegetation efforts, limiting pesticide use to selective herbicides, reducing mowing, and leaving shelter and nesting habitat such as logs and snags.

In 2016, WSDOT revised its mowing practices to be more pollinator friendly. Outside of the clear zone or sightlines where repeated mowing still occurs, WSDOT is choosing to preserve native habitat and manage roadsides for natural succession. When mowing does occur in these areas, it is as part of multi-year treatment strategies that employ a variety of vegetation management tools, including reduced mowing and targeted herbicide use. This approach allows native vegetation to emerge and flourish, with sage (*Artemisia* spp.) and native grasses taking hold in prairie and arid regions, and understory shrubs such as snowberry (*Symphoricarpos* spp.), Oregon grape (*Mahonia aquifolium*), and spirea (Spiraea spp.) thriving in other regions. Special emphasis is placed on plants with high nectar and pollen value, including lupine (Lupinus spp.), milkweed, blackberry (*Rubus* spp.), and native thistles (*Cirsium* spp.).

Whenever possible, WSDOT preserves existing native vegetation, habitat that can provide food, host plants, shelter, and nesting for pollinators. Milkweed, which was once actively removed by WSDOT, now flourishes in roadside habitat along I-82 in the Yakima Valley and I-90 through the Ellensburg Valley. When roadside revegetation is needed, WSDOT prioritizes the use of native plants, including a diversity of native wildflowers and flowering shrubs and trees. Landscape designers focus on "workhorse species" of native plants, those that can establish and grow with minimal input, are long lived, and can compete with weeds. Key considerations for pollinators during the planning process include sequential bloom periods of flowering plants and high plant diversity, where feasible. Maintenance staff are included in the planning process to provide input on how the vegetation will be managed.

It is WSDOT's goal to use the best available science to inform their actions, and undertakes its own research and data collection to determine the right methods for their management needs. Vegetation inventories help to identify areas with weed infestations as well as areas that are conducive to managed succession; experimental plots are used for trialing seed mixes and planting methods. WSDOT monitors the effectiveness of maintenance

Prescribed Fire

There is limited research investigating the potential benefits or detriments of prescribed fire for monarch butterflies and their breeding habitat. The majority of research has been conducted in the eastern United States in prairie habitats (Rudolph and Ely 2006; Vogel et al. 2007; Baum and Sharber 2012; Moranz et al. 2012). The response of adult monarchs has been reported to be positively correlated with the post-fire availability of nectar resources (Vogel et al. 2007), with significantly more monarchs nectaring or using burned areas compared to unburned areas, especially one year after a fire (Rudolph and Ely 2006; Moranz et al. 2012).

In Oklahoma, one study reported that prescribed fire in summer stimulated resprouting of dormant green antelopehorn milkweed, thus increasing plant density; monarch egg density was also significantly greater a few weeks after the fire (Baum and Sharber 2012). The authors concluded that summer prescribed fire in Oklahoma may provide greater host plant availability, and improved host plant patches and migratory corridors for monarchs in the early pre-migration season. In another study in Kansas, spring annual prescribed burning increased the abundance and relative frequency of common milkweed compared to less frequent fire regimes (Johnson and Knapp 1995). See **Box 4** on page 41 for a case study on boosting milkweed growth using fire.

Prescribed fire is also a recommended management practice to maintain open late-seral tallgrass prairies for the federally threatened Mead's milkweed (USFWS 2003). Studies of this species have reported increases in flowering, plant size, and seedling survival of milkweed plants after prescribed fire (Bowles et al. 1998, 2001; Kettle et al. 2000). In addition, Mead's milkweed plants burned by fire put more resources into sexual reproduction, while milkweed plants that are mowed tend to reproduce more frequently by clonal (vegetative) means (Bowles et al. 1998; Tecic et al. 1998). Many species of milkweed in the West are clonal (e.g., showy milkweed), and may respond similarly to fire. However, more research is needed to fully examine this and to determine if encouraging sexual over clonal reproduction is more desirable or vice versa.

techniques as they implement them, and will soon undertake pollinator monitoring as well. Most recently, WSDOT began using newly developed monarch habitat suitability models (see Figure 5) to integrate with their planning efforts.

While managing roadsides for monarchs and other pollinators is a clear goal of WSDOT, their IVM strategies have been carefully designed with budget and environmental stewardship in mind. WSDOT saves approximately $1 million annually due to reduced fuel and equipment needs, and carbon emissions are reduced by an estimated 40 metric tons per year. WSDOT's roadside practices are a great example of how state transportation agencies can manage for pollinators in an effective and budget-friendly way.

Interstate 82 in Prosser, WA, (top) with native milkweed occurring naturally (bottom). WSDOT's GIS analysis identified this site as a priority location for conducting managed succession to replace nonnative invasive species with desirable, native, pollinator friendly species.

Baum and Sharber (2012) found that early summer fire increased the density of milkweed and number of monarch eggs per plant, but it is unknown if milkweed species in the West would respond positively to summer fire. In addition, it may not be feasible to conduct controlled burns in the summer in many western locations, given the high fire danger at that time. To avoid causing direct mortality to immature and immobile stages of monarchs and other pollinators, fall and winter burns are generally advised. Spring or summer burns, however, are used to improve temperate grassland habitat for some sensitive butterflies (Warchola et al. 2017; Schultz and Crone 1998; Warchola et al. 2015; Hill et al. 2017). In these instances, summer burns are implemented in the early morning when temperatures are low (below 26 °C) and fuel moisture is high (at least 9%). These conditions reduce peak soil temperature reached during the fire, and increase the heterogeneity of a fire resulting in more unburned skips of habitat; these unburned skips can function as pollinator refugia (Hill et al. 2017). There is some anecdotal evidence to suggest that prescribed fire used to control invasive woody vegetation may increase the abundance of showy and narrowleaf milkweed. Native Americans in California historically used fire to encourage the growth of milkweed, whose fibers were used to make hunting nets and other items (Anderson and Moratto 1996). However, more research is needed to determine the optimal timing of fire to improve habitat for pollinators while minimizing mortality.

While there is limited research directly focused on fire and monarchs or milkweed, there is a substantial amount of research focused on using fire as a management tool to improve or maintain habitat for other butterflies (Schultz and Crone 1998; Potts et al. 2003; Vogel et al. 2007; Debinski et al. 2011, Warchola et al. 2017), and there are several synthesis studies investigating the effects of fire on butterflies (Smallidge and Leopold 1997; Swengel 2001).

Grassland ecosystems in the West have declined over the last century as a result of fire suppression and subsequent conifer and woody plant encroachment (Hamman et al. 2011; Highland 2011). The use of fire in fire-adapted ecosystems is a focal point of conservation for many specialist butterflies and has been the subject of multiple studies (Smallidge and Leopold 1997; Moranz et al. 2014, Hill et al. 2017; Warchola et al. 2017). Fire is an important management tool to maintain these open plant communities by suppressing woody vegetation encroachment, and maintaining early seral state native plant communities with nectar and larval host plants (Schultz and Crone 1998; Panzer and Schwartz 2000; Kubo et al. 2009; Henderson et al. 2018). The increase in habitat quality is often beneficial for many butterflies in the long term, even if in the short term it causes direct mortality (Schultz and Crone 1998; Warchola et al. 2017). Carefully timed and implemented fire on a rotational basis where ⅓ or less of an area or only small habitat patches of a larger mosaic is burned in any given year, can maintain open grassland habitat and increase abundance of nectar plants and larval host plants critical for some butterflies (Schultz and Crone 1998; Warchola et al. 2017).

Prescribed fire or wildfires may benefit monarchs and other pollinators by causing a pulse in floral resources, or increasing the abundance of flowering herbaceous vegetation. This can lead to an uptick in pollinator abundance a few weeks or months after a fire (Van Nuland et al. 2013; Moranz et al. 2014). In fire-adapted forests and shrublands, the combination of conifer removal and prescribed fire can increase herbaceous flowering vegetation (Roundy et al. 2014; Bates et al. 2016: Bybee et al. 2016) and/or the diversity and abundance of butterflies (McIver and Macke 2014; Huntzinger 2003; Kleintjes et al. 2004; Waltz and Wallace Covington 2004; Taylor and Catling 2012).

Although fire maintains habitat for some butterflies, there is also evidence that fire can have long-lasting detrimental effects on other grassland butterfly species (Powell 1995; Swengel 1996, 1998; Powell et al. 2007; Swengel and Swengel 2007; Schlicht et al. 2009; Vogel et al. 2010; Black et al. 2014). When applying prescribed fire as a management tool, It is important to consider if at-risk pollinator species which are highly-sensitive to fire are present and use the historical fire-return interval for the habitat type.

Prescribed Fire Best Management Practices

Timing and Frequency

Burning during the breeding season can cause direct mortality to immobile immature stages, and reduce availability of host and nectar plants for adults.

- Burn areas with milkweed outside the monarch breeding season in your region (see **Figure 6**, page **21**).
- If burning during the monarch breeding season is necessary for weed control or other management objectives, consider flagging and avoiding milkweed if possible.
- Avoid burning right before or during spring or fall migration in your area, because fire can reduce nectar availability, perhaps for the entire migration period.
- Burn in fall (generally late October and November) to stimulate flower production of spring-blooming nectar sources.
- Burn a site once every 3–10 years, or longer depending on the natural fire interval of the site.
    - Consider site-specific natural fire intervals or rotations for prescribed burns. To determine historical fire regimes consult the LANDFIRE database (https://www.landfire.gov/frg.php).

General Considerations

Manage fire to increase habitat heterogeneity at multiple scales, both within and between sites.

- No more than ⅓ of an area should be burned each year.
- If you have skips (unburned areas) within your burn units, leave them unburned. That is particularly important if you burn when monarch eggs, larvae or, pupae are on milkweeds, but is also important for other pollinators.
- Include unburned refugia in the burn plan, especially areas that contain milkweed.

CASE STUDY

Box 4: Using Education and Fire to Boost Milkweed at the Sacramento National Wildlife Refuge Complex

The US Fish and Wildlife Service's Sacramento National Wildlife Refuge Complex is located in the heart of the Sacramento Valley in northern California, and is a haven for wildlife including tri-colored blackbirds, migrating waterfowl, and monarchs. Together, the refuge's educational and management staff are managing the land for milkweed and increasing public engagement at both the local and landscape scale.

Education: For years, the refuge's visitor services staff have been building an educational program to increase public awareness of monarch conservation. The refuge hosts multiple workshops for children and adults annually, and participates in the Monarch Larva Monitoring Program and Western Monarch Milkweed Mapper citizen-science projects as well as tagging monarchs. In 2015, they engaged a group of local volunteers to plant milkweed near the headquarters and mulch around existing milkweed that was discovered near a popular walking trail. These plantings allow up-close access for the public to see caterpillars and milkweed.

Management: The refuge's wildlife biologists are also focusing on milkweed at a larger scale. They have planted hundreds of showy milkweed plugs on multiple sites within the refuge and have boosted existing narrowleaf milkweed stands by using prescribed fire to eliminate nonnative competitors. For example, in May 2016, staff burned a tract to control yellow star-thistle (*Centaurea solstitialis*) and despite not having any rain, by mid-July the milkweed had re-emerged. The fire had released the milkweed. As one staff member put it, "the biggest key in getting milkweed to come in is to remove the competition."

A monarch egg on milkweed (L); prescribed fire boosted narrowleaf milkweed at this site in the Central Valley of California (R).

Post Prescribed-Fire Seeding
Where regionally appropriate and plant materials are available, include native monarch nectar plants and milkweed species in post-fire restoration and rehabilitation. See Priority Areas for Habitat Conservation and Restoration on page **19.**

Pesticides

Pesticides, including herbicides, insecticides, miticides, and fungicides, are increasingly identified as a factor in pollinator declines, and herbicides and insecticides are both threats to monarchs (Thogmartin et al. 2017b). Pesticides can have both direct (lethal and sublethal) effects and indirect (harm via the effect on habitat) effects on pollinators (Thompson 2003; Decourtye et al. 2004; Desneux et al. 2007; Cousin et al. 2013; Pecenka and Lundgren 2015). Tens of thousands of pesticide products are on the market today, which makes assessing their impacts—directly, indirectly, additively, or synergistically—nearly impossible. Pesticide exposure can occur in areas where an application has occurred as well as in areas that have not been treated but have become contaminated when pesticides move from the application site (Chauzat et al. 2006; Krupke et al. 2012; Botias et al. 2015; Hladik et al. 2016; Long and Krupke 2016). Because potential hazard and exposure routes vary, land managers should be cautious of applying the results of pesticide evaluations—which are often conducted with managed honey bees—to other taxa groups. For example, butterflies may be at higher risk because their larvae ingest residue left on leaves as they feed on plants that have been treated or otherwise contaminated.

Insecticides
Insecticides are the pesticides most likely to directly harm monarchs. Many commonly used insecticides are broad spectrum, and thus could kill or otherwise harm exposed monarchs. As such, insecticide treatments should be planned to avoid direct exposure to both juvenile and adult monarchs. Systemic insecticides, such as neonicotinoids, have the added concern of causing exposure months to years after a treatment as they are taken up by the plant and expressed in the pollen, nectar, and leaves. Neonicotinoids have been associated with delayed development times, smaller body sizes (Pecenka and Lundgren 2015), and lethal effects on monarch caterpillars (Krischik et al. 2015). Studies have also implicated neonicotinoids in declines in other lepidopteran species (Gilburn et al. 2015; Forister et al. 2016), although Forister et al. (2016) found that smaller-bodied butterfly species with fewer generations per year were more severely impacted than monarchs. Numerous studies have found harmful, if not lethal, levels of neonicotinoids in pollen and nectar of wildflowers adjacent to agricultural fields (Goulson 2013; Botias et al. 2016; David et al. 2016), including milkweed (Pecenka and Lundgren 2015). Neonicotinoids can also move off site, and are found in soils and water beyond where they were applied, posing a concern for monarch habitat (Hladik et al. 2014; Sanchez-Bayo 2014; Pisa et al. 2015). See the Xerces Society's report *Neonicotinoids in California's Surface Waters* to learn more about this issue. In addition to neonicotinoids, permethrin, which is used in mosquito control and sometimes for bark beetle management, is also highly toxic to bees and other beneficial insects as well as monarch larvae and adults (Oberhauser et al. 2006; Toynton et al. 2009). Land managers can reduce insecticide use and subsequent impacts on pollinators by creating an integrated pest management plan.

Herbicides
Herbicides can reduce or eliminate plant resources needed by monarchs and other pollinators for foraging and egg laying (Forrester et al. 2005; Russell et al. 2005; Dover et al. 2010). The rise of herbicide-resistant row crops in particular has been linked to large-scale declines in milkweeds in the eastern US,

with negative impacts on eastern monarch populations (Pleasants and Oberhauser 2013; Flockhart et al. 2014; Stenoien et al. 2016; Saunders et al. 2017; Thogmartin et al. 2017b; Zaya et al. 2017). While the effects of the loss of milkweeds due to increased herbicide use on herbicide-resistant crops has been better documented in the eastern US, an increase in herbicide use in the western US has also occurred in the past four decades, and may be influencing the amount of milkweed available to monarchs in the West. For these reasons, herbicide practices that would knock down large swaths of milkweed should be avoided. Herbicide use can also contribute to declines in nectar plants that would negatively affect monarchs (Bohnenblust et al. 2016). Some herbicides, including graminicides, also show direct toxicity to lepidopteran species (Schultz et al. 2016). Land managers can reduce herbicide use and subsequent impacts of herbicides on pollinators by creating an integrated vegetation management plan.

Pesticide Best Management Practices

Monarchs travel over a wide range of landscapes in the West including urban, agricultural, natural, and semi-natural landscapes. The pests and pesticides used to manage them also differ, so the best approach to pollinator protection will vary depending on the landscape, pests, and pesticides involved. The Xerces Society has a number of guidelines and reports on pest management practices. More detailed information on protecting pollinators from pesticides is available on the Xerces website:

- *Guidance to Protect Pollinator Habitat from Pesticide Contamination*
- *Preventing or Mitigating Potential Negative Impacts of Pesticides on Pollinators Using Integrated Pest Management and Other Conservation Practices*
- *Ecologically Sound Mosquito Management in Wetlands*

General Recommendations

- Any pesticide should be used within an integrated pest management (IPM) or integrated vegetation management (IVM) plan that incorporates the following principles:
    - Prevent conditions that allow pest populations to survive and reproduce.
    - Employ diverse management techniques (e.g., biological, physical, and cultural).
    - Use pesticides only when pests pose an economic or public health threat.
    - Select and apply pesticides to minimize risks to nontarget organisms.
- Apply pesticides at the lowest effective application rate specified on the product label.
- Time pesticide applications to avoid monarch exposure.
    - Do not apply pesticides (especially insecticides) when monarchs (adult and immature) are present (see **Figure 6**, page **21**).

Monarch larvae can be exposed to pesticides through multiple routes including through drift and plant uptake from soil or water.

        - Avoid applications when plants in and adjacent to the treatment area are blooming or milkweed is present (e.g., apply pesticides in fall or winter when floral resources are less available and pollinators may be less active).
        - If bloom-time applications are planned, you can minimize exposure to adult monarchs by moving floral blooms in the treatment area prior to pesticide applications; however, you should ensure immature monarchs are not present before mowing milkweed.
    - Avoid pesticide applications during cool, damp periods or when dew is present, as this can extend a pesticide's period of toxicity.
    - Consider the residual activity and release time of the pesticide product being used. Avoid using pesticide products with long residual toxicities.
- Include spatial or vegetative buffers around areas with butterfly host plants or nectar sources as well as around overwintering sites. If using a vegetative buffer, ensure it is not attractive to pollinators (e.g., conifers).
- Use the least hazardous formulation available.
    - Granular formulations are generally less hazardous to pollinators than dusts and liquids.
- Take precautions to avoid off-site movement and reduce the risk of drift.
    - Carefully choose and calibrate your spray nozzles.
    - Conduct applications on calm days when wind speed is <10 mph (avoid applications during gusty or sustained high winds).
    - Avoid application during a temperature inversion and when conditions are likely to cause evaporation.
    - Consider using backpack sprayers and applying from the ground. On boom sprayers, use the lowest effective pressure and largest droplet size possible. Set nozzles low so they operate just above plant height.
    - Avoid aerial applications and mist blowers whenever possible.
- When aerial applications cannot be avoided, take precautions to limit drift.
    - Fly at the lowest height and speeds possible.
    - Use large droplets and low pressure.

Insecticide-Specific Recommendations

- Evaluate the range of management techniques (e.g., chemical, physical, and mechanical) in order to select the most effective, feasible management method.
- When available, choose targeted insecticides least likely to harm monarchs. When possible, avoid use of broad spectrum insecticides.
- Avoid use of long-lived, highly toxic nitroguanidine neonicotinoids (clothianidin, dinotefuran, imidacloprid, and thiamethoxam).
- Do not plant milkweeds or other pollinator attractive nectar plants in locations where neonicotinoids were applied within the previous two years (this includes areas planted with treated seeds), as neonicotinoids could persist in the soil and be uptaken by plants.

- Purchase nectar plants and milkweed host plants that have not been treated with neonicotinoids.

Herbicide-Specific Recommendations

- Consider the ecological benefits of plant species that have historically been managed as weeds (DiTommaso et al. 2016).
- Train staff and contractors in plant identification. The ability to recognize native plants as well as invasive weeds will reduce unintended damage to nontarget plants.
- Evaluate the range of management techniques (e.g., chemical, physical, and mechanical) in order to select the most effective, feasible weed management method.
- Use targeted application techniques.
    - Selectively control undesirable plants with spot treatments, frill treatment, weed wipe, or other well-targeted techniques.
    - Avoid large-scale use of herbicides such as uses with herbicide-resistant crops or to dry-down a crop.
- Apply during plant life stages when weeds are most vulnerable.
    - Plants should not be sprayed in bloom or after they have gone to seed.

Herbicides, such as glyphosate, can kill milkweed and nectar plants as seen in this photo of sprayed plants in Nevada.

Grasshopper and Mormon Cricket Management

Grasshoppers and Mormon crickets are considered pests when their populations reach high levels, although limited research suggests that under some circumstances grasshopper outbreaks may not be detrimental to rangeland production (Thompson and Gardner 1996). These insects are generally managed using one of three chemical treatments: carbaryl, diflubenzuron, or malathion. Diflubenzuron acts as an insect growth regulator and thus, is most toxic to insects in their larval or pre-molting stages. Carbaryl and malathion are adulticides and have been demonstrated to be highly toxic to bees and other beneficial insects (Gervais et al. 2009; Bond et al. 2016). Due to their modes of action, these chemicals are also likely to be harmful to monarchs, and their use as insecticides on rangelands may be detrimental to monarch populations. Before grasshopper or Mormon cricket management occurs, the need for management should be established. Furthermore, some research suggests that grasshoppers could be managed without insecticides by carefully timing fire and grazing to manage vegetation and reduce habitat suitability for target species (Fielding and Brusven 1995; Branson et al. 2006). Still, grasshoppers have species-specific responses to grazing and fire, and more research is needed to develop species- and region-specific management treatments that use alternatives to pesticides (Vermeire et al. 2004).

Milkweeds support a diversity of pollinators and beneficial insects such as this native bee (top) and blue butterflies (bottom).

Grasshopper and Mormon Cricket Recommendations

- Use insecticides only after it is judged that an outbreak will have severe economic-level impacts.
- Implement frequent and intense monitoring to identify populations that can be controlled with small ground-based pesticide application equipment.
    - Monitor sites before and after application of any insecticide to determine the efficacy of the pest management technique as well as if there is an impact on water quality or non-target species.
- Limit applications to ground-based application of diflubezuron or carbaryl granular formulations targeted to infested sites. Avoid aerial applications.
- Avoid using malathion and liquid carbaryl.
- Include large buffers around all water sources, including intermittent and ephemeral streams, wetlands, and permanent streams and rivers, as well as threatened and endangered species habitat, honey bee hives, and any human-inhabited area. For example, Tepedino (2000) recommends a three-mile buffer around rare plant populations, as many of these are pollinated by solitary bees that are susceptible to grasshopper control chemicals.

Restoration

Habitat restoration for monarchs can be incorporated into roadside, rights-of-way, federal, state, tribal, and private land restoration projects. For federal land management agencies, the *National Strategy to Promote the Health of Honey Bees and Other Pollinators*, and its associated *Research Action Plan*, directs agencies to restore or enhance 7 million acres of land for pollinators (Pollinator Research Action Plan 2015, link available on the Xerces Society's website). In the West, habitat restoration for monarchs should focus on areas where breeding and migratory habitat historically occurred and in appropriate habitat types. See Priority Areas for Habitat Conservation and Restoration on page **19** for more guidance on where to focus restoration efforts.

Restoring monarch breeding and migratory habitat should be centered on the principle features of monarch habitat (see What is High Quality Monarch Habitat on page **13**). Adult monarchs require an abundance and diversity of nectar plants during spring and fall migration, and during the breeding season. They rely on roosting sites such as trees and shrubs near breeding sites and along migration routes to rest. Adults also need sources of water, especially in the hot summer months. Immature stages require milkweed to complete the roughly month-long transformation into an adult butterfly. Monarchs continuously breed in many areas of the West, so it is important to provide milkweed plants as larval hosts for the length of time that monarchs are present (see **Figure 6**, page **21**). The overall breeding period in western states is generally from early spring (March–May) through fall (September–October; see **Figures 1** and **6**). These two primary plant groups—nectar plants and native milkweeds—can be incorporated into most restoration projects, and are likely to be compatible with management for other species of conservation concern. (However, see Issues with Planting Milkweed Outside its Historic Range on page **21** for exceptions such as in coastal California).

Milkweeds support a diverse specialist insect community (Van Zandt and Agrawal 2004; James et al. 2016), and management to restore milkweed benefits a variety of other insect species (Zaya et al. 2017). These plants provide nectar resources important for supporting a wide range of pollinators, and beneficial insects that confer benefits to the agricultural sector (Tooker et al. 2002; Borders and Lee-Mäder 2014). They may also support insects that are important forage for gallinaceous birds such as the greater sage-grouse (Dumroese et al. 2016) and provide nesting material for some songbirds (see **Box 2**, page **32**). Further, milkweeds may be a preferred nectar source of adult monarchs, even when other flowering plants are available (Morris et al. 2015).

In addition to incorporating milkweed into restoration projects, it is crucial to provide adult monarchs with diverse nectar plants, particularly during fall migration when milkweed has senesced. Although monarchs are generalist foragers, they do appear to use some plants more than others. Evidence-based nectar species guides for monarchs have been developed for each of 14 regions of the United States (see **Appendix 2** for western guideance). When selecting monarch nectar species, it is important to select a variety of plants that together will provide continuous floral resources throughout the period monarchs are present in your region (see **Figure 6**, page **21**). In the fall, in many places in the West, the primary groups of plants that provide abundant late season nectar for migrating monarchs include rabbitbrush (*Ericameria* spp. and *Chrysothamnus* spp.), goldenrod (*Solidago* spp.), asters (*Symphyotrichum* spp.), sunflowers (*Helianthus* spp.), mule fat (*Baccharis* spp.) and blanketflower (*Gailardia* spp.).

Riparian and mesic habitats may also provide important habitat for both migrating and breeding monarchs. Monarchs have been documented using riparian corridors as migratory routes, and conserving and restoring riparian trees and shrubs, understory flowering plants, and milkweed plants associated with these habitats, may be important to support both breeding and migratory monarchs (Dingle et al. 2005). In a survey of monarch breeding habitat in Arizona, riparian areas were the most common breeding habitat type reported (Morris et al. 2015). Since many milkweed species occur in

Riparian areas are important for monarchs in the West, providing both migrating and breeding habitat.

high abundance along riparian areas and in mesic habitats, restoration of these areas should include milkweed plants and monarch nectar resources, where regionally appropriate.

Restoration Best Management Practices

Site Selection

- Utilize a combination of the monarch breeding and milkweed habitat suitability models to determine priority areas for monarch restoration on the lands you manage (**Figure 4**, page **9**). The inclusion of native, monarch-attractive nectar plants is appropriate for most restoration projects; including milkweed is appropriate in geographic and habitat types in which it historically occurred.
- Select sites for monarch habitat restoration that are safe from pesticides. Consider residual pesticides from past land use such as longer lived neonicotinoids. Bear in mind that local, state, and extension soil laboratories can test soil for pesticides, soil fertility, and microorganisms. See the Pesticides section on page **42.**
- Conduct a site inventory to determine if milkweed or monarch nectar species are already present at a site. Choose plant species that will complement, or fill in gaps in existing native vegetation. For example, if a site lacks late-blooming species, consider including asters, goldenrod, or other late-summer flowers in the seed mix or planting plan.
- Prioritize sites without invasive nonnative, noxious weeds that may impede restoration efforts. Consider whether the seed bank may contain problematic plants.
- Soil type is an important factor in the selection of plant species for restoration. Consider the following:
    - Some native plants (including many milkweed species) grow better in specific soil types such as sand, silt, clay, or loam. Select species that will perform well in the soil type targeted for restoration (e.g., species known to grow in the soil type present).
    - Soil drainage or moisture retention are also important considerations. Some species may have a higher chance of successful establishment and long-term survival in microclimatic niches with moisture retention, such as those that hold snow later in the season (north facing drainages or slopes). Others may do better in well-drained rocky soils.
    - Soil information can be determined using local soil surveys and the National Resources Conservation Service (NRCS) Web Soil Survey available on the NRCS website (www.nrcs.usda.gov).

Plant Composition

Include at minimum one milkweed species (if appropriate) and select nectar species which will provide floral resources throughout the breeding season, with a minimum of 3 species in bloom at any time between spring and fall.

Interseeding

In some areas, it may be appropriate to interseed in order to increase the diversity and abundance of nectar plants and milkweed for monarchs. This may be appropriate for areas that have been subject to overutilization by livestock grazing, wildfire, long-term mowing, or other vegetation-altering management or natural disturbances that have reduced the availability of or exhausted the seed bank of native forbs. It can also help to fill in bloom gaps—such as too few fall-blooming plants.

Interseeding can be low maintenance and successful under certain circumstances, but often it requires thoughtful management. Successful interseeding relies on disturbance (e.g., seeding using a seed drill and drag harrows or into herbicide bands). Disturbance before seeding gives seeds a better chance of bare soil contact and germinating; disturbance afterwards helps suppress dominant vegetation and helps seedlings establish. The amount of suppression required depends on the existing vegetation; invasive weeds and introduced cool season grasses are often difficult to interseed into because they are generally difficult to suppress. Stochastic factors can influence the outcome (as with every restoration), especially soil moisture and precipitation in arid climates

- Check out the Xerces Society's *Interseeding Wildflowers to Diversify Grasslands for Pollinators* to learn more.

Milkweed Species Selection

Select milkweed species native to your area and where it historically occurred or augment existing native milkweed patches. To determine if a milkweed species is native to your region, or if it occurred historically, you can refer to the USDA Plants Database (www.plants.usda.gov), the Western Monarch Milkweed Mapper, local herbaria, or online herbarium consortia. State-level lists are included in **Appendix 1.**

In addition, select species that are appropriate for the habitat in which they will be planted. For example, swamp milkweed (*A. incarnata*) is associated with wet meadows, stream banks, etc., and may not be very tolerant to drier soil conditions. In contrast, desert milkweed (*A. erosa*) grows in dry washes, sagebrush, or creosote communities and would not be suited to a stream restoration site. Habitat types associated with specific milkweed species is also summarized in **Appendix 1**. If drought is expected to become more frequent under climate change in your area, select milkweed species which are drought tolerant.

If regionally appropriate, aim to plant a diversity of milkweed species with differing phenologies. For example in California, several species such as California (*A. californica*) and heartleaf (*A. cordifolia*) milkweeds are the first to emerge in the spring, and provide important early season larval host plants to monarchs as they leave the overwintering grounds. Other species, such

Selecting the right milkweed species for your restoration project is important for establishment success.

Swamp milkweed—as its name implies—does best in wetter areas and habitat types. It is even occasionally found growing in water!

as narrowleaf and showy milkweeds tend to have much longer growing seasons extending into the fall. Thus, planting a variety of milkweed species may extend the temporal availability of larval hosts. Further, research completed in eastern North America found that adult monarchs laid more eggs when presented with four plants of different species of milkweed, compared to four plants of the same species (Pocius et al. 2017). There is limited information on female oviposition preference, larval performance, or demographic input across the landscape of western milkweed species (Robertson et al. 2015), and until more research is available, planting multiple species may increase the likelihood that monarchs will use a given area. In addition, a diversity of milkweed species may also improve monarch health at the population level, although its impacts are not well-understood. Research suggests that trade-offs exist for immature monarchs: low cardenolide content milkweeds allow more rapid larval growth, while high cardenolide content milkweeds provide superior protection from predation and parasites such as OE (De Roode et al. 2008, Tao et al. 2016).

Recommendation Against Planting Nonnative Milkweeds

The nonnative, evergreen tropical milkweed (*A. curassavica*) has been shown to increase the rate of *Ophryocystis elektroscirrha* (OE), a protozoan parasite, in winter-breeding monarchs in California (Satterfield et al. 2016), and may disrupt the natural reproductive diapause monarchs enter during the fall. Thus, the presence of nonnative evergreen milkweeds such as tropical milkweed (and potentially other exotic host species like balloon plant [*Gomphocarpus* spp.]) can become reservoirs of high OE loads that have negative impacts on monarch health. High OE levels have been linked to lower migration success in the eastern monarch population (Altizer et al. 2015). Other effects on monarchs include reductions in body mass, lifespan, mating success, and flight ability (Altizer and Oberhauser 1999; Bradley and Altizer 2005; De Roode et al. 2007; De Roode et al. 2008; Altizer and De Roode 2015). Planting nonnative milkweeds is of particular concern in southern California where climate change may increase year-round breeding (Malcolm 2018) and coastal California where temperatures stay mild. In addition, tropical milkweed may become a less suitable host for monarch development under climate change. One study found that under warmer temperatures which are expected with climate change, tropical milkweed produced higher cardenolide concentrations with an associated decrease in monarch adult survival and mass; the same trend was not seen in native swamp milkweed (*A. incarnata*; Faldyn et al. 2018). To avoid exacerbating the already declining western monarch population with increased disease rates and interrupted migration, it is recommended to avoid planting tropical milkweed and other nonnative milkweed species anywhere, but particularly in coastal and southern California.

Tropical milkweed is an attractive plant to humans and butterflies, but has unintended consequences by staying green too long and interrupting the monarchs' natural cycle.

Milkweed Establishment Guidance

Establishing milkweed from transplants with sufficient rainfall or irrigation may lead to better establishment than seeding.

Milkweed establishment can be a challenge, but there are techniques that can help improve your success rate. Milkweed seeds often require specific stratification, soils, and temperatures to germinate, and reported germination rates can sometimes be very low (5%; Landis 2014). Seed collection and cleaning is complicated by the structure of the seed pods and the floss or hairs attached to the seeds. In addition, it is advised that seed is collected from multiple milkweed patches to increase genetic diversity, especially for species that reproduce vegetatively as one patch may be genetically identical (Landis 2014). If you are not collecting your own seed, source milkweed plant materials as locally as possible and from within your site's ecoregion. See Sourcing Native Plant Materials on page **55**.

In arid landscapes, such as the Central Valley of California, establishment can be particularly challenging. Although more research is needed to identify the best techniques for establishing milkweed in the arid West, below are some suggestions for increasing success:

Transplants

- May have better success than seeding
- Larger plants may be more likely to establish because of deeper root development
- Irrigation will improve establishment, especially if winter rainfall is below average
- Plant in the fall, before plants go dormant (October, November), to improve establishment

Seeding

- Success rate usually not as high as transplants, but can be useful under certain conditions
- Some species and genotypes require or benefit from 2–6 weeks of cold stratification before germination (see Kaye et al. 2018)
- Intensive site preparation will be essential. Milkweed seedlings do not compete well against weeds, so consider beginning seedbed preparation a year or two in advance using solarization, herbicides, or other methods.
    - Check out the Xerces Society's *Organic Site Preparation for Wildflower Establishment*
- To ensure some establishment, include milkweed seed at realistic rates in mixes (ideally, at least 3% to 5%), and formulate mixes to include species of compatible vigor (i.e., low), such as native bunch grasses and perennial forbs.
- Recommended seeding rate is 20 seeds/square foot
- Irrigate if winter rainfall is below average
- Control weeds again in the early spring (February–April) before milkweed germinates if weed pressure is high

Rhizomes

- Limited commercial availability, but you can harvest and save locally
- Flag milkweed during growing season, then selectively dig up rhizomes during dormancy, cutting them into ~4" chunks for replanting elsewhere in the fall
- Irrigate if possible

For all milkweed planting and seeding, getting plants in the ground in the fall or early winter is generally best (October–December). This will allow natural stratification of the seeds, increasing germination success.

The following resources provide detailed information regarding milkweed propagation, including seed collection, cleaning, and germination, and pest management:

- The Xerces Society's *Milkweeds: A Conservation Practitioner's Guide* provides information about optimizing milkweed seed production methods, guidance on incorporating milkweeds into restoration and revegetation efforts, and identification tools for common herbivore pests and plant diseases.
- The Xerces Society's *Managing Milkweed Crop Pests: A Native Seed Industry Guide* provides management strategies for dealing with common milkweed herbivores which may be pests in seed production settings including aphids, milkweed bugs, and milkweed beetles.
- The Native Plant Network's *Propagation Protocols for Asclepias spp.* Available at www.npn.rngr.net.
- The Western Monarch Milkweed Mapper's western milkweed species profiles includes information about habitat type, growth form, and distribution.

Milkweed Patch Density, Size, and Connectivity

Female monarchs typically prefer to lay eggs on isolated milkweed plants or low-density patches (Zalucki and Kitching 1982b; Zalucki and Suzuki 1987). The reasons for this behavior have been suggested as a

Depending on the scale of your restoration, collecting your own milkweed seed can be a good way to ensure locally adapted plants are selected.

response to minimize predation and competition risks for their offspring (Zalucki and Kitching 1982a; Zalucki and Suzuki 1987).

In agricultural areas of the Upper Midwest, researchers found 3.9 times as many eggs per milkweed stem in row crop agricultural fields compared to non-agricultural areas (Oberhauser et al. 2001; Pleasants and Oberhauser 2013). Similar results were found in a study in Ontario, with the highest egg density in agricultural fields compared to roadside and non-agricultural areas (Pitman et al. 2018). These finding that may be explained by the low-density, more isolated patches of milkweeds in crop fields which females prefer to oviposit on. It could also be due to lower predation rates of monarch eggs and larvae in isolated patches due to the distance from alternative prey and—in the case of conventional crop fields—insecticide treatments lowering predator populations. Pitman et al. (2018) found predator abundance was highest in medium-sized patches (16–28 m^2) compared to smaller (<16 m^2) or larger patches (>29–472 m^2). All these factors affect one another: Grainger et al. (2017) examined the interactions of patch size, connectivity, and predator abundance in forest and old field plots in Ontario. They found that monarch caterpillars were found more frequently in small and isolated milkweed patches, especially when predator abundance was high.

However, there are also risks to laying eggs on isolated or very low-density patches: a single plant may not provide sufficient food for a caterpillar's entire development. Moving between plants can be time and energy intensive, especially if plants are far away. In addition, Nail et al. (2015) found that monarch survival was negatively correlated to egg density, so isolated plants that attract many females to lay eggs will not necessarily produce more adult monarchs, if larval competition is too high and there is not enough milkweed.

Based on these studies, it seems best to manage for and restore habitat with varying sizes and densities of milkweed (Stenoien et al. 2016). Smaller, less dense patches are likely better than isolated plants or large, dense stands of milkweed. In addition, interspersing small patches of milkweed into a more diverse wildflower planting (as opposed to mixing the milkweed seed into a diverse seed mix) may increase milkweed establishment success, as milkweeds may not compete well with other planted wildflowers. This also aligns with the goal of supporting a diverse, heterogeneous native plant community rather than a milkweed monoculture.

Showy milkweed seedling peak through the soil at a seed production field in the Central Valley of California.

How Big of an Area Should I Restore?

Because of their high-mobility—breeding adults are thought to be able to travel up to 7 miles per day (Zalucki et al. 2016)—restoring even small areas of habitat can provide some benefit to monarchs. However, the larger and more connected the habitat is, the greater the potential benefit to monarchs in increased egg-laying potential (Grant et al. 2018). More connected habitat offers additional benefits to other species of wildlife such as less-mobile pollinators and beneficial insects. For example, to support native bee pollination of adjacent agricultural lands, an area considered for habitat restoration should be at least one-half acre in size; two acres or more provide even greater benefits (Kremen et al. 2004;

Morandin and Winston 2006). In areas where large-scale restoration is not practical (e.g., urban or suburban areas and farmland), establishing a patchwork of milkweed and/or nectar species plantings of a range of sizes still confers many benefits to monarchs and other pollinators. At a landscape scale, we should collectively aim to create "stepping stones" or corridors of monarch habitat. Creating local- and landscape-scale habitat corridors will increase restoration projects' positive impact on monarchs as well as other wildlife species.

Nectar Plant Species Selection

Perennial Species
Perennials are more likely than annuals to bloom during times of drought, and can provide critical resources for pollinators when annuals are not available (e.g., rabbitbrush; Griswold and Messinger 2009). Make native perennials the basis of restoration plantings.

Temporal Diversity
Seed mixes and plantings should strive for temporal diversity of flowering species to provide nectar resources for adult monarchs during the active breeding season in your region. Late-blooming (fall) species provide critical resources for migrating monarchs building up their energy reserves before entering winter dormancy (Brower et al. 2006).

- Aim for a minimum of 3 blooming nectar plants for each season (spring, summer, fall).
- Refer to the Xerces Society's *Monarch Nectar Plant Guides* or **Appendix 2** to determine regionally appropriate nectar plants for each season.
    - Some common late-season species in the West are rabbitbrush (*Ericameria* spp. and *Chrysothamnus* spp.), goldenrod (*Solidago* spp.), sunflowers (*Helianthus* spp.), blanketflower (*Gaillardia* spp.), mule fat (*Baccharis* spp.), and asters (*Symphyotrichum* spp.).

Incorporate native thistles into restoration projects. Native thistles are visited frequently by butterflies and native bees, and some provide more sugar in their nectar than other native plants (Eckberg et al. 2017).

- Consult the Xerces Society's *Native Thistles: A Conservation Practitioners Guide*.

Thistles are very attractive to bees and butterflies, providing high-sugar nectar as a reward.

Ecoregional Revegetation Assistant Tool
The Ecoregional Revegetation Assistant Tool is a map-based tool to aid practitioners when selecting native plants for restoration and pollinator habitat enhancement. The map can be searched by US Environmental Protection Agency (EPA) Level III Ecoregions, as well as by state. The database includes plant attributes such as soil type, moisture needs, palatability, salt tolerance, and value to pollinators. The plant species found within an ecoregion can be filtered by attributes, and a list of "workhorse" plant species can also be generated. This is part of a collaboration between the Federal Highway Administration, US Forest Service, WSP, and Xerces Society.

- This tool can help practitioners to select native plants suitable for revegetation of a site by using filters for needed plant attributes, including value to pollinators. The tool is available at www.nativerevegetation.org/era.

Remember, it is Not All About Forbs
While milkweed and nectar plants provide the resources monarchs need the most, restoration projects should aim to provide for more than just monarchs. Native grasses are important components to seed mixes, but must also be carefully balanced to ensure the grasses do not easily outcompete forbs.



Top: Early season pineneedle milkweed (*Asclepias linaria*); Bottom left: Late season blanketflower (*Gaillardia aristata*); Bottom right: mid-season Rocky Mountain beeplant (*Cleome serrulata*).

Below are basic recommendations for including grasses in monarch habitat restoration seed mixes:

- Most seed mixes should be 45–65% grasses. For some sites, the grass component may need to be higher.
- Prioritize small-statured, highly clumping grasses.
- Include native rhizomatous grasses at a much lower rate (~5%), but do include them.
- Recommended grass species for the West include Idaho fescue (*Festuca idahoensis*), California fescue (*Festuca californica*), Roemer's fescue (*Festuca roemeri* (Pavlick) Alexeev), meadow barley (*Hordeum brachyantherum*; suited to wet sites), prairie junegrass (*Koeleria macrantha*), and California oatgrass (*Danthonia californica*).

Sourcing Native Plant Materials

The source of the native plant material impacts the quality of the restoration projects and their value to monarchs and other native pollinators. Where available and economical, using local ecotypes for native seed and plant material is ideal; where such sources are not available, regional sourcing may be necessary. Plant material from areas with a different climate, soil, or other abiotic or biotic conditions may be less well adapted and have poor establishment rates. Planting local ecotypes will ensure that the plants will be adapted to the area and will reduce any potential undesirable gene flow with wild plant populations, including for milkweed (Borders and Lee-Mäder 2014).

To source local ecotypes of native plant materials, follow provisional or empirical seed zone guidelines developed by your region, in accordance with the National Seed Strategy (see page 57). For milkweed, consider using provisional milkweed seed zones outlined in Landis (2014), which are based on ecoregions.

It is also ideal to select plant sources and collect plant materials from multiple locations or sources to achieve high genotypic diversity. Using seed or plant sources with a variety of genotypes will ensure floral resources remain available for longer periods of time, especially under drought (Genung et al. 2010). Also, ensure that seed is collected from multiple patches in a seed collection zone to increase genotypic diversity.

To determine if seed of a particular milkweed species is commercially available or find local native plant producers, refer to the following resources:

- The Xerces Society's Milkweed Seed Finder provides a search tool for locating native milkweed seed sources by species and state.
- Monarch Watch's (www.monarchwatch.org) Milkweed Market Vendors provides a map of native milkweed vendors across the country.
- The Xerces Society's Pollinator Resource Center provides region-specific information about native plant nurseries.

Or collect your own seed, referring to other Xerces Society resources:

- *Milkweeds: A Conservation Practitioner's Guide*
- *Collecting and Using Your Own Wildflower Seed*

These resources do not include every native plant material provider, so it may be necessary to contact a local nursery or seed provider to determine if they carry or produce local ecotypes of milkweed. Consult any provider of native milkweed plant material to ensure that the milkweed plant materials are from local ecotypes. If buying plugs or container materials from a nursery, ensure that the plants have not been treated with persistent systemic insecticides such as neonicotinoids, which are known to negatively affect monarch larvae. See the Pesticides section below on page **42** for further guidance. If local milkweed plant materials are not available, then it may be necessary to collect seed from local milkweed populations to directly seed into a site or provide to a commercial producer to increase plant materials for restoration purposes.

Milkweed seedlings growing in a greenhouse.

The availability of native milkweed seed and many other native plant materials is limited in western states (Nahban et al. 2015). Consequently, there is a need to increase commercial seed production of restoration-appropriate seeds in each ecoregion. This is being addressed in part by programs such as Seeds of Success, the national native seed collection program led by the Bureau of Land Management (BLM) in partnership with other federal agencies and nonprofit organizations (available through www.blm.gov). Seeds of Success aims to "get the right seed in the right place at the right time", and to "stabilize, rehabilitate and restore lands in the United States."

This is also a goal of the National Seed Strategy, a framework that connects the private marketplace with federal, state, tribal, and nonprofit organizations to develop native seed sources for restoration and rehabilitation (available through www.fs.fed.us). Oldfield and Olwell (2015) provide an overview of the National Seed Strategy and best practices and strategies for land management agencies to move forward in developing local commercial markets of native seeds for restoration and rehabilitation. According to Oldfield and Olwell (2015), of the roughly 18,000 species of native plants in the United States, there are only 1,949 species available on the commercial market. The process of getting a native plant species into commercial production is slow, and may take 10–20 years before a species is available at a scale adequate for large landscape level restoration or rehabilitation efforts (Olwell and Riibe 2016). The National Seed Strategy also addresses several relevant national initiatives including the *National Strategy to Promote the Health of Honey Bees and Other Pollinators*, the Interior Department Secretarial Orders 3330 (mitigation) and 3336 (rangeland fire), and Executive Order 13112 on invasive species. It is important that land management agencies and other groups work within the framework of the National Seed Strategy to identify and develop commercial sources of milkweed and nectar plant species that are suitable for both restoration and rehabilitation in all regions of the western United States. One of the most important things to do when beginning a large-scale restoration effort is to identify the native species needed and begin working with native seed producers well in advance of when they will be required. See *Pollinators and Roadsides: Best Management Practices for Managers and Decision Makers* (available at www.environment.fhwa.dot.gov) for an example of how Arizona's Department of Transportation had success working with native seed producers about upcoming needs and offering a premium above market value for the species they needed most.

Swamp milkweed growing outside for seed production.

Native plant seeds have a variety of species-specific germination requirements—scarification, cold stratification, or a specific amount of rainfall, for example. Due to this, there is no one-size-fits-all recommendation on seeding time or strategy. Native seeds with very specific germination requirements may need to be treated prior to direct seeding, or seeded separately. Consult regional botanists or plant material specialists to determine optimal seeding times based on the species, your region, and climate conditions. When planting plugs or container materials, generally aim to plant in the fall or winter when plants are dormant.

Water and Irrigation

If feasible, water or irrigate milkweed or nectar plantings during the first year to increase survival of plants. This is particularly important in arid regions of California, Nevada, and the Southwest.

- Take advantage of high precipitation years to plant milkweed, as higher precipitation has been linked to higher survivorship of milkweed plants in restoration projects (Bowles et al. 2001).

- Potential irrigation systems include deep pipe and porous hose systems that are low maintenance and increase planting survival, especially in arid environments (Bainbridge 2002, 2012).
- Consider mulching transplants to retain moisture—but do not mulch seedlings.
- Plant or seed in climactic microsites that will retain moisture longer into the summer such as north facing slopes or gullies that will retain snow or water.

Agricultural Areas

Agricultural areas in the West include some of the most important breeding and migratory habitat for monarchs—such as the Central Valley of California, the Columbia Plateau of southeastern Washington and northeastern Oregon, and the Snake River Plain in Idaho (see **Figure 5**). While these areas are often highly modified from natural habitats, they also can be important landscapes for monarch habitat restoration. Monarch-friendly plantings can be incorporated into hedgerows, orchard understories, pivot corners, crop margins, riparian buffer strips and corridors, or other out-of-production areas. And although it is always important to keep monarch habitat safe from pesticide exposure, it can be more of a challenge when creating monarch habitat in or adjacent to agricultural areas. See **Figure 4** on page **9** and Pesticides on page **42** for more guidance.

Detailed recommendations for monarch habitat restoration in agricultural landscapes is outside the scope of this document, but below you will find many useful resources to help you establish monarch-friendly pollinator habitat in agricultural areas.

- Xerces Society's resources available include
    - Pollinator Conservation Resource Center which includes regional information about plant lists, habitat conservation guides, and more.
    - Pollinator Habitat Installation Guides by region
    - Pollinator Conservation Seed Mixes by region
- Bee Better Certified (www.beebettercertified.org) is a certification program started by the Xerces Society which helps farmers and food companies improve protection for bees and other pollinators in agricultural lands.

There are also financial incentive and technical assistance programs for private (and some public) landowners to help defray the cost of restoring monarch habitat on private lands:

- Farm Bill Programs
    - USDA Natural Resource Conservation Services (e.g., Conservation Stewardship Program,

Xerces Society's pollinator planting on a farm in California includes multiple blooming plants for each season.

Environmental Quality Incentives Program) and Working Lands For Wildlife Monarch Conservation Program (www.nrcs.usda.gov).

- See the Xerces Society's *Using Farm Bill Programs for Pollinator Conservation* (www.xerces.org).
- USDA Farm Service Agency (e.g., Conservation Reserve Program) (www.fsa.usda.gov).
- Partners for Fish and Wildlife Program by the US Fish and Wildlife Service (www.fws.gov/midwest/partners).

Partnering with farmers to create and maintain habitat for pollinators and other beneficial insects in agricultural areas is an integral part of the Xerces Society's work. Many Xerces Society staff serve as partner biologists for the USDA Natural Resources Conservation Service, where they provide one-on-one technical assistance, workshops, and other support for private landowners and NRCS conservation planners. Check out our website to learn more and connect with us.

Post-Wildfire Restoration

Besides soil stabilization, ensure adequate floral resources are provided the year after a wildfire by seeding quick growing, ideally native, annual or perennial flowering plants.

- Avoid seeding only yarrow (*Achillea millefolium*) and flax (*Linum lewisii*). These widely used post-fire restoration and rehabilitation species may be important components of a seed mix to initially establish native vegetation and suppress nonnative plant invasion, but they attract few pollinators, cannot support a diverse pollinator community (Cane and Love 2016), and are not monarch nectar plants.
- Establish corridors or high density plantings, and restore habitat connectivity in the post-fire landscape. Focus seeding or planting efforts in places that will connect remaining intact/unburnt habitat. Plant or seed in high-density corridors or patches to provide connectivity and serve as "stepping stones" (Stanturf et al. 2014). (See Milkweed Patch Density, Size, and Connectivity on page **52** for more information about planting milkweed.)
- Consider the appropriate seeding method for the site. Aerial seeding at low elevation sites in the arid West is generally ineffective at establishing native plants (Knutson et al. 2014; Pyke et al. 2017); using a seed drill or planting bare-root perennial plants may be the more cost-effective. Seeding in high elevation sites is likely to be the most successful and cost-effective use of resources.
- Reduce or eliminate the use of nonnative grasses in post-fire rehabilitation seed mixes, and instead use native grasses and forbs.

Gardens and Urban or Suburban Areas

While the greatest gains to monarch habitat restoration in the West are likely to be achieved on the millions of acres of natural areas, rangeland, and agricultural lands, habitat creation in gardens and urban or suburban areas can still play an important role. These areas can become part of the "all hands on deck" approach to restoring monarch habitat throughout the monarchs' range (Thogmartin et al. 2017a). Because monarchs are so mobile and wide-ranging, even a single milkweed or nectar plant growing among pavement can help these butterflies. Monarch "waystations" and pollinator plantings are becoming increasing popular at schools, businesses, and backyards throughout the West and offer benefits beyond just habitat. Such plantings can offer conservation and educational lessons; raising monarchs has been a rite of passage for many school children (however, see **Box 5** for guidelines on responsible rearing).

For more information about gardening for monarchs, check out the following resources:

- Monarch Joint Venture is full of valuable resources and a webinar series on monarch habitat creation and conservation (https://monarchjointventure.org/).
- Monarch Watch Monarch Waystation Program through the University of Kansas for advice on creating and registering monarch habitat (www.monarchwatch.org).
- The National Wildlife Federation's Mayor's Monarch Pledge to get your city involved in monarch conservation (www.nfwf.org).
- Xerces Society's monarch nectar plant lists, Pollinator Resource Center, books, Bring Back the Pollinators pledge, and more (www.xerces.org).

Invasive Nonnative and Noxious Plant Management

Invasive nonnative plants, including those designated as noxious weeds (referred to as invasive plants hereafter), pose a serious threat to ecosystems and can significantly alter plant community composition, ecosystem processes, soil chemistry, and fire regimes (DiTomaso 2000; Duncan et al. 2004). Invasive plants compete with native plants for resources and can cause significant reductions in the abundance and diversity of pollinators and other herbivorous insects (e.g., Samways et al. 1996; Kearns et al. 1998; Burghardt et al. 2009; Wu et al. 2009; Fiedler et al. 2012). Invasive plants often only provide floral resources for generalist pollinators (Aizen et al. 2008), reduce habitat for specialist pollinators (Traveset and Richardson 2006), and may facilitate establishment of nonnative pollinators (Morales and Aizen 2002). Furthermore, invasive plants may reduce conspecific pollen deposition on native plants, reducing reproductive output (Litt et al. 2014). Cane (2011) suggest that the greatest threats to pollinators from invasive plants is their ability to displace native vegetation (which may provide both floral and host plant resources), alter fire regimes, and change soil chemistry through allelopathy (e.g., knapweed [*Centaurea* spp.], tamarisk [*Tamarix* spp.]).

There are few studies which have assessed the effects of invasive plant management on monarchs or monarch habitat in the West. However, the effects of invasive plant removal on other pollinators have been summarized in several synthesis studies from various regions of North America and Europe (Goodell 2008; Bartomeus et al. 2008; Stout and Morales 2009; Morales and Traveset 2009; Roulston and Goodell 2011; Montero-Castaño and Vilà 2012; Bezemer et al. 2014; Litt et al. 2014; Tonietto and Larkin 2017). These studies suggest that pollinators are affected negatively by an invasive plant if it alters the abundance of native floral resources, and this effect is often species- or taxa-specific (Roubik and Villanueva-Gutiérrez 2009; Cane 2011; Roulston and Goodell 2011). Research suggests that native bees, butterflies, and other insects prefer to feed on native rather than invasive nonnative plants (Williams et al. 2011; Hopwood 2008; Burghardt et al. 2009; Wu et al. 2009; Morandin and Kremen 2013), and that native plants support a greater diversity of Lepidoptera species compared to nonnative plants (Tallamy and Shropshire 2009).

Research suggests that invasive plant removal can have positive effects (Hanula and Horn 2011; Baskett et al. 2011; Fiedler et al. 2012; Tonietto and Larkin 2017; Goodell and Parker 2017) on native bees and butterflies. A meta-analysis by Tonietto and Larkin (2017) investigated the overall effects of restoration treatments, including invasive plant removal, on native bees. The analysis found that

Box 5: Keep Monarchs Wild: Issues with Rearing and Releasing Monarchs

Rearing monarchs in the classroom or at home has been a valuable educational tool for teachers and for citizen science studies (such as tagging) for decades. Unlike many wildlife species, monarchs are easily raised and offer a captivating, up-close look at metamorphosis. However, as monarch populations have declined, some people have turned to rearing and releasing monarchs on a large scale as an attempt to save the species. While often well-meaning, there are serious concerns with this practice because rearing monarchs is likely not an effective conservation strategy and can even have negative effects on local populations. Some of the issues include artificially inflating local monarch populations and skewing population counts, introducing parasites and disease to wild monarch populations, and/or causing a loss of genetic diversity in even just a few generations. As such, **the Xerces Society does not recommend rearing monarchs as a conservation strategy.** The Xerces Society and several other monarch researchers have released an official statement (available on the Xerces Society's website) outlining concerns with the captive breeding and release of monarchs, which provides more details about risks. In addition, tag recovery efforts have shown that captive-bred monarchs have lower migration success compared to wild monarchs (Morris et al. 2015).

If you do choose to rear monarchs for educational reasons or personal enjoyment, the Xerces Society recommends that you do not rear more than 10 monarchs per year (whether by a single individual or family) and that you follow these best practices:

- Collect immature monarchs locally from the wild, heeding collection policies on public lands; never buy or ship monarchs.
- Raise monarchs individually and keep rearing containers clean between individuals by using a 20% bleach solution to avoid spreading diseases or mold.
- Provide sufficient milkweed including adding fresh milkweed daily.
- Keep rearing containers out of direct sunlight and provide a moist (not wet) paper towel or sponge to provide sufficient, not excessive, moisture.
- Release monarchs where they were collected and at appropriate times of year for your area.
- Participate in citizen science including testing the monarchs you raise for OE, tracking parasitism rates, and/or tagging adults before release. Check out the Monitoring Monarch Populations section on page **66** to learn more.

Rearing monarchs can be an excellent educational tool, but rearing is not a conservation strategy.

of all restoration treatments, invasive plant removal had the greatest positive effect on the diversity and abundance of native bees. One study included in the meta-analysis (Hanula and Horn 2011), demonstrates the significant benefits. They found that the removal of Chinese privet (*Ligustrum sinense*) greatly improved habitat for butterflies and bees in riparian forest in southeastern US: Five years after shrub removal, treatment plots had three times as many bees and butterflies compared to control plots.

While invasive plant removal improves habitat for pollinators in the long-term, removal of flowering invasive plants has been suggested as a cause of decline for some pollinator populations by reducing floral resources (Tepedino et al. 2008; Severns and Moldenke 2010; Bezemer et al. 2014; Harmon-Threatt and Chin 2016). Controlling or removing invasive plants is particularly a balance for land managers working in degraded landscapes where native nectar for pollinators may be scarce. In some landscapes, invasive plants such as Canada and bull thistles may be the only species available as forage for monarchs. Removal of invasive plants under these circumstances may reduce nectar availability for monarchs and other pollinators—but removal of invasive plants is generally more important than the nectar they are providing. To minimize these negative, short-term impacts, a plan should be in place to plant commensurate native floral resources before or immediately after large-scale removal of invasive plants that are known to provide nectar resources for pollinators.

Invasive plants are often found and spread along roadsides—where some common milkweed species in the West also grow. Roadside invasive plants are commonly managed with mowing and herbicide applications during times when milkweed is actively growing and monarchs are present. These management practices have the potential to kill milkweed plants and immature monarchs, but are also important to reduce the spread of invasive plants. See the Roadsides and other Rights-of-Way section on page **37** more guidance.

Overall, removal of invasive plants with the goal of maintaining or conserving healthy, native plant communities is desirable at an ecosystem level, but care should be taken in the short-term to ensure phased removal and replacement with alternative resources for monarchs. In the long-term, managing to reduce the abundance of invasive plants can increase the abundance and diversity of both native plants and pollinators. See **Box 4** on page **41** and **Box 6** on page **63** or case studies of controlling invasive species and benefiting monarchs.

Invasive Plant Best Management Practices

Use an Integrated Vegetation Management (IVM) Plan

IVM includes strategies to prevent establishment and/or spread of invasive and noxious plants; makes site- and plant-specific determinations regarding the need for and level of intervention; considers a combination of management techniques (biological, physical, chemical, and cultural practices); and ensures treatments are completed a manner that minimizes risks to nontarget organisms and the environment.

Use Early Detection Rapid Response (EDRR) for New Invasive Plant Occurrences

- Learn more about this approach and EDRR networks on the website www.invasive.org/edrr.

Ensure Revegetation Plans are in Place

Before or directly following invasive plant removal on a large scale, ensure there will be similar native floral resources available for pollinators.

- Native perennial plants can deter recolonization of invasive plants.
- Replace with native perennial monarch nectar or host plants with similar phenology as the

Box 6: Considering Monarch Butterflies in Riparian Restoration at the Curlew National Grassland

The Curlew National Grassland, managed as a part of the Caribou-Targhee National Forest in southeastern Idaho, consists of over 47,000 acres of sagebrush steppe. Today, the US Forest Service is working to restore riparian areas in the national grassland. Riparian areas, while a small footprint of the landscape, are extremely important for private landowners for cattle and agricultural uses, for recreationists, and for the conservation of wildlife such as monarchs, greater sage-grouse, and migratory birds.

Deep Creek is in one of the riparian areas currently undergoing restoration in the Curlew National Grassland and a site where a multidisciplinary restoration team is really keeping monarchs in mind. Deep Creek's banks are currently choked with Russian olive (*Elaeagnus angustifolia*), native to central and western Asia, which staff are targeting for removal as part of the restoration. However, staff have noticed that showy milkweed growing near Russian olive attracts many monarch adults and caterpillars, especially during the hotter times of the summer when the Russian olive trees offer shade. One goal of the project is to maximize structural diversity while completing a phased removal of Russian olive. They hope this approach will also conserve some of the existing and establishing native riparian trees (willows [*Salix* spp.] and cottonwoods [*Populus* spp.]) along the banks to maintain shade for the milkweed and monarchs. The restoration team is also working to retain and boost milkweed and other native forbs. Milkweed plants are identified and preserved when possible. When not possible, rhizomes are sometimes dug up and replanted elsewhere. The restoration team are also restoring habitat with a seed mix containing species beneficial to greater sage-grouse and pollinators, as well as planning for the planting of shrubs and trees in key areas.

But every restoration project has its challenges. At this site, there are many invasive nonnative species on which monarchs and other pollinators currently rely for nectar, and these undesirable plants will likely increase with the disturbance and removal of Russian olive. Replacing these sources of nectar with native plants will take time and the team will have to balance removal with replacement. The restoration team says they hope this project serves as an opportunity to share and learn about managing for pollinators, especially monarch butterflies, within the US Forest Service and with other land managers and the public. Their on-the-ground learning of best management practices for monarchs may offer more lessons in the years to come.


Riparian restoration included removing Russian olive in phases. Photos below show pre- (left) and post-restoration (right) of two different areas of the Curlew National Grassland.

invasive species targeted for removal.

- If the invasive plant is providing nectar during a time of scarce floral resources, then removal can have negative impacts on monarchs and other native pollinators. Consider a phased-removal and revegetation plan to avoid removing major floral resources.

Prioritize control of invasive plants in habitats with high native plant diversity and abundance, and resiliency to invasion. Distance from native plant communities is directly related to native pollinator abundance and diversity.

Minimize Invasive Plant Spread by Limiting Vectors

- There are many vectors for invasive plant spread including wind, water, recreation (on boots, bike tires, OHV tires, horses, mules, etc.), livestock (on hooves, hair), livestock feed (hay), roads, and cars. The spread of invasive plants can increase in response to disturbances such as fire, recreation, roads, fuels reduction, forest thinning, logging, restoration, floods, and grazing.

Pallid milkweed is often found on dry, rocky hillsides, requiring little water, but its non-clonal growth form makes it vulnerable to grazing and OHV disturbances.

Other Considerations

Climate Change

In the West, climate change is expected to lead to reduced snowpack, earlier spring snowmelt, and long-term drought, and extreme events—storms, floods, large forest fires, and prolonged heat waves—are projected to become more common (USGCRP 2017). In addition, climate change may lead to additional pest pressure in agricultural areas, including the Central Valley of California, which may lead to an increased use of pesticides (Chiu et al. 2017; Taylor et al. 2018). Some of these changes in climate are expected to have negative effects on monarch populations because of impacts such as drought; however there may also be positive effects such as range expansion—especially northward or to higher elevations—and a longer breeding season.

Given the emphasis on monarch restoration projects throughout the country, considering the potential impacts of climate change on the landscape and available monarch resources should be incorporated into conservation planning efforts whenever possible.

- Prioritize conservation and restoration of areas which are likely to be resilient under climate change. For example, northern and higher-elevation areas may become more important as the climate warms.

Higher-elevation areas—such as this mountain sagebrush community in central Nevada—may become more important to monarchs if climate change causes uphill shifts in the ranges of milkweeds and nectar plants.

- Select milkweed and nectar plant species that are drought tolerant, especially in more southern and arid areas which are expected to become more drought-impacted.
- Create stepping stones or corridors of habitat across the landscape are beneficial to wildlife movement, but may be especially important under the stressors of climate change including species' range and phenological shifts.
- Anticipate changes in landscape suitability for host and nectar plants and plan restoration activities accordingly. (This is an area of active research, but there are not currently good projections of westwide milkweed habitat suitability under climate change scenarios).

Recreation

Hiking, trail running, equestrian use, mountain biking, off-highway vehicles (OHV), and other recreational activities can affect pollinator habitat by altering the quantity and structure of vegetation (Cole and Spildie 1998; Ballantyne et al. 2014; Hennings 2017), increasing soil erosion, altering soil composition and microflora (cryptobiotic crusts; Wilshire 1983), and spreading invasive plants (Trombulak and Frissell 2000; Trunkle and Fay 1991). Although recreation is generally unlikely to have a large impact on monarch populations in the West, OHV use is a concern for milkweeds in desert habitats including dunes and washes. This activity can cause direct mortality to butterflies (Blair and Launer 1997; Center for Biological Diversity et al. 2004; Wayne et al. 2009), severely damage butterfly habitat (Hoffman-Black et al. 2013), and spread invasive species (Trunkle and Fay 1991).

- Limit or eliminate OHV access in areas with milkweed, especially in desert environments and during the monarch breeding season.
- Develop weed washing stations in high-use OHV areas in order to limit the spread of invasive species.

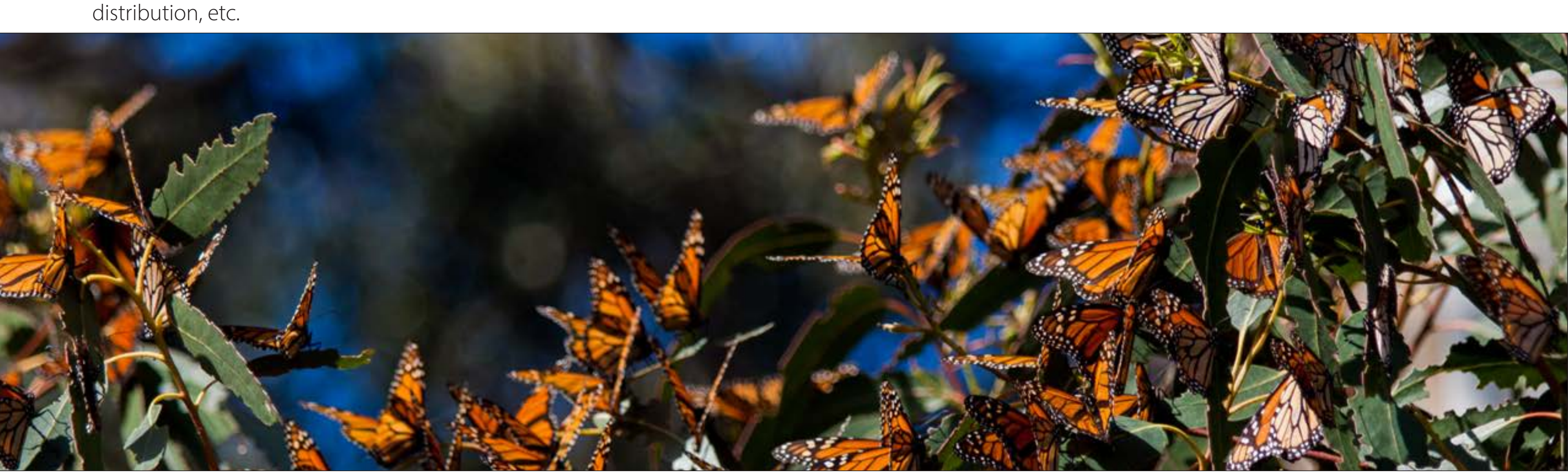
6

Monitoring Monarch Populations

Establishing baseline information and trends is essential to our understanding of monarchs and how to best manage their habitat in the West. In some of the monarch's breeding range in the West, basic information such as where milkweed grows and when monarchs breed is only beginning to emerge, and ideally any long-term monitoring strategy would collect this information. Monarch adults and larvae can be easily identified in the field, and milkweed is usually identifiable to genus. Because of this, monarch, milkweed, and habitat monitoring can often be implemented by a wide variety of practitioners, from agency biologists to citizen scientists. Monarch populations, like those of many insects, are subject to large fluctuations from one year to the next, so regular monitoring over multiple years is more valuable than single year snapshots. In addition, if monarch monitoring will be used to assess the effects of any management actions, then long-term monitoring begun before the project and continuing for several years after may be necessary. Monarch monitoring should occur when monarchs are expected to be present in your area; refer to **Figure 7** on page **24** to determine the best timing for monarch breeding surveys. See **Box 7** on page **68** for an example of a statewide monitoring effort in Idaho.

Public engagement has played a key role in the history of monarch science and the emergence of the monarch as a "conservation icon" (Gustafsson et al. 2015). Much of what we know about monarch migration and population trends in the West is due to the efforts of citizen scientists (e.g., Morris et al. 2015; Pelton et al. 2016). For example, a recent population viability analysis (Schultz et al. 2017) and an analysis of long-term monarch records (Espeset et al. 2016) used citizen-science data from the Western Monarch Thanksgiving Count to reveal that western monarchs are far more endangered than previously thought. Western land managers have access to a wide array of established monitoring programs for monarchs and milkweed, from simple occurrence reporting platforms to dedicated citizen-

Participating in monarch citizen science programs helps generate data and knowledge about the size of monarch populations, mortality, distribution, etc.



science projects and detailed, nationwide monitoring schemes. Below are some of the largest monarch and milkweed monitoring programs active in the West, several of which have international coverage.

A monarch chrysalis can be one of the most difficult life stages to find—the cryptic green keeps it well-hidden among milkweed leaves.

Integrated Monarch Monitoring Program

This monitoring program is a tri-national initiative led by the Monarch Conservation Science Partnership to monitor monarch populations and habitat throughout their breeding range. Training events and protocols are available on their website. Data gathered through this effort are used to inform local, regional, and national conservation efforts. See the MJV website (https://monarchjointventure.org/) to learn more.

Western Monarch Milkweed Mapper

This project is part of a collaborative effort to map and better understand monarch and milkweed occurrence across the western US. Data contributed to the Mapper will improve our understanding of the distribution and phenology of monarchs and milkweeds, identify important breeding areas, and help us better understand monarch conservation needs. It also collects data on which plants monarchs nectar on. Partners include the Xerces Society, US Fish and Wildlife Service, Idaho Department of Fish and Game, and Washington Department of Fish and Wildlife. See the website (www.monarchmilkweedmapper.org) to learn more. If you live in Canada, check out **Mission Monarch** instead (www.mission-monarch.org).

Western Monarch Thanksgiving Count

This project is led by the Xerces Society and Mia Monroe to track the number of monarchs overwintering in the western US. A dedicated group of citizen scientists monitors overwintering groves each year, gathering information on habitat conditions and estimating population numbers. Highlights of this effort are the annual Thanksgiving Count and New Year's Count, which take place at set times each fall and winter season. See the website (www.westernmonarchcount.org) to learn more.

Monarch Larva Monitoring Program

The MLMP is a citizen science project of the University of Minnesota Monarch Lab. Volunteers in the US and Canada monitor milkweed stands weekly to count monarch eggs, larvae, and pupae in order to better understand how and why monarch populations vary in time and space. Data collected from this effort have been used to determine the phenology of breeding in different areas, survivorship rates from egg to fifth instar larvae, year-to-year and site-to-site changes in monarch densities, the number of monarchs produced (on average) by a milkweed plant, and rates of parasitism. See their website (https://monarchlab.org/) to learn more.

Project Monarch Health

Participants in Project Monarch Health help researchers monitor monarchs for the parasite OE. Volunteers press small clear stickers to the abdomen of monarchs (which should not cause harm to the butterflies) and then submit the samples to the project's lab at the University of Georgia–Athens. The samples are analyzed for parasite load and the results added to a growing dataset of monarchs sampled across North America. See their website (www.monarchparasites.org) to learn more.

Box 7: Case Study: Coordinated Statewide Surveys of Monarch and Milkweeds in Idaho

The Idaho Department of Fish and Game (IDFG) is engaged in several efforts aimed at improving the state's knowledge of where monarchs and milkweeds are found including compiling existing occurrence records, implementing coordinated surveys to define baseline distributions, and training Idaho Master Naturalists and other citizen scientists. Prior to the mid-2010s, little was known about the distribution of monarchs and milkweeds in Idaho. Although suspected to be an important state for breeding monarchs, occurrence records were scarce. In order to establish baseline distributions of monarchs and milkweeds in Idaho, in 2016, IDFG initiated a two-year coordinated survey project across the state.

IDFG used outputs from the first phase of habitat suitability modeling developed by USFWS and the Xerces Society (US Fish and Wildlife Service and Xerces Society 2016) to narrow their statewide survey to areas with predicted higher relatively suitability for showy milkweed. The survey framework included a spatially-balanced sampling effort across three strata based on low, medium, and high relative habitat suitability. Surveys were conducted within 223 randomized grid cells in order to better understand where milkweeds do and do not occur on the landscape. This approach increased survey efficiency and reduced cost while allowing IDFG to groundtruth the model. IDFG's 2016 data was included in the second phase of habitat suitability modeling by USFWS, the Xerces Society, and the University of Nevada-Reno (Dilts et al. 2018) and both their 2016 and 2017 data are part of the Western Monarch Milkweed Mapper.

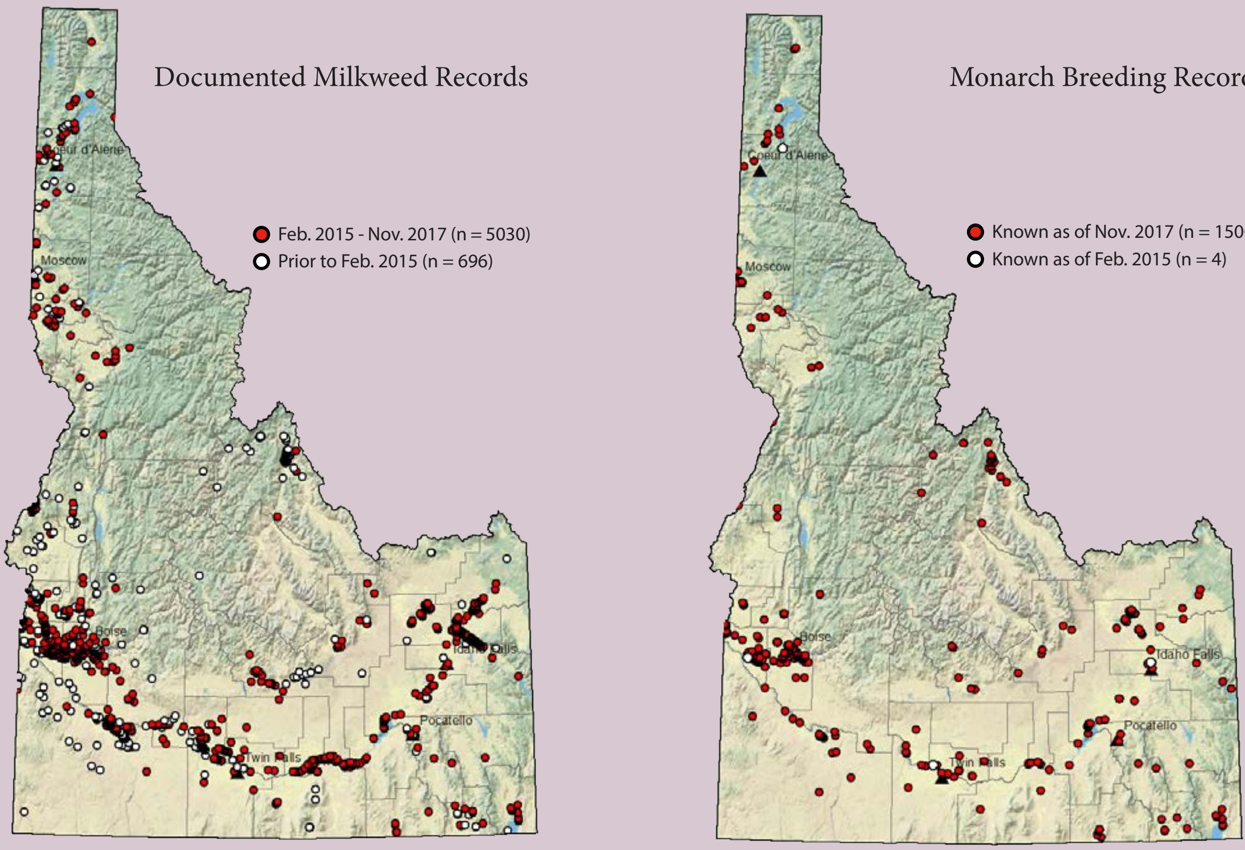
Some of IDFG's key findings include:

- Monarch breeding was found in all 10 of Idaho's climate divisions.
- In 2016, adult monarchs arrived in Idaho in late May/early June, and peak departure of the migratory generation occurred in mid- to late August.
- Idaho produces multiple generations each year.
- Natural areas with a wetland/floodplain component appear to be important monarch breeding areas.
- Productive breeding habitats appear to have co-occurring milkweed species (showy and swamp milkweed) with staggered phenologies.
- Milkweed distribution appears limited in northern Idaho, presumably due to cool, wet conditions and prevalence of dense-canopy forest cover. Areas where it does occur are generally open agricultural lands.
- Nectar sources during fall migration may be limiting in Idaho, given most nectar-producing plants are senesced by late summer/early fall.
- Herbicide spraying, mowing, and irrigation ditch maintenance were prevalent impacts in agricultural landscapes and roadsides.

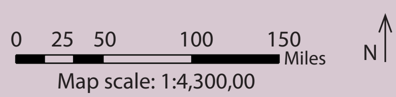
IDFG is now using these newly collected and compiled observation data in conjunction with climate data

A stand of showy milkweed growing in a southeastern Idaho grassland.

Monarch and Milkweed Observations in Idaho (1910-2017)



Point data are from the Idaho Fish and Wildlife Information System's Observation's database as of April 18, 2018. These data were compiled from numerous sources and underwent extensive quality control. Map created April 19, 2018.



to develop species distribution models for both milkweed and monarchs under moderate and severe future climate scenarios. This research will generate important information needed to assess the environmental variables key to the distribution of milkweed and monarchs in Idaho as well as the degree to which these distributions may be affected by changes in climate. In addition, models produced will help IDFG biologists and conservation partners address actions recommended in the newly revised Idaho State Wildlife Action Plan.

These actions include identifying priority monarch breeding sites and landscapes for habitat restoration and enhancement; addressing threats resulting in the loss, fragmentation, and modification of monarch breeding habitat; and investigating the direct and indirect effects of climate change on monarch populations.

Monarch tagging programs help us understand the butterfly's migratory paths.

Tagging and Tracking Programs

In addition to the monitoring programs described above, several programs focus on tagging and tracking the monarch migration. Tagging studies are especially important for answering questions about the geographic origins of monarchs at overwintering sites, possible migratory routes, and the overall timing of migration. Tagged western monarchs have been recovered at overwintering sites in both California and Mexico. However, little is known about the percentage of western monarchs that migrate to Mexico in any given year, and researchers are still trying to understand how much exchange occurs between the eastern and western populations. The majority of tagging studies in the West have focused on late summer migrants. However, information on spring migration routes and movement between overwintering sites can also be obtained through tagging. Below are some programs that track the monarch migration in the West.

Journey North
Participants report observations of migrating monarchs to real-time migration maps. These maps also track first emergence of milkweeds, first monarch eggs, and first monarch larvae across the country. See their website (www.learner.org/jnorth/monarchs) for more information.

Monarch Alert
A tagging and monitoring program based at Cal Poly in San Luis Obispo, California. The program focuses on tagging monarchs at California overwintering sites to study movement between sites and spring migration. Volunteers must complete a mandatory online training in order to tag in compliance with permitting regulations from the California Department of Wildlife. See their website (www.monarchalert.calpoly.edu) for more information.

Monarch Butterflies in the Pacific Northwest
A tagging program based in the Pacific Northwest whose online portal can be used to post tag recoveries and other reports of monarch sightings as well as share butterfly research and conservation news. See their Facebook page by the same name for more information.

Southwest Monarch Study
A tagging program based in the Southwest which provides tags for the arid West generally. Southwest Monarch Study also holds frequent workshops, monitors milkweed populations, identifies breeding habitat, and encourages establishment of monarch habitat. See their website (www.swmonarchs.org) for more information.

Western monarchs form overwintering aggregations in both coastal California and in central Mexico.

Resources

Below is a list of major resources of monarch conservation information. The list is not exhaustive, but provides a few of the most complete and accurate sources of general information about monarchs in the West.

General Monarch Resources

Monarch Joint Venture is a partnership of over 75 conservation, education, and research partners from across the US. Their website (https://monarchjointventure.org/) contains hundreds of resources including handouts, FAQs, a monarch conservation webinar series, and the Monarch Conservation Implementation Plan (updated annually), which provides extensive and wide-ranging information and prioritization of conservation actions.

The Xerces Society's website (www.xerces.org) which include links to the following (and many other) resources:

- Monarch Nectar Plant Guides
- Milkweed Seed Finder
- Regional Milkweed Guides
- Pollinator Conservation Resource Center

Monarch Conservation Science Partnership is a group of scientists, managers, and conservationists who work on furthering the science of monarch conservation. The group is managed by the US Geological Survey and you can find out more on their website (www.usgs.gov). The Xerces Society manages a western working group affiliated with the partnership.

Western Monarch Breeding and Migratory Habitat

The Western Monarch Milkweed Mapper website (www.monarchmilkweedmapper.org) provides information including an interactive map of milkweed and monarch occurrences and western milkweed species profiles. It also includes information about the habitat suitability modeling work which is a joint project of US Fish and Wildlife, Xerces Society, and the University of Nevada–Reno. This project modeled relative habitat suitability for milkweed and monarch breeding across the West.

California Overwintering Sites

Xerces Society's Western Monarch Thanksgiving Count website (www.westernmonarchcount.org) provides information about overwintering sites including an interactive map of site locations and monitoring efforts.

The Xerces Society's *State of the Monarch Butterfly Overwintering Sites in California* report summarizes the status, threats, and prioritization of overwintering sites. The Xerces Society's *Protecting California's Butterfly Groves: Management Guidelines for Monarch Butterfly Overwintering Habitat* provides best management practices for managing overwintering sites. Available on the Xerces Society website (www.xerces.org).

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Appendix 1. Western Milkweed Species by State

Includes information about which species are documented monarch larval hosts and species' phenology, associated habitat type, commercial plant materials availability, and region of state appropriate for planting.

Species	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Documented as Monarch Larval Host	Commercially Available Seed/plants	Suitabilty for Restoration (X=yes, U=uncommon, R=rare)	Species Distribution in State
Asclepias albicans	whitestem milkweed			x	x	x								Yes		X	SW
Asclepias angustifolia	Arizona milkweed					x	x	x	x					Yes	Yes	X, U	S
Asclepias asperula	spider milkweed			x	x	x	x	x	x	x	x			Yes	Yes	X	Entire state
Asclepias brachystephana	bract milkweed				x	x	x	x	x	x				Unknown		U	S
Asclepias cryptoceras	pallid milkweed				x	x	x							Yes		U	N
Asclepias cutleri	Cutler's milkweed				x	x	x							Unknown		R	NE
Asclepias engelmanniana	Engelmann's milkweed						x	x	x	x				Unknown		X	Entire state
Asclepias erosa	desert milkweed				x	x	x	x	x	x	x			Yes	Yes	X	W
Asclepias fascicularis	narrowleaf milkweed					x	x	x	x	x	x			Yes		U	N
Asclepias glaucescens	nodding milkweed							x	x	x				Unknown		R	SE
Asclepias hallii	Hall's milkweed						x	x	x					Unknown		R	N
Asclepias hypoleuca	mahogany milkweed						x	x	x	x				Unknown		R	S, W
Asclepias incarnata	swamp milkweed						x	x	x					Yes		U	N
Asclepias involucrata	dwarf milkweed				x	x	x	x						Unknown		U	N, SE
Asclepias latifolia	broadleaf milkweed					x	x	x	x					Unknown		U	N, SE
Asclepias lemmonii	Lemmon's milkweed							x	x					Unknown		R	SE
Asclepias linaria	pineneedle milkweed		x	x	x	x	x	x	x	x	x			Yes	Yes	X	S
Asclepias macrosperma	Largeseed milkweed					x	x							Unknown		U	N, E

Habitat Type
Arizona
Dry rocky places in deserts, including desert flats, slopes, and creosote bush scrub communities.
Riparian woodlands, arroyos, mountains, canyons, and along streambeds, as well as on hill slopes.
Well-drained rocky or sandy soils of prairies, roadsides, pastures, plains, hillsides, brushlands, and woodlands. Also grows in gravelly and rocky soil or on exposed talus in ponderosa pine woodlands and pinyon-juniper, oak chaparral, sagebrush, and mountain brush communities.
Desert mountains and dry plains, grasslands, mesas, and roadsides.
Dry, open, barren places such as washes, slopes, and hillsides, in pinyon-juniper woodland, sagebrush communities, salt desert shrublands, and aspen zones. May grow in clay, sand, gypsum, or serpentine soils.
Dry sandy areas, usually on dunes, sometimes in gravelly places in mixed desert shrub and pinyon-juniper communities.
Creeks, canyons, and open woodlands, as well as in swales, open sandy hillsides, draws, washes, and bottoms.
Dry washes, gulches, canyons, and roadsides in open deserts; in creosote bush, shadscale, and sometimes sagebrush communities.
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. It is found in similar places in the Northwest, including dry to moist meadows, fields, roadsides, open woods, and along waterways.
Canyons, rocky stream beds, open woodlands, and mountains.
Sandy and gravelly roadsides, wash-bottoms, and gullies and sagebrush, pinyon-juniper, mountain brush, cottonwood, ponderosa pine, and aspen communities. It is also found in the sandy soils of prairies.
Open oak and pine forests in the mountains.
Wet, flat, grassy meadows as well as streams and ditch-banks, marshes, and moist or wet ground. Occasionally found growing in water.
Dry sandy places, plains, mesas, often in blackbrush communities, sometimes in pinyon-juniper woodlands.
Dry washes, plains, mesas, canyon bottoms, and open desert. Can be abundant along roadsides.
Mountains in open dry (limestone) slopes and in canyons, in burned areas and grazed grassland, and in oak and pine-oak forests. Also found along roadsides and in open woodlands.
Dry, rocky slopes and mesas.
Sandy soils along washes.

Species *(continued)*	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Documented as Monarch Larval Host	Commercially Available Seed/plants	Suitabilty for Restoration (X=yes, U=uncommon, R=rare)	Species Distribution in State
Asclepias macrotis	longhood milkweed						x	x	x					Unknown		R	SE
Asclepias nummularia	tufted milkweed			x	x	x	x							Unknown		R	SE
Asclepias nyctaginifolia	Mojave milkweed					x	x	x	x	x				Yes		U	W, S
Asclepias quinquedentata	slimpod milkweed						x	x	x					Unknown		U	N, SE
Asclepias rusbyi	Rusby's milkweed						x	x						Unknown		U	N, SE
Asclepias ruthiae	Ruth's milkweed				x	x	x							Unknown		R	NE
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes	Yes	U	N
Asclepias subulata	rush milkweed				x	x	x	x	x	x	x			Yes	Yes	X	S
Asclepias subverticillata	horsetail milkweed					x	x	x	x	x				Yes	Yes	X	Most counties
Asclepias tuberosa	butterfly milkweed					x	x	x	x	x				Yes	Yes	X	Most counties
Asclepias uncialis	wheel milkweed				x	x	x							Unknown		R	NE, SE
Asclepias verticillata	whorled milkweed						x	x	x	x				Yes		U	N, SE
Asclepias viridiflora	green comet milkweed						x	x						Yes		U	N
Asclepias welshii	Welsh's milkweed					x	x	x	x					Unknown		R	NE
Asclepias albicans	whitestem milkweed			x	x									Yes		X	SE
Asclepias asperula	spider milkweed			x	x	x	x	x	x	x	x			Yes		U	SE
Asclepias californica	California milkweed				x	x	x	x						Yes		X	W

Habitat Type
Rocky (limestone) ridges and hills, grasslands, open woodlands, mountains.
Rocky hillsides, arid grasslands, dry ravines, mesas, and slopes, in gravel or clay. Oak and conifer woodlands, grasslands.
Canyons, hillsides, arroyos, dry slopes. Can be common on plains and mesas, often in sandy washes.
Open mountain woodlands with oak, ponderosa pine, and Douglas-fir.
Dry, open sites with rocky soil in sagebrush-oak, ponderosa pine, pinyon-juniper and yellow pine stands; also found in sagebrush, oak brush, and mountain brush in Utah.
Sandy and hard-packed loamy soils, clay hills, often growing along small gullies and drainage channels of flats, in desert scrub communities.
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.
Dry slopes, mesas, plains, and desert washes.
Sandy soils in moist places and grows in creosote bush, blackbrush, saltbush, sagebrush, rabbitbrush, pinyon-juniper, mountain brush, and open ponderosa pine communities. Common along roadsides. Can also be found along ditches and streams.
In the Rocky Mountain vicinity, the regional habitats described are near springs (in western Colorado); in moist to somewhat moist, sandy (or sometimes gravelly) soils in open ponderosa pine, oak, and pinyon-juniper communities (in Utah and Arizona) and in sage and mountain brush communities (in Utah). Generally found in moist to moderately moist sandy or gravelly soils, but habitats can be highly variable.
Open hills, upland grasslands.
Sandy, clayey, or rocky calcareous soils of prairies, flood plains, and open woods. Also found along roadsides and in pastures.
Dry plains and hills, often in rocky soils.
Naturally unstable shifting sands and dunes adjacent to sagebrush, juniper, and ponderosa pine communities. It occupies both the crest and lee slopes of dunes, adjusting readily to changes in depth of the sand.
California
Dry rocky places in deserts, including desert flats, slopes, and creosote bush scrub communities.
Well-drained rocky or sandy soils of prairies, roadsides, pastures, plains, hillsides, brushlands, and woodlands. Also grows in gravelly and rocky soil or on exposed talus in ponderosa pine woodlands and pinyon-juniper, oak chaparral, sagebrush, and mountain brush communities.
Flats and grassy or brushy slopes in many plant communities, including valley grassland, foothill woodland, yellow pine forest, pinyon-juniper woodland, and chaparral.

Species *(continued)*	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Documented as Monarch Larval Host	Commercially Available Seed/plants	Suitabilty for Restoration (X=yes, U=uncommon, R=rare)	Species Distribution in State
Asclepias cordifolia	heartleaf milkweed					x	x	x						Yes	Yes	X	N, E
Asclepias eriocarpa	woollypod milkweed					x	x	x	x	x	x			Yes	Yes	X	W
Asclepias erosa	desert milkweed				x	x	x	x	x	x	x			Yes		X	SE
Asclepias fascicularis	narrowleaf milkweed					x	x	x	x	x	x			Yes	Yes	X	Most counties
Asclepias nyctaginifolia	Mojave milkweed					x	x	x	x	x				Yes		R	SE
Asclepias solanoana	serpentine milkweed						x							Unknown		R	NW
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes	Yes	X	Most counties
Asclepias subulata	rush milkweed				x	x	x	x	x	x	x			Yes		U	SE
Asclepias vestita	wooly milkweed				x	x	x	x						Yes		X	S
Asclepias arenaria	sand milkweed					x	x	x	x					Unknown		U	E
Asclepias asperula	spider milkweed			x	x	x	x	x	x	x	x			Yes		X	Most counties
Asclepias cryptoceras	pallid milkweed				x	x	x							Yes		U	W
Asclepias engelmanniana	Engelmann's milkweed						x	x	x	x				Unknown		U	E
Asclepias hallii	Hall's milkweed						x	x	x					Unknown		U	W
Asclepias incarnata	swamp milkweed						x	x	x					Yes	Yes	X	N, E
Asclepias involucrata	dwarf milkweed				x	x	x	x						Unknown		U	S
Asclepias latifolia	broadleaf milkweed					x	x	x	x					Unknown		U	E

Habitat Type
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. There are also a few records from isolated hills within the Sacramento Valley. In the Great Basin, it is found on slopes and hillsides in rocky or gravelly soil in chaparral, juniper woodland, shrub steppe, and open pine and fir forests. It also grows on lava flows. In Oregon it can be found on dry, rocky slopes and hillsides and in open woods. Can also be found on talus slopes in open forests of ponderosa pine, Jeffrey pine, white fir, Douglas fir, and incense cedar.
Dry, rocky areas in many plant communities, including valley grassland, chaparral, and foothill woodland. It also grows along stream banks and roadsides.
Dry washes, gulches, canyons, and roadsides in open deserts; in creosote bush, shadscale, and sometimes sagebrush communities.
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. It is found in similar places in the Northwest, including dry to moist meadows, fields, roadsides, open woods, and along waterways.
Canyons, hillsides, arroyos, dry slopes. Can be common on plains and mesas, often in sandy washes.
Serpentine outcrops.
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.
Dry slopes, mesas, plains, and desert washes.
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.
Colorado
Primarily in sandy soils.
Well-drained rocky or sandy soils of prairies, roadsides, pastures, plains, hillsides, brushlands, and woodlands. Also grows in gravelly and rocky soil or on exposed talus in ponderosa pine woodlands and pinyon-juniper, oak chaparral, sagebrush, and mountain brush communities.
Dry, open, barren places such as washes, slopes, and hillsides, in pinyon-juniper woodland, sagebrush communities, salt desert shrublands, and aspen zones. May grow in clay, sand, gypsum, or serpentine soils.
Creeks, canyons, and open woodlands, as well as in swales, open sandy hillsides, draws, washes, and bottoms.
Sandy and gravelly roadsides, wash-bottoms, and gullies and sagebrush, pinyon-juniper, mountain brush, cottonwood, ponderosa pine, and aspen communities. It is also found in the sandy soils of prairies.
Wet, flat, grassy meadows as well as streams and ditch-banks, marshes, and moist or wet ground. Occasionally found growing in water.
Dry sandy places, plains, mesas, often in blackbrush communities, sometimes in pinyon-juniper woodlands.
Dry washes, plains, mesas, canyon bottoms, and open desert. Can be abundant along roadsides.

Species *(continued)*	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Documented as Monarch Larval Host	Commercially Available Seed/plants	Suitabilty for Restoration (X=yes, U=uncommon, R=rare)	Species Distribution in State
Asclepias macrosperma	Largeseed milkweed					x	x							Unknown		U	S
Asclepias macrotis	longhood milkweed						x	x	x					Unknown		U	SE
Asclepias pumila	low milkweed						x	x	x					Unknown		U	E
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes	Yes	X, U	Most counties
Asclepias subverticillata	horsetail milkweed					x	x	x	x	x				Yes		X	Most counties
Asclepias tuberosa	butterfly milkweed					x	x	x	x	x				Yes	Yes	X, U	Most counties
Asclepias uncialis	wheel milkweed				x	x	x							Unknown		R	E
Asclepias verticillata	whorled milkweed						x	x	x	x				Yes		U	E
Asclepias viridiflora	green comet milkweed						x	x						Yes		X	E
Asclepias asperula	spider milkweed			x	x	x	x	x	x	x	x			Yes		U	SE
Asclepias cryptoceras	pallid milkweed				x	x	x							Yes		R	S
Asclepias fascicularis	narrowleaf milkweed					x	x	x	x	x	x			Yes		U	S
Asclepias incarnata	swamp milkweed						x	x	x					Yes		X	S
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes		X	Most counties
Asclepias incarnata	swamp milkweed						x	x	x					Yes		U	S
Asclepias pumila	low milkweed						x	x	x					Unknown		X	E

Habitat Type
Sandy soils along washes.
Rocky (limestone) ridges and hills, grasslands, open woodlands, mountains.
Dry sites on plains and low hills.
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.
Sandy soils in moist places and grows in creosote bush, blackbrush, saltbush, sagebrush, rabbitbrush, pinyon-juniper, mountain brush, and open ponderosa pine communities. Common along roadsides. Can also be found along ditches and streams.
In the Rocky Mountain vicinity, the regional habitats described are near springs (in western Colorado); in moist to somewhat moist, sandy (or sometimes gravelly) soils in open ponderosa pine, oak, and pinyon-juniper communities (in Utah and Arizona) and in sage and mountain brush communities (in Utah). Generally found in moist to moderately moist sandy or gravelly soils, but habitats can be highly variable.
Open hills, upland grasslands.
Sandy, clayey, or rocky calcareous soils of prairies, flood plains, and open woods. Also found along roadsides and in pastures.
Dry plains and hills, often in rocky soils.
Idaho
Well-drained rocky or sandy soils of prairies, roadsides, pastures, plains, hillsides, brushlands, and woodlands. Also grows in gravelly and rocky soil or on exposed talus in ponderosa pine woodlands and pinyon-juniper, oak chaparral, sagebrush, and mountain brush communities.
Dry, open, barren places such as washes, slopes, and hillsides, in pinyon-juniper woodland, sagebrush communities, salt desert shrublands, and aspen zones. May grow in clay, sand, gypsum, or serpentine soils.
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. It is found in similar places in the Northwest, including dry to moist meadows, fields, roadsides, open woods, and along waterways.
Wet, flat, grassy meadows as well as streams and ditch-banks, marshes, and moist or wet ground. Occasionally found growing in water.
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.
Montana
Wet, flat, grassy meadows as well as streams and ditch-banks, marshes, and moist or wet ground. Occasionally found growing in water.
Dry sites on plains and low hills.

Species *(continued)*	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Documented as Monarch Larval Host	Commercially Available Seed/plants	Suitabilty for Restoration (X=yes, U=uncommon, R=rare)	Species Distribution in State
Asclepias speciosa	showy milkweed			x	x	x	x	x	x	x				Yes		X	Most counties
Asclepias syriaca	common milkweed			x	x	x	x	x	x					Yes		U	E
Asclepias verticillata	whorled milkweed						x	x	x	x				Yes		X	E
Asclepias viridiflora	green comet milkweed						x	x						Yes		X	Most counties
Asclepias asperula	spider milkweed			x	x	x	x	x	x	x	x			Yes		U	SE
Asclepias cordifolia	heartleaf milkweed					x	x	x						Yes		U	W
Asclepias cryptoceras	pallid milkweed				x	x	x							Yes		U	Most counties
Asclepias engelmanniana	Engelmann's milkweed						x	x	x	x				Unknown		R	SE
Asclepias erosa	desert milkweed				x	x	x	x	x	x	x			Yes		X	Most counties
Asclepias fascicularis	narrowleaf milkweed					x	x	x	x	x	x			Yes	Yes	X	Most counties
Asclepias hallii	Hall's milkweed						x	x	x					Unknown		U	E
Asclepias incarnata	swamp milkweed						x	x	x					Yes		U	S
Asclepias nyctaginifolia	Mojave milkweed					x	x	x	x	x				Yes		R	S
Asclepias rusbyi	Rusby's milkweed						x	x						Unknown		R	SE
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes	Yes	X	Most counties
Asclepias subulata	rush milkweed				x	x	x	x	x	x	x			Yes		U	S
Asclepias subverticillata	horsetail milkweed					x	x	x	x	x				Yes		U	S

Habitat Type
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.
Prairies, old fields, and margins of woods, in the flood plains of lakes, ponds, or waterways, and along creek banks, roadsides, and railways. Grows in sandy, clay, or rocky calcareous soils.
Sandy, clayey, or rocky calcareous soils of prairies, flood plains, and open woods. Also found along roadsides and in pastures.
Dry plains and hills, often in rocky soils.
Nevada
Well-drained rocky or sandy soils of prairies, roadsides, pastures, plains, hillsides, brushlands, and woodlands. Also grows in gravelly and rocky soil or on exposed talus in ponderosa pine woodlands and pinyon-juniper, oak chaparral, sagebrush, and mountain brush communities.
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. There are also a few records from isolated hills within the Sacramento Valley. In the Great Basin, it is found on slopes and hillsides in rocky or gravelly soil in chaparral, juniper woodland, shrub steppe, and open pine and fir forests. It also grows on lava flows. In Oregon it can be found on dry, rocky slopes and hillsides and in open woods. Can also be found on talus slopes in open forests of ponderosa pine, Jeffrey pine, white fir, Douglas fir, and incense cedar.
Dry, open, barren places such as washes, slopes, and hillsides, in pinyon-juniper woodland, sagebrush communities, salt desert shrublands, and aspen zones. May grow in clay, sand, gypsum, or serpentine soils.
Creeks, canyons, and open woodlands, as well as in swales, open sandy hillsides, draws, washes, and bottoms.
Dry washes, gulches, canyons, and roadsides in open deserts; in creosote bush, shadscale, and sometimes sagebrush communities.
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. It is found in similar places in the Northwest, including dry to moist meadows, fields, roadsides, open woods, and along waterways.
Sandy and gravelly roadsides, wash-bottoms, and gullies and sagebrush, pinyon-juniper, mountain brush, cottonwood, ponderosa pine, and aspen communities. It is also found in the sandy soils of prairies.
Wet, flat, grassy meadows as well as streams and ditch-banks, marshes, and moist or wet ground. Occasionally found growing in water.
Canyons, hillsides, arroyos, dry slopes. Can be common on plains and mesas, often in sandy washes.
Dry, open sites with rocky soil in sagebrush-oak, ponderosa pine, pinyon-juniper and yellow pine stands; also found in sagebrush, oak brush, and mountain brush in Utah.
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.
Dry slopes, mesas, plains, and desert washes.
Sandy soils in moist places and grows in creosote bush, blackbrush, saltbush, sagebrush, rabbitbrush, pinyon-juniper, mountain brush, and open ponderosa pine communities. Common along roadsides. Can also be found along ditches and streams.

Species *(continued)*	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Documented as Monarch Larval Host	Commercially Available Seed/plants	Suitabilty for Restoration (X=yes, U=uncommon, R=rare)	Species Distribution in State
Asclepias uncialis	wheel milkweed				x	x	x							Unknown		R	Central
Asclepias arenaria	sand milkweed					x	x	x	x					Unknown		U	E
Asclepias asperula	spider milkweed			x	x	x	x	x	x	x	x			Yes		X	Most counties
Asclepias brachystephana	bract milkweed				x	x	x	x	x	x				Unknown		U	S
Asclepias emoryi	Emory's milkweed				x	x	x	x	x	x				Unknown		R	E
Asclepias engelmanniana	Engelmann's milkweed						x	x	x	x				Unknown		U	Most counties
Asclepias glaucescens	nodding milkweed							x	x	x				Unknown		R	S
Asclepias hypoleuca	mahogany milkweed						x	x	x	x				Unknown		U	SE
Asclepias incarnata	swamp milkweed						x	x	x					Yes		U	N, W
Asclepias involucrata	dwarf milkweed				x	x	x	x						Unknown		U	Most counties
Asclepias latifolia	broadleaf milkweed			x	x	x	x	x	x					Unknown		U	Most counties
Asclepias linaria	pineneedle milkweed		x	x	x	x	x	x	x	x	x			Yes		U	SW
Asclepias macrosperma	Largeseed milkweed					x	x							Unknown		U	W
Asclepias macrotis	longhood milkweed						x	x	x					Unknown		U	Most counties
Asclepias nummularia	tufted milkweed			x	x	x	x							Unknown		R	SW
Asclepias nyctaginifolia	Mojave milkweed					x	x	x	x	x				Yes		U	S
Asclepias pumila	low milkweed						x	x	x					Unknown		U	NE
Asclepias quinquedentata	slimpod milkweed						x	x	x					Unknown		U	N, W
Asclepias rusbyi	Rusby's milkweed						x	x						Unknown		R	N, W
Asclepias ruthiae	Ruth's milkweed				x	x	x							Unknown		R	SW

Habitat Type
Open hills, upland grasslands.
New Mexico
Primarily in sandy soils.
Well-drained rocky or sandy soils of prairies, roadsides, pastures, plains, hillsides, brushlands, and woodlands. Also grows in gravelly and rocky soil or on exposed talus in ponderosa pine woodlands and pinyon-juniper, oak chaparral, sagebrush, and mountain brush communities.
Desert mountains and dry plains, grasslands, mesas, and roadsides.
Dry, sandy plains.
Creeks, canyons, and open woodlands, as well as in swales, open sandy hillsides, draws, washes, and bottoms.
Canyons, rocky stream beds, open woodlands, and mountains.
Open oak and pine forests in the mountains.
Wet, flat, grassy meadows as well as streams and ditch-banks, marshes, and moist or wet ground. Occasionally found growing in water.
Dry sandy places, plains, mesas, often in blackbrush communities, sometimes in pinyon-juniper woodlands.
Dry washes, plains, mesas, canyon bottoms, and open desert. Can be abundant along roadsides.
Dry, rocky slopes and mesas.
Sandy soils along washes.
Rocky (limestone) ridges and hills, grasslands, open woodlands, mountains.
Rocky hillsides, arid grasslands, dry ravines, mesas, and slopes, in gravel or clay. Oak and conifer woodlands, grasslands.
Canyons, hillsides, arroyos, dry slopes. Can be common on plains and mesas, often in sandy washes.
Dry sites on plains and low hills.
Open mountain woodlands with oak, ponderosa pine, and Douglas-fir.
Dry, open sites with rocky soil in sagebrush-oak, ponderosa pine, pinyon-juniper and yellow pine stands; also found in sagebrush, oak brush, and mountain brush in Utah.
Sandy and hard-packed loamy soils, clay hills, often growing along small gullies and drainage channels of flats, in desert scrub communities.

Species *(continued)*	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Documented as Monarch Larval Host	Commercially Available Seed/plants	Suitabilty for Restoration (X=yes, U=uncommon, R=rare)	Species Distribution in State
Asclepias scaposa	Bear Mountain milkweed			x	x	x	x	x	x	x	x			Unknown		R	SW
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes	Yes	U	N
Asclepias subverticillata	horsetail milkweed					x	x	x	x	x				Yes	Yes	X	Most counties
Asclepias tuberosa	butterfly milkweed					x	x	x	x	x				Yes	Yes	X, U	Most counties
Asclepias uncialis	wheel milkweed				x	x	x							Unknown		U	Central, SW
Asclepias verticillata	whorled milkweed						x	x	x	x				Yes		U	Most counties
Asclepias viridiflora	green comet milkweed						x	x						Yes		X	NE
Asclepias cordifolia	heartleaf milkweed					x	x	x						Yes		X	SW
Asclepias cryptoceras	pallid milkweed				x	x	x							Yes		R	E
Asclepias fascicularis	narrowleaf milkweed					x	x	x	x	x	x			Yes	Yes	X	Most Counties
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes	Yes	X	Most Counties
Asclepias asperula	spider milkweed			x	x	x	x	x	x	x	x			Yes		X	Most counties
Asclepias cryptoceras	pallid milkweed				x	x	x							Yes		U	Most counties
Asclepias cutleri	Cutler's milkweed				x	x	x							Unknown		R	SE
Asclepias erosa	desert milkweed				x	x	x	x	x	x	x			Yes		X	SW

Habitat Type
Dry hills.
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.
Sandy soils in moist places and grows in creosote bush, blackbrush, saltbush, sagebrush, rabbitbrush, pinyon-juniper, mountain brush, and open ponderosa pine communities. Common along roadsides. Can also be found along ditches and streams.
In the Rocky Mountain vicinity, the regional habitats described are near springs (in western Colorado); in moist to somewhat moist, sandy (or sometimes gravelly) soils in open ponderosa pine, oak, and pinyon-juniper communities (in Utah and Arizona) and in sage and mountain brush communities (in Utah). Generally found in moist to moderately moist sandy or gravelly soils, but habitats can be highly variable.
Open hills, upland grasslands.
Sandy, clayey, or rocky calcareous soils of prairies, flood plains, and open woods. Also found along roadsides and in pastures.
Dry plains and hills, often in rocky soils.
Oregon
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. There are also a few records from isolated hills within the Sacramento Valley. In the Great Basin, it is found on slopes and hillsides in rocky or gravelly soil in chaparral, juniper woodland, shrub steppe, and open pine and fir forests. It also grows on lava flows. In Oregon it can be found on dry, rocky slopes and hillsides and in open woods. Can also be found on talus slopes in open forests of ponderosa pine, Jeffrey pine, white fir, Douglas fir, and incense cedar.
Dry, open, barren places such as washes, slopes, and hillsides, in pinyon-juniper woodland, sagebrush communities, salt desert shrub-lands, and aspen zones. May grow in clay, sand, gypsum, or serpentine soils.
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. It is found in similar places in the Northwest, including dry to moist meadows, fields, roadsides, open woods, and along waterways.
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.
Utah
Well-drained rocky or sandy soils of prairies, roadsides, pastures, plains, hillsides, brushlands, and woodlands. Also grows in gravelly and rocky soil or on exposed talus in ponderosa pine woodlands and pinyon-juniper, oak chaparral, sagebrush, and mountain brush communities.
Dry, open, barren places such as washes, slopes, and hillsides, in pinyon-juniper woodland, sagebrush communities, salt desert shrub-lands, and aspen zones. May grow in clay, sand, gypsum, or serpentine soils.
Dry sandy areas, usually on dunes, sometimes in gravelly places in mixed desert shrub and pinyon-juniper communities.
Dry washes, gulches, canyons, and roadsides in open deserts; in creosote bush, shadscale, and sometimes sagebrush communities.

Species *(continued)*	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Documented as Monarch Larval Host	Commercially Available Seed/plants	Suitabilty for Restoration (X=yes, U=uncommon, R=rare)	Species Distribution in State
Asclepias fascicularis	narrowleaf milkweed					x	x	x	x	x	x			Yes		U	E
Asclepias hallii	Hall's milkweed						x	x	x					Unknown		U	Most counties
Asclepias incarnata	swamp milkweed						x	x	x					Yes	Yes	X	N, W
Asclepias involucrata	dwarf milkweed				x	x	x	x						Unknown		X	SE
Asclepias labriformis	Utah milkweed					x	x	x	x					Unknown		R	E
Asclepias latifolia	broadleaf milkweed					x	x	x	x					Unknown		U	S
Asclepias macrosperma	Largeseed milkweed					x	x							Unknown		N	SE
Asclepias rusbyi	Rusby's milkweed						x	x						Unknown		R	S
Asclepias ruthiae	Ruth's milkweed				x	x	x							Unknown		R	S, E
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes		X	Most counties
Asclepias subverticillata	horsetail milkweed					x	x	x	x	x				Yes		X	S
Asclepias tuberosa	butterfly milkweed					x	x	x	x	x				Yes	Yes	U	S
Asclepias uncialis	wheel milkweed				x	x	x							Unknown		R	SE
Asclepias verticillata	whorled milkweed						x	x	x	x				Yes		U	W
Asclepias welshii	Welsh's milkweed					x	x	x	x					Unknown		R	SE
Asclepias cryptoceras	pallid milkweed				x	x	x							Yes		R	SE

Habitat Type
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. It is found in similar places in the Northwest, including dry to moist meadows, fields, roadsides, open woods, and along waterways.
Sandy and gravelly roadsides, wash-bottoms, and gullies and sagebrush, pinyon-juniper, mountain brush, cottonwood, ponderosa pine, and aspen communities. It is also found in the sandy soils of prairies.
Wet, flat, grassy meadows as well as streams and ditch-banks, marshes, and moist or wet ground. Occasionally found growing in water.
Dry sandy places, plains, mesas, often in blackbrush communities, sometimes in pinyon-juniper woodlands.
Dry sandy soil with moist subsoil in washes, sandstone canyons, gulches and roadsides, and flats. Associated with saltbush (Atriplex sp.) and Mormon tea (Ephedra viridis var. viridis), mixed desert shrub (including blackbrush, rabbitbrush, and sagebrush), and pinyon-juniper communities.
Dry washes, plains, mesas, canyon bottoms, and open desert. Can be abundant along roadsides.
Sandy soils along washes.
Dry, open sites with rocky soil in sagebrush-oak, ponderosa pine, pinyon-juniper and yellow pine stands; also found in sagebrush, oak brush, and mountain brush in Utah.
Sandy and hard-packed loamy soils, clay hills, often growing along small gullies and drainage channels of flats, in desert scrub communities.
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.
Sandy soils in moist places and grows in creosote bush, blackbrush, saltbush, sagebrush, rabbitbrush, pinyon-juniper, mountain brush, and open ponderosa pine communities. Common along roadsides. Can also be found along ditches and streams.
In the Rocky Mountain vicinity, the regional habitats described are near springs (in western Colorado); in moist to somewhat moist, sandy (or sometimes gravelly) soils in open ponderosa pine, oak, and pinyon-juniper communities (in Utah and Arizona) and in sage and mountain brush communities (in Utah). Generally found in moist to moderately moist sandy or gravelly soils, but habitats can be highly variable.
Open hills, upland grasslands.
Sandy, clayey, or rocky calcareous soils of prairies, flood plains, and open woods. Also found along roadsides and in pastures.
Naturally unstable shifting sands and dunes adjacent to sagebrush, juniper, and ponderosa pine communities. It occupies both the crest and lee slopes of dunes, adjusting readily to changes in depth of the sand.
Washington
Dry, open, barren places such as washes, slopes, and hillsides, in pinyon-juniper woodland, sagebrush communities, salt desert shrublands, and aspen zones. May grow in clay, sand, gypsum, or serpentine soils.

Species *(continued)*	Common Name	J	F	M	A	M	J	J	A	S	O	N	D	Documented as Monarch Larval Host	Commercially Available Seed/plants	Suitabilty for Restoration (X=yes, U=uncommon, R=rare)	Species Distribution in State
Asclepias fascicularis	narrowleaf milkweed					x	x	x	x	x	x			Yes		X	E
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes		X	E
Asclepias arenaria	sand milkweed					x	x	x	x					Unknown		R	E
Asclepias cryptoceras	pallid milkweed				x	x	x							Yes		R	SE
Asclepias hallii	Hall's milkweed						x	x	x					Unknown		U	SE
Asclepias incarnata	swamp milkweed						x	x	x					Yes	Yes	X	SE
Asclepias pumila	low milkweed						x	x	x					Unknown		R	E
Asclepias speciosa	showy milkweed					x	x	x	x	x				Yes	Yes	X	Most counties
Asclepias subverticillata	horsetail milkweed					x	x	x	x					Yes		X	SE
Asclepias viridiflora	green comet milkweed						x	x						Yes		X	SE

Habitat Type
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. It is found in similar places in the Northwest, including dry to moist meadows, fields, roadsides, open woods, and along waterways.
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.
Wyoming
Primarily in sandy soils.
Dry, open, barren places such as washes, slopes, and hillsides, in pinyon-juniper woodland, sagebrush communities, salt desert shrublands, and aspen zones. May grow in clay, sand, gypsum, or serpentine soils.
Sandy and gravelly roadsides, wash-bottoms, and gullies and sagebrush, pinyon-juniper, mountain brush, cottonwood, ponderosa pine, and aspen communities. It is also found in the sandy soils of prairies.
Wet, flat, grassy meadows as well as streams and ditch-banks, marshes, and moist or wet ground. Occasionally found growing in water.
Dry sites on plains and low hills.
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.
Sandy soils in moist places and grows in creosote bush, blackbrush, saltbush, sagebrush, rabbitbrush, pinyon-juniper, mountain brush, and open ponderosa pine communities. Common along roadsides. Can also be found along ditches and streams.
Dry plains and hills, often in rocky soils.

Appendix 2. Native Monarch Nectar Plants in the West

www.xerces.org/monarch-nectar-plants

Scientific Name	Common Name	Flower Color	Bloom Period	Region(s) Where Found: Maritime NW	Region(s) Where Found: Inland NW
Asclepias speciosa	Showy milkweed	Pink	Summer to fall	x	x
Ericameria nauseosa	Rubber rabbitbrush	Yellow	Summer to fall		x
Asclepias fascicularis	Narrow-leaved milkweed	Pink/white	Summer to fall	x	x
Asclepias sp.	Milkweed	Varies	Summer to fall	x	x
Euthamia occidentalis	Western goldentop	Yellow	Summer to fall	x	x
Cleome lutea	Yellow spiderflower	Yellow	Spring to summer		x
Ericameria sp.	Goldenbush	Yellow	Summer to fall		x
Solidago sp.	Goldenrod	Yellow	Summer to fall	x	x
Chrysothamnus sp.	Rabbitbrush	Yellow	Summer to fall		x
Solidago canadensis	Canada goldenrod	Yellow	Summer to fall	x	x
Helianthus annuus	Common sunflower	Yellow	Spring to summer		x
Bidens laevis	Smooth beggartick	Yellow	Summer to fall		
Asclepias cordifolia	Heartleaf milkweed	Pink/purple	Summer to fall	x	x
Symphyotrichum chilense	Pacific aster	Purple	Summer to fall	x	x
Symphyotrichum sp.	Aster	Varies	Summer to fall	x	x
Baccharis pilularis	Coyotebrush	White/yellow	Fall to winter	x	x
Cleome serrulata	Rocky Mountain beeplant	White/pink	Summer to fall		x
Monardella odoratissima	Mountain monardella	White/purple	Summer to fall	x	x
Cirsium sp.	Thistle	Varies	Summer to fall	x	x
Helianthus sp.	Sunflower	Yellow	Spring to summer		x
Cephalanthus occidentalis	Common buttonbush	White	Summer to fall		
Baccharis salicifolia	Mule-fat	White/pink	Year round		
Baccharis sarothroides	Desertbroom	White/pink	Fall to winter		
Bidens cernua	Nodding beggartick	Yellow	Summer to fall	x	x
Verbena lasiostachys	Western vervain	Purple	Summer	x	

					# of Nectaring Records from Xerces Database	
Coastal CA	Inland CA	Great Basin	Rocky Mountains	Southwest	In the West	In the US
	x	x	x	x	211	212
x	x	x	x	x	83	83
	x	x			42	42
	x	x	x	x	18	42
x	x	x	x	x	8	8
	x	x	x	x	7	7
x	x	x	x	x	7	7
x	x	x	x	x	6	251
	x	x	x	x	6	6
x	x	x	x	x	5	111
x	x	x	x	x	5	20
x	x			x	5	7
	x	x			5	5
x	x				5	5
x	x	x	x	x	4	99
x	x				4	4
	x	x	x	x	4	4
x	x	x			4	4
x	x	x	x	x	3	56
x	x	x	x	x	3	20
	x			x	3	13
x	x	x		x	3	3
	x			x	3	3
x	x	x	x	x	3	3
x	x				3	3

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